MALAWI GOVERNMENT

MINISTRY OF NATURAL RESOURCES AND CLIMATE CHANGE
ENVIRONMENTAL AFFAIRS DEPARTMENT



MALAWI'S FIRST BIENNIAL TRANSPARENCY REPORT AND FOURTH NATIONAL COMMUNICATION TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE UNDER THE PARIS AGREEMENT

SEPTEMBER 2025



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SEPTEMBER, 2025

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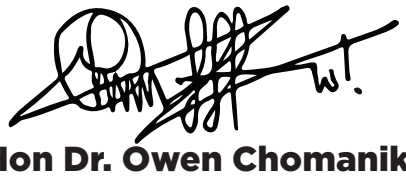
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FOREWORD

Climate change is one of the most pressing global challenges, significantly impacting sustainable development and the management of natural resources. As a Party to the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol, and the Paris Agreement, the Government of Malawi is committed to fulfilling its obligations under these international treaties by pursuing pathways for low-carbon and climate-resilient development.

In recent decades, Malawi has experienced an increase in the frequency and intensity of climate-related shocks, such as prolonged dry spells, erratic rainfall patterns, floods, and rising temperatures. These challenges have had a significant impact on key economic sectors, including agriculture, energy, water, transport, forestry, health, and infrastructure development. Recognizing these challenges, the Government of Malawi is taking measures by implementing robust strategies to enhance climate resilience and contribute to achieving the low carbon emission pathways, national development priorities as well as Sustainable Development Goals (SDGs).

The Government of Malawi (GoM), through the Ministry of Natural Resources and Climate Change MNRCC, remains fully committed to implementing the strategies outlined in this report. These efforts are guided by the National Climate Change Management Policy (2016) and the Malawi 2063, which prioritize climate action as a key driver for sustainable development. Achieving these goals requires collective action from government institutions, the private sector, academia, civil society, development partners, and local communities. The GoM) will continue to provide the necessary support for the implementation, monitoring, and evaluation of the BTR1/NC4, ensuring that Malawi's contributions to global climate action are well-documented and impactful.



Hon Dr. Owen Chomanika, MP

MINISTER OF NATURAL RESOURCES AND CLIMATE CHANGE

PREFACE

Malawi's economy is heavily reliant on the agriculture sector, which depends on sufficient and consistent rainfall. Consequently, the country's economic prosperity, food security, and overall well-being are highly vulnerable to the impacts of climate change and climate variability. In recent years, Malawi has faced an increase in climate-related challenges, such as prolonged droughts, erratic rainfall patterns, and floods. These threats have adversely affected critical sectors including energy, water, health, transport, forestry, tourism, biodiversity and infrastructure development. In light of these challenges, it is essential to adopt robust strategies and scientific approaches that allow for accurate assessments of climate trends, greenhouse gas (GHG) emissions, and their related impacts on development.

While climate change presents complex challenges that go beyond national borders, it also opens up opportunities for global cooperation to mitigate its adverse effects and enhance resilience. As a Party to the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol, and the Paris Agreement, the Government of Malawi reaffirms its commitment to addressing climate change through data-driven policies, measures to reduce emissions, and increased transparency.

This Fourth National Communication and Biennial Transparency Report (BTR1/NC4), builds upon previous National Communications and assesses Malawi's GHG emissions and removals, mitigation efforts, adaptation strategies, and emerging opportunities for addressing climate change. The report provides information on the following:

i. An updated and comprehensive assessment of greenhouse gas (GHG) emissions and removals in Malawi;

ii. Information necessary to track progress made in implementing and achieving nationally determined contributions under Article 4 of the Paris Agreement;

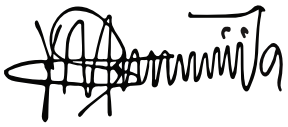
iii. Information related to climate change impacts and adaptation under Article 7 of the Paris Agreement;

iv. Information on financial, technology development and transfer and capacity-building support needed and received under Articles 9–11 of the Paris Agreement; and

v. Any other information Malawi considers relevant to the achievement of the objective of the Paris Agreement.

The report adheres to the Modalities, Procedures, and Guidelines (MPGs) established under the Enhanced Transparency Framework (ETF) of the Paris Agreement, ensuring compliance with the latest international reporting requirements. Furthermore, the report addresses new and emerging issues that were not included in previous reports and highlights both mitigation and adaptation actions based on national circumstances, sectoral developments, and evolving policy frameworks.

The Government of Malawi remains committed to transparency, accountability, and climate action, ensuring that the findings and recommendations from this report inform national policies, sectoral strategies, and international reporting obligations under the Paris Agreement. We look forward to continuing our collaboration with all stakeholders to achieve a climate-resilient low-carbon economy and sustainable future for Malawi.



Yusuf M. Mkungula, PhD

SECRETARY FOR NATURAL RESOURCES AND CLIMATE CHANGE

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I would like to thank the Minister of Natural Resources and Climate Change, Dr. Owen Chomanika, M.P, the Principal Secretary for Natural Resources and Climate Change, Dr. Yusuf M. Mkungula, my colleagues at the Environmental Affairs Department (EAD), (Messrs Evans Njewa, Ben Yassin, Jarvis Mwenechanya, Golivati Gomani, Yamikani Idriss, Hannah Siame, Christopher Mpanga and all staff for facilitating training sessions, stakeholder consultations and for general guidance and support throughout the NC4/BRT1 development process. I would also like to thank the thematic team leaders: Dr Kenneth Gondwe, Dr. Suzgo Kaunda, Dr. Geoffrey Chavula and Mr. Chikumbutso Kilembe and sectoral team experts for their effort to undertake this work of developing Malawi's NC4/ BTR 1 report in close liaison with the EAD project team.

The Malawi's First Biennial Transparency Report and Fourth National Communication Reports/s to the United Nations Framework Convention on Climate Change (UNFCCC) was developed with technical and financial support from the Global Environment Facility (GEF) through United Nations Environment Programme (UNEP), under the NCs/BTR Enabling Activity Project.

The BTR1/NC4 development process benefited from technical input and expertise from a broad range of stakeholders involved in climate change governance in Malawi. The preparation of this report was a collaborative effort involving Government Ministries, Agencies, the Academia, the private sector, the civil society, and development partners. In addition, I would like to acknowledge the valuable contributions made by many other organisations, groups and individuals for enabling us to access data and providing useful feedback to our report.

I extend my sincere gratitude to all stakeholders who contributed to this process. Special appreciation goes to the Global Environment Facility (GEF) and the United Nations Environment Programme (UNEP) for their financial and technical support in facilitating the development of this report. I would also extend my appreciation to the UNEP Global support Programme, the PATPA and the Consultative Group of Experts for Capacity Building support to Malawi on the Enhanced Transparency Framework and development of these reports.

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EXECUTIVE SUMMARY

ES.1 Background to Malawi's First Biennial Transparency Report and the Fourth National Communication

As a Party to both the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement, Malawi is obliged, under Article 4 (2) of the Paris Agreement to "prepare, communicate and maintain successive Nationally Determined Contributions (NDCs) that it intends to achieve". In line with this, under Article 13 of the Paris Agreement, among others Malawi is also obliged to "regularly communicate its national inventory report of anthropogenic emissions by sources and removals by sinks of greenhouse gases; information necessary to track progress made in implementing and achieving its NDCs under Article 4; and information related to climate change impacts and adaptation under Article 7 of the Paris Agreement. Malawi updated and communicated its NDCs in July 2021 with revised sectoral mitigation and adaptation targets up to 2040 with an GHGs emission reduction target of 51% by 2040. The NDCs demonstrate the commitment of the Government of Malawi to meet its obligations towards addressing the challenges of climate change. Malawi also communicated is first Biennial Update Report (BUR) in November, 2021 which provided a comprehensive outlook of the status of sectoral climate change issues in the country and taking into consideration emerging issues since the Second National Communication.

The Government of Malawi (GoM) received financial support from the Global Environment Facility (GEF) through the United Nations Environment Programme (UNEP) to prepare its Fourth National Communication (NC4) and first Biennial Transparency Report (BTR1) to the UNFCCC. The Ministry of Natural Resources and Climate Change through the Environmental Affairs Department (EAD) has developed the BTR1/NC4 report covering the period from 1st January, 2021 to 31st December, 2023 documenting what Malawi is doing in climate change management. The report has taken into consideration emerging issues as outlined in the Malawi's updated NDCs as well as the Malawi 2063. In this regard, areas that were not covered in the previous National Communications have been given adequate attention and detail in this report. In addition, the process of developing the BTR1/NC4 enhanced the visibility, awareness and knowledge, on climate change issues through increased involvement of all relevant stakeholders. The EAD in the Ministry of Natural Resources and Climate Change is the executing agency for the BTR1/NC4 process. The EAD has the overall mandate of monitoring the process to meet the objectives of the study, achieving results (outputs) and impact; and accounting for all financial resources to UNEP.

Four National Team Leaders were identified and each had a team comprising various and complementary experts to develop various reports and chapters that contributed to the compilation of the BTR1/NC4. The team members comprised a pool of experts that were involved in the preparation of previous National Communications as well as new experts. Details on the overall institutional arrangement for climate change management in Malawi as well as governing policy and legal frameworks is provided in the introduction chapter of this report.

ES.2 National Inventory Report of Anthropogenic Emissions by Sources and Removals by sinks of Greenhouse Gases

Malawi has undertaken three GHG inventories as part of the initial, second and third national communications to the UNFCCC in 2002,2010 and 2021. In 2024/2025, Malawi has undertaken the fourth national GHG inventory as part of Malawi's BTR1/NC4. The inventory covers five sectors, namely, energy, industrial processes and product use, agriculture forestry and other land use and waste covering three major gases- carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). In terms of methodology, 2006 IPCC Guidelines and 2019 Refinements were used together with the Modalities, Procedures and Guidelines (MPGs) which provided the approach for the BTR. Global Warming potentials from the Fifth Assessment Report (AR5) were used and Tier 1 was applied across all the sectors. The compilation of the BTR1/NC4 also benefitted from past climate change studies such as Nationally Appropriate Mitigation Action (NAMAs) report in 2015, Intended Nationally Determined Contribution (INDCs) in 2015, Biennial Update Report (BUR) in 2020 and Updated NDCs in 2021. The Table ES2-2 provides a summary of methodology and sources of activity data and emission factors for the categories. Malawi's economy is agrarian and the industrial sector is low but steadily growing. As such the GHG emissions are driven by population dynamics, economic activities agriculture, industry, energy, transport, and natural resources-based livelihood systems of the rural population and extreme climate events damaged power generation infrastructure which resulted in increased use of fossil fuels in energy industries.

Table ES2-1: Total GHG Emissions for 2018 and 2022

SECTOR	TOTAL EMISSIONS (Gg CO_2e)	
	2018	2022
Energy	1629.071	1810.16
Industrial Processes and other Products Use (IPPU)	107.539	188.316
Agriculture	4489.383	5714.19
Forestry and other Land Use (FOLU)	51631.71	46705.4
Waste	15635.912	17547.9
Total without FOLU	21861.904	25261.3
Total with FOLU	73493.614	71966.7

Emissions grew from 8,604.38 Gg CO2-e Gg in 1994 to 25,261.32 Gg in 2022. Further analysis showed that between 2018 and 2022, the total emissions (without FOLU) grew from 21,861.904 $GgCO_2$-e to 25,261.32 Gg in 2022, giving a total of 116,777.04 Gg of CO_2-e. The increase of emissions in the five years represents 32% of the total emissions over the entire period of 1994 to 2022. The overall analysis of the gases without FOLU showed that CO_2 account for 13.1 to 13.3%, CH_4 76.6 to 77.6% and N_2O 9.4 to 10.1%. Livestock and Waste sectors account for the larger percentage. The overall analysis

with FOLU showed that CO_2 accounted for 69.5 to 74.2%, CH_4 22.8% to 27.2% and N_2O 3% to 3.3%. Malawi applied flexibility in terms of number of gases reported (para 48)and time series (para 57 and 58). Malawi remains committed to progressively enhancing its national inventory capacity, data quality, methodological rigor, and reporting transparency over time.

Table ES2-2: Summary of methods, activity data and emission factors.

Energy Sector (1A, 1B)					
GHG source & sink category	Method	Emission factor (kg CO□/TJ)	Emission factor (kg CH□/TJ)	Emission factor (kg N□O/TJ)	Activity data source
1A1. Energy industries (electricity generation, 1.A.1.a.i)	Tier 1	74,100	3	0.6	Ministry of Energy, MERA, EGENCO
1A2. Manufacturing industries (food, beverages, tobacco 1.A.2.e)	Tier 1	Gas/Diesel oil: 74,100 Sub-bituminous coal: 96,100	3 (diesel) 10 (coal)	0.6 (diesel) 1.5 (coal)	MERA, Ministry of Industry, NSO
1A3. Transport (aviation, road, navigation)	Tier 1	Aviation Gas: 70,000 Jet Kerosene: 71,500 Gas/Diesel oil: 74,100 Motor Gasoline: 69,300	0.5 (AvGas, Jet) 3.9 (diesel) 33 (gasoline) 7 (navigation diesel)	2 (AvGas, Jet) 3.9 (diesel) 3.2 (gasoline) 2 (navigation diesel)	MERA, NOCMA, Road Traffic Directorate, NSO
1A4. Other sectors (residential, commercial, agri, fisheries)	Tier 1	LPG: 63,100 Kerosene: 71,900 Charcoal: 0 Fuelwood/Wood waste: 0	LPG: 5 Kerosene: 10 Charcoal: 200 Biomass: 300	LPG: 0.1 Kerosene: 0.6 Charcoal: 1 Biomass: 4	NSO, IHS, MERA, Ministry of Agriculture
1B1. Fugitive emissions from solid fuels (coal production, 1.B.1.a.i.1)	Tier 1	0	25 m³ CH□/tonne coal	0	Dept. of Mines, coal operators
IPPU (2A)					
2A.1 Cement production	Tier 1	0.51	0	0	Dept. of Mines, cement producers
2A.2 Lime production	Tier 1	0.59 (t CO□/t lime)	0	0	Lime makers, Dept. of Mines
Agriculture (3A, 3B, 3C)					
3A Enteric fermentation	Tier 1	0	Dairy cows: 46 Other cattle: 31 Sheep: 5 Goats: 5 Poultry: 0 Swine: 1 Rabbits: 0.92	0	Min. of Agriculture, FAOSTAT
3B Manure management	Tier 1	0	Dairy/other cattle: 1 Sheep: 0.2 Goats: 0.17 Poultry: 0.02 Swine: 1 Rabbits: 0.08	N□O = 0.005 (cattle, sheep, goats, rabbits) Poultry = 0.001 Swine = 0.02	Min. of Agriculture, FAOSTAT
3C.2 Liming	Tier 1	0.13 (t CO□/t lime applied)	0	0	Fertiliser importers
3C.3 Urea application	Tier 1	0.20 (t CO□/t urea)	0	0	Fertiliser importers
3C.4 Direct N□O emissions (soils)	Tier 1	0	0	EF1 = 0.01	MoA, FAOSTAT
3C.5 Indirect N□O volatilisation	Tier 1	0	0	EF4 = 0.01	MoA, FAOSTAT
3C.6 Indirect N□O leaching/runoff	Tier 1	0	0	EF5 = 0.0075	MoA, FAOSTAT
3C.7 Rice cultivation	Tier 1	0	1.3 (kg CH□/ha/day)	0	MoA, FAOSTAT
FOLU (4A–4F)					
4A Forest land	Tier 1	0.015419	0.00605	8.93×10□□(N□O) 2.72×10□□(other)	Forestry Dept., FAOSTAT
4B Cropland	Tier 1	4.7999×10□□	0.00554	3.53×10□□1.00×10□□	NSO, MoA
4C Grassland	Tier 1	2.7578×10□³	0.00579	5.15×10□□1.78×10□□	MoA
4D Wetlands	Tier 1	0.0136599	—	—	MoA, Forestry
4E Settlements	Tier 1	0.0136610–0.015431	—	—	NSO, MoL
Waste (5A–5D)					
5A Solid waste disposal	Tier 1	0	0	0	Local Govt, councils
5C Open burning of waste (5.C.2)	Tier 1	—	6,500 (kg CH□/Gg dry waste)	150 (kg N□O/Gg dry waste)	Local Govt, WASH NGOs
5D Wastewater	Tier 1	0	Sewer: 0.3 (kg CH□/kg BOD) Septic tank: 0.3 Latrine: 0.06	0.3–0.06 (kg N□O/person/yr)	Water Boards, councils

The analysis at the sector level showed the following:

i. **Energy:** The analysis for 2018 and 2022 showed that CO_2 was the dominant gas with values ranging from 81.97% to 82.98%, followed by CH_4 which ranged from 14.94% to 15.85% and N_2O ranging from 2.08% to 2.28%. The main drivers in emissions in the energy sector are combustion processes in transport and manufacturing industries, with slight moderation due generation using solar photovoltaic.

ii. **Industrial Processes and Product Use (IPPU):** The sector consisted of cement and lime processing which involved calcination of limestones resulting in emission of only CO_2. IPPU has been growing at 1.54% per annum driven by cement due growth in the construction industry.

iii. **Agriculture:** The main gases were CH_4 which accounted for 75.95% to 79.44%, followed by N_2O at 17.88% to 22.37% and CO_2 at 1.69% to 2.68%. Enteric fermentation and manure management contributed to methane emissions;

iv. **FOLU:** The sector contributed to emission of 100% CO_2; and

v. **Waste:** The major gas was CH_4 which accounted for 83.67% to 84.23%, followed by CO_2 at 8.29% to 8.84% and N_2O at 7.48% to 7.5%. Methane emission is from anaerobic digestion processes. The waste sector has been growing in tandem with population growth rate.

The emission patterns reflect Malawi's socio-economic trajectory—an economy rooted in agriculture but transitioning toward agro-processing and service-based industries (Government of Malawi, 2023). Key national trends influencing GHG emissions include use of chemical fertiliser in Agriculture, deforestation and land use change influenced by demand for biomass fuel and opening up of new farm land, poor waste treatment infrastructure failing to cope with high urbanisation and extreme climate events that damaged hydro-electric power generation thereby increasing the use of diesel-based generators between 2018 and 2022.

As regards Key Category Analysis, it was done based on the Approach 1 level and trend assessment. The assessments were done with and without FOLU sector. The findings showed:

Level assessment with FOLU sector:

- 4.A Forest Lands – CO_2: accounted for 51.43% in 2022;
- 5B Solid waste disposal-unmanaged waste CH4 accounted for 22.68%;
- Croplands CO_2 accounted for 6.98%;
- Wetlands CO_2 was 6.19%;
- Goats CH4 was at 2.43%;
- Non-dairy cattle was at 2.53%
- Road transport CO2 was at 1.735; and
- Grasslands was at 1.42%.

Trend assessment with FOLU sector:

- Forest Lands, CO_2 accounted for 47.29%;
- Solid waste disposal-unmanaged, CH_4 was 27.42%;
- Grasslands, was 6.46%;
- Goats, CH_4 was 5.73%;
- Non-dairy cattle, CH_4 was 4.26%;
- Road transport, CO_2 was 1.83%;
- Biomass burning, CO_2 was 1.02%; and
- Urea application, CO_2 was 0.86%.

Cross-Sectoral Improvements

Malawi has seen steady improvement in its human capacity in terms of numbers and skill levels in the preparation of national GHG inventories since the publication of its Initial National Communication in 2002. Malawi strives to continuously improve the quality and transparency of its GHG inventories through:

- Strengthening quality assurance/quality control (QA/QC) processes for sector-specific GHG emission reporting;
- Expanding training programs for national experts on the application of the 2006 IPCC Guidelines, including the use of IPCC Inventory Software;
- Formalisation of data sharing with data providers;
- Operationalising activity data management and archiving system;
- Developing country-specific emission factors for key categories in all sectors to enhance accuracy;
- Improving the national Measurement, Reporting, and Verification (MRV) system to support comprehensive data collection and reporting on mitigation actions; and
- Enhancing institutional arrangements and inter-agency coordination to facilitate sustainable GHG inventory planning and reporting.

ES.3 Information Necessary to Track Progress Made in Implementing and Achieving Nationally Determined Contributions Under article 4 of the Paris Agreement

Malawi submitted its revised NDCs under Article 4 of the Paris Agreement in 2021, pledging to reduce 17.7 million tCO2e by 2040 relative to a *business as usual (BAU) emission* scenario that would emit 34.61 million tCO2e by that year. This is an ambitious emission reduction, which targets a 51% emission reduction relative to BAU by 2040. Revised NDCs measures are categorized into unconditional and conditional measures, basing on their planned sources of financing. Unconditional measures are those that are to be implemented using domestic financial resources. Emissions from implementation of unconditional measures describe emissions path under *"with measures"* scenario. Unconditional measures are planned to contribute 2.1 million tCO2e emission reduction over the period, representing a reduction of 6% relative to BAU. On the other hand, conditional measures are planned to contribute 15.6 million tCO2e (45% relative to BAU). Emissions resulting from implementation of conditional measures describe emissions under "*with additional measures*" scenario. Conditional measures are planned to contribute 15.6 million tCO2e (representing 45% relative to BAU emissions). Modelling emission projections up to 2040 under these three scenarios are presented in Figure 3-E1.

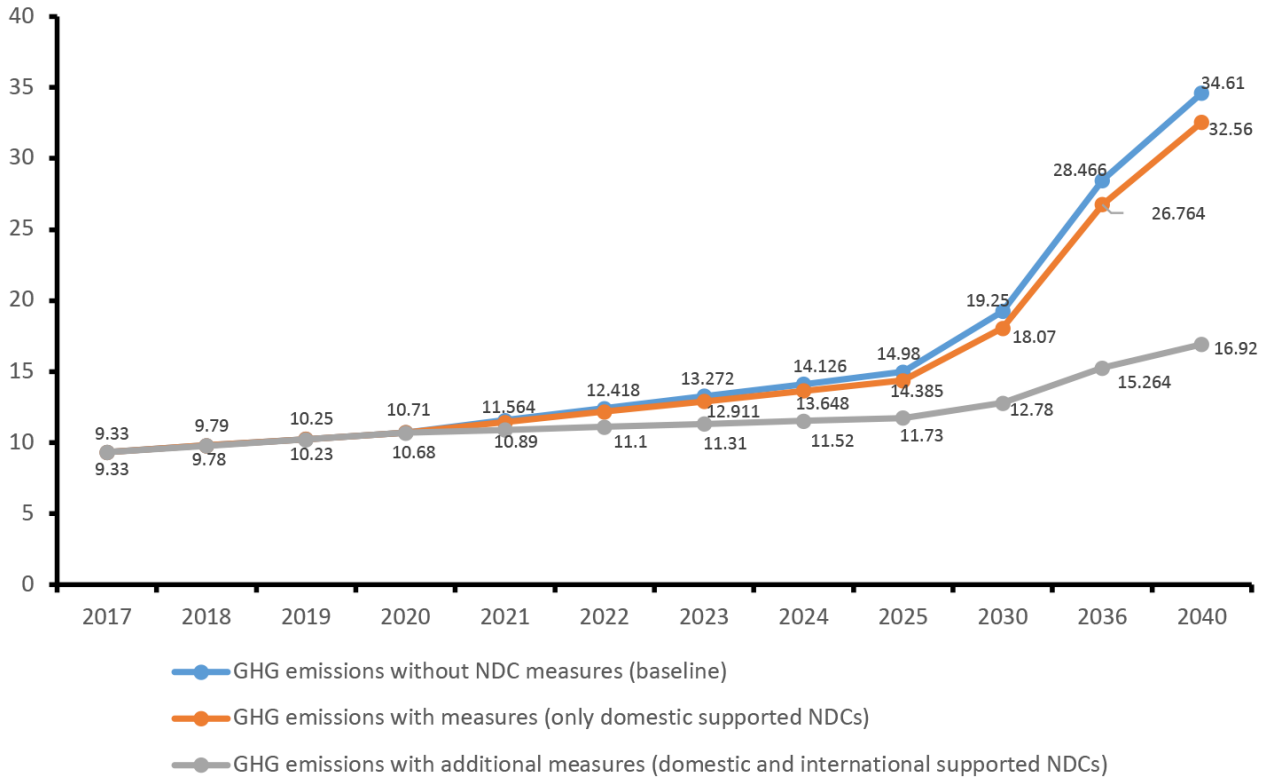


Figure 3-E1: GHG emission projection under different NDCs scenarios

The indicator, absolute GHG emission relative to baseline emission as described in NDCS, has been used to track progress of NDCS implementation. This is the indicator that Malawi, as Party, selected to track its implementation and achievement of its NDCS by 2040. With respect to reporting requirement for the BTR, actual GHG emissions for 2021 and 2022, are compared with emissions described by the mitigation scenario in the NDCS. It is the expectation that actual emissions are to be constantly below the mitigation emission scenario (hence BAU scenario) to achieve the projected emission reduction of 17.7 million tCO2e by 2040. From the GHG Inventory conducted for this BTR, emissions (excluding FOLU) in 2021 and 2022 (refer to Table 3-E1) are very much higher than for the mitigation scenario described the revised NDCS.

Table 3-E1: Comparison between GHG emissions for reference years (during NDCS.2 estimation) and current GHG Inventory for reporting years of 2021 and 2022

Inventory Year	Energy (Gg CO2e)	Industrial Processes and Product Use (Gg CO2e)	Agriculture (Gg CO2e)	Waste (Gg CO2e)	Total (Gg CO2e)	Total emission in the Current Inventory (million tCO2e (million tCO2e)	Total Emission Under Mitigation scenario where all NDCS-2 measures implemented (million tCO2e)	Relative difference between emissions when all NDCS-2 measures are implemented and actual emissions (%)
2017	1,366.32	89.38697	4,056.55	14,631.92	20,144.18	20.144	9.33	-116%
2018	1,629.07	107.5394	4,489.38	15,635.91	21,861.90	21.862	9.78	-124%
2019	1,693.66	146.0092	4,258.79	16,125.19	22,223.65	22.224	10.23	-117%
2020	1,859.69	179.4682	4,638.31	16,622.88	23,300.36	23.300	10.68	-118%
2021	1,697.86	194.8529	5,113.06	17,124.02	24,129.79	**24.130**	**10.89**	-122%
2022	1,810.16	188.3158	5,714.96	17,547.87	25,261.30	**25.261**	**11.1**	-128%

Since actual emissions emission levels are much higher than planned emissions described by NDCS mitigation scenario, Malawi is not making progress in reducing emission relative to its business as usual emission, with high level of unlikely to meet the target of reducing 17.7 million tCO2e by 2040. Therefore, basing on actual emissions provided by the GHG inventory, Malawi's progress in NDCS implementation is not satisfactory. However, it was noted that emissions from the waste sector (refer to Table E1) in the current GHG inventory are extremely high relative to other sectors and to prior GHG inventories. It is recommended to check the methodology and data sources on estimation of emissions from the waste sector in the revision of NDCS and in the subsequent GHG inventory compilations.

In its revised NDCs, Malawi submitted a total of 34 mitigation measures, and a number of 79 adaptation measures. This Chapter tracks progress made in implementing the revised NDCs. Tracking progress of implementation is in terms of evaluating the indicator, which in the case of Malawi, is the absolute economy-wide GHG reduction relative to BAU. Thus, tracking of progress considered only GHG reductions from mitigation NDCs measures. In order to understand the opportunities and challenges related to NDCs implementation, national circumstances and institutional arrangements for the country have been provided. Challenging economic conditions facing the country have limited its capacity to implement most of the planned

NDCs measures, while the need for adapting to impacts of climate change increases as frequency and magnitude of climate related impacts continue to rise. The country's power sector, planned to have considerable amount of coal-fired power plants is still dominated by hydropower generated from a climate sensitive resource, along the Shire River. Population continues to rise, putting pressure on natural resources and the need to have efficient biomass cookstoves.

Energy Sector makes a significant share of contributions in the revised NDCs, designed to mitigate emissions that would come from planned coal-fired power plants at Kam'mwamba (350 MW) in Neno District and in Salima District (120 MW), as well as the diesel electric generators powered by EGENCO to generate electricity. A prioritized list of NDCs measures were identified for tracking, using the following criteria, with equal weighting: availability of data (whether the measure is implemented or not), the measure addresses a key category in emission inventory, and potential for GHG emission reduction. Four NDCs measures were identified and tracked, as follows: Grid-connect hydropower generation; Off-grid small scale solar PV systems; Grid-connected large-scale solar PV; and Improved Biomass Cookstove (Charcoal and Firewood). The Table 3-E1 provides summary of status and its projected GHG-based outcomes for the prioritized measures.

Table 3-E2: Summary of NDCs measures tracked in terms of status and GHG-based mitigation outcomes

NDCS measure	**Status of Implementation** **During the NDCs-2 implementation period (2021 to 2024)**	**GHG-based mitigation outcomes from the measure**
Grid-connect hydropower generation	Grid based hydropower generation as an NDCs has a target of having 410 MW of additional electricity to the grid by 2030. By 2024, the following were achieved 1. Reviewing and updating the hydropower component of Malawi's IRP (2015 - 2035) was being done, but not yet completed. 2. Technical and financial feasibility studies conducted for the following for priority grid-connected hydropower projects: Wovwe Extension, Mpatamanga, Kholombidzo, Lower Fufu, Songwe, and Chasombo and Chizuma. Financial proposals are produced, including technical designs of the power plants. 3. Financing secured for the 360 MW Mpatamanga Hydropower Project (from World Bank) and major construction works to commence by end of 2025. Preliminary construction works have already started. **Implementation of this NDCs is satisfactory and will likely surplus its target of 410 MW by 2030.**	Electricity from grid connected hydropower is estimated to replace emissions from planned coal power plants at Kam'mwamba, Neno (350 MW) and at Pamodzi, Salima (120 MW). Total estimated hydropower energy from the 7 priority projects is 4,370,337.80 MWh. Estimated cumulative GHG reduction potentials for all priority grid connected hydropower projects are: 0.73 million tCO2e by 2030, 1.28 million tCO2e by 2035, and 2.25 million tCO2e by 2040

Off-grid small scale solar PV systems	The target is to achieve at least 50,000 of additional small scale off-grid PV systems/solar lanterns by 2025 through Malawi. **This measure has been achieved, beyond the target,** through project supported SHS installations. For example, during the period, The Malawi Electricity Access Project (MEAP), which was approved in 2009, in 2024, it registered 38,000 SHS through Ngwengwengwe Fund installed Tier 1 SHS. Tier 1 category of SHS are those that comprise of a solar lantern at least 1,000 lumen-hours (lm-hr) per day and sufficient energy to keep a well-used mobile phone operational. With support from World Bank, Government of Malawi implements Accelerating Sustainable and Clean Energy Access Transformation in Malawi (ASCENT-Malawi) Project from 2025 to 2030, which aims to provide solar home systems (SHS) to over 800,000 households, contributing towards a 70% electricity access level by 2030. Further, The USAID funded Solar Home System Kickstarter Programme in Malawi installed over 108,000 SHS in Malawi from 2019 to 2022, through market activities of 4 companies it contracted to implement the project, namely SolarWorks, Vitalite, Yellow, and Zuwa Energy. During this implementation period, Malawi about 6 solar PV mini-grids have been installed in Malawi. However, some of the mini-grids in Chikwawa District were damaged by flooding. **Implementation of this NDCs measure is progressing satisfactorily.**	The SHS/solar lanterns displace kerosene lamps. The quantified GHG emission reductions from the reported SHS installations are as follows 2021 = 29,380 tCO2e 2022 = 39,757 tCO2e Projected GHG emission reductions are estimated as follows 2030 = 301,985 tCO2e 2036 = 404, 902 tCO2e 2040 = 491,902 tCO2e

Grid-connected large-scale solar PV	With the enabling environment for private sector participation in the power market, for example through favorable energy sector-wide policy of 2018, putting in place regulatory system, power purchase agreements, the first implementation period of NDCs (2021 – 2025), saw a number of negotiated large-scale solar projected installed and commissioned, presented as follows. i. Installation of the 60 MW Salima Solar PV power station by JCM Solar company of Germany and commissioned. This plant was commissioned in 2021; ii. Installation of 20 MW solar PV power systems installed by JCM company at Golomoti in Ntcheu District, commissioned in 2022; iii. Serengeti Energy installed 21 MW Solar PV, and commissioned in 2023 in Nkhotakota; iv. Votalia Company installed 40 MW of solar PV in Dwangwa in 2023. Addition of solar PV electricity has enabled Malawi to decommission diesel power electric generators of 78MW installed capacity, contributing to avoiding related carbon emissions from the electricity generation industry. The Ministry of Energy reported that installation of battery-based energy storage system in Lilongwe would be commissioned in mid-2025. This battery storage power system will enable Ministry of Energy to integrate more solar PV based electricity to the grid. At a time of reporting this BTR, Press Corporation Malawi Limited was negotiating with Ministry of Energy to install 50 MW solar PV electricity in Lilongwe. Also, Atlas Energy company was negotiating to install 20 MW to be installed in Balaka. These two projects would put 70MW of electricity into the grid by 2027. A summation of installed and commissioned grid connected large scale solar PV give an installed capacity of 141 MW (by 2024). Together with planned installed of 70MW, there would be at least 210 MW of grid-connected large-scale PV by 2027. Therefore, **grid-connected large-scale solar PV as an NDCS measure, is progressing well** and would surpass the target of 200MW before its NDCs target year of 2030.	Grid connected solar PV power stations has displaced diesel-powered electric generators for generating electricity. The GHG emission reduction are estimated as follows 2021 = 92,012 tCO2e 2022 = 122,683 tCO2e 2023 = 216,229 tCO2e

Improved Biomass Cookstove (Charcoal and Firewood)	During this NDCs 2.0 implementation period, Malawi has registered several players in promoting improved biomass cookstoves, through coordinated clean cooking programmes, such as the Ministry of Energy, non-Governmental organizations (local and international), some of whom are involved in carbon trading. However, numbers on actual biomass cookstoves are difficult to get, because of limitations in data collection on stoves. There are conflicting numbers of stoves that are reported, possibly because there is lack of tracking and recording of information related to implementation of wood fuel cookstoves. The most reliable information is those from the Ministry of Energy, reporting that up to 2 million improved cookstoves were distributed in Malawi by October 2020 through a presidential decree in 2013 to intervene to control deforestation through popularizing use of efficient biomass cookstove. However, data from Malawi Energy Compact document on available improved biomass cookstoves in 2020 show that less than 2 million biomass cookstoves reported to have been achieved. Since the Malawi Energy Compact was validated through a rigorous process, this BTR uses the data from this source, which has also estimated cookstove numbers from 2025 upto 2030.	The estimated GHG emission reduction through use of improved cookstoves replacing 3-stone open fire stoves as provided as follows: 2021 = 1.28 million tCO2e 2022 = 1.75 million tCO2e 2023 = 2.19 million tCO2e 2024 = 2.56 million tCO2e 2028 = 2.86 million tCO2e 2030 = 3.59 million tCO2e

During the NDCs-2 reporting period (2021 to 2024), Malawi has traded in internationally transferred mitigation outcomes, with first transferred emissions deducted from GHG reductions in the improved cookstove NDCs. Authorised ITMOs, issued to Hestian Innovation Limited as in May 2025, are presented in Table 3-E3.

Table 3-E3: Issued carbon credits to Hestian Innovation Limited as of May 2025.

Year	tCO2e issued under GS11677
2021	989,219
2022	563,536
2023	207,295
2024	18,425
Total	1,778,475

Malawi has developed tools to help in tracking NDCs implementation: Malawi NDCs score-card; NDCS implantation plan, and resource mobilization strategy. However, the following are the challenges that limit implementation of NDCs measures: financing challenges; limited collaboration among NDCs stakeholders, and limited awareness on NDCs measures especially at local level.

ES.4 Information related to climate change impacts and adaptation under Article 7 of the Paris Agreement

The main thrust of the adaptation chapter of Malawi's BTR1/NC4 is to shed light on the country's vulnerability to the vagaries of climate change and propose measures for addressing adverse impacts and risks associated with this phenomenon. This entails the description of various actions and adjustments that individuals, communities, and the Government of Malawi is making or should implement in order to prepare for and acclimatize with the impacts of climate change, both current and anticipated. Climate change adaptation involves reducing the severity of the vulnerability and builds resilience to climate-related hazards such as floods, droughts, strong winds, pests and diseases, heat stress, and many other hazards. The discussion on Malawi's adaptation to climate change focuses on nine social economic sectors in the country, namely: agriculture, water resources, human health, energy, fisheries, tourism, infrastructure, wildlife, and forestry.

Agriculture: Adaptation strategies for the agriculture sector include: promotion of crop diversification, planting drought tolerant crops and early maturing varieties, promotion of irrigated agriculture, encouraging farmers to adopt agroforestry technologies, promoting the use of manure to enhance soil fertility, promotion of mechanization to reduce drudgery, crop rotation, promotion of farmer field schools (FFS), adoption of smart agriculture, capacity building of all cadres of agriculture staff, promotion of technologies for reducing post-harvest losses, crop insurance, improved feeding of livestock, vibrant parasite and disease control, and drilling of boreholes as livestock watering points. In addition to scientific approaches highlight above, communities are also encouraged to complement these adaptation strategies with Local Indigenous Knowledge Systems and Practices (LIKSP).

Water Resources: Climate change adaptation strategies for the water sector primarily focus on managing water resources under various scenarios, and these include: constructing more upstream storage dams; increased sustainable utilization and monitoring of groundwater resources; promoting conjunctive use of surface and groundwater resources; protecting catchment areas through adopting land husbandry practices; adopting water demand management practices; leakage monitoring and control in pipe networks to reduce non-revenue water (NRW) losses; expanding the network of buoys installed in Lake Malawi for collecting weather and climate data, and for water quality monitoring; constructing dykes, and diversion structures to minimize flood damage; improving early warning systems by expanding both manual and telemetry hydrometeorological flood and drought forecasting networks; delineating flood prone areas through the production of flood zoning maps; using LIKSP to complement scientific EWS for floods and droughts; and capacity building of various cadres of stakeholders, ranging from policy makers to technocrats and beneficiary communities.

Human Health: Potential strategies for increasing the resilience of the country to adverse impacts of climate change on human health mainly address five key diseases, namely: malaria, diarrhea (cholera and dysentery), malnutrition, hypertension, and depression which are a major concern in Malawi. For

malaria, key strategies that the Ministry of Health has put in place include: (i) prevention and control mechanism for malaria, and (ii) promotion of Long-lasting insecticide treated nets (LLITNs) insecticide-treated mosquito nets (ITMNs). Preventive measures for diarrheal diseases include: boiling drinking water; filtration and chlorination of drinking water; strengthening infection, prevention and control (IPC) measures; provision of potable water supply; immediate burial of cholera victims; pot-to-pot chlorination of water at household level; and strengthening patient and guardian education. To combat malnutrition in the face of climate change, adaptation methods include: diversifying crop production with drought-tolerant varieties; promoting nutrient-rich crops (biofortification); improving water management practices; enhancing food storage and post-harvest handling; implementing community-based nutrition education; and strengthening social safety nets to ensure access to food during climate-related disruptions, while considering gender equality and the local context to maximize effectiveness. Climate change adaptation strategies for hypertension primarily focus on alleviating the impacts of extreme heat, which can significantly worsen blood pressure control, and these measures include: increasing access to cool spaces, promoting heat awareness campaigns, modifying medication regimens based on weather conditions, and ensuring healthcare systems are prepared to manage heat-related hypertension complications. In order to adapt to potential impacts of depression triggered by climate change, the following strategies may be employed: engaging in pro-environmental actions, seeking social support, practicing mindfulness and cognitive restructuring, accessing professional mental health services, building resilience through community involvement, and staying informed about climate change.

Energy: Adaptation strategies for the energy sector primarily focus on diversifying energy sources away from heavy reliance on hydropower, which is vulnerable to droughts, by promoting solar, biomass, and mini-grid solutions, alongside improving energy efficiency measures, particularly in rural areas, to mitigate the impacts of climate change on energy access and supply.

Fisheries: To address challenges in the fisheries sector, the Government of Malawi is implementing various adaptation strategies which primarily focus on enhancing fish stock management through practices such as aquaculture development, monitoring fish populations closely, implementing fishing restrictions during vulnerable periods, diversifying fish species, promoting community-based management, integrating climate data into fisheries management decisions, reducing post-harvest losses, all the while considering impacts of changing water temperatures and rainfall patterns on Lake Malawi and other water bodies in the country.

Tourism: Adaptation strategies for the tourism sector in Malawi mainly focus on promoting sustainable practices, diversifying tourism offerings, investing in resilient infrastructure, and building community engagement to alleviate impacts of climate change while maximizing the benefits of tourism for local communities, particularly in the face of potential challenges like fluctuating water levels in Lake Malawi and the changing weather patterns.

Infrastructure: Climate change adaptation in the transport infrastructure mainly focuses on integrating resilience measures into the development of roads and bridges, by conducting climate risk assessments before construction of the respective infrastructure to identify vulnerable areas and implementing design modifications to the infrastructure to enhance its resilience to increased floods, droughts, and extreme weather events, as mandated by the National Transport Policy, with the goal of minimizing long-term reconstruction costs due to climate-related damage. Other measures include: Implementing design modifications such as raised road sections, improved drainage systems, and stronger bridge foundations to withstand increased water flow during floods; choosing construction materials that are more resistant to weather extremes; developing systems to monitor weather patterns and issue alerts for potential climate-related disruptions; and prioritizing regular maintenance and repair of existing infrastructure to mitigate damage from climate events.

Wildlife: Adaptation strategies for climate change in the wildlife sector primarily focus on managing water availability through constructing watering points, improved fire management practices in protected areas, and considering animal translocation and breeding programs to help wildlife populations adjust to changing environmental conditions, particularly in response to increased drought events caused by climate change.

Forestry: Measures for forest sector adaptation to adverse impacts of climate change are primarily through initiatives like reforestation, planting drought-resistant tree species, community-based forest fire management, and improved forest management practices, aiming to lessen the severity of effects of increasing droughts, extreme weather events, and land degradation, while also preserving biodiversity and vital ecosystem services like water regulation and carbon sequestration.

ES.5 Information on financial, technology development and transfer and capacity-building support needed and received under Articles 9–11 of the Paris Agreement

This chapter and its associated CTF Tables III.6, III.7, III.8, III.9, III.10, III.11, III.12 and III.13 provide detailed information on financial support needed and received, technology development and transfer support needed and received, capacity building support needed and received and capacity building support needed and received for the implementation of article 13 of the Paris Agreement and transparency-related activities.

Malawi's national circumstances are described in the context of the climate finance landscape and institutional arrangements relevant to reporting on financial, technology and capacity building support needed and received in section 4.1. In terms of policy framework for climate finance mobilization, Malawi is guided by policy frameworks such as the Malawi 2063, the NCCMP, revised NDCs and the NDCs resource mobilization strategy.

Malawi's climate finance needs are informed by the revised Nationally Determined Contributions (NDCs). The country needs a total of US$41.8 billion for mitigation priorities, and US$4.5 billion for adaptation priorities, representing a combined funding requirement of over US$46.3 billion from 2020 through 2040. Of these amounts, US$24.6 Billion is required from external sources for mitigation actions, US $2.2 Billion for adaptation and US$0.753 Billion for cross-cutting climate action. During the reporting period, Malawi received an estimated US$ 0.875 Billion in climate financial support while a further US$2.17 Billion has been committed by different funding institutions.

Information on adaptation and mitigation technology support needed and received is described in sections 4.5 and 4.6 derived from the Technology Needs Assessment exercise of 2020. Technologies that were prioritized emanate from the following sectors: Energy, Forestry, Agriculture and Water. The most supported technologies during the reporting period include: Landscape restoration for improved land productivity; Solar PV Technology (both grid based and off-grid); Improved cook stoves and clean cooking; Early Warning Systems and Hazard Monitoring; Integrated Flood Management and Crop diversification for increased resilience.

Related to capacity building support needed and received, Malawi identified and prioritized three components of capacity building namely: individual capacity building, institutional capacity building and resource mobilization.

Finally, related to support needed and received for the implementation of Article 13 of the Paris Agreement and transparency-related activities, including for transparency-related capacity-building, Malawi has received support from three projects namely: Preparation of the First Biennial Transparency Report (BTR) and Fourth National Communication to the UNFCCC; Malawi Climate Transparency Framework under the Capacity Building Initiative for Transparency (CBIT) and Initiative for Climate Action Transparency – ICAT.

ES.5.2 Research and systematic observation

This section provides a general overview of the status of research and systematic observation in Malawi. Through the Department of Climate Change and Meteorological Services, Malawi participates in two Regional Climate Outlook Forums (RCOFs); Southern African Region COF (SARCOF) annually and South-west Indian Ocean COF (SWIOCOF) on invitation. At national level, observation stations are not adequate and sparsely distributed thereby limiting functionality of climate observation. The country has developed a National Framework for Water and Climate Services (NFWCS) to run from 2024 to 2029 with a total budget of USD 63,413,706 and will require external support.

ES.5.3 Gender and Climate Action

Regarding gender and climate action, climate change affects different gender categories differently. However, it has been observed that in Malawi, women tend to sell their assets in order to cope with climate impacts. GoM has prioritized mainstreaming gender in Natural Resources, Environment and Climate Change Management through the gender policy. In addition, at international level, Malawi signed up to the Lima Work Programme on Gender to promote gender balance and achieve gender-responsive climate policy.

ABBREVIATIONS AND ACRONYMS

ADC	Area Development Committee
ADD	Agricultural Development Division
AET	Actual Evapotranspiration
AEZ	Agro-Ecological Zone
AF	Adaptation Fund
AfDB	African Development Bank
APES	Agricultural production Estimate Survey
AR4	Fourth Assessment Report
ASP	Aspirational Development
AU	African Union
BCA	Basement Complex Aquifer
BoP	Balance of Payments
BTR1	First Biannual Transparency Report
CAB	Congo Air boundary
CBIT	Capacity Building Initiative for Transparency
CBO	Community Based Organization
CC	Climate Change
CCA	Climate Change Adaptation
CCDR	Country Climate and Development Report
CCH	Climate Change on Health
CCS	Carbon capture and Storage
CCUS	Carbon Capture, Utilization and Storage
CHAM	Christian Health Associations of Malawi
CISONECC	Civil Society Network on Climate Change
CMIP6	Coupled Model Intercomparison Project 6
COMESA	Common Market for East and Southern Africa
COP	Conference of Parties
CSA	Climate-smart agriculture
c-Si	Crystalline Silicon
CSO	Civil Society Organization

CTF	Common Tabular Format
CUNIMA	Catholic University of Malawi
DAPS	Department of Agricultural Planning Services
DCCMS	Department of Climate Change and Meteorological Services
DCERCC	Development Cooperation Group on Environment, Resilience and Climate Change
DEC	District Executive Committee
DESC	District Environmental Sub-Committee
DJF	December-January-February
DMEC	District Monitoring and Evaluation Committee
DO	Dissolved Oxygen
DRM	Disaster Risk Management
EAD	Environmental Affairs Department
ECHO	European Civil Protection and Humanitarian Aid Operations
EGENCO	Electricity Generation Company
EIB	European Investment Bank
EMA	Environment Management Act
ENSO	El Nino and Southern Oscillation
ESB	Earth Stabilized Blocks
ESCOM	Electricity Supply Corporation of Malawi
ESM	Earth Systems Model
EU	European Union
EUS	Epizootic Ulcerative Syndrome
EWG	Expert Working Group
EWS	Early Warning Systems
FAO	Food and Agriculture Organization
FCDO	Foreign, Commonwealth and Development Office
FFS	Farmer Field School
FLR	Forest Landscape Restoration
GCF	Green Climate Fund
GCM	General Circulation Model
GEF	Global Environment Facility
GETF	Green Economic Transition Facility
GFCS	Global Framework for Climate Services

GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GoM	Government of Malawi
GVH	Group Village Headmen
HDI	Human Development Index
HMIS	Health Management Information System
ICAT	Initiative for Climate Action Transparency
ICPAC	IGAD Climate Prediction and Application Centre
IDA	International Development Association
IDSR	Integrated Diseases Surveillance System
IEA	International Energy Agency
IGAD	Intergovernmental Authority in Development
INDCS	Intended Nationally Determined Contributions
IO	Indian Ocean
IOD	Indian Ocean Dipole
IPC	Infection, Prevention and Control
IPCC	Intergovernmental Panel on Climate Change
IPDM	Integrated pest and disease management
IPP	Independent Power Producer
IRBM	Integrated River Basin Management
IRP	Integrated Resource Plan
ITCZ	Inter Tropical Convergence Zone
ITMN	Insecticide-Treated Mosquito Net
IUCN	International Union for Conservation of Nature
JFM	January-February-March
JICA	Japan International Cooperation Agency
KC	Crop Coefficient
KPA	Key Priority Areas
KuHES	Kamuzu University of Health Sciences
LDC	Least Developed Countries
LDCF	Least Developed Countries Fund
LEAP	Low Emissions Analysis Platform
LFG	Landfill Gas

LIFE-AR	Least Developed Countries Initiative for Effective Adaptation and Resilience
LIKSP	Local Indigenous Knowledge Systems and Practices
LLITNs	Long-Lasting Insecticide Treated Net
LPG	Liquefied Petroleum Gas
LUANAR	Lilongwe University of Agriculture and Natural Resources
LULC	Land Use Land Cover
MAR	Managing Aquifer Recharge
MCA	Multi-Criteria Analysis
MCC	Millennium Challenge Corporation
MDA	Ministry/Department/Agency
MEPA	Malawi Environment Protection Agency
MERA	Malawi Energy Regulatory Authority
MIP-1	Malawi 2063 Implementation Plan 1
MIP-1	Malawi 2063 First 10-Year Implementation Plan (MIP-1)
MIS	Management Information System
MoEPD	Ministry of Economic Planning and Development
MoH	Ministry of Health
MoNRCC	Ministry of Natural Resources and Climate Change
MRDRMP	Malawi Resilience and Disaster Risk Management Project
MRES	Malawi Renewable Energy Strategy
MRV	Measurement, Reporting and Verification
MUBAS	Malawi University of Business and Applied Sciences
MUST	Malawi University of Science and Technology
MWASIP	Malawi Watershed Improvement Project
MWASIP	Malawi Watershed Services Improvement Project
MZUNI	Mzuzu University
NAMAs	Nationally Appropriate Mitigation Actions
NAPA	National Adaptation Programmes of Action
NC4	Fourth National Communication
NCCF	National climate Change Fund
NCCIP	National Climate Change Investment Plan
NCCMP	National Climate Change Management Policy
NCD	Non-Communicable Diseases

NDCs	Nationally Determined Contributions
ND-GAIN	Notre Dame Global Adaptation Index
NES	National Electrification Strategy
NFWCS	National Framework for Water and Climate Services
NGO	Non-Governmental Organization
NLDP	National Livestock Development Policy
NORAD	Norwegian Agency for Development Cooperation
NRM	Natural Resources Management
NRS	National Resilience Strategy
NRSWG	Natural Resources Sector Working Group
NRW	Non-Revenue Water
NSCCC	National Steering Committee on Climate Change
NSO	National Statistical Office
NTCCC	National Technical Committee on Climate Change
NWA	Noxious Weeds Act
OCHA	Office for the Coordination of Humanitarian Affairs
ODSS	Operation Decision Support System
OECD	Organization for Economic Cooperation and Development
OND	October-November-December
PET	Potential Evapotranspiration
PML	Power Market Limited
PPA	Power Purchase Agreement
PPP	Public Private Partnership
PS	Principal Secretary
PV	Photovoltaic
QC	Quality Control
RCOF	Regional Climate Outlook Forums
RCP	Representative Concentration Pathway
REDD+	Reducing Emissions from Deforestation and Forest Degradation, plus conservation, sustainable management of forests, and enhancement of forest carbon stocks
RHA	Rice Husk Ash
SADC	Southern African Development Community
SAPP	Southern African Power Pool

SARCOF	Southern African Region Climate Outlook Forum
SCCF	Special Climate Change Fund
SDG	Sustainable Development Goals
SID	Simpson's Index of Diversification
SOE	State-Owned Enterprise
SON	September-October-November
SRES	Special Report on Emissions Scenarios
SSP	Shared Socio-economic Pathways
SVTP	Shire Valley Transformation Programme
SWIOCOF	South West Indian Ocean Climate Outlook Forum
TDS	Total Dissolved Solids
TF	Thin Film
UNDP	United Nations Development Programme
UNECA	United Nations Economic Commission for Africa
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Fund
USAID	United Sates Agency for International Development
VDC	Village Development Committee
VNRMC	Village Natural Resources Management Committee
WASH	Water, Sanitation and Hygiene
WB	World bank
WFP	World Food Programme
WHO	World Health Organization
WIM	Warsaw International Mechanism
WMO	World Meteorological Organization
WRA	Water Resources Area
WRU	Water Resources Unit
WtE	Waste to Energy
ZAB	Zaire Air Boundary

1.0 BACKGROUND TO MALAWI'S FIRST BIENNIAL TRANSPARENCY REPORT AND FOURTH NATIONAL COMMUNICATION REPORT

Malawi signed the United Nations Framework Convention on Climate Change (UNFCCC) on 10th June 1992 and ratified it on 21st April 1994. Malawi also ratified the Kyoto Protocol on 26th October 2001 and most recently the Paris Agreement on 17th June, 2017. As a Party to both the Convention and the Paris Agreement, Malawi is obliged, under Article 4 (2) to "prepare, communicate and maintain successive Nationally Determined Contributions (NDCs) that it intends to achieve". In line with this, under Article 13 of the Paris Agreement, among others Malawi is also obliged to "regularly communicate its national inventory report of anthropogenic emissions by sources and removals by sinks of greenhouse gases; information necessary to track progress made in implementing and achieving its NDCs under Article 4; and information related to climate change impacts and adaptation under Article 7 of the Paris Agreement.

Malawi updated and communicated its NDCs in July 2021 with revised sectoral mitigation and adaptation targets up to 2040 with an GHGs emission reduction target of 51% by 2040. The NDCs demonstrate the commitment of the Government of Malawi to meet its obligations towards addressing the challenges of climate change. The NDCs articulate areas of priority for climate change management through both mitigation and adaptation measures needed to address challenges of climate change. Malawi needs an estimated USD 46.3 Billion in total with USD 11.1 Billion – Domestic support (Unconditional) and USD 35.2 Billion – External support (Conditional). Malawi intends to revise the current NDCs and raise its ambition and include emerging issues in line with the provision of the Paris Agreement.

Malawi also communicated is first Biennial Update Report (BUR) in November, 2021 whish provided a comprehensive outlook of the status of sectoral climate change issues in the country and taking into consideration emerging issues since the Second National Communication. The Report highlighted mitigation efforts that are feasible for Malawi, taking into consideration national circumstances and provisions of the various policy frameworks that guide environment and climate change management in the country. The Report also presents an updated Greenhouse Gas (GHG) inventory which establishes Malawi as a net GHG emitter. The BUR 1 also aimed at taking stock of the achievements, gaps, challenges and constraints encountered in the last submitted national communication and also provides an update on the actions taken by the country to implement the Convention.

1.1 Preparation of first Biennial Transparency Report (BTR1) and Fourth National Communication Report

The Government of Malawi (GoM) received financial support from the Global Environment Facility (GEF) through the United Nations Environment Programme (UNEP) to prepare its Fourth National Communication (NC4) and first Biennial Transparency Report (BTR1) to the Conference of Parties (CoP) of the UNFCCC. It is an obligation for Parties to the Convention and the Paris Agreement to submit reports on their activities aimed at addressing climate change. Malawi produced and submitted its Initial (first), Second, and Third National Communications in 2003, 2011 and 2020 respectively. The Country also prepared and submitted its first Biennial Update Report (BUR1) in February 2021.

The Ministry of Natural Resources and Climate Change (MNRCC) through the Environmental Affairs Department (EAD) has developed the BTR1/NC4 report documenting what Malawi is doing in climate change management. The thematic areas in the report have taken into consideration emerging issues as outlined in the Malawi's updated NDCs as well as the Malawi 2063 (MW2063). In this regard, areas that were not covered in the previous National Communications have been given adequate attention and detail in this report. In addition, the process of developing the BTR1/NC4 will enhance the visibility, awareness and knowledge, on climate change issues through increased involvement of all relevant stakeholders.

The BTR1 has been developed in accordance with the Modalities, Procedures, and Guidelines (MPGs) for the Enhanced Transparency Framework (ETF) for action and support as outlined in Article 13 of the Paris Agreement (FCCC/PA/CMA/2018/3/Add.2), with specific attention to the perspectives and priorities of Malawi. All the supporting Common Reporting Tables (CRTs) and Common Tabular Formats (CTFs) as per Decision 5/CMA.3 including its Annexes has been completed through the final UNFCCC ETF Reporting Tools application. Electronic reporting of information on NIRs used common reporting tables (CRTs) and will be submitted as annexes to this BTR. Information necessary to track progress made in implementing and achieving NDCs will be provided as annexes in common tabular formats (CTFs). This information includes details on financial, technology development and transfer, and capacity-building support needed, and received. The BTR1 covers the period from 1st January 2021 to 31st December 2023. Detailed contributing chapters to this BTR1/NC4 report could be accessed through the EAD.

1.2 Legal Framework for Climate Change

Malawi's legal framework on climate change is based on policies and laws that have been developed over the years to address these matters. The legal framework spells out who has powers in terms of the development and adoption of various laws and policies. Section 5 of the Constitution of Malawi states that any act of Government or any law that is inconsistent with the provisions of this Constitution shall, to the extent of such inconsistency, be invalid. Section 7 explains that the executive branch of government is responsible for the initiation of policies and legislation, and for the implementation of all laws which embody the express wishes of the people of Malawi, and which promote the principles of this Constitution. Therefore, the responsibility on development of policies and legislation on climate change lies with the Executive Branch of Government through Ministries, Departments and Agencies (MDAs).

The MW2063, a long-term development blue-print for Malawi that succeeded the Vision 2020, is anchored on three key pillars, namely: Agriculture Productivity and Commercialization; Industrialization; and Urbanization. The MW2063 is operationalized by the first 10-year Implementation Plan (MIP-1) which spans the period 2021 to 2030. The MIP-1 has identified priority areas under the key pillars which will set Malawi on a path to actualize MW2063. Under Pillar1: Agriculture Productivity and Commercialization, whose objective is to have an optimally productive and commercialized agriculture sector, the following areas will be focused; (a) Agriculture Diversification, (b) Irrigation Development, (c) Anchor farms, (d) Agriculture Inputs, (e) Agriculture mechanization, (f) Structured Markets, (g) Agriculture Research, Innovation and Dissemination. Agriculture production in Malawi is highly vulnerable to the vagaries of climate change.

Malawi has also developed the following in order to achieve her national vision on climate change management as well as to support implementation of the UNFCCC, Kyoto Protocol, and the domestication of the Paris Agreement:

a. **The National Climate Change Management Policy (2016)** – to guide coordination, planning, formulation, implementation, monitoring, reporting and evaluation and financing of climate actions in the country.

b. **The Nationally Determined Contributions (NDCs) (2021)**– plans to move the country's development pathways towards a green economy based on Malawi's national circumstances and capabilities;

c. **National Resilience Strategy (2018 – 2030) –**The National Resilience Strategy medium-term goal is to start the transition from recurrent humanitarian appeals to protective and productive investments targeting chronically and/or predictably food insecure and poor households, while also strengthening markets, infrastructure, and economic growth supported through strong institutional coordination and multi-sectoral planning and implementation.

d. **Environment Management Act (EMA) (2017)**: which provides for conservation and management of the environment in Malawi and prescribes environmental standards.

e. **The National Climate Change Investment Plan (NCCIP) (2013) –** a tool for mobilizing and disbursing climate finance in key investment areas on climate change management.

f. **The National Climate Change Response Framework (2015)** – guiding tool in responding to climate change;

g. **The Nationally Appropriate Mitigation Actions (NAMAs) (2015)** – priority mitigation actions to reduce greenhouse gas emissions;

h. **The National Adaptation Programmes of Action (NAPA) (2015)** – these are urgent and immediate adaptation actions;

i. **The Monitoring & Evaluation Framework for the NCCIP (2015)** – this will contribute towards improved management of climate change related programmes through timely provision of information to policy makers and implementers of evidence-based decision making;

j. **The National Strategy on Climate Change Learning (2021)**: a tool for strengthening human resources and skills development for the advancement of green, low emission and climate resilient development;

k. **The Strategic Programme for Climate Resilience (SPCR) (2017)** – a framework for addressing challenges of climate change that impact on the national economy and community livelihoods. This builds on the available enabling frameworks and efforts in climate resilience-building programmes; and

l. **The National Environment and Climate Change Communication Strategy –** provides a platform and methodologies for enhancing access, development, sharing and utilization of environment and climate change information.

Government is also in a process of:

a. Developing a **Climate Change Management Bill** – expected to provide legal support on climate change management issues in the country;

b. Developing a **National Adaptation Plan (NAP)** – medium to long-term adaptation strategies to ensure resilience to climate change;

c. Establishing a **National Climate Change Fund** – to enhance financing for implementation and coordination of climate change management initiatives.

d. Updating **NDCs 2.0 to 3.0** - higlighing the countries prioritised climate action and raising ambition.

1.3 Institutional Arrangement

The EAD in the MNRCC is the executing agency for the BTR1/NC4 process. The EAD has the overall mandate of monitoring the process to meet the objectives of the study, achieving results (outputs) and impact; and accounting for all financial resources to UNEP. Four National Team Leaders were identified and each had a team comprising various and complementary experts to develop various reports and chapters that contributed to the compilation of the BTR1/NC4. The team members comprised a pool of experts that were involved in the preparation of previous National Communications as well as new experts.

Overall, the institutional arrangement for climate change management in Malawi provides for several committees shown in Figure 1-1:

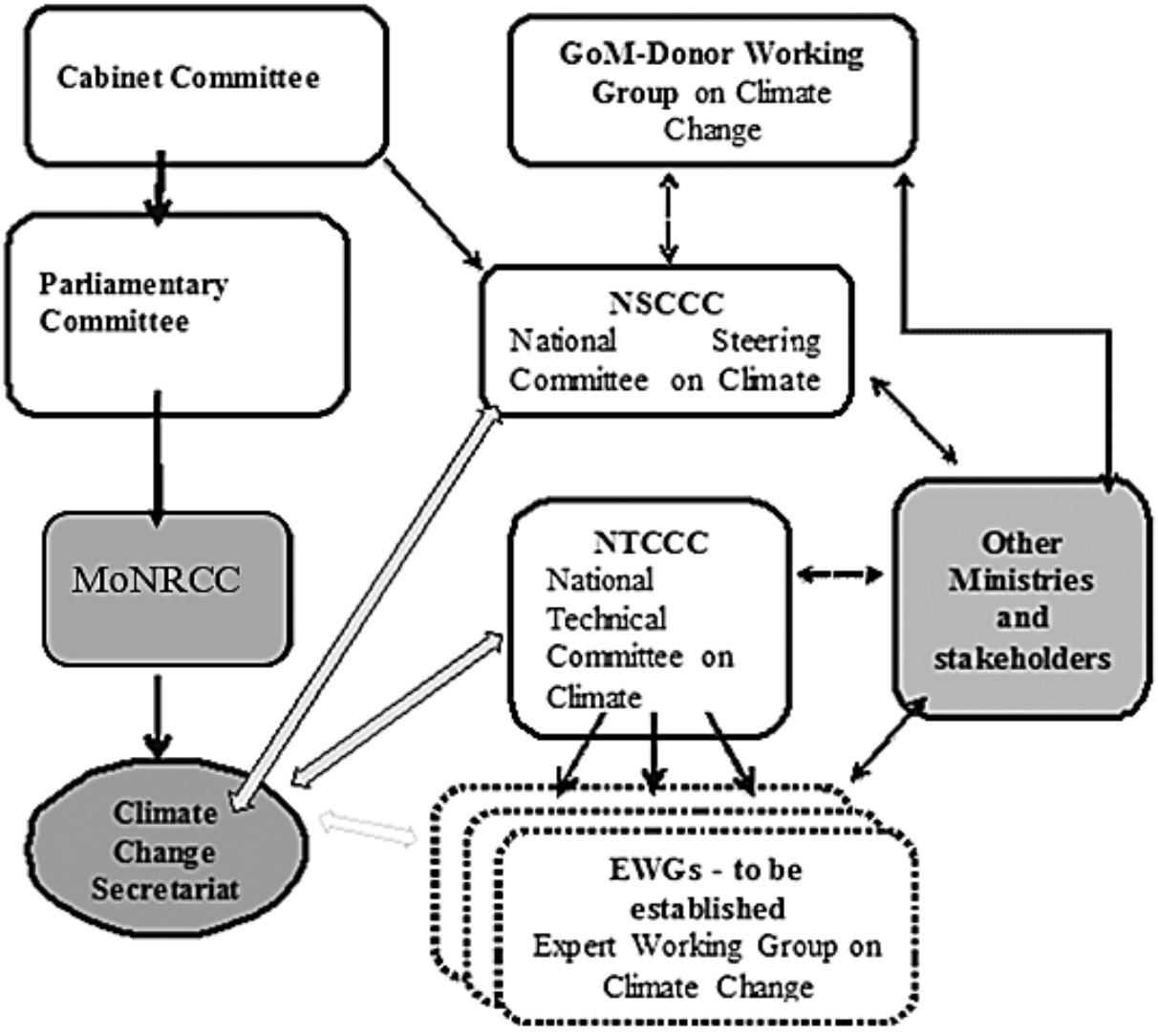


Figure 1-1:Institutional arrangement for climate change in Malawi

Source: Government of Malawi (2021)

a. The Cabinet Committee – it enables all arms of government to coordinate their actions;

b. The Parliamentary Committee – serves to assist in lobbying for the passing of environment related policies and legislations in the national assembly; and

c. The National Steering Committee on Climate Change (NSCCC) – provide policy level oversight, guidance and direction on climate change management.

d. The National Technical Committee on Climate Change (NTCCC) and the Expert Working Groups (EWGs) - provides technical level guidance and direction on matter of climate change management.

At District Level, the District Executive Committee (DEC) provides overall leadership and oversight and the District Environmental Sub-Committee (DESC) is responsible for issues of environmental management, climate change, forestry and other natural resources. The secretariat to the DESC is in the office of the Environmental District Officer under the Directorate of Agriculture, Environment and Natural Resources. The Chairpeson to the DESC is the Director of Planning and Development (DPD) that is able to ensure that climate change issues are mainstreamed throughout the District programmes.

At the community level, climate change issues are addressed by a number of committees, key among which is the Village Natural Resources Management Committee (VNRMC), which mostly focuses on the protection of the environment in order to promote climate change mitigation and adaptation; and it is mandated to do this through established By-laws.

1.4 National circumstances

In the context of climate change, "national circumstances" refer to specific conditions and circumstances of a particular country that may influence its ability to meet its commitments and obligations under the UNFCCC. These circumstances may include: economic development, social factors, climate change impacts, and technological capabilities.

1.4.1 Location

Malawi is a landlocked country located in southern Africa, at latitudes 9° 22' and 17° 03' south of the equator, and longitudes 33° 40' and 35° 55' east of the Greenwich meridian (Figure 4.1). It is bordered by Tanzania to the north and north-east, Mozambique to the south-west, south and the east; and Zambia to the west. It is 910 km long, and varies in width from 60 to 161 km, with a total surface area of 11.8 million ha. Of this total area, 9.4 million ha (80%) is land and the remaining 2.4 million ha (20%) is covered by water, mainly Lake Malawi (GoM, 2021). In addition, 1.8 million ha of the total 9.4 million ha is public land, 1.2 million ha is estate land, 0.3 million ha is urban land, and 6.1 million ha is customary land. Arable land constitutes 39.8% of the total land area; with 1.4 percent of the land area under permanent cropland, forests cover 34.0 percent, and the remaining 24.8 percent is classified as other lands (FAO, 2015).

Because of its location in the tropics, Malawi is vulnerable to global warming resulting from increased temperature caused by anthropogenic emissions. As such, the country is prone to flooding and strong winds caused by tropical cyclones, as well as severe droughts resulting from the El Nino and Southern Oscillation (ENSO) phenomena and the Indian Ocean Dipole (IOD).

1.4.2 Physiography

Malawi may be divided into four main physiographic zones, namely: alluvial plain, steep escarpment, the plateau area, and highland (mountain area). Highlands, such as Nyika, Viphya, Zomba, Mulanje and Dedza (1,350 to 3,000 m above sea level), are characterized by gentle to moderate slopes, bounded by scarps or deeply dissected zones, and undulating landforms dominated by Lithosols, Leptosols and Regosols and montane type of vegetation. The plateau area (1,000 - 1,350 m above sea level) covers three quarters of the country, with undulating and level crests that are dominated by Latosols on upland sites and Hydromorphic soils on poorly drained dambos, and Brachystegia (Combretum-Acacia-Bauhimia) plateau woodland. The escarpment zone is characterised by thin soils and very steep slopes. The alluvial plain, which comprises the Lakeshore Plain and the Upper Shire Valley (450 and 600 m above sea level), is dominated by Entisols and Lithosols while the Lower Shire Valley (35 to 105 m above sea level) is dominated by Calcimorphic alluvial soils and Vertisols, and some Hydromorphic soils in dambos and along river valleys, with a vegetation type that includes Acacia tree species (Pike and Remington, 1965).

As a result of Malawi's varied physiography, alluvial plains are prone to sediment deposition and widespread flooding and while escarpment zones are vulnerable to soil erosion and mudslides.

1.4.3 Climate

Malawi experiences a tropical-continental climate with three distinct seasons, namely: a wet season from November to April, a cold season between May and August, and a dry season from September to October. The cold and dry seasons are characterized by strong southeasterly trade winds (locally known as *Mwera*) while during the wet season the winds are generally northeasterly ***(Mpoto)*** and weaker (Chavula, 2008). The climate is greatly influenced by altitude and its proximity to Lake Malawi, a water body that covers nearly two thirds of the country's length. There are three main synoptic systems which bring rainfall to the country: (i) the Inter Tropical Convergence Zone (ITCZ), (ii) the Congo Air Mass or Zaire Air Boundary (ZAB), and (iii) Tropical Cyclones. Tropical cyclones originate in the Indian Ocean and move from East to West general direction, but sometimes veer away to mainland Africa from the Mozambique Channel.

The mean annual rainfall in Malawi ranges from 500 mm in low-lying marginal rainfall areas, such as the Shire Valley and some areas along the Lakeshore Plain, to well over 3,000 mm on high altitude plateaus, such as Nyika plateau. The mean annual rainfall distribution pattern for Malawi is shown in Figure 4.2. The rain shadow areas, such as the Shire Valley, the western parts of the Shire Highlands, Lake Chilwa Plain, and the north-western parts of the Viphya and Nyika plateaus, receive the lowest total annual rainfall. The high-altitude plateaus, such as Mulanje, Thyolo, Nyika, Misuku and Viphya plateaus, and some areas along the Lakeshore Plain, such as the Nkhata Bay and north Karonga, receive the highest total annual rainfall. However, the overall total rainfall received over Malawi shows a high degree of inter- and intra-seasonal variability which has been increasing (Ngongondo *et al*., 2011).

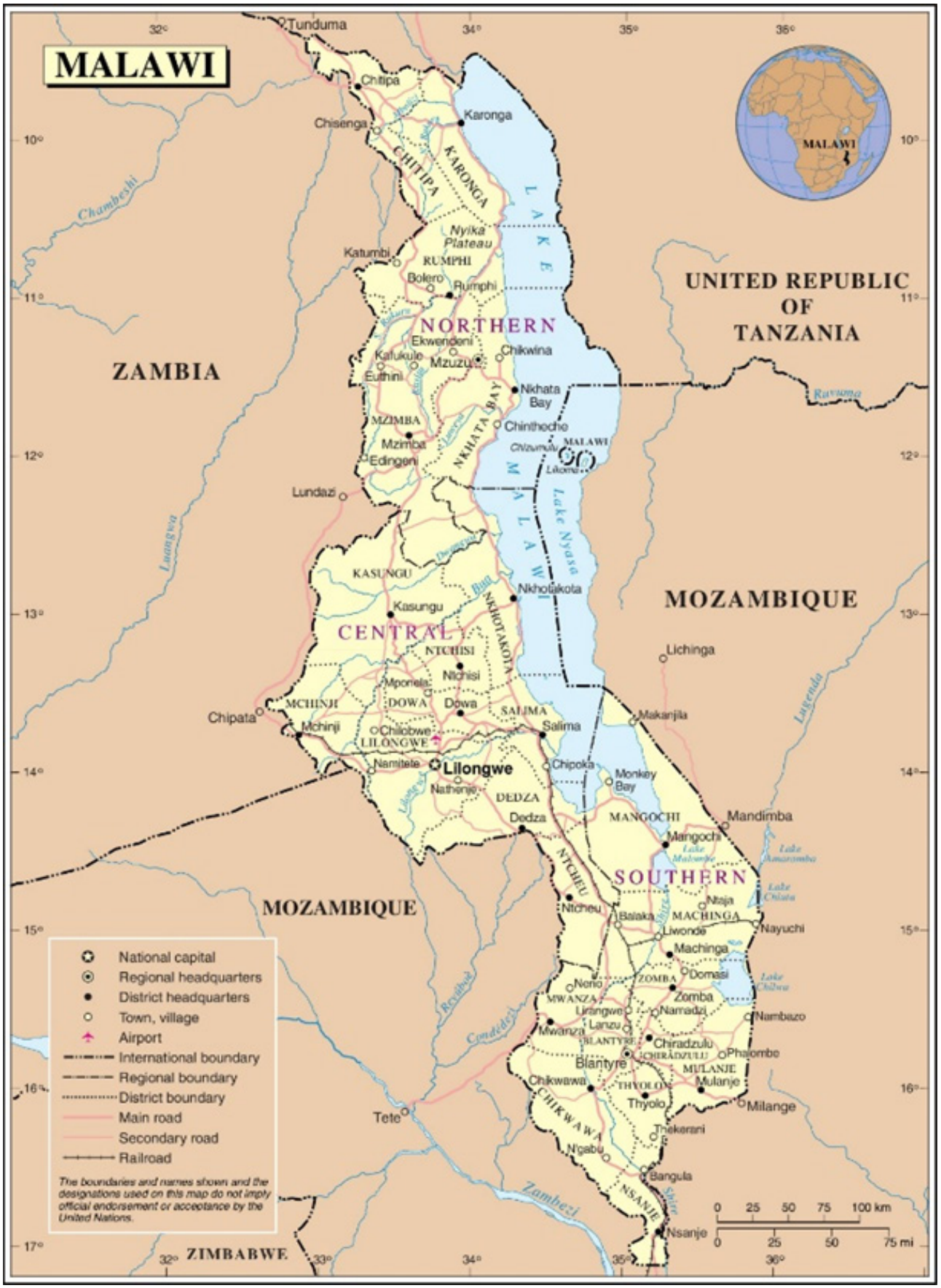


Figure 1-2: Map of Malawi

The mean annual minimum and maximum temperatures range from 12 to 32 oC. The highest temperatures occur at the end of October or early November, and the lowest in June or July (DCCMS, 2024). The highest mean air temperatures are recorded in the Lower Shire Valley (25-26oC) and some areas along the Lakeshore Plain (23-25oC). The lowest mean temperatures (13-15oC) are recorded over the Nyika, Viphya, Dedza, Mulanje and Zomba plateaus, Misuku Hills, and the Shire Highlands. From May to August, it is relatively cold on most high-altitude plateaus and hilly areas, such as the Shire Highlands.

Because of Malawi's location in the tropics, the country receives high amounts of solar radiation from the sun which, coupled with increased anthropogenic conditions, creates a conducive environment for increased atmospheric warming, a scenario which fuels climate change.

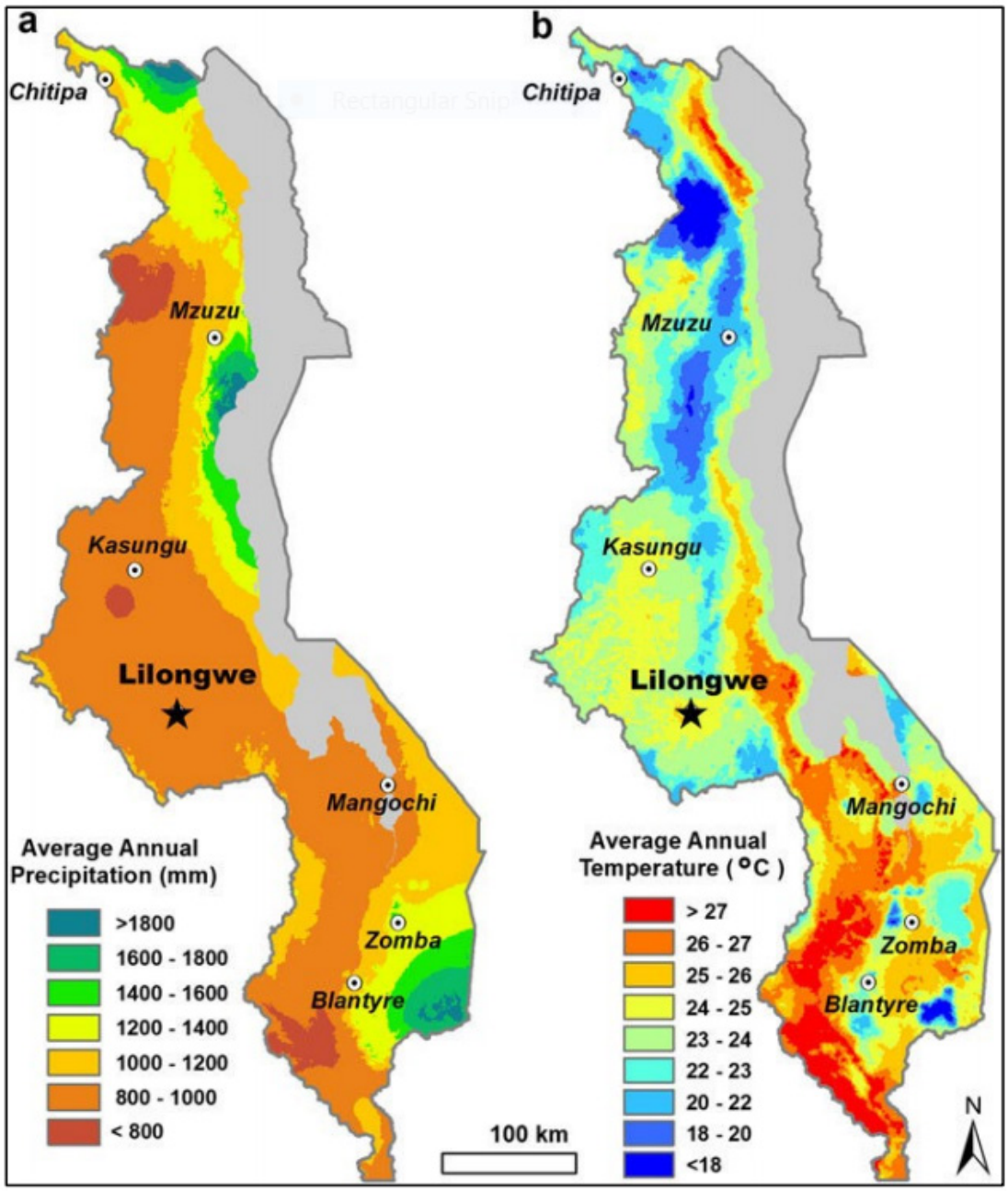


Figure 1-3: Distribution of annual rainfall and temperature

(**Source:** GoM, 2024)

1.4.4 Population

According to the World Bank (2023), Malawi's human population is estimated to be 21.01 million, with a population density of 203 people per square kilometre, one of the highest in the Southern African Development Community (SADC) region. The annual growth rate stands at 2.5 percent. The population has nearly doubled between 2000 and 2022. The Southern Region has the largest population, followed by Central and Northern Regions. A significant portion of the population, 54 percent, is under 18 years old, and the national mean age is 21. Malawi is experiencing a youthful population bulge, with high fertility rates and a relatively high death rate. Nearly 90 percent of the people live in rural areas.

Increased population growth is a critical factor in causing increased anthropogenic emissions of GHGs which cause global warming.

1.4.5 Economy

Malawi's economy is predominantly agrobased, and mostly rainfed; and hence highly vulnerable to climate change and climate variability. Agriculture accounts for 30 percent of the country's GDP and generates over 80 percent of national export earnings. The sector employs 64 percent of the Malawi's workforce and contributes to food and nutrition security. Although there is potential for better production and productivity, the agriculture sector operates below its capacity. As a result, the country continuously faces food shortages at national and household levels. Major industries in Malawi include agro-processing, textiles, and building materials. The sector's performance has been relatively low, and challenges like high transportation costs and infrastructure issues hinder growth. A substantial proportion of the country's population lives below the national poverty line, with a significant percentage experiencing extreme poverty.

Malawi's agrobased economy is highly susceptible to climate change impacts, including droughts, floods, strong winds and other extreme weather events, mostly resulting from unpredictable rainfall pattern. The country's dependence on rainfed agriculture only exacerbates the dismal performance of the economy. It is worth noting that the economy continues to experience a period of low growth and faces challenges such as food insecurity, infrastructure limitations, and macroeconomic imbalances.

1.4.6 Transport

Road Transport - Over the last two decades, Malawi has been promoting the development of road transport corridors through neighbouring countries of Tanzania and Mozambique to the Indian Ocean as one way of facilitating the transportation of goods, and attracting investments into the country. So far, the following corridors have been established: (i) the Zambia–Malawi–Mozambique Growth Triangle, launched in November 2000 with Zambia and Mozambique; (ii) the Nacala Development Corridor, launched in September 2000 with Zambia and Mozambique, and (iii) the Mtwara Development Corridor, launched in

December 2004 with Zambia, Mozambique and Tanzania. The bulk of the roads in Malawi are bituminized but poorly maintained, and are therefore highly vulnerable to flooding and road-away (GoM, 2021).

Water Transport - Lake Malawi provides the main water transport from Mangochi in the south to Karonga in the north, with port facilities at Monkey Bay in Mangochi, Chipoka in Salima, Nkhotakota, Likoma Island, Nkhata Bay, and Chilumba in Karonga. Apart from the four development corridors cited above, Malawi is exploring the practical possibility of linkages to the Indian Ocean through the Shire and Zambezi Rivers, under the Shire-Zambezi Waterway Initiative. However, this sector is characterised by underexploited and poorly maintained acess to ports.

Rail Transport - The railway line links Nsanje in the south with Mchinji in the centre through Chiromo, Luchenza, Blantyre, Balaka, Salima and Lilongwe. This railway line also connects Malawi to the port of Beira in Mozambique. However, the portion between Nsanje and Beira has been out of use since the beginning of the civil war in Mozambique in the 1970s, though it is being rehabilitated and test train runs have been conducted through Luchenza and Balaka to Lilongwe. Another line links Liwonde Township in southern Malawi to the port of Nacala in Mozambique. Recently, efforts have been made to revitalize Mchinji to Chipata line, in Zambia.

Air Transport - Malawi has five main airports: (i) Chileka in Blantyre, (ii) Kamuzu International Airport in Lilongwe, (iii) Mzuzu Airport in Mzuzu, (iv) Karonga Airport in Karonga, and (vi) Club Makokola in Mangochi. Air transport operations are affected by heavy rains, fog and clouds that interfere with aircraft navigation. These climatic extremes are expected to increase in frequency and magnitude in the future in response to changes in climate.

As stated above, because of Malawi's high dependence on road transport, the country is vulnerable to frequent road and bridge wash-away caused by flash floods whereas strong winds are a menace to water transport because of the high waves.

1.4.7 Water Supply and Sanitation

Accessibility to potable water supply at national level was at 88.3 percent in 2020. The proportion of households with access to improved water supply was higher in urban areas at 97.1 percent than in rural areas which was at 86.5 percent (NSO, 2020). Stand pipes are the main source of drinking water supply for the households in urban areas (64.9%) while boreholes are the main source for rural areas (73.9%). At a national level, boreholes are the main source of drinking water supply at 64.5 percent and only 17.8 percent of households have stand pipes in their houses (NSO, 2020). Kalin et al. (2022) stated that there were 85,327 boreholes in Malawi in 2022 from which groundwater was being abstracted for domestic and other uses.

According to the National Sanitation and Hygiene Strategy for the period 2018-2024 period, about 35.2 percent of the households in Malawi has access to improved sanitation. The proportion is higher in urban areas (65.5 percent) than in rural areas (29.3 percent).

Water, Sanitation and Hygiene (WASH) infrastructure is vulnerable to damage caused by severe floods and strong winds, particularly pipe networks, overhead tanks, pit latrines, and borehole handpumps.

1.4.8 Land Resources

Malawi's total land area of 9.4 million ha is presently supporting an estimated human population of 21 million people. Out of the 9.4 million ha, (i) 3.70 million ha is forests and woodlands, (ii) 1.85 million ha is permanent pastures, (iii) 3.85 million ha is total agricultural land (0.13 million ha is permanent crops and 1.88 million ha is arable land), and (iv) 7.41 million ha is non-arable land (NSO, 2008). Thus, only 31 percent of the country's total land area is suitable for rain-fed agriculture at traditional level of management due to variations in topography, slope, rainfall, temperature, soil type and soil depth. This scenario presents the limited nature of the land resource base that is heavily utilized and prone to environmental degradation, hence also highly vulnerability to climate change. Malawi's land resource base is under threat from increasing human and livestock population pressures, and the expanding of agricultural production to marginal and fragile areas.

Other factors that contribute to land degradation include: (i) insecure and unforeseeable property rights, leading to open access exploitation for agricultural production, (ii) limited information on the costs of land degradation and the benefits of conservation, (iii) lack of access to credit for soil conservation and management practices, and (iv) poor agricultural production practices. However, the new Malawi Land Policy (GoM, 2007) is addressing some of these constraints.

1.4.9 Biodiversity

According to a report by the Convention on Biological Diversity on Country Profiles and GoM (2021), Malawi has diverse habitats and ecosystems including woodlands, montane grasslands, wetlands and fresh water bodies that harbour a rich variety of flora and fauna, including more than 5,000 plants and over 8,500 invertebrate species. Major ecosystems comprise both terrestrial and aquatic systems, with the latter making up around 20% of the total surface area. The greatest diversity of plants and animals are found in the country's 97 protected areas, 90 percent of which are forest reserves. Malawi has a total of over 6,000 flowering plant species, of which 122 are endemic, and 248 species are threatened with extinction. Animal species in Malawi consist of both vertebrates and invertebrates. Vertebrates include amphibians, mammals, reptiles, birds and fish. There are about 192 mammal species in the country, of which 8 are listed as threatened under IUCN (2013). The total number of fish species found in Malawi is estimated to be in excess of 1000 species. Over 800 fish species have been described in Lake Malawi, 95 percent being haplochromine cichlids, and 99 percent

of which are endemic to the Lake. Biodiversity plays a critical role in the social economic development of the country. For example, major tourist attractions in the country include water bodies, national parks, wildlife reserves, mountains and cultural heritage sites that provide site-seeing, photographic safaris and mountain hiking opportunities. Lake Malawi National Park is of global importance for biodiversity conservation due to its fish diversity in particular. However, Malawi's biodiversity is being degraded by the unsustainable utilization and management of natural resources, fuelled by the expansion of agriculture production and deforestation in order to meet biomass energy demands for domestic cooking and heating.

The severe deforestation and general degradation of biodiversity that Malawi is experiencing have serious repercussions on climate change mitigation i.e., carbon emission and sequestration, as well as climate change adaptation.

1.4.10 Geology

As stated in Malawi's Third National Communication (GoM, 2021), the Geology of Malawi is dominated by metamorphic rocks of Pre-Cambrian to lower Palaeozoic age which are the oldest rocks in the country. These are overlain by sedimentary rocks of Permo-Triassic age and intruded by a variety of alkaline rocks of Jurassic to Cretaceous age. These are overlain by younger sediments (Tertiary to Quaternary age) deposited in the major drainage basins of the country. Malawi is endowed with a variety of mineral resources with high potential for exploitation. Rare earth metals are a particularly distinctive feature of Malawi's geology. Also, there is potential for oil, gas, and unconventional hydrocarbons in the Tertiary to recent sediments of Lake Malawi.

The geology of an area determines the type of foundation required for the construction of different types of infrastructure, e.g., roads and bridges and buildings. For example, different technologies will be applied in the construction of roads and bridges in sedimentary environments and plateau areas covered by metamorphic rocks.

2.0 NATIONAL INVENTORY REPORT OF ANTHROPOGENIC EMISSIONS BY SOURCES AND REMOVALS BY SINKS OF GREENHOUSE GASES

2.1 Introduction

The UNFCCC, in Article 4.1 and 12, obliges the Parties to 'develop, periodically update, publish and make available to the Conference of the Parties (CoPs), national inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases' (United Nations, 1992). Malawi undertook its first, second and third national GHG inventories as part of national communications in 2002, 2010 and 2021 respectively (GoM, 2002, 2010, 2021). Furthermore, Malawi published its NAMA report in 2015, INDCs in 2015, BUR in 2020 and Updated NDCs in 2021. These reports provided useful information not only in terms of identified gaps and constraints but also the areas for further improvements.

This chapter on the national greenhouse gas inventory is part of Malawi's Fourth National Communication (NC4) and First Biennial Report (BTR1), and the associated Common Reporting Tables (CRTs) aim to meet Malawi's reporting obligations under the UNFCCC and PA. The report covers the period 2018 to 2022 and trends for the period 1994 to 2022. The report meets the reporting requirements as outlines in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (including the associated 2019 Refinements) and the Modalities, Procedures, and Guidelines (MPGs) for the transparency framework for action in support under Article 13 of the Paris Agreement as recommended in paragraphs 20 to 24 of the MPGs (Decision -/CMA.1).

2.2 National Circumstances: key drivers of GHG emissions and removals in Malawi

Malawi's economy is agro-based. The main crops are tobacco, tea and sugar for export while maize and rice are the main food crops. Agriculture contributes to 22.8% of forex, 64% of employment and majority of rural Malawians depend on subsistence agriculture for their livelihoods (Government of Malawi, 2021). The industrial sector involves processing of agricultural produce and to some extend mineral resources especially cement. Although the population is rural-based and accounts for 84% of the total 20.6 million people in 2022, urbanisation rate is high, currently increasing at 4.1% per annum (UNHABITAT, 2023). Poverty level is around 50%. Most Malawians depend on natural resource-based activities for their livelihood i.e. agriculture, fishery, artisanal mining and forest-based activities (firewood, timber, poles, charcoal) (Mphande, 2016; Senganimalunje & Chirwa, 2020). Malawi grid electricity is renewable consisting of hydro and solar photo voltaic. Diesel operated thermal power plants are used for peaking and during maintenance of the hydro power plants. These factors are elaborated further in the respective sectors.

With such social economic and demographic profiling, it has been observed the primary drivers of GHG emissions and removal in Malawi are:

- Demographic drivers: This factor affects demand for goods and services, land for cultivation and settlement, as well as urbanization, transportation and waste generation amongst others. Malawi's annual population growth rate has been between 2% and 3.3% per annum. Table 2-1 shows population trend and intercensal population growth between 1966 and 2022 (National Statistical Office, 2018);

Table 2-1: Population trend and intercensal population growth between 1966 and 2022

Year	Population	Intercensal growth rate
1966	4039583	3.3
1977	5547460	2.9
1987	7988507	3.7
1998	9933868	2.0
2008	19077160	2.8
2018	17563749	2.9

Source: National Population Census, 2018 (NSO)

- Economic drivers: The key issues involve agriculture, industry, energy, transport, and natural resources-based livelihood systems of the rural population;
- Environmental drivers: Extreme climate impacts have negatively affected hydro power plants resulting increased use of fossil-based plants. Despite afforestation and reforestation efforts deforestation is high due to opening of forestland for agriculture, settlements and biomass fuels (firewood and charcoal).

2.3 Institutional arrangements

The EAD in the MNRCC, is the National Focal Point (NFP) for managing climate change affairs which includes the national greenhouse gas inventory system. For inquiries on the national GHG inventories, the Department can be reached at:

The Director of Environmental Affairs
Lingadzi House, Robert Mugabe Crescent
Private Bag 394,
Lilongwe 3,
Malawi.
Email: ead@ead.gov.mw
Phone: +265 (0) 1 771 111

The EAD, as the national focal point, worked closely with other stakeholders in the government ministries, departments and agencies (MDAs), academia, private sector and NGOs in data sourcing and sharing, undertaking sectoral studies, technical evaluations and other support activities. As a developing

country, Malawi produced the national GHG inventory report as part of its national communication to the UNFCCC (Government of Malawi, 2021b). Climate change programmes and activities are implemented within a coordinated framework as shown in Chapter 1 Figure 1-1.

Table 2-2 provides the summary of roles played by the lead government institutions in facilitating and aiding inventory preparation process.

Table 2-2: Roles of government ministries, departments and agencies.

Institution	Responsibilities
Environmental Affairs Department in the Ministry of Natural Resources and Climate Change	Overall planning, coordination, training, QA/QC, approval process, publication and submission to the UNFCCC
Ministry of Finance and Economic Planning	Overall economic and fiscal policies and economic development. It manages data portal with lots of sectoral data*
Ministry of Energy (MoE)	MoE has been developing capacity to prepare national Energy balances
Malawi Energy Regulatory Authority (MERA)	Manages petroleum import data and issues licenses for energy generators
Department of Mines	The Department manages mineral production statistics- coal and cement production data
Ministry of Trade and industry	The Ministry receives industrial production statistics from the registered industries
Ministry of Agriculture	Produces data on crop production (including paddy and upland rice), fertiliser usage, livestock statistics and land use data.
Department of Forestry	Provides data on forestry cover and land use change
Ministry of Transport and Infrastructure Development Road Transport, Aviation, Rail and Marine	Provides statistics on registered motor vehicles, registered ships and boats, fuels usage by rail and aviation.
Ministry of Local Government and Rural development (city, municipal, town and district councils) Water Boards	Management of municipal solid waste is delegated to local government Malawi has five water boards who have the responsibility of management of wastewater treatment and discharge.
National Statistical Office (NSO)	NSO manages collection and archiving of various demographic, social and economic data for the country. It manages data portal on various data **
Malawi Revenue Authority (MRA)	MRA collects revenue for the government through duties and taxes

* https://psip.malawi.gov.mw/reports/economic.php; ** https://malawi.opendataforafrica.org/

Malawi, through the EAD, has been developing a robust and sustainable system of national GHG inventory preparation. In the past few years, climate change focal persons in government ministries, departments and agencies (MDAs) were trained in data collection and archiving to support the national GHG inventory preparation. The MDAs involved came from energy, agriculture, forestry, trade and industry, local government, transport, NSO, MRA, mining, and water, amongst others. The EAD assembled a team of experts from various sectors for data collection, entry, methodology improvement, emissions estimation, report preparation, and review. The collected data was used in compiling the GHG Inventory report.

2.4 Inventory Management and Inventory Preparations

The national GHG inventory preparation process in Malawi typically involves a well-structured approach that includes the following: planning at Secretariat level, setting up the GHG inventory team, reviewing and selecting methodologies, engagement of data sources, collecting and entering data, implementing quality control and assurance measures, estimating emissions and associated uncertainties, preparing reports, reviewing emissions data and reports with stakeholders and experts, identifying areas for improvement, data archiving and publishing the final reports.

2.4.1 Archiving of information

Malawi has been publishing and disseminating the national GHG inventories as part of national communications through online, electronic and print media (Government of Malawi, 2021b). The government, with support from development partners, has also been working GHG database system to ensure reliable data collection, storage and sharing to support the inventory preparation. However, data and detailed sectoral reports have not been effectively archived to make them accessible to stakeholders. The absence of an efficient and effective archiving system makes it difficult to verify historical data and limits the ability to improve methodologies over time. This gap posed challenges in ensuring consistency, traceability, and transparency in the national greenhouse gas inventory process. Recognizing the importance of a reliable data repository, efforts are underway to establish an archiving system as part of the fourth national communication deliverables. This repository will contribute towards the centralized platform the government has been developing for storing and managing emissions data, facilitating better data retention, and accessibility.

2.4.2 Processes for official consideration and approval of inventory

Once the draft GHG inventory report was produced, it went through several review stages to ensure accuracy and consistency of the reported information. The first step involves internal review by the team of experts within EAD to ensure that all aspects of the terms of reference were fulfilled. The second stage involved the presentation of the report to the sectoral stakeholders from MDAs, academia, and industry who offered critical reviews in their respective sectors and offered additional checks on the accuracy and consistency of the data that was used

in the inventory. As shown in Figure 1-1, climate change activities are well coordinated in Malawi. At the Government approval level, there were two government committees that reviewed the report, namely, the Technical Committee on Climate Change (TCCC) and National Steering Committee on Climate Change (NSCCC). The TCCC and NSCCC reviewed the report at technical and policy levels respectively (Government of Malawi, 2016). These steps, as part of quality assurance and quality control activities, are essential to improve the credibility and accuracy of the data. The finalised inventory was subsequently submitted to the UNFCCC Secretariat by the Environmental Affairs Department.

2.4.3 Methodological processes

Once the draft GHG inventory report was produced, it went through several review stages to ensure accuracy and consistency of the reported information. The first step involves internal review by the team of experts within EAD to ensure that all aspects of the terms of reference were fulfilled. The second stage involved the presentation of the report to the sectoral stakeholders from MDAs, academia, and industry who offered critical reviews in their respective sectors and offered additional checks on the accuracy and consistency of the data that was used in the inventory. As shown in Figure 1, climate change activities are well coordinated in Malawi. At the Government approval level, there were two government committees that reviewed the report, namely, the Technical Committee on Climate Change (TCCC) and National Steering Committee on Climate Change (NSCCC). The TCCC and NSCCC reviewed the report at technical and policy levels respectively (Government of Malawi, 2016). These steps, as part of quality assurance and quality control activities, are essential to improve the credibility and accuracy of the data. The finalised inventory was subsequently submitted to the UNFCCC Secretariat by the Environmental Affairs Department.

Consistent with the reporting requirements and flexibility provisions in the MPGs, paragraph 48, this Report covers at least three of the recommended seven greenhouse gas emissions and removals by sinks associated with anthropogenic activities, focusing on the major greenhouse gases, namely, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O). Indirect greenhouse gases such as carbon monoxide (CO), oxides of nitrogen (NO_X), and non-methane volatile organic compounds (NMVOCs) and Sulphur dioxide (SO_2), have not been covered in the current report but efforts will be made to ensure that future inventories cover such gases. In the computation of aggregate GHG emissions, the major greenhouse gases are expressed as carbon dioxide equivalents (CO_2-e), calculated using the 100-year global warming potential (GWP) from the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) as shown in Table 2-3 (IPCC, 2014). This standardization allows for a direct comparison of the combined effects of different gases, considering their varying radiative activity and atmospheric residence times.

Table 2-3: Global Warming Potential - IPCC AR5

Gas type	Chemical formula	GWP AR5
Carbon dioxide	CO_2	1
Methane	CH_4	28
Nitrous oxide	N_2O	265

Emissions and removals are categorized into four sectors, as outlined in the 2006 IPCC Guidelines representing key human activities that release or capture greenhouse gases. However, Agriculture, Forestry and Other Land Use (AFOLU) was broken down into Agriculture, and Forestry and Other Land Use (FOLU) to align with the reporting requirements in MPGs paragraph 50 as follows:

i. Energy: Includes activities such as fuel combustion for electricity, transportation, fugitive emissions and 'other' sectors;

ii. Industrial Processes and Product Use (IPPU): Covers emissions from cement and lime production;

iii. Agriculture: Encompasses emissions from livestock and crop production;

iv. Forestry and Other Land Use (FOLU): Accounts for emissions and removals from deforestation, reforestation, and changes in land use practices; and

v. Waste: Includes emissions from municipal solid waste disposal, open waste burning, and wastewater treatment and disposal.

The reporting periods for NC4 is 2018 to 2022 and for BTR 1 is from 1990 to 2022. However, in line with flexibility provisions in MPGs paragraph 57, Malawi's report covers the period 1994 to 2022 because Malawi's base year for the Initial National Communication (INC) was 1994 (Government of Malawi, 2002). Malawi's reporting aligns with the IPCC 2006 Guidelines and reflects consistent methodologies across all reporting periods, IPCC 2019 Refinement and MPGs. The inventory includes recalculations from earlier submissions, specifically the initial, second and third national communications, and introduces updated data for the first BTR and fourth national communication. These recalculations are essential for maintaining methodological consistency, addressing data gaps, and incorporating advancements in techniques for estimating emissions. This comprehensive framework ensures consistency and comparability in reporting across sectors, for all parties. Tier 1 approaches (Table 2-4) were used due to the lack of country-specific emission factors. 2006 IPCC default emission factors were used.

Table 2-4: Methodologies used for the sectors

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Method
1A1. Energy industries	Tier 1
1A2. Manufacturing industries and construction	Tier 1
1A 3. Transport	Tier 1
1A 4. Other sectors	Tier 1
1A 5. Other	NO
1B 1. Fugitive emissions from Solid fuels	Tier 1
1B 2. Fugitive emissions from Oil and natural gas	NO
1C. CO_2 transport and storage	NO
2A. Mineral industry	Tier 1
2B. Chemical industry	NO
2C. Metal industry	NO
2F. Product uses as ODS substitutes	NO
3A. Enteric fermentation	Tier 1
3B. Manure management	Tier 1
3C. Rice cultivation	Tier 1
3D. Agricultural soils	Tier 1
3E. Prescribed burning of savannas	Tier 1
3F. Field burning of agricultural residues	Tier 1
3G. Liming	Tier 1
3H. Urea application	Tier 1
3I. Other carbon-containing fertilizers	Tier 1
3J. Other	Tier 1
4A. Forest land	Tier 1
4B. Cropland	Tier 1
4C. Grassland	Tier 1
4D. Wetlands	Tier 1
4E. Settlements	Tier 1
4F. Other land	Tier 1
4G. Harvested wood products	Tier 1
4H. Other	Tier 1
5A. Solid waste disposal	Tier 1
5B. Biological treatment of solid waste	NO
5C. Incineration and open burning of waste	Tier 1
5D. Waste water treatment and discharge	Tier 1
5E. Other	NO

2.5 Greenhouse Gas Profile

2.5.1 Trends in Greenhouse Gases

Figure 2-1 shows the total emissions in Gg of CO_2e. Between 1994 and 2022, Malawi emitted a total of 429,874.02 Gg of CO_2-e over the period of 28 years, giving an average annual GHG emission of 15,352.64 Gg of CO_2-e. Emissions grew from 8,604.38 Gg CO2-e Gg in 1994 to 25,261.32 Gg in 2022. Further analysis showed that between 2018 and 2022, the emissions grew from 21,861.91 GgCO_2-e to 25,261.32 Gg in 2022, giving a total of 116,777.04 Gg of CO_2-e. The increase of emissions in the five years represents 32% of the total emissions over the entire period of 1994 to 2022.

Figure 2-2 shows the per capita GHG emissions over the period of assessment. The analysis shows that the figure increased from 9.02 x 10^{-4} Gg/person to 13.751 x 10^{-4} Gg/person. The steady increase is a clear indication that is not just because of population increase but also the society is becoming more carbon intensive as the levels of income and economic activities improve such owning motor vehicles and opening up new industrial operations amongst others

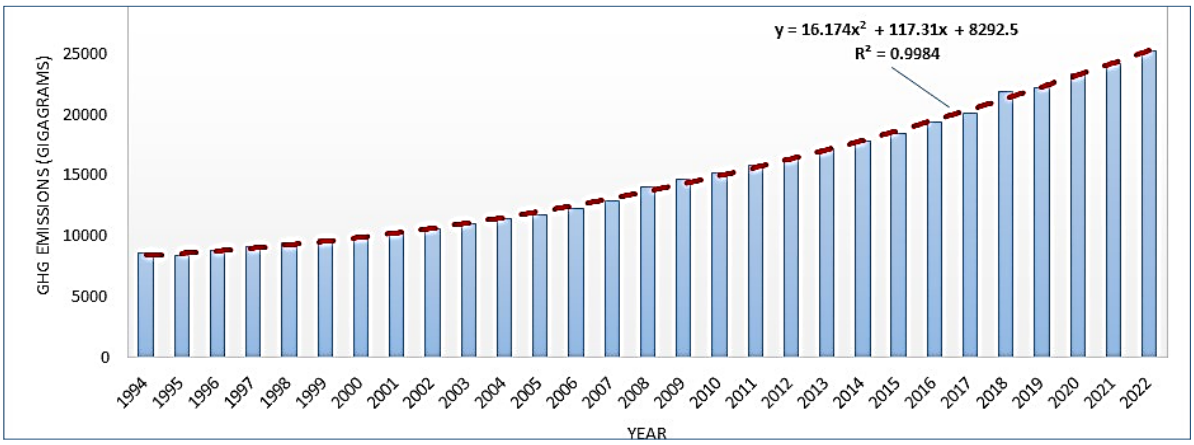


Figure 2-1: GHG Emissions from 1994 to 2022.

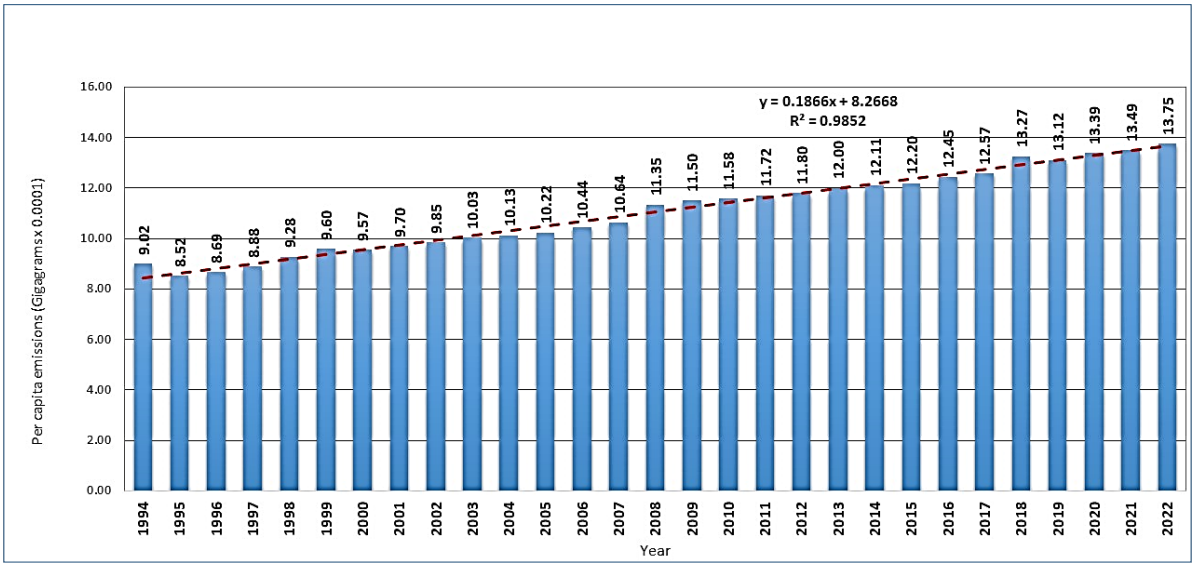


Figure 2-2: Per GHG emission over the period 1994 to 2022

Table 2-5 show the contributions of the emissions by gas type measured in absolute values in Gg and CO_2 equivalents (Gg of CO_2-e).

Table 25: Total emission by gas type

SECTORS	2018 GHG Emissions (Gg)				2022 GHG Emissions (Gg)			
	CO_2	CH_4	N_2O	CO_2e	CO_2	CH_4	N_2O	CO_2e
ENERGY *	1335.35	9.222	0.134	1629.071	1502.09	9.658	0.142	1810.16
	81.97%	15.855%	2.18%		82.98%	14.94%	2.08%	
IPPU *	107.539	0	0	107.539	188.316	0	0	188.316
	100%	-	-		100%	-	-	
AGRICULTURE *	75.738	3409.56	1004.09	4489.383	153.02	162.137	3.857	5714.19
	1.69%	75.95%	22.37%		2.86%	79.44%	17,88%	
FOLU *	51631.7	0	0	51631.71	46705.4	0	0	46705.4
	100%	-	-		100%	-	-	
WASTE *	1381.74	467.217	4.423	15635.91	1454.29	527.8929	4.953	17547.9
	8.84%	83.67%	7.5%		8.29%	84.23%	7.48%	
TOTAL WITH FOLU *	54532.1	16749.8	2211.69	73493.61	50003.1	699.689	8.952	71966.7
	74.2%	22.8%	3.0%		69.5%	27.2%	3.3%	
TOTAL WITHOUT FOLU *	2900.37	16749.8	9211.68	21861.904	32997.72	699.689	8.952	25261.3
	13.3%	76.6%	10.1%		13.1%	77.6%	9.4%	

* **Note:** The percentages were based on CO_2 equivalents.

The overall analysis of the gases without FOLU showed that CO2 account for 13.1 to 13.3%, CH4 76.6 to 77.6% and N2O 9.4 to 10.1%. Livestock and Waste sectors account for the larger percentage. The overall analysis with FOLU showed that CO2 accounted for 69.5 to 74.2%, CH4 22.8% to 27.2% and N2O 3% to 3.3%.

The analysis at the sector level showed the following:

i. Energy: The analysis for 2018 and 2022 showed that CO_2 was the dominant gas with values ranging from 81.97% to 82.98%, followed by CH_4 which ranged from 14.94% to 15.85% and N_2O ranging from 2.08% to 2.28%. Emissions in the energy sector arise from combustion processes;

ii. IPPU: The sector consisted of cement and lime processing which involved calcination of limestones resulting in emission of 100% CO_2;

iii. Agriculture: The main gases were CH_4 which accounted for 75.95% to 79.44%, followed by N_2O at 17.88% to 22.37% and CO_2 at 1.69% to 2.68%. Enteric fermentation and manure management contributed to methane emissions;

iv. FOLU: The sector contributed to emission of 100% CO_2; and

v. Waste: The major gas was CH_4 which accounted for 83.67% to 84.23%, followed by CO_2 at 8.29% to 8.84% and N_2O at 7.48% to 7.5%. Methane emission is from anaerobic digestion processes.

2.5.2 Key Category Analysis

Malawi undertook key category analysis (KCA) in line with MPGS paragraph 25. The KCA identify categories that together contribute to at least 95 percent of national emissions or to the most significant trends in emissions growth. The KCA was conducted using Approach 1 and covers both the base year (2018) and the latest reporting year (2022). The first set of analysis did not include FOLU in the total national emissions while the second set included FOLU in the total. Figure 2-3 & Figure 2-4 show KCA for GHG emission levels and trends excluding FOLU. The analysis shows that the Waste and Agriculture sectors dominate Malawi's emissions profile. Emissions from incineration and open burning of waste (category 5.C) and unmanaged solid waste disposal sites (category 5.A.2) consistently ranked highest by level of emissions. Within the Agriculture sector, enteric fermentation from non-dairy cattle and goats (categories 3.A.1.b and 3.A.4) are among the most significant contributors. Road transportation (1.A.3.b) and fuel combustion in manufacturing industries (1.A.2) also appear prominently across both level and trend assessments. Key emerging trends were noted in emissions from urea application (3.H) and cement production (2.A.1), which have shown marked increases in recent years. The key category analysis that included FOLU showed that Forest-Lands category displaced the waste sector to second position both in levels and trends with values around 51.43% and 47.23% respectively.

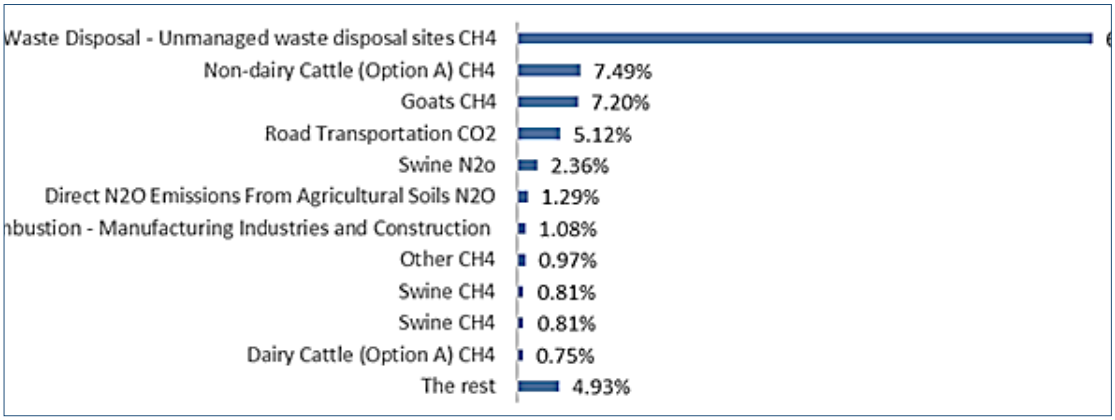


Figure 2-3: % share of the categories without FOLU (2022)

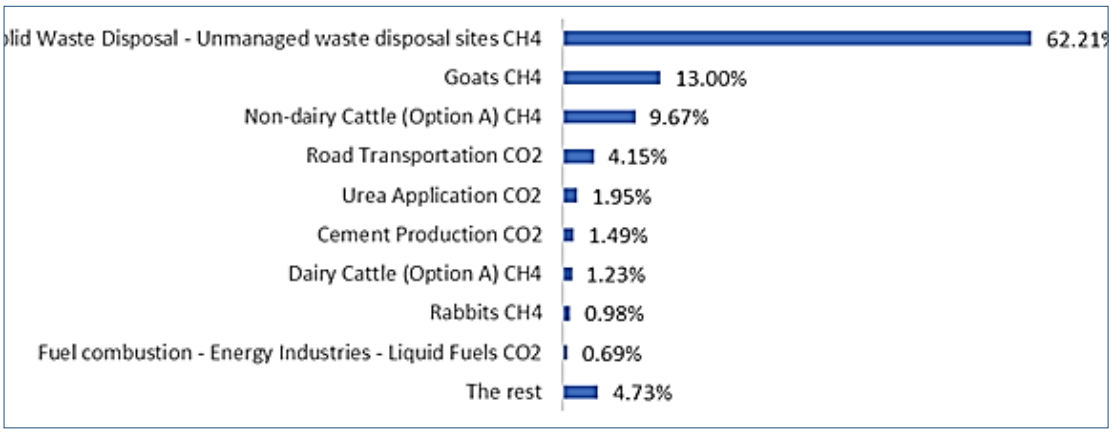


Figure 2-4: KCA GHG trends without FOLU

Figures 2-5 and 2-6 show the key category analysis that included the categories under FOLU.

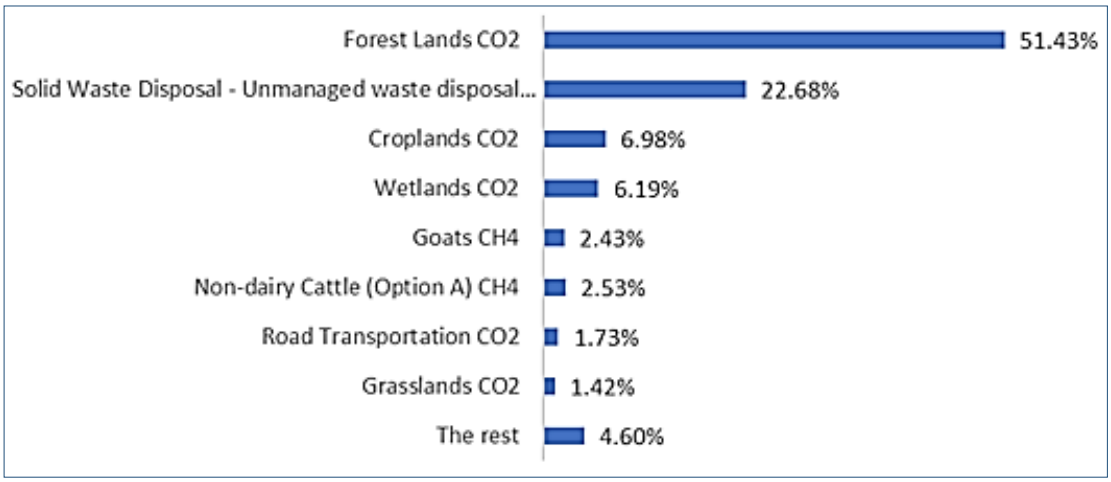


Figure 2-5: KCA GHG levels with FOLU (2022)

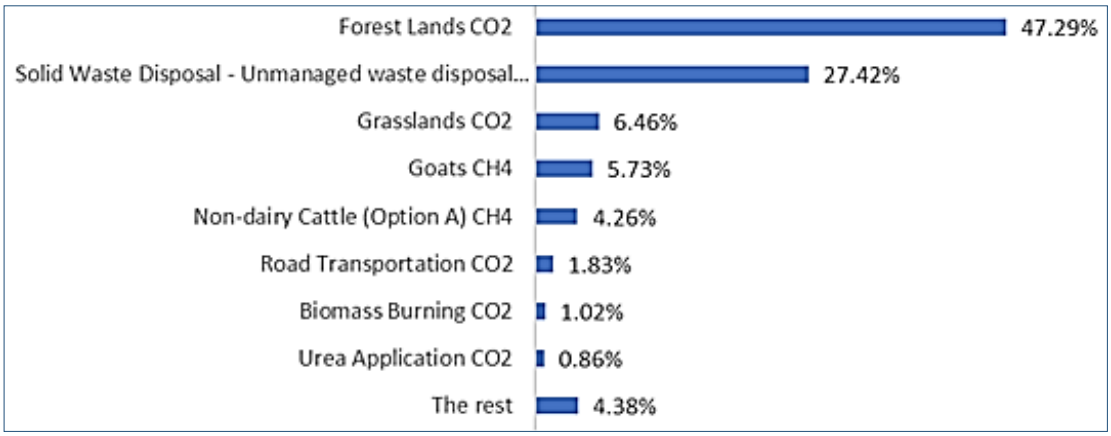


Figure 2-6: KCA GHG trend with FOLU

2.6 General description of QA/QC plan and implementation

2.6.1 Inventory Improvement Plans

Malawi implemented a Quality Assurance/Quality Control (QA/QC) framework in accordance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, as prescribed by Decision 18/CMA.1 under the Paris Agreement. The implementation of QA/QC is a central component of the national inventory system and is aimed at enhancing the accuracy, transparency, consistency, comparability, completeness, and reduction of uncertainty in greenhouse gas (GHG) estimates.

The QA/QC Plan outlines the systematic procedures and responsibilities that guide inventory compilation and review. The QA/QC processes are designed to ensure that the inventory is both technically robust and well-documented, supporting the overall integrity of the reporting system.

2.6.1.1 Quality Control (QC)

Quality control comprises routine technical activities implemented during the preparation of the GHG inventory. Malawi's Tier 1 QC procedures include:

i. Verification of data entry accuracy through consistency checks;

ii. Cross-referencing activity data with source documentation;

iii. Reviewing calculations for emissions estimates against IPCC formulas and default values;

iv. Ensuring that source-specific emission factors are appropriately referenced and used; and

v. Documentation and archiving of datasets, calculation files, and QA/QC checklists.

QC activities are conducted internally by sector experts during each stage of inventory compilation and are repeated at the review stages facilitated by the EAD.

2.6.1.2 Quality Assurance (QA)

Quality assurance consists of independent reviews and evaluations of the inventory by personnel not directly involved in its preparation. For Malawi, QA is implemented through:

i. Peer review of draft reports and datasets by external consultants or local academic institutions;

ii. Validation workshops with stakeholders, including government departments, research bodies, and sectoral experts;

iii. Review sessions under the National Technical Committee on Climate Change (NTCCC); and

iv. Regional and international technical support, including informal consultations with UNFCCC roster experts and IPCC regional capacity-building initiatives.

The QA process also includes the reception of feedback from past UNFCCC technical review teams during the BUR and NIR review cycles, and these inputs are systematically addressed in subsequent inventory improvements.

2.7 Cross Cutting Elements

2.7.1 Sources of Activity Data

The activity data was sourced from government ministries, departments and agencies, private sector, academic institutions, and publications from credible sources. The summary of data sources are shown in Table 2-6.

Table 2-6: Data Providers and Sources Used for the National Inventory Report

SECTOR/ CATEGORY	DATA PROVIDERS **(full names -key below)	TYPE OF DATA
Energy		
Energy: Fuel Combustion (1A) - Energy industries	EGENCO, MERA, MoFEPD	Installed capacity, diesel generation (GWh), fuel imports, electricity mix
Energy: Fuel Combustion (1A) - Manufacturing industries	MERA,	Industrial fuel consumption (diesel, coal, LPG), energy use by sector
Energy: Fuel Combustion (1A) – Transport	MERA, MRA, DRTSS, MoTPW	Fuel sales (petrol, diesel, Jet A-1), vehicle fleet data
Energy: Fuel Combustion (1A) - Other sectors	MERA, MoE, NSO, FAO	Biomass and fossil fuel consumption in residential, commercial and institutional sectors
Energy: Fugitive Emissions from Fuels (1B) - Solid fuels	MoM, MoFEPD, MoE	Annual coal production data
IPPU		
IPPU: Mineral Industry (2A) - Cement production	MoM, MoFEPD, Lafarge and USGS, publications Shayona, CPL	Cement production Clinker production and CaO content
IPPU: Mineral Industry (2A) - Lime production	MoM, MoFEPD, Lime producers/ Cooperatives, USGS , publications	Quicklime and hydrated lime production * Some lime data contains mixture of hydrated lime and agricultural lime
Agriculture		
Agriculture: Enteric Fermentation (3A)	MoA, DAHLD, NSO and FAO, publications	Livestock population by type and region
Agriculture: Manure Management (3B)	DAHLD, FAO, NSO, publications	Livestock waste production characteristics, manure systems distribution
Agriculture: Rice Cultivation (3C)	MoAFS, NSO, FAOSTAT, publications	Annual rice harvested area (ha), water management regime

Agriculture: Agricultural Soils (3D)	MoAFS, FAO, publications	Fertilizer use, livestock waste, crop residues, leaching/runoff parameters
Agriculture: Liming (3G)	Fertilizer importers, MoFEPD, FAO	Dolomitic lime consumption (tonnes) - approximated from import data
Agriculture: Urea application (3H)	FAM, MoAFS, publications	Urea application statistics (tonnes)
Agriculture: Other carbon-containing fertilizers (3I)	Not Occurring (NO)	Malawi does not use these at scale; category not reported
Forestry and Other Land Use		
FOLU: Forest Land (4A)	DoF, NSO, FAO, JICA, publications	Forest area, biomass stock changes, conversion trends
FOLU: Cropland (4B)	Ministry of Agriculture, APES	Area and type of crops, land use change data
FOLU: Grassland (4C)	MoAFS, DoLR, publications	Area under pasture, grazing management practices
FOLU: Settlements (4E)	FRIM, NSO, publications	Settlement expansion, land conversion rates
Waste		
Waste: Solid waste disposal (5A)	MOLGRD, City and Town Councils (34 in total), NSO, JICA, publications	Municipal waste generation, waste disposal methods
Waste: Biological treatment of solid waste (5B)	Not Occurring (NO)	Malawi does not use these at scale; category not reported
Waste: Incineration and open burning of waste (5C)	City Assemblies, NGOs, Community Reports	Practices and estimates of open burning at local level
Waste: Wastewater treatment and discharge (5D)	Water Boards, City Assemblies, NSO	Population served by sewerage systems, treatment types

KEY:

ADD	Agriculture Development Division
CPL	Cement Products Limited
DAHLD	Department of Animal Health and Livestock Development
DoF	Department of Forestry
DLR	Department of land Resources
DoM	Department of mines
DRTSS	Department of Roads and Safety Services
EGENCO	Energy Generation Company
FRIM	Forestry Research Institute of Malawi
GSD	Geological Surveys Department
JICA	Japanese International Cooperation Agency
MERA	Malawi Energy Regulatory Authority
MoAIWD	Ministry of Agriculture Irrigation and Water Development
MoE	Ministry of Energy
MoLGRD	Ministry of Local Government and Rural Development
MoM	Ministry of Mining
MoTPW	Ministry of Transport and Public Works
NSO	National Statistical Office

2.7.2 Sources of Emission Factors

Malawi is making progress in developing local emission factors due to research efforts in the livestock, IPPU (cement and lime) and energy sectors to develop local emission factors. It is expected that by the time the next GHG inventory is estimated, the work would have been peer reviewed and published. But for this inventory, Malawi has used Tier 1 in approach and the default emission factors from 2006 IPCC guidelines and its 2019 Refinements.

2.7.3 Uncertainty Assessments

Uncertainty analysis is a natural part of all estimations, such as greenhouse gas (GHG) inventories. The 2006 IPCC Guidelines focus on managing uncertainty as a central component of building inventories, especially for developing nations. Sources of uncertainty include variability in measurement instruments, assumptions in emissions modelling, and incomplete data coverage—especially in sectors with high biological or spatial variability such as agriculture, FOLU, and waste. Emissions from CO_2 combustion in the energy and industrial sectors generally exhibit lower uncertainty due to the availability of structured fuel and production data. In contrast, estimates from agricultural soils, forest conversions, and unmanaged waste streams display higher uncertainty due to natural heterogeneity and methodological constraints.

The national uncertainty in total GHG emissions for the latest inventory year (2022) is estimated at ±0.545%, while the uncertainty in the trend across the full time series (1994–2022) is estimated at ±2.241%. These estimates assume no correlation between uncertainty sources and reflect conservative bounds of national inventory reliability.

These uncertainty levels are largely consistent with those expected under IPCC guidelines for Tier 1-based inventories. Ongoing improvements in national data systems, institutional arrangements, and stakeholder coordination are expected to reduce uncertainty over future reporting cycles. The full uncertainty analysis is provided in the annex to Malawi full national GHG inventory report.

2.7.4 Areas of improvement

Several challenges were observed during the TNC preparation and the reviews from international experts. These involved inadequate human technical capacity, lack of data, incomplete data, aggregated data and data traceability. The specific aspects of improvements are covered in more details within the sectors.

2.7.5 Summary of the flexibilities as provided in the MPGs

The MPGs provided flexibilities that developing countries could be applied to lack of capacities, data and other limitations. Table 2-7 summaries the flexibilities that Malawi evaluated.

Table 2-7: Flexibility options evaluated by Malawi

Flexibility provision	Reference paragraph	Status	Provision used
Key categories	25	No	Did not utilize the flexibility provision that allows for the identification of fewer key categories or the use of less complex methodologies for non-key categories. Instead, the inventory maintained a rigorous approach, considering and reporting all categories comprehensively in line with the full IPCC guidelines.
Uncertainty analysis	29	No	Despite the challenges related to data availability, every effort was made to collect the most accurate data possible, and uncertainty was assessed and reported wherever feasible, in line with the full requirements of the MPGS.
Completeness	32	No	The flexibility to omit estimation of more insignificant categories was not applied.
QA/ QC	34, 35	No	Flexibility not applied regarding the development of a QA/QC plan. A formal QA/QC plan has been reported.
Gases	48	Yes	Option to report fewer gases was used. Due to data limitations, Malawi reported only CO_2, CH_4 and N_2O.
Time series	57, 58	Yes	Malawi made attempt to report all the time series from 1994 to 2022, but due to data challenge reported shorter series (2018 to 2022) for the FOLU sector. Extrapolation was applied where data was missing to complete, ensuring consistency and transparency in the inventory's temporal coverage.

2.8 Energy

2.8.1 Overview of the sector and background information

Malawi is endowed with several energy resources such as hydro, solar, wind, geothermal, coal and biomass. Biomass energy accounts for 86% of supply, followed by petroleum products, electricity and coal at 10%, 3% and 1% respectively. On the demand side of the energy balance equation, household accounts for 81%, followed by Transport, industry and other at 9%, 8% and 2% respectively. General access to electricity is at 25% while access to grid electricity is estimated at 12 to 14%. Malawi's energy landscape is characterized by a high dependence on firewood and charcoal for cooking and heating, particularly in rural areas where access to electricity remains low, at approximately 18% nationally (World Bank, 2023). This reliance on unsustainable biomass energy continues to decrease the sink capacity. Figure 2-7 shows Malawi's energy mix.

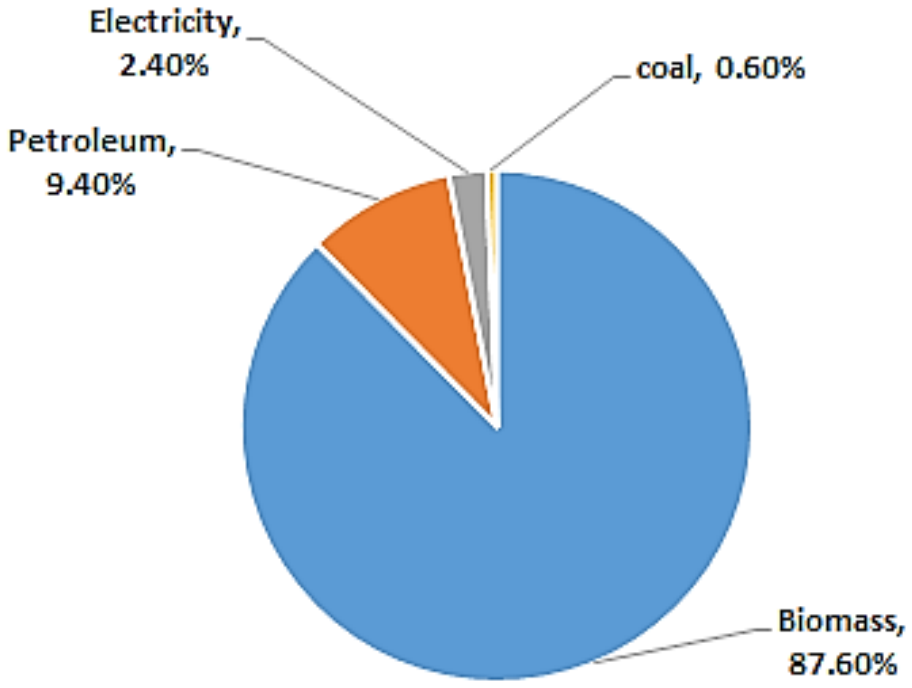


Figure 2-7: Malawi's energy mix

Figure 2-8 shows how the generation changed in composition between 2018 and 2022. The report on electricity supply and demand by the Ministry of Energy showed that electricity generation capacity increased from 475.4 MW to 533.4MW. The change net increase was attributed to:

- Hydro power generation increased from 358.7 MW to 398.9 MW
- Thermal power from diesel generators reduced from 115.4 MW to 51,4 MW due to end of contract with Aggreko and increase in solar PV from 1.4 MW to 83.1 MW by 2022 (Figure 9).

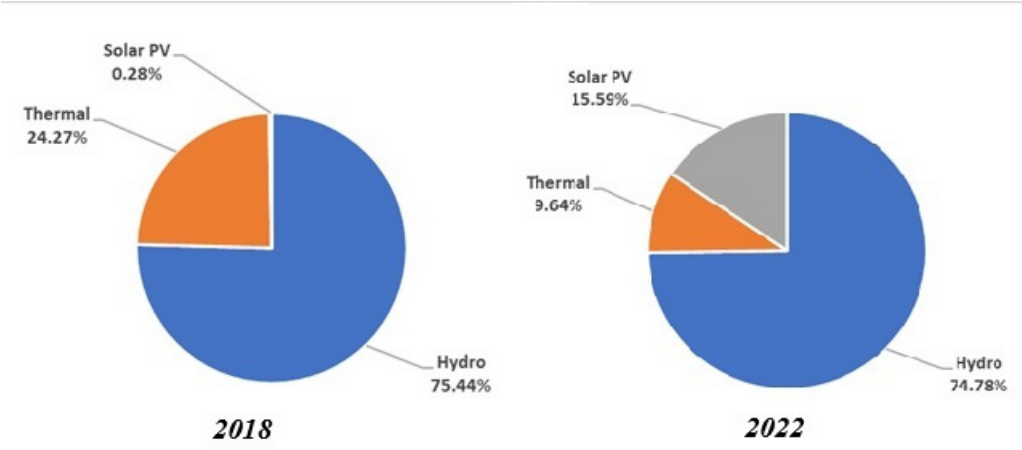


Figure 2-8: Electricity generation mix: 2018 and 2022

Hydropower still dominates the electricity generation mix, contributing approximately 75% of the grid electricity (Table 2-8), but the sector is vulnerable to climate change and climate variability, as evidenced by recurring extreme climate events such as droughts, floods and cyclones that disrupt power supply (MERA, 2021; Government of Malawi, 2016b).

Table 2-8: Electricity generation by fuel (GWh)

Years	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Hydro	1877.1	1864.5	1969.5	1952.3	1850.6	1757.1	1696.9	1758.4	1870.6	2197.1	1523.5
Diesel	0.0	0.0	0.0	0.0	5.6	14.2	170.5	207.3	159.6	42.0	62.6
Solar	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	39.7	165.4
Bagasse	148.2	106.0	106.3	140.1	133.4	130.7	98.0	71.8	108.9	0.0	0.0
Petrol	0	0	0	0	0	1.8	1.8	1.8	1.8	0.0	0.0
Other biomass	0	0	0	0	0	0.1	0.1	0.1	0.1	0.0	0.0
Total	2025.3	1970.5	2075.8	2092.4	1989.6	1904.0	1967.4	2039.5	2141.1	2278.8	1751.5

Source: Government of Malawi, 2023

The use of fossil fuels in transportation and industry's growing contribution to GHG emissions. Despite these challenges, Malawi has made strides in promoting renewable energy and energy efficiency as part of its climate change mitigation strategies, as outlined in its National Energy Policy of 2018 and the Updated Malawi's NDCs under the Paris Agreement (Government of Malawi, 2018; Government of Malawi, 2021).

2.8.2 Energy sector key categories

The energy sector is divided into three categories; Fuel Combustion, Fugitive Emissions from Fuel, and Carbon Dioxide Transport and Storage. These three categories are divided further in subcategories as shown in Table 2-9.

Table 2-9: Energy emission categories

1 - Energy
1.A - Fuel Combustion Activities
1.A.1 - Energy Industries
1.A.2 – Manufacturing Industries and Construction
1.A.3 - Transport
1.A.4 - Other Sectors
1.A.5 - Non-Specified
1.B - Fugitive emissions from fuels
1.B.1 - Solid Fuels
1.B.2 - Oil and Natural Gas
1.B.3 - Other emissions from Energy Production
1.C - Carbon dioxide Transport and Storage
1.C.1 - Transport of CO_2
1.C.2 - Injection and Storage
1.C.3 - Other

- **Fuel Combustion (CRT Category 1.A)**

  Fuel combustion remains a significant source of GHG emissions in Malawi, resulting from the oxidation of carbon-based fuels across various energy-consuming sectors. Emissions under this category primarily include CO_2, CH_4, and N_2O, emitted during the use of fossil fuels and biomass in energy generation, industry, transport, residential, and commercial applications.

- **Fugitive emissions from fuels (CRT 1.B)**

  This category covers fugitive methane (CH_4) emissions from solid fuel production in Malawi, specifically coal mining and handling. In accordance with the 2006 IPCC Guidelines (Volume 2, Chapter 4), fugitive emissions are unintentional releases of CH_4 during the mining process and post-mining operations.

- **Carbon Dioxide Transport and Storage (CRT Category 1.C)**

  This category is defined under the 2006 IPCC Guidelines (Volume 2, Chapter 5) as a system involving four major components:

  - Capture and compression of CO_2 at point sources (e.g., power plants or industrial facilities),
  - Transportation of the captured CO_2, typically via pipeline or tanker,
  - Injection of CO_2 into a long-term geological storage site (such as depleted oil/gas reservoirs or deep saline formations),
  - Monitoring and verification to ensure containment and prevent leakage.

  The principal purpose of CCS is to reduce CO_2 emissions from fossil-fuel-based or industrial processes, particularly in sectors with high point-source emissions.

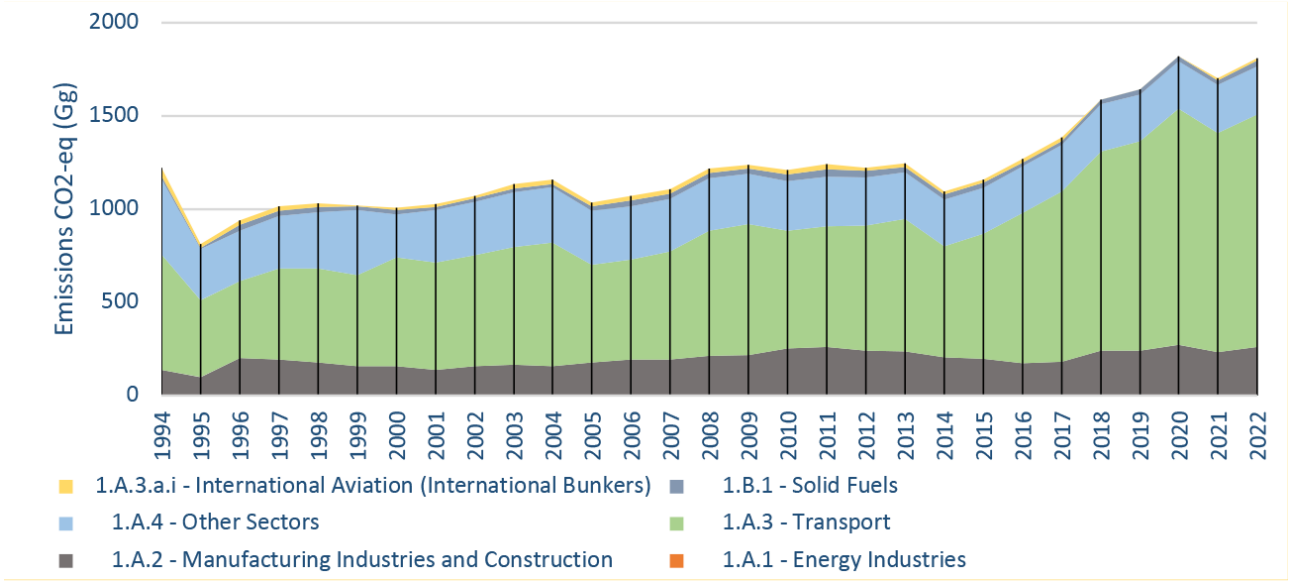
  As of 2022, Malawi has no operational or planned CCS infrastructure.

The relevant categories for Malawi are 1A and 1B. Activities under the Carbon Dioxide Transport and Storage categories do not occur in Malawi.

2.8.3 Total GHG emissions

Emissions in the energy sector stem mainly from fuel combustion in transport, manufacturing, and households. In 2022, diesel and petrol use in transport exceeded 500 million litres (Government of Malawi, 2023).Total energy sector emissions rose from 1,178.5 Gg CO2e in 1994 to 1,796.5 Gg CO2e in 2022, an increase of 52%. Figure 2-9 shows total annual GHG emissions in the energy sector from 1994 to 2022.

Figure 2-9: 1994 to 2022 Total annual GHG emissions in the energy sector



The national trend in GHG emissions from the energy sector continued to increase between 2018 and 2022, driven primarily by growth in the transport and manufacturing sectors, while other subsectors experienced variable or declining trends. This is indicated in Table 2-10.

Table 2-10: the total annual GHG emissions in the energy sector 1994 to 2022 by CO_2 eq

Years	1.A.1 - Energy Industries	1.A.2 - Manufacturing Industries and Construction	1.A.3 - Transport	1.A.4 - Other Sectors	1.B.1 - Solid Fuels	1.A.3.a.i - International Aviation (International Bunkers)
1994	3.13	133.06	619.85	406.19	16.24	133.18
2000	3.13	155.40	582.87	231.34	21.06	155.43
2010	3.13	247.87	633.42	265.89	37.14	247.85
2017	1.50	177.51	912.10	251.73	21.21	177.50
2018	3.81	239.11	1,067.91	253.10	23.33	239.21
2019	55.47	239.10	1,120.63	252.81	25.67	239.18
2020	42.71	268.71	1,266.98	255.46	25.74	268.74
2021	11.23	228.89	1,174.95	258.88	23.92	229.01
2022	16.75	257.47	1,247.28	259.49	29.16	257.49

The annual average growth rate in emissions from selected energy sector categories during this period is summarized in 2-10.

Table 2-11 shows the annual growth rate of net emissions by energy sub-sectors. The table show the following:

i. Energy industries 1.A.1

Between 2018 and 2022, GHG emissions from this category declined at an average annual rate of -22.15%, a significant reversal from the 2.82% growth recorded between 2001 and 2017. The recent decline is attributed to a reduction in diesel-based thermal electricity generation, as hydropower and solar energy installations increased their share in the national energy mix. Despite these short-term reductions, the long-term trend (1994–2022) shows an overall growth of 6.17%, primarily reflecting the surge in thermal power use during crisis years (e.g., 2017–2020) due to droughts and cyclone-induced infrastructure damage.

ii. Manufacturing Industries and Construction (1.A.2)

During the 2018–2022 period, GHG emissions from this category increased at an average annual rate of 1.87%. This is a slight moderation compared to the 3.85% average annual growth observed between 2001 and 2017(Table 2-11). In 2003, main clinker plant which is major consumer of coal closed operations.

Table 2-11: Annual Growth Rate of Net Emissions by Energy Sub-sector

		Annual change per reporting period			
Subsectors	Overall 1994-2022	2018-22 Emissions	2001-2017	1995-2000	1994
Energy industries 1.A.1	6.17%	-22.15%	2.82%	--	--
Manufacturing Industries and Construction 1.A.2	2.39%	1.87%	3.85%	4.88%	--
Transport 1.A.3	2.53%	3.96%	6.82%	3.52%	--
Other 1.A.4	-1.59%	0.63%	-1. 48%	-1. 66%	--
Fugitive emissions 1B	2.11%	5.73%	3.98%	11.87%	--

iii. Transport (1.A.3)

This subcategory experienced the most substantial increase in emissions, with an average annual growth rate of 3.96% between 2018 and 2022. The rise reflects an expansion in the national vehicle fleet and increasing fuel consumption. According to the 2023 Malawi Economic Report, fuel sales for petrol increased from 154.8 million litres in 2018 to 183.2 million litres in 2022, while diesel sales rose from 271.4 million litres to 351.7 million litres in the same period. These trends underscore a growing reliance on fossil-fuel-powered transport modes.

iv. Other Sectors (1.A.4)

GHG emissions from residential, commercial, and institutional sectors grew at an annual average of 0.63% during 2018–2022. This is a rebound from the -1.48% decline recorded during 2001–2017. The current positive trend may be attributed to increased biomass use in peri-urban and rural households, offsetting gains from the uptake of electricity and LPG in urban centres.

v. Fugitive Emissions from Solid Fuels (1.B)

Fugitive emissions from coal mining activities grew significantly at an annual average rate of 5.73% between 2018 and 2022. This surge corresponds with the increased coal production in Karonga and Rumphi Districts, where coal output rose from 171,236 metric tons in 2018 to over 220,000 metric tonnes in 2022. The expansion of domestic coal demand in manufacturing industries such as cement, ethanol, tobacco processing, food processing and textiles, is a major contributing factor. When compared to the 2001–2017 period, which recorded more accelerated growth across most subcategories (e.g., 6.82% for transport), the 2018–2022 period reflects relatively stabilized emission growth.

2.8.4 Efforts to Improve Emission Estimation

Recognizing the significance of the energy sector in national GHG emissions, Malawi has undertaken measures to improve both data quality and reliability. These include:

i. **Taking steps to adopt Tier 2 methodologies** for key emission categories where sufficient disaggregated activity data is available;

ii. **Development of local emission factors** for biomass and coal combustion in industrial applications;

iii. **Enhancement of data systems** such as digital fuel import tracking by MRA and improved Energy Balance reporting by the Department of Energy Affairs; and

iv. Continued investment in data systems, stakeholder engagement, and policy implementation will be key to reducing uncertainty and supporting Malawi's climate commitments under the UNFCCC.

2.8.5 Comparison of Sectoral and Reference Approaches

Malawi has applied both the sectoral and reference approaches for estimating CO_2 emissions from fuel combustion, Table 2-12 and Figure 2-10. The sectoral approach (CRT 1.AA) estimates emissions based on reported fuel consumption across specific sub-sectors, while the reference approach (CRT 1.AB) provides a top-down estimate using total national fuel supply data (imports, exports, and stock changes). These two methods serve as cross-verification tools, and while perfect alignment is not expected, significant differences may indicate inconsistencies in fuel statistics or assumptions used in the estimation process.

Table 2-12: Emissions from Sectoral vs. Reference Approaches

Inventory Year	Reference Approach	Sectoral Approach	Difference (%)
1994	948.44	905.76	4.50%
2000	623.98	609.75	2.28%
2010	923.53	900.23	2.52%
2017	1016.01	996.97	1.87%
2018	1334.97	1335.35	-0.03%
2019	1394.65	1395.01	-0.03%
2020	1556.39	1556.81	-0.03%
2021	1408.04	1396.64	0.81%
2022	1515.54	1502.09	0.89%

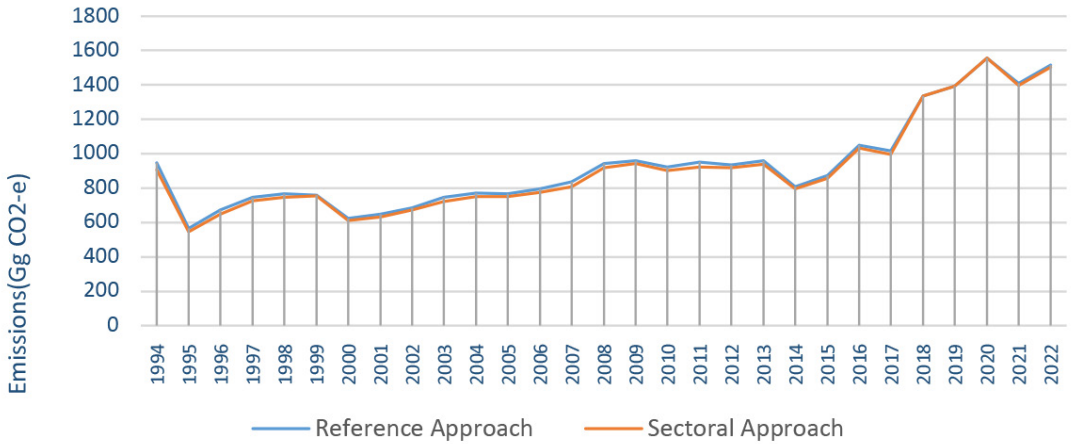


Figure 2-10: Emissions from Sectoral vs. Reference Approaches

Post-2018, differences between the two are consistently under ±1%, confirming data accuracy. Earlier discrepancies (up to 4.8% in 1994) were due to trade data uncertainties. Solid fuels show almost perfect alignment due to clear coal production records. This consistency affirms the reliability of Malawi's energy statistics in recent years. These highlights are indicated on Table 2-12 and Figure 2-10.

2.8.6 GHG Emissions by categories and sub-categories

2.8.6.1 Fuel Combustion Emissions (1.A)

Fuel combustion in stationary and mobile sources is a major GHG contributor, Figure 2-11. Biomass is widely used in households, while diesel dominates in transport and industrial self-generation.

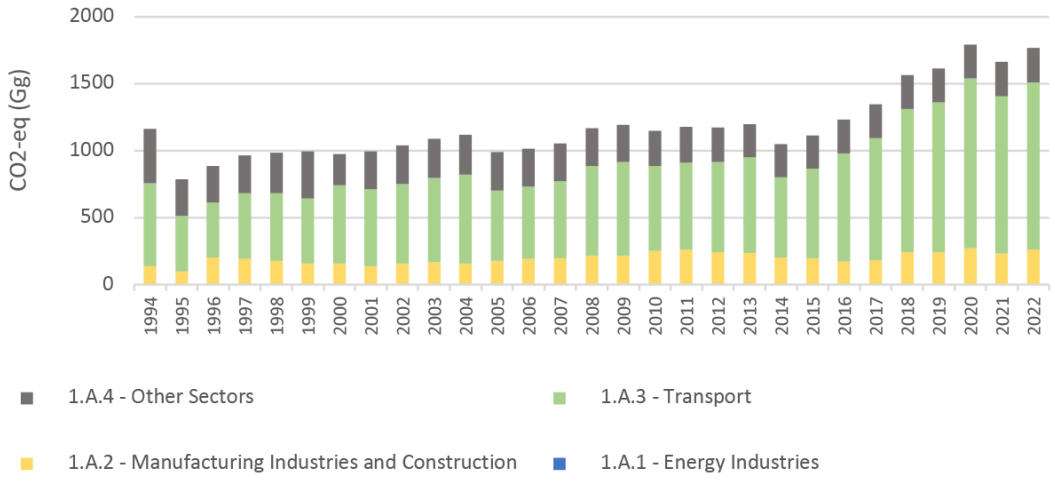


Figure 2-11: Trend of net GHG emissions from different sub-categories

2.8.6.2 Breakdown by Category:

i. 1.A.1 Energy Industries: Hydropower is dominant, but diesel generators used during power shortages add emissions;

ii. 1.A.2 Manufacturing: Cement and sugar sectors rely on coal and biomass;

iii. 1.A.3 Transport: Diesel and petrol drive emissions from a growing vehicle fleet; and

iv. 1.A.4 Residential/Commercial: Biomass use generates CH_4 and N_2O due to inefficient combustion.

2.8.6.3 International Bunker Fuels

Malawi does not currently report bunker fuel emissions due to limited data. As shown in Table 2-13, Jet A-1 fuel imports fell during COVID-19, from 7.87 million litres (2018) to 1.87 million (2020), then recovered to 6.96 million by 2022 (Government of Malawi, 2023).

Table 2-13: Jet A-1 Imports, 2018–2022 (Million Litres)

Year	Jet A-1 Imports (Litres)
2018	7,871,569
2019	5,570,403
2020	1,865,837
2021	5,914,856
2022	6,956,643

The main challenge is distinguishing between domestic and international aviation use. Planned improvements include data disaggregation through airport and fuel supplier collaboration.

2.8.6.4 Feedstocks and Non-Energy Use of Fuels

Small quantities of bitumen, lubricants, and paraffin wax are imported. Due to limited data, emissions are either marked Not Occurring (NO) or Not Estimated (NE). Plans include data system improvements and coordination with stakeholders like the National Roads Authority (NRA).

2.8.6.5 Electricity Generation (1.A.1.a.i)

Malawi's 2022 electricity mix shows that: 71.4% hydro, 16.5% solar, 7.4% diesel. Diesel use peaked in 2019 (746.37 TJ), fell, then rose again in 2022 due to Cyclone Ana's impact on hydropower as shown by the GHG emissions on Figure 2-12.

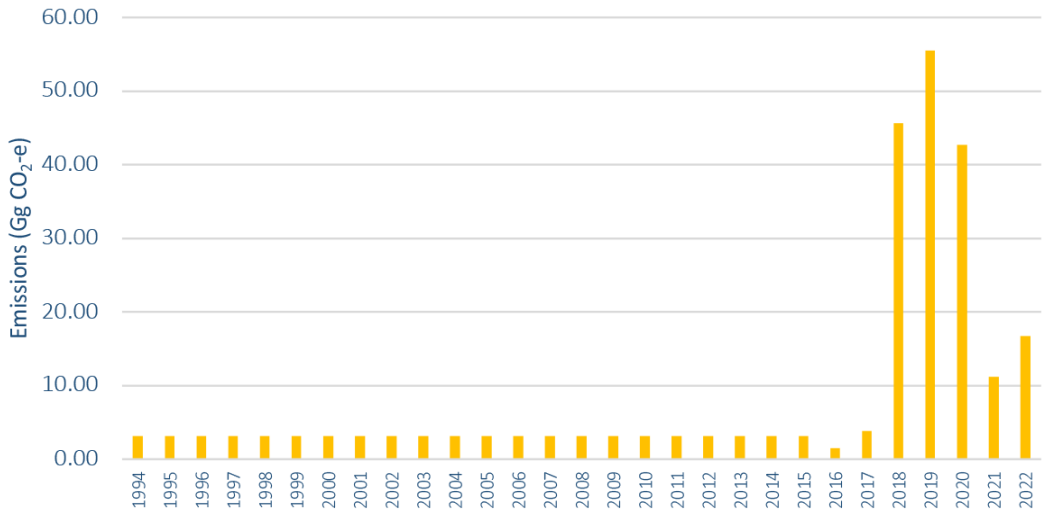


Figure 2-12: Emissions from electricity generation from diesel

Emissions varied accordingly, with 2022 diesel generation emitting 16.71 Gg CO_2. Fluctuations reflect infrastructure vulnerability to extreme climate events.

2.8.6.6 Manufacturing: Food, Beverages, Tobacco (1.A.2.e)

This subcategory contributes significantly to emissions due to high energy use. Emissions rose 1.87% annually (2018–2022), driven by diesel and coal use, Table 2-14 and Figure 2-13. It aligns with a 10.1% GDP contribution in 2022.

Table 2-14: GHG Emissions – Food Processing, Beverages, and Tobacco (1994–2022) by gas type

Years	CO_2	CH_4
1994	132.391	0.009
2000	154.581	0.011
2010	246.519	0.019
2017	176.625	0.012
2018	237.987	0.015
2019	237.942	0.016
2020	267.461	0.017
2021	227.794	0.015
2022	256.200	0.018

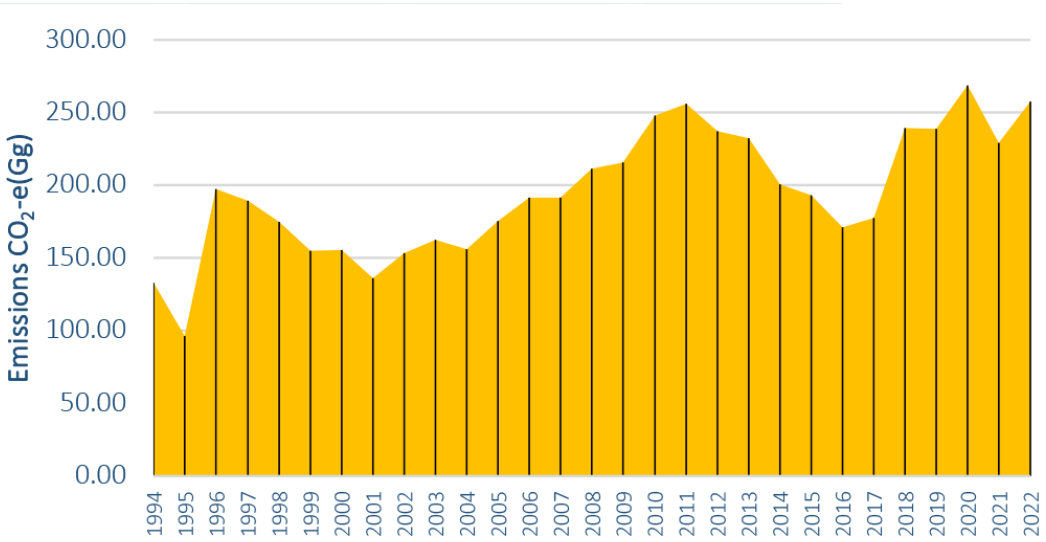


Figure 2-13: GHG Emissions – Food Processing, Beverages, and Tobacco (1994–2022)

2.8.6.7 Transport (Category 1.A.3)

The Transport Sector captures GHG emissions resulting from fuel combustion in various modes of transport, including road, domestic aviation, and domestic water-borne navigation. As per the 2006 IPCC Guidelines, emissions are disaggregated by mode and function, and in Malawi's context, three subcategories are relevant:

i. 1.A.3.a.ii – Domestic Aviation;

ii. 1.A.3.b – Road Transportation; and

iii. 1.A.3.d.ii – Domestic Water-borne Navigation

Among these, **road transportation** remains the most significant contributor to emissions, accounting for over **90% of internal freight and passenger movement** in 2022 (Government of Malawi, 2023).

Fuel combustion in the transport sector is primarily based on **diesel and petrol (gasoline)**, with negligible shares from alternative fuels such as **ethanol** or **biodiesel**, despite existing potential for biofuel production in Malawi. The reliance on **second-hand vehicles**, predominantly imported from Japan and South Africa, further exacerbates emissions due to outdated technologies and lower fuel efficiency.

2.8.7 Transportation emission Trends Summary (1994–2022)

Table 2-15 shows brief a summary of GHG emission trends in the transport sector for selected years.

Table 2-15: GHG emission trends in the transport sector for selected years.

Year	Domestic Aviation (1.A.3.a.ii)	Road Transport (1.A.3.b)	Water Transport (1.A.3.d.ii)
1994	6.86	611.76	1.22
2000	2.30	455.29	0.71
2010	3.77	628.90	0.64
2015	2.80	666.98	0.64
2020	0.00	1,265.67	1.32
2022	2.21	1,243.94	1.13

The results show that:

i. Road Transport (1.A.3.b) demonstrates a steady and significant increase in emissions over the reporting period. From 611.76 Gg in 1994 to 1,243.94 Gg in 2022, road transport nearly doubled its contribution to total transport emissions. This growth mirrors increased fuel consumption, expanding vehicle fleet, and urbanization;

ii. Domestic Aviation (1.A.3.a.ii) exhibits a fluctuating but overall low emissions profile, with noticeable impacts from the COVID-19 pandemic, including zero emissions recorded between 2018–2020. Post-pandemic recovery is visible, but emissions have yet to return to pre-2010 levels; and

iii. Domestic Water-borne Navigation (1.A.3.d.ii) remains the least significant emitter in the transport subcategories, consistently below 2 Gg CO_2e annually, but demonstrates a modest increase post-2015, which may reflect improvements in fleet operations and fuel use tracking.

2.8.7.1 Road Transport (1.A.3.b)

Most emissions in this category. Vehicle registrations doubled since 2010 (Figure 2-14). Petrol and diesel imports rose by ~17% between 2018 and 2022. This is indicated on Table 2-16. All of this corresponds to the rapid rising of emissions by 2.38% between 2018 to 2022 (Figure 2-15).

Table 2-16: Fuel consumption by road transportation

YEAR	Consumption (Mass (Gg))		
	Motor Gasoline	Gas/Diesel Oil	Biogasoline(Ethanol)
1994	122.69	69.64	11.7952956
2000	62.57	79.81	5.27801614
2010	74.56	121.79	7.488
2017	147.04	137.59	11.62886
2018	154.07	179.71	16.22916
2019	182.21	168.66	14.41009
2020	192.07	204.23	11.86985
2021	203.12	164.53	12.19984
2022	215.85	174.4	5.8982585

Figure 2-14: Vehicle population (2008-2022)

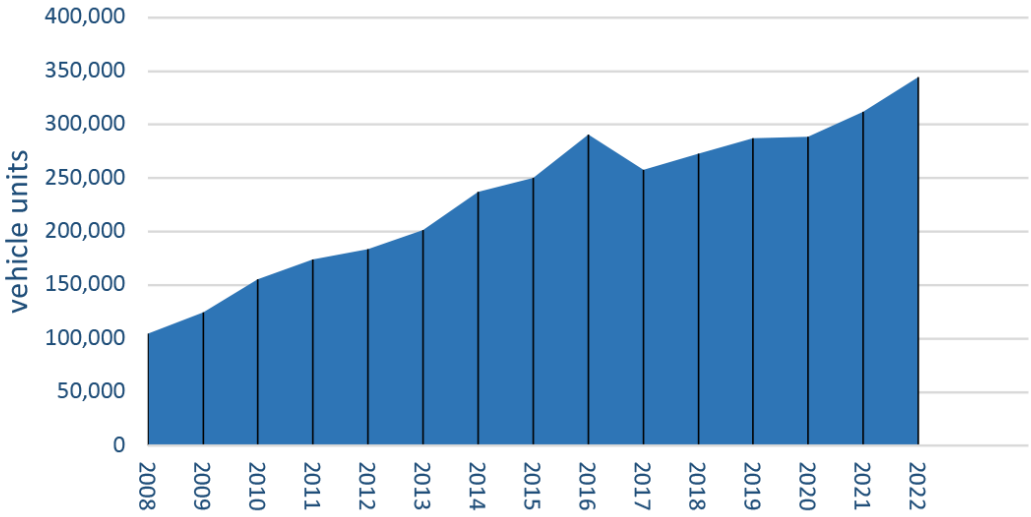
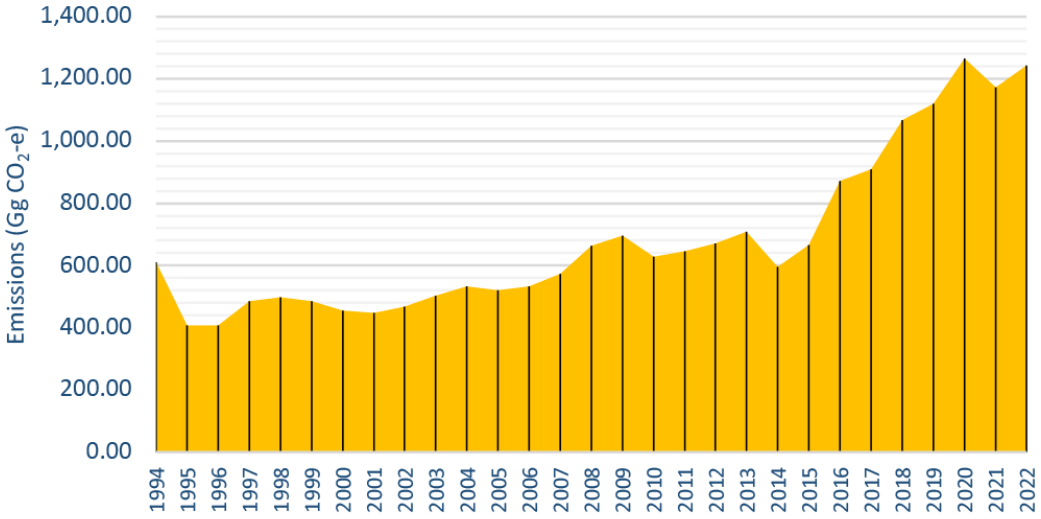


Figure 2-15: Road Transport Emissions Trend (1994–2022)



2.8.7.2 (1.A.3.a.ii)

Emissions dropped to zero in 2020 due to COVID-19, then resumed in 2022. Long-term emissions remain low (Figure 2-16).

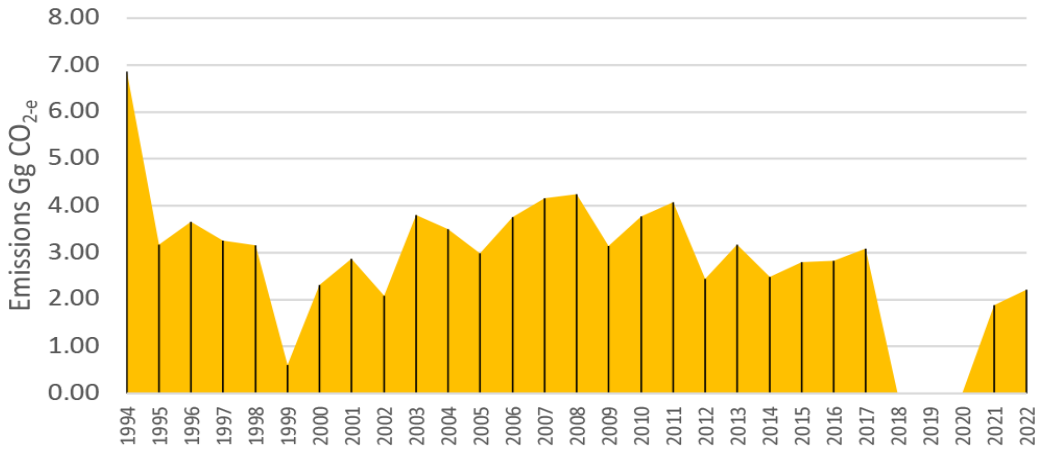


Figure 2-16: Domestic Aviation Emissions Trend (1994–2022)

2.8.7.3 Water-borne Navigation (1.A.3.d.ii)

Low but rising slightly since 2016. as shown by the fuel consumption in Table 217. Emissions stayed under 1.5 Gg CO_2e/year Figure 2-17.

Table 2-17: Diesel consumption by waterborne navigation

YEAR	Consumption (Mass (Gg))
	Gas/Diesel Oil
1994	0.38
2000	0.22
2010	0.2
2017	0.23
2018	0.36
2019	0.33
2020	0.41
2021	0.33
2022	0.35

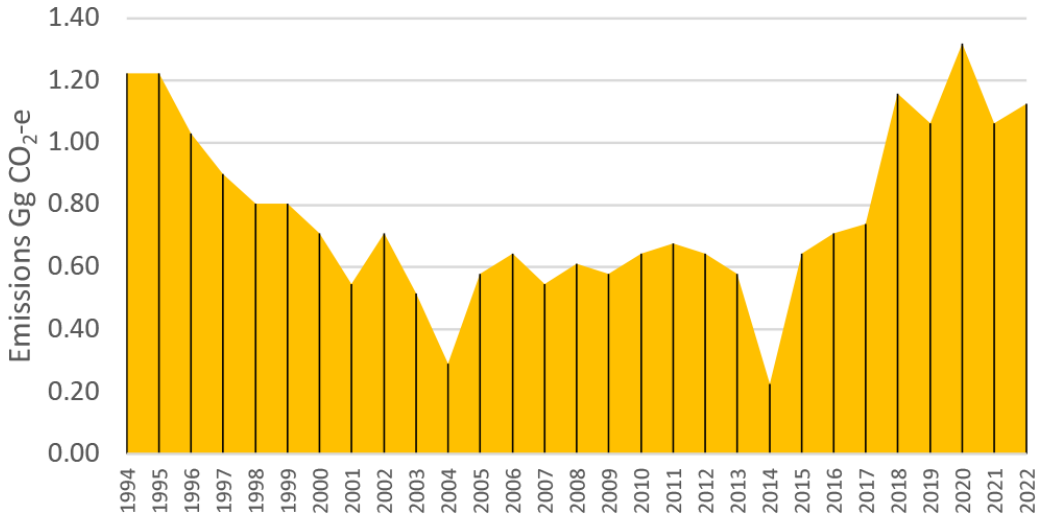


Figure 2-17: Domestic Navigation Emissions (1994–2022)

2.8.7.4 Others (Residential - 1.A.4.b)

Sources include; Liquified Petroleum Gas (LPG), Firewood and Charcoal. Biomass use continues to dominate. Table 2-20 shows residential fuel consumption. While CO2emissions fell by 36% from 1994 to 2022, CH_2 and N_2O remain high due to inefficient stoves and open-fire cooking. The emissions are indicated in CO_2-e on Figure 2-18.

Table 2-18: Residential Fuel consumption

YEAR	Consumption (Mass (Gg))				Consumption (Energy Unit (TJ))
	Other Kerosene	Liquefied Petroleum Gases	Wood/Wood Waste	Other Primary Solid Biomass	Charcoal
1994	28.47	24.8	0.00048	1623.08	10855
2000	0.42	0.452	0.00043	1466.01	11557
2017	0.78	0.884	0.00039	1336.2	17048
2018	0.39	1.308	0.00039	1328.04	17429
2019	0.27	1.032	0.00039	1315.51	17819
2020	0.56	1.109	0.00038	1307.83	18218
2021	0.75	1.528	0.00038	1299.97	18633
2022	0.25	2.258	0.00038	1299.97	18633

Source: FAOSTAT(2024)

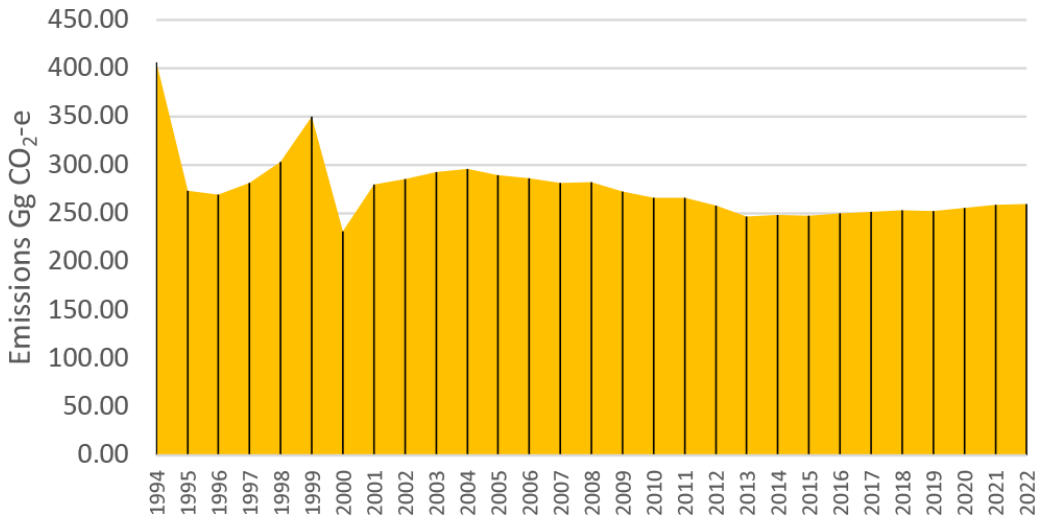


Figure 2-18: Emissions from Residential sources

2.8.7.5 Fugitive Emissions from Solid Fuels (1.B.1.a)

This category covers fugitive methane (CH_4) emissions from solid fuel production in Malawi, specifically coal mining and handling. In accordance with the 2006 IPCC Guidelines (Volume 2, Chapter 4), fugitive emissions are unintentional releases of CH_4during the mining process and post-mining operations.

2.8.7.6 Coal mining and handling (1.B.1.a)

Coal remains Malawi's only significant solid fossil fuel, and there is no oil or natural gas production in the country. Coal mining in Malawi is concentrated in Karonga and Rumphi districts in the Northern Region. The main active mines are Mchenga, Kaziwiziwi, Kasikizi, and Chombe, which primarily produce sub-bituminous coal (Table 2-19 and Figure 2-19) used in tobacco curing, cement manufacturing, food processing and beverage processing industry.

Table 2-19: Amount of Coal Produced (tonne) from Underground Coal Mining

YEAR	Amount of Coal Produced (tonne)
	Sub-Bituminous Coal
1994	34630
2000	44900
2017	45230
2018	49753
2019	54728
2020	54875.8
2021	51000
2022	62166

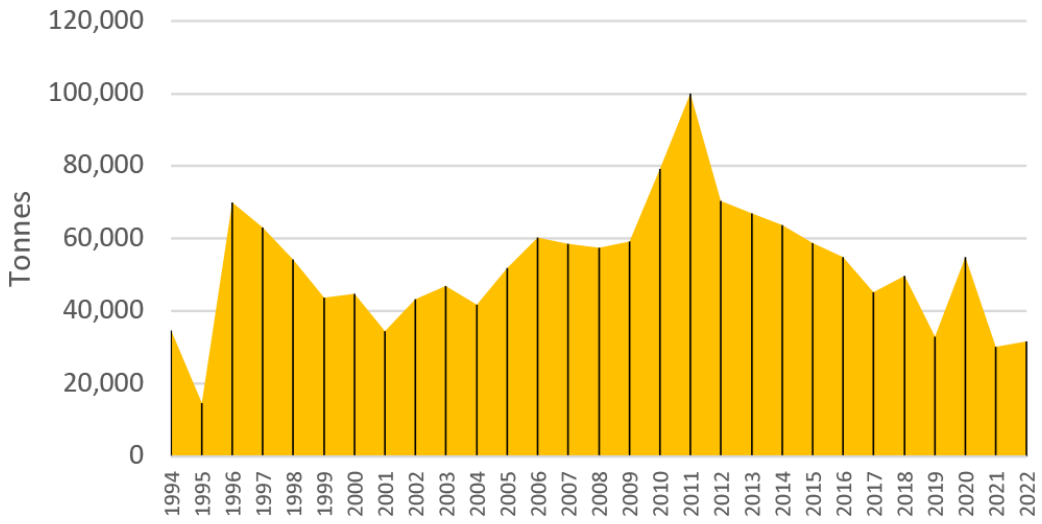


Figure 2-19: Coal Available for Production

2.8.7.7 Estimated Fugitive CH_4 Emissions (1994–2022)

As shown in Figure 2-20, fugitive CH_4 emissions display significant inter-annual variability. However, the long-term trend from 1994–2022 suggests a **gradual increase**, particularly in the post-2010 period where industrial use of coal has expanded due to increased energy demands.

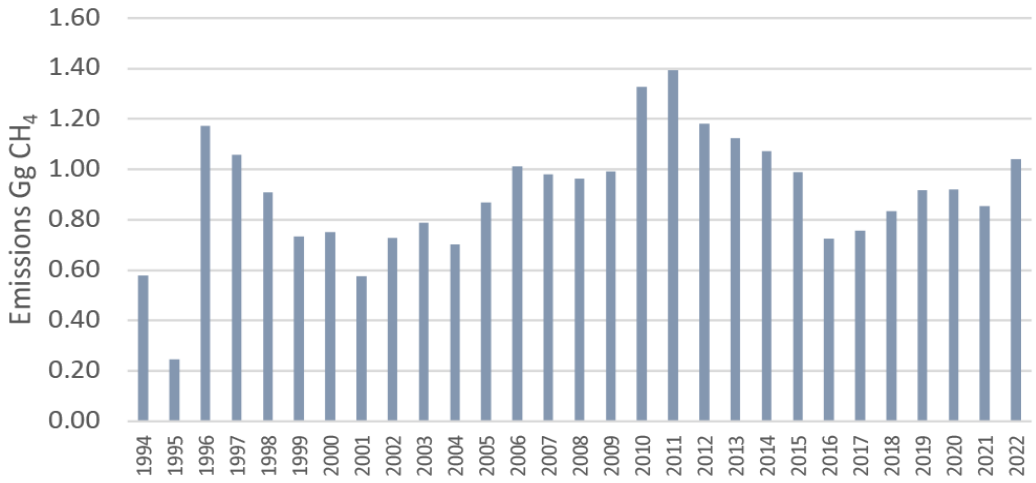


Figure 2-20: Estimated Fugitive CH_4 Emissions (1994–2022)

2.8.8 Carbon Dioxide Transport and Storage (1.C)

Since Malawi has no reported CCS infrastructure, this category is reported as Not Occurring (NO) for 1994–2022.

2.9 Industrial Process and Product Use

2.9.1 Overview of the sector and background information

The Industrial Processes and Product Use (IPPU) sector in Malawi accounts for greenhouse gas (GHG) emissions from chemical and physical industrial processes, excluding fuel combustion. Key subsectors include:

i. Cement and Lime Production (2A) – CO_2 from carbonate decomposition;

ii. Ceramics Manufacturing (2A4) – CO_2 from high-temperature processing; and

iii. Paints and Coatings (2B10) – Emissions include volatile organic compounds (VOCs) and GHGs.

Between 2018 and 2022, the manufacturing sector contributed between 11.8% to 12.2% to Malawi's GDP while the mining sector, which includes cement and lime production, contributed between 0.7% and 0.8% to the GDP (Government of Malawi, 2023). Malawi has abundant limestone deposits (Malunga, 2020). Considering the fact that Malawi is a net cement importer, the sector has potential for rapidly increase local clinker production.

2.9.2 Cement Production (Category 2A1)

Cement production is a major GHG source due to calcination of limestone in clinker production. The main plant which started operation at changalume in Zomba in the 1960's closed its clinker plant in 2003. Currently, Cement is being produced from two main plants in the country which are situated in Kasungu and Mangochi that produces high-quality clinker aligned with IPCC (2006) CaO content guidelines (60–65%). However, emissions are estimated using the Tier 1 method, due to lack of published local emission factor. The emission factor value used is 0.52 tCO_2/tonne clinker, with a clinker fraction of 0.75 in cement (IPCC, 2006). The combined activity data for the two plants is shown in Table 2-20.

Table 2-20: Volume of cement produced (tonnes)

YEAR	Volume of Cement Produced (tonne)
1994	119500
2000	111800
2010	241100
2017	163100
2018	202351.52
2019	294366.59
2020	347977.69
2021	382706.55
2022	361247.37

2.9.2.1 Emissions Trends (1994–2022)

Process-based carbon dioxide emissions from cement production have fluctuated significantly over the years, primarily influenced by economic conditions, changes in production capacity, and shifts in clinker sourcing strategies. The emission estimates are indicated in Figure 2-21.

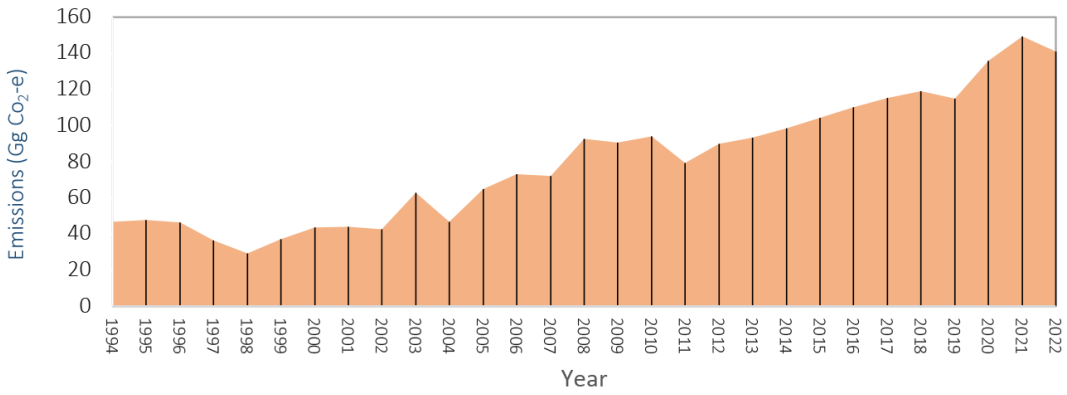


Figure 2-21:GHG Emissions from cement production

Some notable trends and milestones include:

i. **Sharp decline in emission in 1996:**

This drop was largely due to a reduction in domestic cement production, which coincided with a period of economic slowdown and reduced infrastructure investment in Malawi. The decrease in production meant less clinker was produced locally, resulting in lower process emissions. In 1997, the Kasungu cement plant started its operations with a shaft kiln producing about 80 tonnes per day;

ii. **Gradual increase to 3.64 Gg CO2by 2000:**

Economic recovery and growth in construction activities during this period led to a rebound in cement demand. Local production resumed at higher capacities, particularly at major facilities such as Changalume, contributing to the rise in process-related CO_2 emissions; and

iii. **Impact of the closure of Changalume cement plant in 2003:**

The shutdown of this key clinker production facility marked a significant turning point. Malawi began to **import more clinker** to meet domestic cement demand. Although the Kasungu plant continued to upgrade its production, local production of cement was met by shifting million operations using imported clinker from neighbouring countries. As a result, post-2003 emissions from the cement production category primarily reflected the small amounts of clinker still produced locally. The shift to clinker imports helped stabilize emissions at lower levels despite continued growth in cement consumption.

2.9.2.2 Methodological Flexibility

Due to a lack of detailed data, no differentiation by cement type was made; default factors were used for consistency. Major sources of uncertainty include:

i. Chemical composition of clinker;

ii. Production data reliability;

iii. Trade data on clinker imports; and

iv. Interpolation and extrapolation were used to fill in data gaps.

2.9.3 Lime Production

Lime production in Malawi falls under the IPPU sector and involves the calcination of limestone ($CaCO_3$) to produce quicklime (CaO), releasing CO_2 in the process. Lime is mainly used in construction, agriculture, and water treatment. Process-based emissions are influenced by limestone composition (calcium carbonate content) and process efficiency which could impact calcination level. Due to lack of published local emission factor, the Tier 1 method from the IPCC 2006 guidelines was used. National lime production is largely informal and artisanal; therefore, secondary data and proxy estimates were relied upon. A default emission factor of 0.75 tonnes of CO_2 per tonne of lime was applied based on IPCC guidelines (IPCC, 2006). The activity data for lime production for the period from 1994 to 2022 is shown on Table 2-21.

Table 2-21: Production data from the lime industry

YEAR	Mass of Lime Produced (tonne)	Net CO2 (Gg)
1994	3544	2.09
2000	6177	3.64
2010	45851	15.21
2017	43650	25.75
2018	48461	28.59
2019	52817	31.16
2020	74075.71	43.70
2021	77186.26	45.54
2022	80296.82	47.38

Figure 2-22 shows the emissions from lime production for the period from 1994 to 2022.

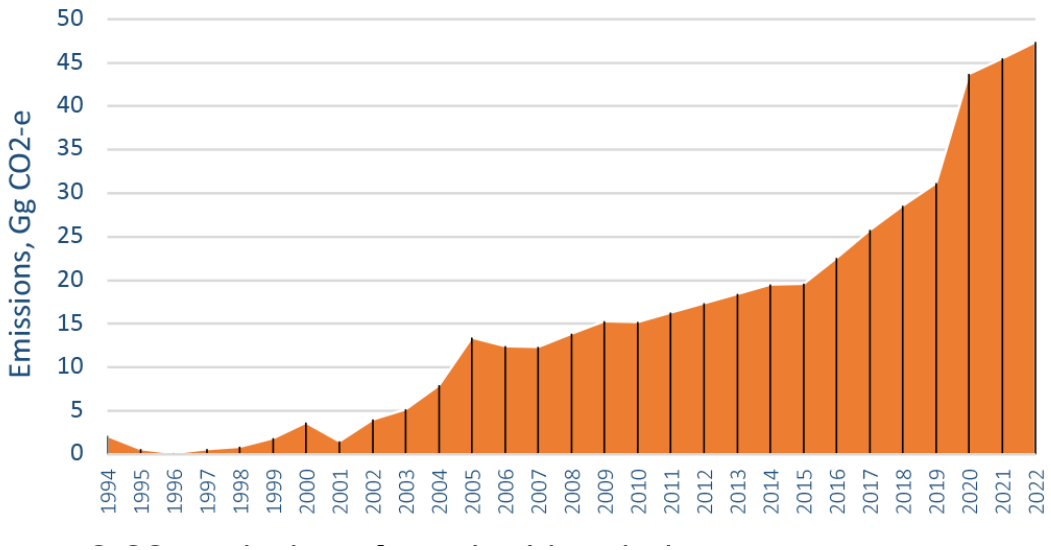


Figure 2-22: emissions from the Lime industry

There is no carbon capture technology in Malawi's lime industry. The sector's emissions from 1994 to 2022 show a general upward trend—from 2.09 Gg CO_2 in 1994 to 47.38 Gg CO_2 in 2022, reflecting growth in lime demand and production capacity. The lime production is operated by artisanal miners using basic tools and traditional kilns.

In order to address data gaps and ensure consistency:

i. Proxy data and historical trends were used where needed;

ii. QA/QC processes involved stakeholder engagement, review of national standards, and consistency checks across the time series; and

iii. Despite variability in how lime plants report data, national standards (e.g., MBS MS 29:2001) guided quality assurance.

2.9.4 Chemical Industry (Category 2B)

In the current inventory cycle, **Category 2B was excluded** because Malawi does not have significant or reported industrial chemical production activities, such as **ammonia or nitric acid manufacturing**, that result in process-related emissions. Furthermore, there is **no verified data** to support emissions estimation for this sector. Future inventories may revisit this category if Malawi's chemical industry develops or new data become available.

2.9.5 Other Process Uses of Carbonates (Category 2A4 – Non-Metallic Mineral Products)

Other process use of carbonates includes GHG emissions from the manufacturing of ceramics, glass, gypsum, and other mineral-based products. Emissions mainly result from chemical reactions like carbonate decomposition and high-temperature processing, particularly in the production of clay bricks, tiles, and gypsum products, which release CO_2 (IPCC, 2006).

For this cycle, these emissions were not estimated due to a lack of reliable data on industrial production of ceramics, glass, and gypsum in Malawi. No formal sources or industry-level data were found to support the inclusion of this category in national GHG estimates. However, with growing industrial activity in the country, future inventory cycles may investigate this sector further, improve data collection methods, and determine the relevance of including emissions from non-metallic mineral products in the national GHG profile.

2.10 Agriculture

2.10.1 Overview of the sector and background information

The Malawi livestock subsector contributes 11% of GDP and about 36% of agriculture GDP (Government of Malawi, 2021b). Crop and livestock production play pivotal roles in Malawi as source of income, food and nutrition security, create employment along value chains and resilience buffering effect from rampant climatic shocks that Malawi has been exposed to in recent years. The main livestock species reared are cattle, goats, sheep, pigs, poultry and other non-conventional species like guinea fowls, ducks, rabbits and pigeons. Figure 2-23 shows the population composition of the livestock types.

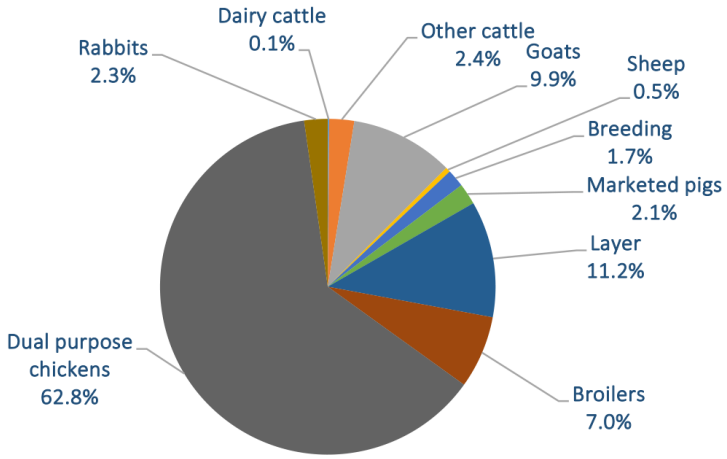


Figure 2-23: Livestock types and composition

Most of these livestock are indigenous and owned by smallholder farmers applying extensive management practices.

Extreme climatic parameters in form of rainfall and temperature as well as the onset and cessation of rains have major impacts of growth of the plant and yields. Malawi's crop production is largely rain-fed and involves use of chemical fertilisers to improve crop yields. To avert the impacts of climate change on smallholder farmers, the Ministry of Agriculture and other stakeholders have been promoting climate smart agricultural practices (Government of Malawi, 2024).

2.10.2 Source category description

Table 2-22 shows summary descriptions of the sources of enteric methane from the livestock sector.

Table 2-22: Sources of enteric CH_4 emission from livestock sector

Emissions sources	Sources included	Method	Emission factors
3.A.1.a.i	Dairy cattle enteric fermentation	Tier 1	IPCC (2006) Table 10.11
3.A.1.a.ii	Other cattle enteric fermentation	Tier 1	IPCC (2006) Table 10.11
3.A.1.C	Sheep enteric fermentation	Tier 1	IPCC (2006) Table 10.10
3.A.1.D	Goat enteric fermentation	Tier 1	IPCC (2006) Table 10.10
3.A.1.H.i	Breeding pigs enteric fermentation	Tier 1	IPCC (2006) Table 10.10
3.A.1.H.ii	Marketed pigs enteric fermentation	Tier 1	IPCC (2006) Table 10.10
3.A.1.J	Rabbits enteric fermentation	Tier 1	IPCC (2006) Table 10.10
Gases reported	CH_4		
Completeness	All major livestock types (except poultry) are covered. Donkeys and horses were not included because they are not considered major livestock (because of their low numbers) and are not widely distributed in the country. They may be included in future revisions.		
Improvements since last submission	This is the first inventory for that includes rabbits in response to a 2019 QA review finding		

Table 2-23 shows the emission factors for enteric fermentation for cattle, sheep, goats and rabbits.

Table 2-23: Enteric fermentation emission factors (kg CH_4 head-1 year-1)

Species	Emission factors	Reference
Dairy cattle	46	IPCC 2006 Table 10.11
Other cattle	31	IPCC 2006 Table 10.11
Sheep	5	IPCC 2006 Table 10.10
Goat	5	IPCC 2006 Table 10.10
Breeding pigs	1	IPCC 2006 Table 10.10
Marketed pigs	1	IPCC 2006 Table 10.10
Rabbits*	0.92	Estimated based on approximate emission factors (p.32, IPCC 2019).

*The approach for developing the approximate emission factors for rabbits was to use the Tier 1 emissions factor for an animal with a similar digestive system (horse) and to scale the emissions factor using the ratio of the weights of the animals raised to the 0.75 power.

The IPCC Tier 1 Method was applied for dairy and other cattle, sheep, goats, pigs and rabbits

**Approximate emissions factor = [(Rabbit weight, 4.5 kg)] / (Horse weight, 235 kg)]0.75 **

Horse IPCC emission factor (18 kg CH4/head/year)

2.10.3 Activity data: Livestock population

The activity data for emissions from livestock were for the major livestock types: cattle (dairy and other), sheep, goats, pigs and rabbits. The same activity data have been used for manure management and managed soils. The table below shows the activity data for livestock emissions.

Table 2-24: Activity for livestock emissions

Years	Dairy Cattle	Other Cattle	Sheep	Goats	Mature Swine	Growing Swine
1994	26,407	767,693	81,286	1,534,104	123,921	149,618
2000	37,243	773,231	131,140	1,767,000	131,626	158,922
2010	55,303	1,027,397	214,230	3,893,922	873,881	1,055,097
2017	90,355	1,449,552	302,090	7,672,737	2,700,501	3,260,501
2018	98,144	1,590,730	317,491	8,374,006	3,102,541	3,745,912
2019	105,637	1,620,610	331,272	9,147,837	2,133,024	2,575,346
2020	113,885	1,711,058	351,458	10,028,678	2,431,095	2,935,228
2021	125,943	1,790,018	373,715	11,104,382	2,700,501	3,260,501
2022	137,885	2,054,208	404,956	12,238,382	3,102,541	3,745,912

Table 2-25 and Figure 2-24 show the population trends of poultry and rabbits in Malawi for the period 1994 to 2022.

Table 2-25: Poultry and rabbits population trend 1994 to 2022

Years	Broiler chickens	Layer chickens	Dual purpose chickens	Rabbits
1994	4,165,277	816,030	7,833,183	36,938
2000	3,828,821	2,550,930	8,294,935	124,406
2010	3,268,061	5,442,430	21,168,556	894,025
2017	4,628,592	6,737,380	53,076,214	1,735,875
2018	6,496,873	7,443,847	60,676,441	2,285,239
2019	9,124,592	8,132,924	69,107,661	2,577,733
2020	10,392,520	8,804,436	77,690,553	3,096,033
2021	13,850,596	9,803,012	86,170,934	3,458,230
2022	14,039,674	11,088,264	96,956,612	3,861,884

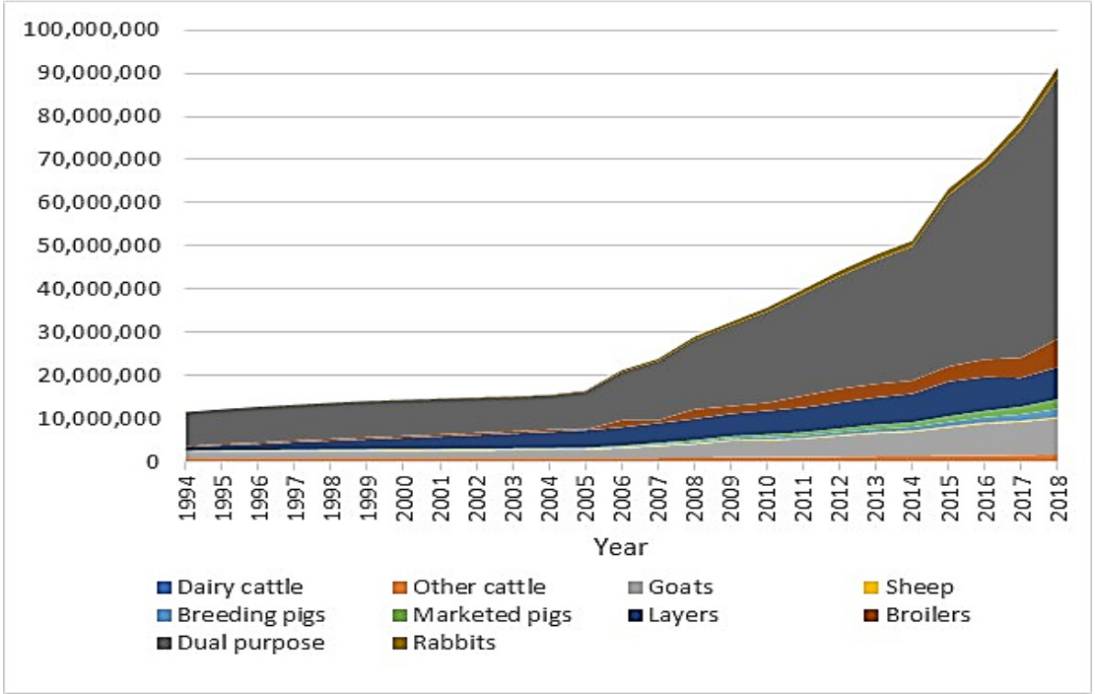


Figure 2-24: Livestock population trends 1994 to 2022

Malawi saw rappid increase in poultry population from around 2005. The rapid increase was attributed to government initiates which promoted livestock production as well as emergent of commercial poultry farming for egg and meat production.

2.10.4 Enteric fermentation emissions

The GHG emission values are given in Table 2-26 and Figure 2-25.

Table 2-26: CH_4 emissions from Enteric fermentation

Years	Dairy Cattle	Other Cattle	Sheep	Goats	Mature Swine	Growing Swine	Rabbits
1994	1.21	23.80	0.41	7.67	0.12	0.15	0.03
2000	1.71	23.97	0.66	8.84	0.13	0.16	0.11
2010	2.54	31.85	1.07	19.47	0.87	1.06	0.82
2017	4.16	44.94	1.51	38.36	2.70	3.26	1.60
2018	4.51	49.31	1.59	41.87	1.84	5.01	2.10
2019	4.86	50.24	1.66	45.74	1.47	3.24	2.37
2020	5.24	53.04	1.76	50.14	1.61	3.76	2.85
2021	5.79	55.49	1.87	55.52	1.74	4.22	3.18
2022	6.34	63.68	2.02	61.19	2.07	4.77	3.55

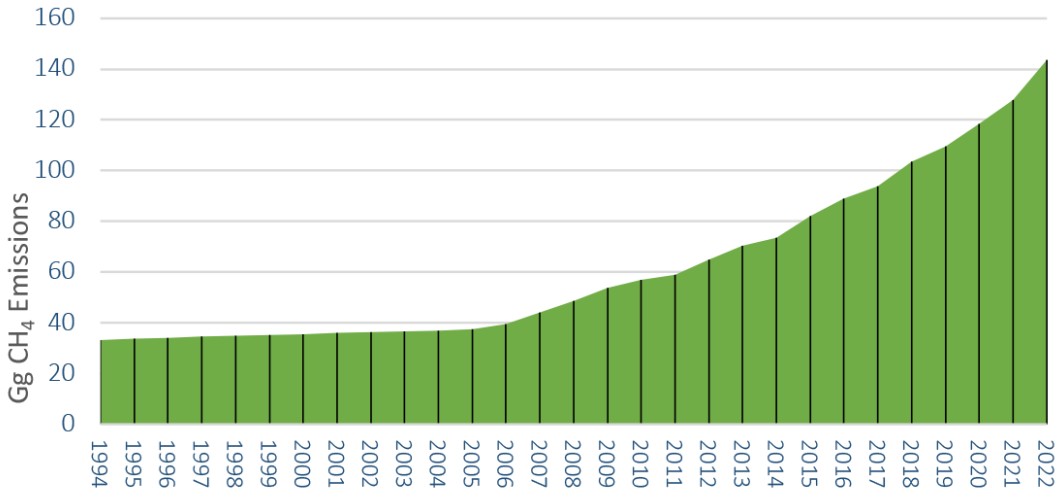


Figure 2-25: CH_4 emissions from Enteric fermentation

The 1994 and 2022 enteric fermentation emissions were 31.8 and 144 Gg, respectively, representing a 351 percent increase. The large increase in emissions is attributed to the increased number of livestock due to increased livestock ownership and adoption of recommended livestock husbandry practices. The key source categories were other cattle and goats, which together contributed between 96 percent and 87 percent of all enteric methane emissions in 1994 and 2022, respectively. The contribution of other cattle has been going down, while that of goats has been going up in the last decade. Pigs and rabbits showed the most increase in emissions between 1994 and 2022, due to the high increase in their numbers.

2.10.5 Emissions from manure management (Category 3.A2)

This section describes the estimation of CH_4 and direct N_2O emissions from animal manure management systems.

2.10.5.1 Source category description

The sources of CH_4 emission from livestock sector is shown in Table 2-27.

Table 2-27: Sources of CH_4 emission from livestock sector

Emissions sources	Sources included	Method	Emission factors
3.A.2.a.i	Dairy cattle manure management	Tier 1	IPCC (2006) Table 10.14
3.A.2.a.ii	Other cattle manure management	Tier 1	IPCC (2006) Table 10.14
3.A.2.c	Sheep manure management	Tier 1	IPCC (2006) Table 10.15
3.A.2.d	Goat manure management	Tier 1	IPCC (2006) Table 10.15
3.A.2.h.i	Breeding pigs manure management	Tier 1	IPCC (2006) Table 10.14
3.A.2.h.ii	Marketed pigs manure management	Tier 1	IPCC (2006) Table 10.14
3.A.2.i.i	Layers	Tier 1	IPCC (2006) Table 10.15
3.A.2.i.ii	Broilers	Tier 1	IPCC (2006) Table 10.15
3.A.2.i.iii	Dual purpose chickens	Tier 1	IPCC (2006) Table 10.15
3.A.2.j	Rabbits manure management	Tier 1	IPCC (2006) Table 10.16
Gases reported	CH_4, N_2O		
Completeness	All major livestock species covered		
Improvements since last submission	This is the first inventory for sheep, goat, pigs, rabbits that uses a Tier 1 approach to estimate direct N_2O emissions. Indirect N_2O from manure management is reported separately according to the IPCC 2006 Guidelines.		

2.10.5.2 Emission factors

The summary of emission factors applied in the livestock manure management are shown in Table 2-28.

Table 2-28: Methane emission factors from manure management (kg CH_4/head/year)

Species	Emission factors*	Reference
Dairy cattle	1	IPCC 2006 Table 10.14
Other cattle	1	IPCC 2006 Table 10.14
Sheep	0.2	IPCC 2006 Table 10.15
Goat	0.22	IPCC 2006 Table 10.15
Breeding pigs	1	IPCC 2006 Table 10A-8
Marketed pigs	1	IPCC 2006 Table 10A-7
Layer	0.02	IPCC 2006 Table 10.15
Broiler	0.02	IPCC 2006 Table 10.15
Dual Purpose chickens	0.02	IPCC 2006 Table 10.15
Rabbits	0.08	IPCC 2006 Table 10.16

*These emission factors are for developing countries in the tropical, warm and dry climates.

Table 2-29: Trends in methane emissions from ruminants

	Dairy cattle	Other cattle	Goats	Sheep	Breeding pigs	Market pigs
	Gg CH_4 $year^{-1}$	Gg CH_4 $year^{-1}$	Gg CH_4 $year^{-1}$	Gg CH_4 $year^{-1}$	Gg CH_4 $year^{-1}$	Gg CH_4 $year^{-1}$
1994	0.026	0.768	0.338	0.016	0.073	0.088
2000	0.037	0.773	0.389	0.026	0.136	0.164
2010	0.055	1.027	0.857	0.043	0.540	0.652
2017	0.090	1.450	1.688	0.060	1.465	1.769
2018	0.098	1.591	1.842	0.063	1.853	2.237
2019	0.106	1.621	2.013	0.066	2.133	2.575
2020	0.114	1.711	2.206	0.070	2.431	2.935
2021	0.126	1.790	2.443	0.075	2.701	3.261
2022	0.138	2.054	2.692	0.081	3.103	3.746

Table 2-30: Trends in methane emissions from poultry and rabbits

	Layers	Broilers	Dual-purpose poultry	Rabbits
	Gg CH_4 $year^{-1}$	Gg CH_4 $year^{-1}$	Gg CH_4 $year^{-1}$	Gg CH_4 $year^{-1}$
1994	0.016	0.006	0.157	0.003
2000	0.051	0.009	0.166	0.010
2010	0.109	0.036	0.423	0.072
2017	0.135	0.093	1.062	0.139
2018	0.149	0.130	1.214	0.183
2019	0.163	0.182	1.382	0.206
2020	0.176	0.208	1.554	0.248
2021	0.196	0.277	1.723	0.277
2022	0.222	0.281	1.939	0.309

Figure 2-26 shows methane emissions from manure management for the period 1994 to 2022.

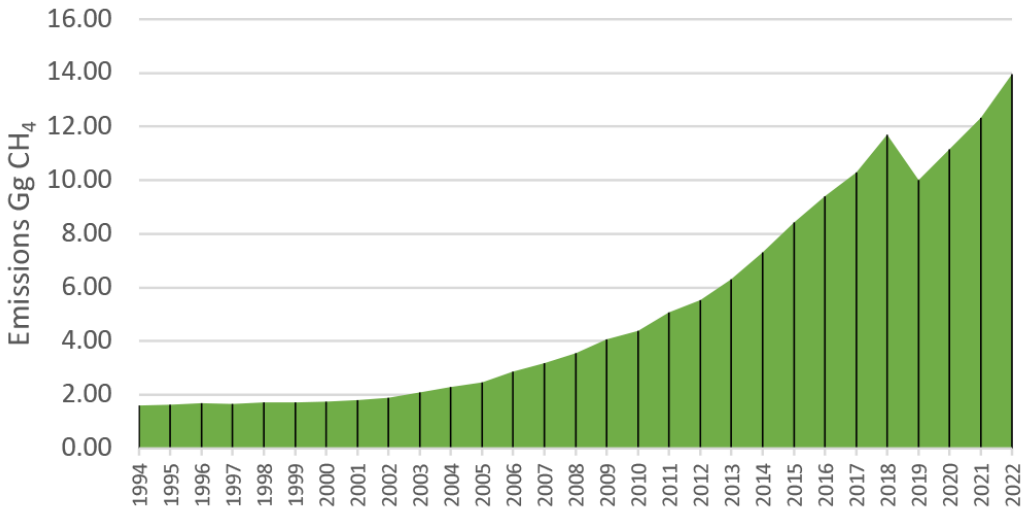


Figure 2-26: Methane emissions from manure management (Gg CH4 /year)

Methane emissions from manure in other cattle were nearly 50 percent of the total methane emission from the manure management systems in the 94 's and early 2000's, but their proportion of the total has been declining ever since to about 12 percent in 2022. Methane emissions from manure in goats have remained roughly close to 20 percent, with a noticeable dip to 16 percent after 2017. Methane emissions from manure management in pigs and poultry (broiler and dual-purpose) have been going up steadily in the last decade. As of 2022, the most significant sources of methane from manure management were pigs (41%) and poultry (28%).

2.10.6 Direct N_2O emissions from manure management

This section covers the nitrous oxide released during the storage and treatment of manure before it is applied to the land or used elsewhere.

2.10.6.1 Emission factors

Table 2-31 shows the emission factors for estimating direct N_2O emissions from manure management.

Table 2-31: Emission factors for estimating direct N_2O emissions from manure management.

Manure management system	EF_3 [kg N_2O-N (kg Nitrogen excreted)$^{-1}$]	Source
Uncovered anaerobic lagoon	0	IPCC 2019 Table 10.21
Liquid/slurry	0	IPCC 2019 Table 10.21
Pit Storage	0.002	IPCC 2019 Table 10.21
Dry lot	0.02	IPCC 2019 Table 10.21
Solid storage	0.005	IPCC 2019 Table 10.21
Daily spread	0	IPCC 2019 Table 10.21
Burned as fuel/waste	unavailable	The emissions associated with the burning of the dung are to be reported under the IPCC category 'Fuel Combustion' if the dung is used as fuel.
Anaerobic digester	0	IPCC 2019 Table 10.21
Pasture/range/paddock	NO*	Direct and indirect N2O emissions associated with the manure deposited on agricultural soils and pasture, range, paddock systems are covered in the category 3.C.6 and 3.C.4
Poultry manure with litter	0.001	IPCC 2019 Table 10.21
Poultry manure without litter	0.001	IPCC 2019 Table 10.21

*NO indicates not occurring in this GHG emission source.

Table 2-32: Trends in N_2O emissions from ruminants

Year	Dairy cattle	Other cattle	Goats	Sheep	Breeding pigs	Market pigs
	Gg N_2O/year	Gg N_2O/year	Gg N_2O/year	Gg N_2O/year	Gg N_2O/ year	Gg N_2O/ year
1994	0.015	0.290	0.218	0.009	0.007	0.023
2000	0.021	0.292	0.252	0.015	0.007	0.024
2010	0.032	0.388	0.555	0.024	0.047	0.161
2017	0.052	0.547	1.093	0.034	0.144	0.497
2018	0.061	0.649	1.289	0.039	0.106	0.825
2019	0.060	0.612	1.303	0.038	0.079	0.493
2020	0.067	0.668	1.477	0.041	0.089	0.592
2021	0.069	0.650	1.521	0.041	0.089	0.619
2022	0.080	0.791	1.776	0.047	0.113	0.741

	Layers	Broilers	Dual-purpose poultry	Rabbits
	Gg N_2O/year	Gg N_2O/year	Gg N_2O/year	Gg N_2O/year
1994	0.0006	0.0049	0.0055	0.0047
2000	0.0018	0.0045	0.0058	0.0157
2010	0.0038	0.0039	0.0148	0.1129
2017	0.0047	0.0055	0.0371	0.2193
2018	0.0052	0.0077	0.0424	0.3119
2019	0.0057	0.0108	0.0483	0.3256
2020	0.0061	0.0123	0.0543	0.4045
2021	0.0068	0.0164	0.0602	0.4200
2022	0.0077	0.0167	0.0677	0.4971

Figure 2-27 shows the N_2O emissions from manure management.

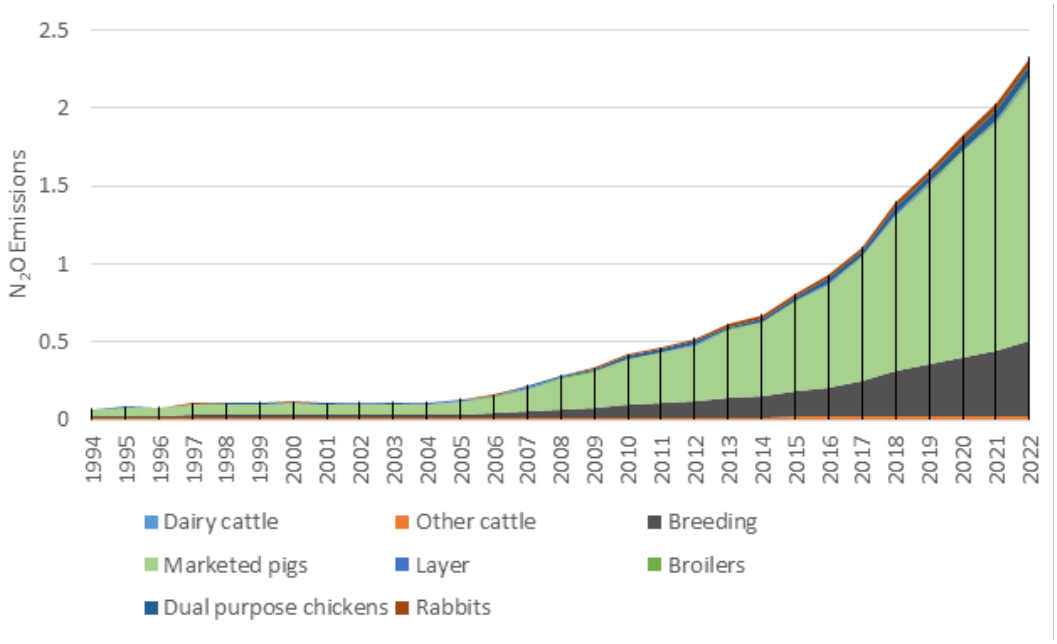


Figure 2-27: Direct N2O emissions from manure management, Gg N2O, 1994 - 2022

In 1994 and 2022, total direct N_2O emissions from manure management increased from approximately 0.05 Gg to about 2.55 Gg respectively. The largest contributor to this rise was broiler chickens (poultry), whose emissions grew significantly, especially after 2010, and accounted for most of the total emissions by 2022. Breeding pigs were the second-largest contributors, showing steady growth over the same period. In contrast, emissions from other livestock types such as dairy cattle, other cattle, layers, marketed pigs, dual-purpose chickens, and rabbits remained relatively low and stable, each contributing only a small fraction of total emissions. The sharpest acceleration in emissions occurred after 2006, with rapid growth continuing through to 2022.

2.10.7 Indirect emissions of nitrous oxide from manure management (Category 3.C.6)

This category reports indirect emissions of N_2O from management of manure from different livestock species.

2.10.7.1 Source category description

The descriptions of sources of indirect N2O emissions from manure in the livestock sector are given in Table 2-33.

Table 2-33: Sources of indirect N2O emissions from manure in the livestock sector

Emissions sources	Sources included	Method	Emission factors
3.C.6.a.i	Dairy cattle manure management	Tier 1	IPCC (2006)
3.C.6.a.ii	Other cattle manure management	Tier 1	IPCC (2006)
3.C.6.c	Sheep		
3.C.6.d	Goats		
3.C.6.h.i	Breeding pigs manure management	Tier 1	IPCC (2006)
3.C.6.h.ii	Marketed pigs manure management	Tier 1	IPCC (2006)
3.C.6.i.i	Layers	Tier 1	IPCC (2006)
3.C.6.i.ii	Broilers	Tier 1	IPCC (2006)
3.C.6.i.iii	Dual purpose chickens	Tier 1	IPCC (2006)
3.C.6.j	Rabbits manure management	Tier 1	IPCC (2006)
Gases reported	N_2O		
Completeness	All major livestock species covered.		
Improvements since last submission	This is the first inventory for pigs, rabbits that uses a Tier 1 approach.		

2.10.8 Indirect N_2O emissions

Emissions trends for indirect N_2O emissions are given in Table 2-34 .

Table 2-34: Emissions trends for indirect N_2O emissions from ruminants

	Dairy cattle	Other cattle	Goats	Sheep	Breeding pigs
	Indirect N_2O	Indirect N_2O	Indirect N_2O	Indirect N_2O	Indirect N_2O
	Gg N_2O/year	Gg N_2O/year	Gg N_2O/year	Gg N_2O/year	Gg N_2O/year
1994	0.005961519	0.095289985	0.013701232	0.000578659	0.002621554
2000	0.008407803	0.09597739	0.015781249	0.00093356	0.00278456
2010	0.012484943	0.127525775	0.034776995	0.001525061	0.018486985
2017	0.020398116	0.179925814	0.068525959	0.002150519	0.057129197
2018	0.021814184	0.183257731	0.061590991	0.001861304	0.035654163
2019	0.023848108	0.201158409	0.081700221	0.00235826	0.031162365
2020	0.025491498	0.214081426	0.088351254	0.002467996	0.033291565
2021	0.028544675	0.223001471	0.103213087	0.002768745	0.03745871
2022	0.03102014	0.259216535	0.110785918	0.002921934	0.043542715

Table 2-35: Emissions trends for indirect N_2O emissions from poultry and rabbits

	Market pigs	Layers	Broilers	Dual-purpose poultry	Rabbits
	Indirect N_2O	Indirect N_2O	Indirect N_2O	Indirect N_2O	Indirect N_2O
	Gg N_2O/year	Gg N_2O/ year	Gg N_2O/year	Gg N_2O/year	Gg N_2O/year
1994	0.009035159	0.002617	0.022694027	0.025117	0.000293
2000	0.009596958	0.008179	0.020860887	0.026597	0.000985
2010	0.063715198	0.017451	0.017805652	0.067876	0.007081
2017	0.196895174	0.021603	0.025218347	0.170187	0.013749
2018	0.277178358	0.023868	0.035397456	0.194557	0.014906
2019	0.195374703	0.026078	0.04971428	0.221591	0.020417
2020	0.221741999	0.028231	0.056622438	0.249112	0.02419
2021	0.25998081	0.031433	0.075463359	0.276304	0.028507
2022	0.286112236	0.035554	0.076493532	0.310888	0.031004

Figure 2-28 shows emissions trends for indirect N2O emissions

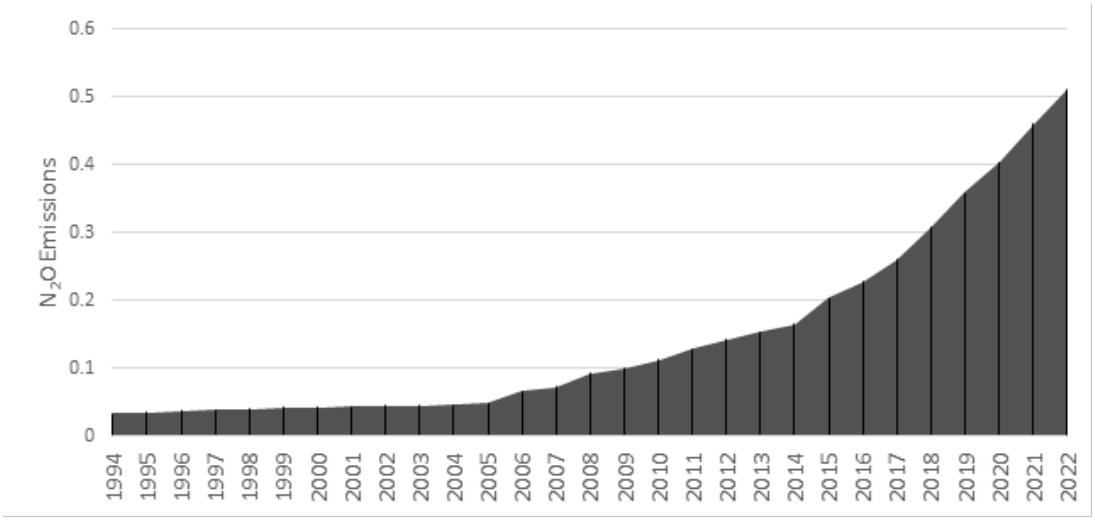


Figure 2-28 : Indirect N2O emissions from manure management, Gg N2O, 1994 - 2022

Indirect N_2O emission from manure management were high in broiler and dual-purpose chickens, which accounted for about 0.978 Gg N_2O in 2022. Between 1994 and 2022, chickens accounted for 72-89% of indirect N_2O emissions, with an average of 81%.

2.10.8.1 Direct nitrous oxide emissions from managed soils due to livestock deposit of dung and urine (Category 3.C.4)

Direct N_2O emissions from urine and dung N deposited on pasture, range and paddock by grazing animals is categorized under reporting category 3C4.

2.10.8.2 Source category description

The descriptions of the source categories for direct nitrous oxide emissions from managed soils due to livestock deposit of dung and urine are given in Table 2-36.

Table 2-36: Source categories for direct nitrous oxide emissions from managed soils due to livestock deposit of dung and urine

Emissions sources	Sources included	Method	Emission factors
3.C.4.a.i	Dairy cattle manure management	Tier 1	IPCC (2006)
3.C.4.a.ii	Other cattle manure management	Tier 1	IPCC (2006)
3.C.4.c	Sheep manure management	Tier 1	IPCC (2006)
3.C.4.d	Goat manure management	Tier 1	IPCC (2006)
3.C.4.h.i	Breeding pigs manure management	Tier 1	IPCC (2006)
3.C.4.h.ii	Marketed pigs manure management	Tier 1	IPCC (2006)
3.C.4.i.i	Layers	Tier 1	IPCC (2006)
3.C.4.i.ii	Broilers	Tier 1	IPCC (2006)
3.C.4.i.iii	Dual purpose chickens	Tier 1	IPCC (2006)
3.C.4.j	Rabbits manure management	Tier 1	IPCC (2006)
Gases reported	N_2O		
Completeness	All the major animals were included.		
Improvements since last submission	This is the first inventory for sheep, goat, pigs, rabbits that uses a Tier 1 approach.		

Direct N_2O emissions from urine and dung N deposited on pasture, range and paddock by grazing animals is categorized under reporting category 3C4.

2.10.8.3 Direct N_2O from urine and dung deposited in the pasture.

The resulting time series data for direct N_2O emissions from pasture deposit of dung and urine are given in Figure 2-29..

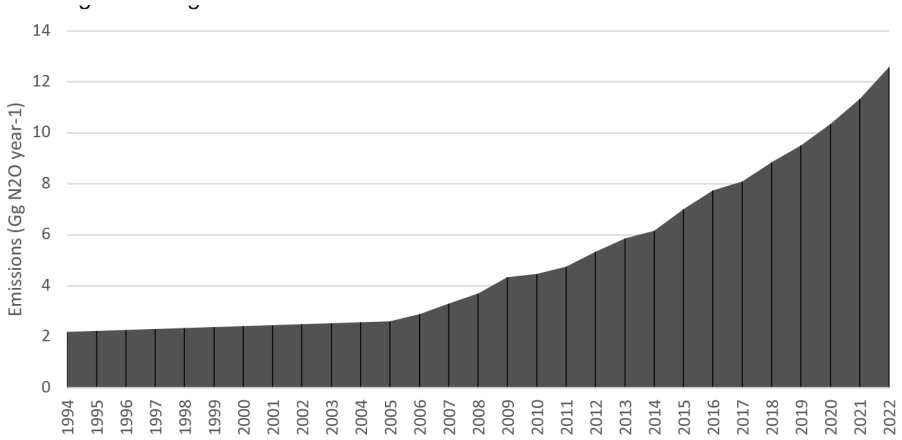


Figure 2-29:Direct N2O emissions from dung and urine deposited on pasture by different livestock species, 1994 - 2022 (Gg N2O year-1)

For direct nitrous oxide emissions from manure management the most sensitive factors affecting emissions were proportion of manure deposited on pasture, range and paddocks ($MS_{(T)}$) and the proportion of nitrogen (N) deposited to the soil through ruminant excreta, which is emitted as N_2O. The trends correspond to a sustained increase of government supported livestock development programmes and projects throughout the country.

2.10.8.4 Indirect emissions of nitrous oxide from managed soils due to grazing animals (Category 3.C.5)

This category reports indirect emissions of N_2O from dung and urine deposited on pasture by grazing animals. Table 2-37 shows the sources of emission factors used.

Table 2-37: Emission factors for indirect nitrous oxide emissions from managed soils due to livestock deposit of dung and urine

Emissions sources	Sources included	Method	Emission factors
3.C.5.a.i	Dairy cattle manure management	Tier 1	IPCC (2006)
3.C.5.a.ii	Other cattle manure management	Tier 1	IPCC (2006)
3.C.5.c	Sheep manure management	Tier 1	IPCC (2006)
3.C.5.d	Goat manure management	Tier 1	IPCC (2006)
3.C.5.h.i	Breeding pigs manure management	Tier 1	IPCC (2006)
3.C.5.h.ii	Marketed pigs manure management	Tier 1	IPCC (2006)
3.C.5.i.i	Layers	Tier 1	IPCC (2006)
3.C.5.i.ii	Broilers	Tier 1	IPCC (2006)
3.C.5.i.iii	Dual purpose chickens	Tier 1	IPCC (2006)
3.C.5.j	Rabbits manure management	Tier 1	IPCC (2006)
Gases reported	N_2O		
Completeness	All the major animals were included in this analysis.		
Improvements since last submission	This is the first inventory for sheep, goat, pigs, rabbits that uses a Tier 1 approach. This is the third time that dairy and other cattle use a Tier 1 approach.		

2.10.8.5 Indirect N_2O from pasture deposit

Indirect N_2O emissions from deposit of dung and urine on pasture by grazing animals were calculated by modifying IPCC equation 11.9 (for volatilization). Default emission factors for EF_4 (0.010) and EF_5 (0.0075) and default fractions for $Frac_{GASM}$ (0.20) were used (IPCC 2006, Table 11.3). F_{PRP} used the value calculated for direct nitrous oxide emissions from urine and dung deposited on pasture. Figure 2-29 presents the resulting estimated indirect N_2O emissions from deposit of dung and urine on pasture by the different livestock categories. Cattle and goats are the most significant contributors of indirect nitrous oxide. The goat contribution has been steadily going up in the last decade.

Table 2-38:Indirect N_2O emissions from dung and urine deposited on pasture by different livestock types

	Dairy cattle	Other cattle	Goats	Sheep	Breeding pigs	Market pigs
			Gg N_2O	Gg N_2O	Gg N_2O	Gg N_2O
	Gg N_2O	Gg N_2O	0.008782841	0.000370935	0.00026583	0.000916181
1994	0.000606934	0.011655009	0.009005065	0.000408852	0.000276447	0.000952773
2000	0.000855987	0.011739086	0.010338409	0.000636352	0.000346011	0.001192525
2010	0.001271075	0.0155978	0.024198504	0.00101552	0.002267928	0.007816389
2017	0.002076704	0.022006899	0.046813665	0.001414728	0.003852748	0.029951574
2018	0.002202649	0.023582003	0.052371936	0.001511705	0.003159918	0.019811333
2019	0.002427942	0.024603878	0.057414806	0.00160382	0.003453482	0.023002282
2020	0.002617513	0.025977047	0.062825357	0.001685323	0.003682738	0.025559911
2021	0.002860597	0.026856091	0.067592599	0.001782728	0.004292243	0.028203647
2022	0.003057273	0.030085996				

Table 2-39: Indirect N2O emissions from dung and urine deposited on pasture by different livestock types

	Layers	Broilers	Dual-purpose poultry	Rabbits
	Gg N_2O	Gg N_2O	Gg N_2O	Gg N_2O
1994	1.15E-05	9.99E-05	0.000110525	0.000187547
2000	3.60E-05	9.18E-05	0.00011704	0.000631651
2010	7.68E-05	7.84E-05	0.000298685	0.004539266
2017	9.51E-05	0.000110972	0.000748898	0.008813621
2018	0.000105032	0.000155764	0.000856136	0.011329917
2019	0.000114754	0.000218765	0.000975099	0.013088017
2020	0.000124229	0.000249164	0.001096203	0.015719601
2021	0.000138319	0.000332072	0.00121586	0.017352025
2022	0.000156454	0.000336605	0.001368044	0.018916034

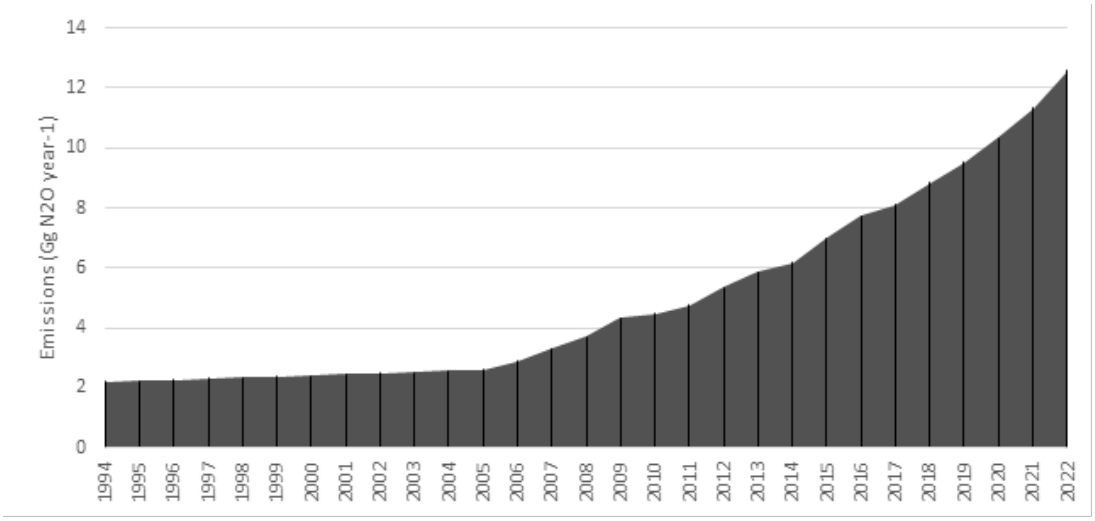


Figure 2-30: Indirect N2O emissions from dung and urine deposited on pasture by different livestock types, 1994 - 2022 (Gg N2O year-1)

This inventory estimates the amount of N deposited on pasture (F_{PRP}) separately for cattle, poultry and pigs (F_{PRP_CPP}) and for sheep and other animals, i.e. goats (F_{PRP_SO}). Emissions increased from 2 Gg in 1994 to 13 Gg in 2022. Goats were the most significant contributors of direct N_2O, followed by other cattle. Direct N_2O from goats has been going up steadily in the last decade.

2.10.9 Liming (Category 3.C.2)

This reports carbon dioxide (CO_2) emissions resulting from the application of lime—primarily dolomitic lime ($CaMg(CO_3)_2$)—to agricultural soils.

2.10.9.1 Methodological Issues and Emission Trend (1994–2022)

Emissions from lime application are estimated using the Tier 1 methodology from the 2006 IPCC Guidelines (Vol. 4, Ch. 11). The emissions are shown in Table 2-40 and Figure 2-30.

Table 2-40: Emission Trend (1994–2022)

YEAR	Annual amount of lime (tonnes / yr)	Emissions CO_2 (Gg)
1994	13,225.10	6.30
2000	16,641.78	7.93
2010	31,790.00	15.15
2017	33,158.00	15.81
2018	38,278.00	18.25
2019	42,000.00	20.02
2020	24,725.59	11.79
2021	27,198.15	12.96
2022	29,917.96	14.26

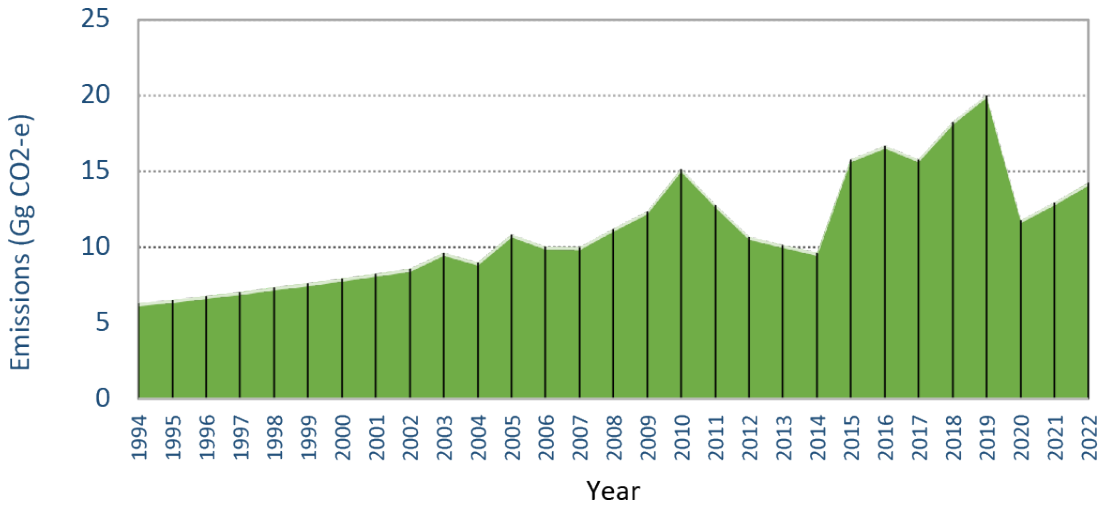


Figure 2-31: Annual CO_2 Emissions from Dolomitic Lime Use in Malawi (1994–2022)

Between 1994 and 2022, emissions from dolomitic lime application rose from 1.72 Gg CO_2 to 3.89 Gg CO_2, with an average annual growth rate of 2.83%. The peak was in 2019 (5.46 Gg CO_2), mainly due to increased lime use under donor-supported soil fertility programs and favourable agro-climatic conditions (MoAFS, 2020; World Bank, 2020).

2.10.10 Urea Application (Category 3.C.)

This sub-category captures direct carbon dioxide (CO2) emissions resulting from the application of urea-based nitrogen (N) fertilizers to agricultural lands.

2.10.10.1 Methodological Issues and Emission Trends

The Tier 1 approach in line with the 2006 IPCC Guidelines (Volume 4, Chapter 11) was applied to estimate emissions from urea application. The approach uses a default emission factor (EF) of 0.20 tonnes of CO2 per tonne of urea applied.

Table 2-41: Emission trends

YEAR	Annual amount of Carbonate N-fertilizer (tonnes / yr)		Emissions
	Cropland - Flooded rice fields	Cropland	
1994		30514	8,604.38
2000		41150	9,864.85
2010		120967	15,197.33
2017		89852.18	20,144.15
2018	6507.848	71890.06	73,493.61
2019	6826.956	83239.76	22,223.66
2020	7479.586	93162.97	23,300.35
2021	18784.82	196255.3	24,129.80
2022	15365.5	173851.1	71,958.88

Figure 2-31 shows emissions from urea application.

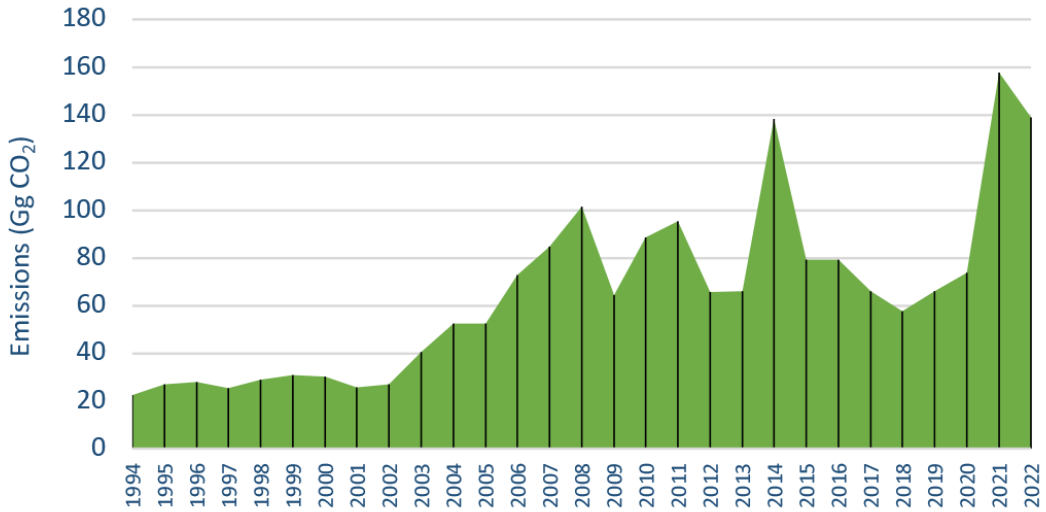


Figure 2-32: CO_2-e emissions from urea application (1994–2022)

Urea usage has increased significantly over the time series. The annual application rate of urea in Malawi rose from 30,514 tonnes in 1994 to a peak of 196,255 tonnes in 2021. **The Annual Growth Rate** for total urea-based emissions between 2018 and 2022 was **4.52%**, driven by increased input subsidies, expanded irrigation schemes and intensified fertilizer demand, especially in the maize-growing central region.

2.10.11 Direct N_2O Emissions from Managed Soils (CRT Category 3.C.4)

This category accounts for direct emissions of nitrous oxide (N_2O) from nitrogen (N) inputs to managed agricultural soils.

2.10.11.1 Methodological Approach

Direct N_2O emissions from managed soils are estimated using the Tier 1 methodology outlined in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Vol. 4, Chapter 11). This approach uses a default emission factor applied to the total annual nitrogen input to soils.

- **Emission Factor (EF):** 0.01 kg N_2O–N / kg N input (equivalent to 1%)

Table 2-42: Emissions Trends

YEAR	Emissions CO_2 e(Gg)
1994	15.37
2000	16.43
2010	87.98
2017	260.495
2018	298.655
2019	212.265
2020	241.15
2021	267.65
2022	306.605

Figure 2-32 shows emissions from urea application.

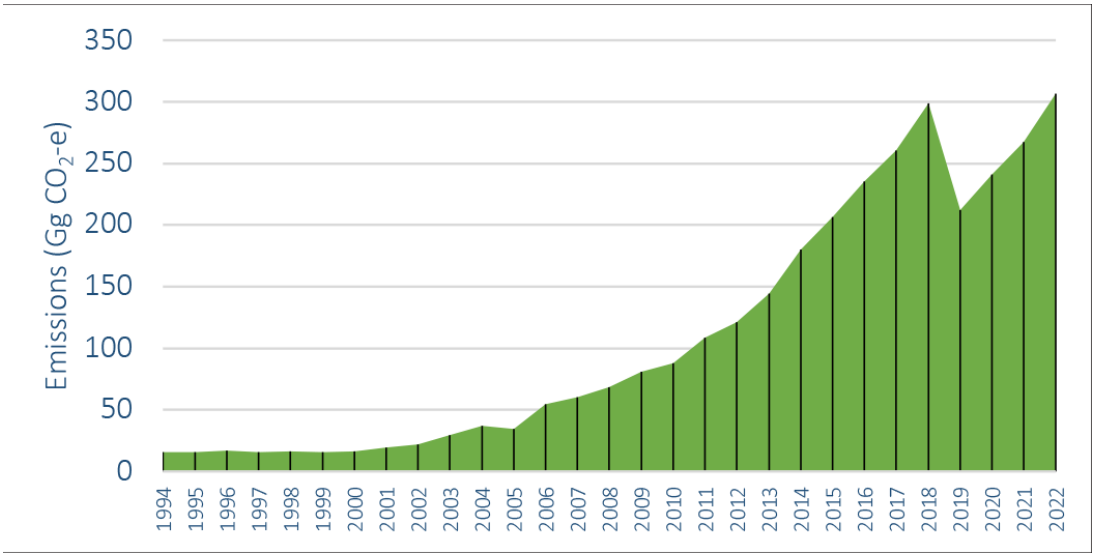


Figure 2-33: Emission trends for N_2O from managed agricultural soils

Between 1994 and 2022, direct N_2O emissions from managed agricultural soils in Malawi exhibited a gradual upward trend, primarily driven by increased nitrogen inputs associated with the intensification of crop production. Emissions increased from approximately 0.32 Gg CO_2e in 1994 to 1.12 Gg CO_2e in 2022.

2.10.12 Indirect N_2O Emissions from Managed Soils (CRT Category 3.C.5)

This accounts for indirect nitrous oxide (N_2O) emissions resulting from nitrogen (N) that is initially volatilized as ammonia (NH_3) and nitrogen oxides (NO_2) or leached/run off as nitrate (NO_3^-) following application to managed soils.

Source Description

2.10.12.1 In Malawi, the main sources contributing to indirect N_2O emissions include:

i. Volatilization losses from synthetic and organic fertilizers, particularly urea and ammonium-based compounds; and

ii. Leaching and runoff during the rainy season, especially in high rainfall regions such as Thyolo, Mulanje, Nkhatabay, Mzimba, and parts of Dedza.

2.10.12.2 Methodological Issues

Estimates were developed using the Tier 1 methodology of the 2006 IPCC Guidelines (Vol. 4, Ch. 11). This approach uses default emission factors and nitrogen loss fractions to estimate indirect N_2O emissions from volatilization and leaching pathways.

Table 2-43: Emissions Trends

YEAR	Emissions CO_2 e(Gg)
1994	2.12
2000	2.12
2010	3.18
2017	5.035
2018	5.565
2019	5.83
2020	6.36
2021	6.625
2022	7.685

Figure 2-33 shows Indirect N_2O emissions from managed soils.

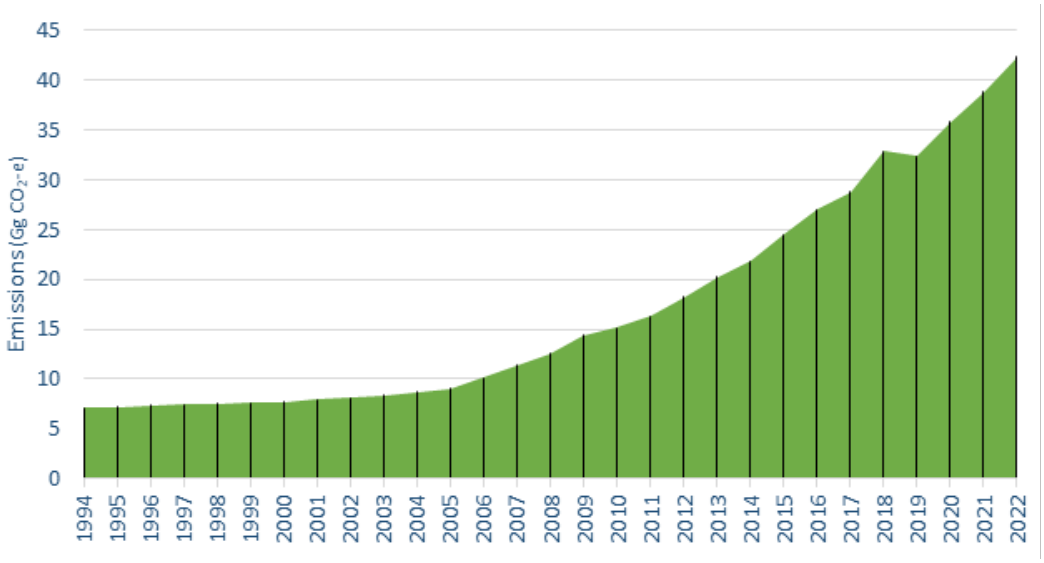


Figure 2-34: Indirect N_2O Emissions from Managed Soils, 1994–2022 (Gg CO2e)

Direct N_2O emissions from managed soils in Malawi have exhibited a consistent upward trend over the period 1994 to 2022, increasing from 15.37 Gg CO_2 eq. in 1994 to 306.61 Gg CO_2 eq.

2.10.13 Rice Cultivation (CRT Category 3.C.7)

The principal greenhouse gas emitted from rice cultivation is methane (CH_4), generated through the anaerobic decomposition of organic matter in water-saturated soils.

2.10.13.1 Methodological Issues

A Tier 1 method has been applied, in accordance with Volume 4, Chapter 5 of the 2006 IPCC Guidelines, using the default emission factors and scaling coefficients for rice systems without organic amendments.

2.10.13.2 Activity Data

Annual harvested area data from the Ministry of Agriculture and FAO is used for the 1994–2022 period. The rice ecosystem is classified under deep-water, continuously flooded paddy fields.

Table 2-44: Emission Trends

YEAR	Annual harvested area (ha/yr)	Emissions
1994	27067	45.43532
2000	43523	73.05872
2010	59098	99.20316
2017	64881	108.91076
2018	63971	107.38308
2019	70573	118.46548
2020	72763	122.1416
2021	76000	127.57528
2022	75787	127.21772

Figure 2-34 shows CH_4 emissions from rice cultivations.

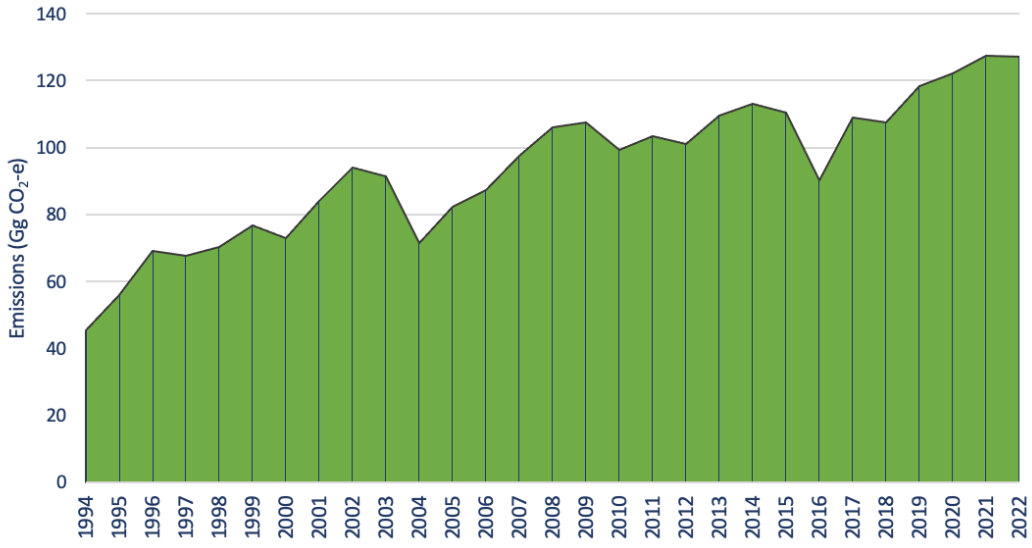


Figure 2-35: Emissions from Rice Cultivation (1994–2022)

Emissions from rice cultivation have increased significantly over the past three decades, rising from 0.107 Gg CH_4 (2.67 Gg CO_2e) in 1994 to 1.205 Gg CH_4 (30.12 Gg CO_2e) in 2022. This trend closely follows the expansion in harvested area, which nearly tripled from 27,067 ha in 1994 to 75,787 ha in 2022.

2.11 Land Use, Land Use Change and Forestry (LULUCF)

2.11.1 Overview of the sector and background information

The FOLU sector covers greenhouse gas (GHG) emissions associated with forestry and land management practices that impact carbon stored in vegetation and soils. The GHGs emissions sources reported in this report are presented in Table 2-45. The write-up further entails FOLU emissions by category for the year 2022, thus depicting changes in the years; 2018, 2019, 2020, and 2021. Overall, for the reporting period (2018 to 2022), there has been a noticeable fluctuation in emissions which registered a decreased of 5,347.13 $GgCO_2e$ (10.29%) averaging to -2.06% annually. Furthermore, for the period 2018 to 2022 the greatest contribution of the emissions emanated from the forestland (79.08%), followed by cropland (9.70%) and Wetland (8.50%). Grassland and settlement contributed the lowest, 2.60% and 0.12%, respectively.

Table 2-45: Sources of GHG Emissions by Category in FOLU Subsector

No.	Category	GHG's emission sources
1	Forestland	1. Forestland remaining forestland 2. Land converted to forestland 3. Harvested wood products 4. Biomass burning in forestland
2	Cropland	1. Cropland remaining cropland 2. Land converted to cropland 3. Biomass burning in cropland
3	Grassland	1. Grassland remaining cropland 2. Land converted to cropland 3. Biomass burning in grassland
4	Wetland	1. Wetland remaining wetland 2. Land converted to wetland
5	Settlement	1. Settlement remaining settlement 2. Land converted to settlement

The highest reliability in data occurred in cropland (0.20%), wetland (0.64%), and settlement (0.69%). Grassland had the highest uncertainty (6.05%) due to fire-related emissions.

Table 2-46: FOLU Subsector Emissions by Category for the Year 2022 With Changes since, 2018, 2019, 2020, and 2021

	Change in 2022 emissions (GgCO2-e) since:				2022 emissions (G
Category	2018	2019	2020	2021	
Forestland	-4464.27	-5031.02	-5547.68	-4862.49	36258.53
	- 11 %	- 12.2 %	- 13.3 %	- 11.8 %	--
Cropland	-28.1	-21.08	-14.06	-7.03	4922.24
	- 0.6 %	- 0.4 %	- 0.3 %	- 0.1 %	--
Grassland	-610.5	-502.02	-302.17	-196.26	1002.89
	- 37.8 %	- 33.4 %	- 23.2 %	- 16.4 %	--
Wetland	80.16	60.12	39.08	20.04	4366.06
	+1.9 %	+1.4 %	+0.9 %	+0.5 %	--
Settlement					58.42
	- 1.4 %	- 0.8 %	- 0.4 %	- 0.6 %	--
overall	-5023.57	-5494.49	-5825.09	-5045.38	46608.15
	-9.7 %	- 10.5 %	- 11.1 %	-9.8 %	--

The reduction in emissions was largely due to less forest conversion and more regrowth, especially of Miombo forests. Wetter conditions from La Niña encouraged biomass growth in croplands and grasslands, though forest emissions increased from wildfires and soil carbon losses.

Malawi's climate strategy recognizes FOLU as central to mitigation, with priorities including REDD+, afforestation, and the carbon trading initiatives. Carbon potential is estimated at 19 million metric tons per year.

2.11.2 Land Use Definitions and Land Use Change Matrix

Six Land classes based on current or potential use are nationally defined in Malawi as indicated in Table 2-47. Their distribution for the reporting periods are presented in Table 22. The findings indicate that "forestland to cropland," and "wetland to cropland," were the major land use changes from the year 2000 to the year 2022. Forestland steadily declined at a rate of 13,591 ha (0.5%) per annum. Similarly, grassland declined at the rate of 1,651 ha (0.5%) per annum. On the other hand, cropland, wetland, and settlements steadily increased at the rate of 8,228 ha (0.14%); 5,257 ha (0.17%); and 1,941 ha (8.1%) per annum, respectively. Furthermore, these results indicate that the "grassland to forestland" changes were higher than the "forestland to grassland" changes, suggesting forest regeneration was occurring.

Table 2-47: Malawi's land use classes and their definitions

No.	Land use class	Definition
1	Forestland	Land with woody vegetation consistent with thresholds used to define forest land. These thresholds are minimum mapping area or unit (MMU), minimum crown closure at maturity, minimum height, and minimum width of linear features. Recommended definition thresholds for the GoM are a minimum mapping area of 0.5 hectare, a minimum 10% crown closure, a minimum height of 5 meters, and a minimum linear feature width of 20 meters.
2	Cropland	Arable and tillage land, and agroforestry systems where vegetation falls below the thresholds used to define forest land. The FAO Land Cover Classification System (LCCS) calls these Agriculture Lands.
3	Grassland	Rangelands and pastureland that is not considered cropland.
4	Wetland	Land that is covered or saturated by water for all or part of the year and that does not fall into the previous categories or settlements.
5	Settlements	developed land, including transportation infrastructure and human settlements of any size unless they are already included under other categories
6	Other land	Bare ground, rock, and all unmanaged land not in the previous categories.

Table 2-48: Area distribution by land classes and forest sub-classes (in ha) from 2018 to 2022

Year	Miombo	Pine	Eucalyptus	Cropland	Grassland	Wetlands	Settlements	Other Lands
2018	2071558.1	69827.8	186207.5	6008600.0	304606.7	3117143.3	62880.0	11216.7
2019	2061533.7	69489.9	185306.4	6016982.5	302927.5	3120510.0	64325.0	10965.0
2020	2051509.3	69152.0	184405.3	6025365.0	301248.3	3123876.7	65770.0	10713.3
2021	2041485.0	68814.1	183504.3	6033747.5	299569.2	3127243.3	67215.0	10461.7
2022	2031460.6	68476.2	182603.2	6042130.0	297890.0	3130610.0	68660.0	10210.0

Table 2-49: Malawi Land Use Statistics from 2000 to 2022

Year	2000		2010		2022	
Classes	Area (ha)	%	Area (ha)	%	Area (ha)	%
Forest Land	2595140	21.9	2417700	20.4	2282540	19.3
Cropland	5852880	49.5	5941540	50.2	6042130	51.1
Grassland	335860	2.8	318040	2.7	297890	2.5
Wetland	3009710	25.4	3090210	26.1	3130610	26.5
Settlements	24010	0.2	51320	0.4	68660	0.6
Other Land	14440	0.1	13230	0.1	10210	0.1

Table 2-50: Major Land Use Changes (in Hectares) for Malawi

Land use cover change	2000- 2010	2010-2022
Forest land to Cropland	368060	220840
Forest land to Grassland	25509	15360
Cropland to Forest land	187070	112240
Grassland to Forest land	22060	31240
Wetland to Forest land	39240	23540
Wetland to Cropland	147930	88770
Forest land to Settlement	2730	2480

Figure 2-35 shows land use distribution for Malawi for years 2000, 2010 and 2022.

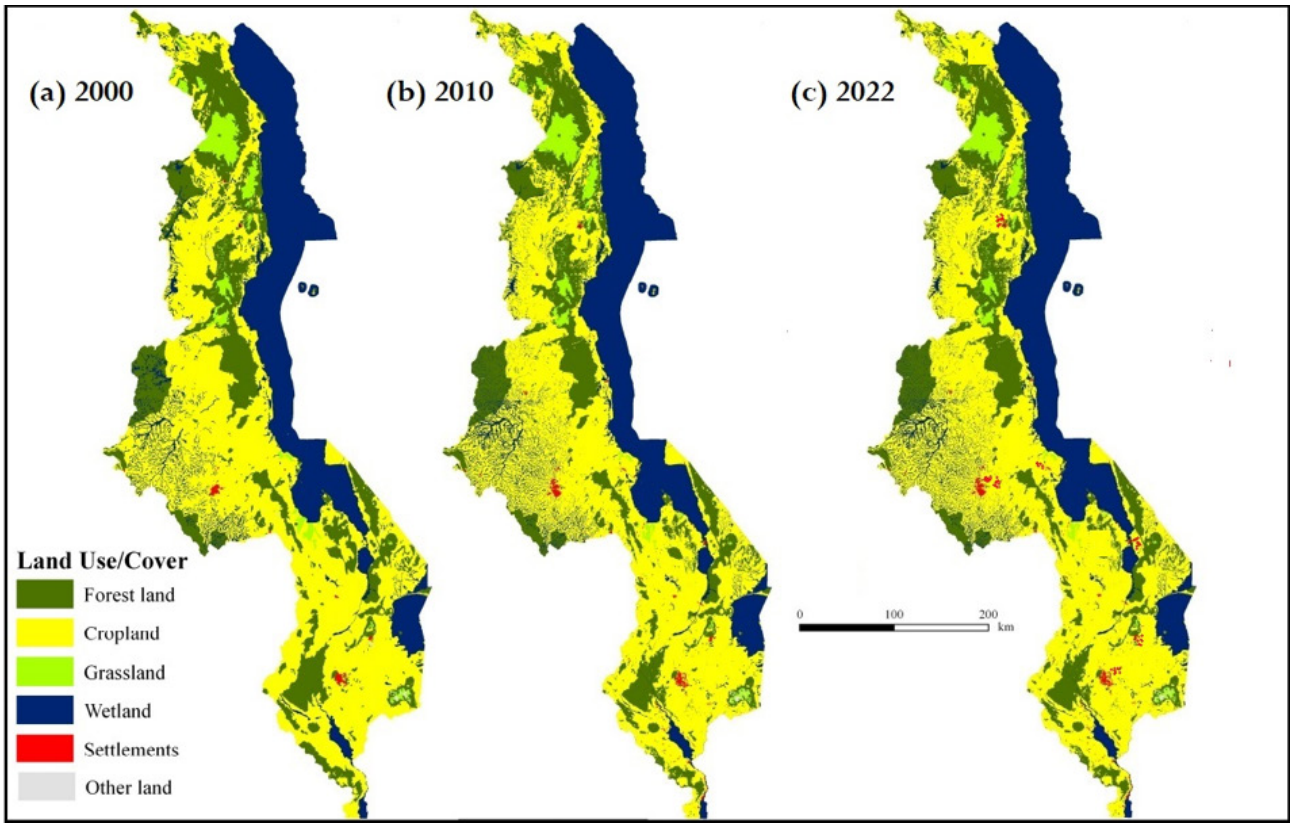


Figure 2-36: Malawi's Land Use/Cover Distribution for the Years 2000, 2010 and 2022

2.11.3 Country-Specific Approaches

Malawi uses IPCC Approaches 1 and 2 as described in the 2006 IPCC Guidelines for National GHG Inventories (Eggleston et al., 2006) to monitor FOLU. Remote sensing and forest inventories from 2011 and 2022 provide the basis for estimating carbon stock changes using the Carbon Stock Change method.

The Miombo emission factor is 13.66 tCO_2e/ha/year (2.44% uncertainty). Three carbon pools (AGB, BGB, SOC) were used. Pine, eucalyptus, and non-forest categories used default values. Biomass burning, mainly from bush fires, was the principal natural disturbance considered. Wood harvesting emissions followed the stock-change approach. QA/QC measures relied on remote sensing, forest inventory cross-checks, and third-party validation.

i. Activity data

Malawi uses Approaches 1 and 2 as described in the 2006 IPCC Guidelines for National GHG Inventories (Eggleston et al., 2006) to monitor forestry and other land use (FOLU). The principal monitoring system is a remote sensing programme used to identify forestlands and changes in forest cover. Malawi's land cover maps for the year 2022 were produced to supplement the land cover maps for the years 2000, and 2010 that were produced by Air Asia Survey (AAS, 2012). A more detailed production of Malawi's land cover maps for the year 2022 is available in Missanjo and Kadzuwa (2024). Data between the three epochs was linearly interpolated while extrapolation was conducted for the period 2018 to 2021.

ii. Emission factor

The emission factor was developed using Forest Inventory techniques. Essentially, the Carbon Stock Change approach was used. In the Carbon Stock Change approach, carbon stocks are measured at two-time intervals and the difference between those two intervals determines the carbon stock change. Equation 2-1 was used in the Carbon Stock Change approach (IPCC, 2019).

$$\Delta C = \frac{C_{t2} - C_{t1}}{t_2 - t_1} \qquad \textit{Equation 2-1}$$

Where: is annual carbon stock change in pool (tC/ha/yr); is carbon stock in pool at time t_2 (tC/ha); and is carbon stock in pool at time t_1 (tC/ha). In this reporting period, Forest Inventory data collected by the JICA project in the year 2011 was used as time (t_1). On the other hand, Forest Inventory data collected by the Modern Cooking for Healthy Forests (MCHF) Project in the year 2022 was used as time (t_2). Both datasets were obtained from the Department of Forestry Headquarters, National Forest Monitoring Unit. However, the time (t_2) dataset was supplemented by a forest inventory conducted in Lilongwe Urban Forest in November 2022.

Above-ground biomass (AGB) and Below-ground biomass (BGB) were estimated using the site-specific allometric equation 2-2 and equation 2-3, respectively, developed by Kachamba et al. (2016).

$$AGB = 0.103685 \times (DBH)^{1.921719} \times ht^{0.844561} \quad \text{Equation 22}$$

$$BGB = 0.284615 \times (DBH)^{1.992658} \quad \text{Equation 23}$$

where: AGB and BGB are above-ground biomass and below-ground biomass (kg dry matter per tree), respectively; DBH is a diameter at breast height (1.3 m above the ground level), measured in centimetres (cm); and *ht* is the total tree height, measured in metres (m).

The total living biomass of a tree (TLB) was calculated as the sum of AGB and BGB, while carbon stock (C) was calculated using equation 2-4:

$$C = TLB \ \ CF \quad \textbf{Equation 2-4}$$

where: CF is the carbon factor and varies from 0.45 to 0.50 (Hirita et al., 2012). In this reporting period, a value of 0.47 was used as informed by previous key studies (Missanjo and Kadzuwa, 2021).

Soil organic carbon (SOC) was calculated using equation 2-5 as recommended by Pan et al. (2011).

where: SOC is soil organic carbon (tC/ha), AGC and BGC are above-ground carbon stock and below-ground carbon stock (tC/ha), respectively. Therefore, the developed emission factor for Miombo (indigenous trees) used for the estimation of emissions was 13.66 $tCO_2eha^{-1}yr^{-1}$, with an uncertainty of 2.44%. The UNFCCC guidelines require the use of five carbon pools when estimating emission factors. These pools include above-ground biomass, below-ground biomass, deadwood (DW), litter, and soil organic carbon (SOC) (IPCC, 2019). The developed emission factor used three carbon pools, above ground biomass, below ground biomass, and soil organic carbon. It should be noted that Malawi's populace is highly dependent on fuel wood and less wood is left lying for longer periods in the forestlands unlike in other highly significant areas like peatlands. Furthermore, litter is burned in the dry season to achieve ecosystem goals (Nieman, 2021). Therefore, the assumption is that the carbon stocks in deadwood and litter do not significantly change over time. The default emission factors were used for the Pine plantation, Eucalyptus plantation, cropland, grassland, wetland, and settlement categories.

iii. Uncertainty Assessment

Carbon stock or biomass estimates are usually associated with uncertainties from sources such as sampling error, measurement error, and estimation error (FAO, 2005). It is a good practice to quantify uncertainties to understand the accuracy of the Carbon Stock Estimations (FAO, 2015). Therefore, the Monte Carlo procedure, well-explained by other researchers (Sierra et al., 2007) was used to estimate the uncertainty of the parameters studied at a 95% confidence interval

2.11.4 Forestland (4.A)

2.11.4.1 Forestland Remaining Forestland

Forest types include Miombo (89%), pine (3%), and eucalyptus (8%). Emissions from forestland remaining forestland reduced from 33,830.53 to 33,494.63 $GgCO_2e$ between 2018 and 2022 (Table 2-51).

Table 2-51: Emissions and removals ($GgCO_2e$) from forestland remaining forestland

Year	Miombo woodland	Pine plantations	Eucalyptus plantations	Total
2018	26652.02	1133.17	6045.34	33830.53
2019	26585.86	1130.36	6030.33	33746.55
2020	26519.70	1127.55	6015.33	33662.58
2021	26453.55	1124.73	6000.32	33578.60
2022	26387.39	1121.92	5985.32	33494.63

2.11.4.2 Land Converted to Forestland

Annual conversion and emissions declined steadily. In 2022, emissions were 2,577.44 $GgCO_2e$, down from 2,995.90 in 2018 (Table 2-52 & Table 2-53).

Table 2-52: Annual area in hectares for land converted to forestland

Year	Cropland converted to forestland	Grassland converted to forestland	Wetlands converted to forestland	Total
2018	137183.36	28180.00	28773.36	194136.70
2019	130947.53	28945.00	27465.03	187357.60
2020	124711.70	29710.00	26156.70	180578.40
2021	118475.87	30475.00	24848.37	173799.20
2022	112240.00	31240.00	23540.00	167020.00

Table 2-53: Annual net emissions ($GgCO_2e$) for land converted to forestland

Year	Cropland converted to forestland			Grassland converted to forestland			Wetlands converted to forestland			Total
	Miombo	Pine	Eucalyptus	Miombo	Pine	Eucalyptus	Miombo	Pine	Eucalyptus	
2018	1667.79	70.91	378.30	342.60	14.57	77.71	349.81	14.87	79.35	2995.90
2019	1591.98	67.69	361.10	351.90	14.96	79.82	333.90	14.20	75.74	2891.28
2020	1516.17	64.46	343.90	361.20	15.36	81.93	318.00	13.50	72.13	2786.67
2021	1440.36	61.24	326.71	370.50	15.75	84.04	302.09	12.84	68.52	2682.05
2022	1364.55	58.02	309.51	379.80	16.15	86.15	286.19	12.17	64.91	2577.44

2.11.4.3 Biomass Burning in Forestland

Forest biomass burning emissions dropped significantly to 96.27 $GgCO_2e$ in 2022, from a 2020 peak of 5,227.17 $GgCO_2e$, likely due to improved fire control and COVID-19 lockdowns (Table 2-54).

Table 2-54: Annual area burnt and net emissions for burning biomass in forestland

Year	Area burnt (ha)	Emissions from CO_2 ($GgCO_2e$)	Emissions from CH_4 ($GgCO_2e$)	Emissions from N_2O ($GgCO_2e$)	Emissions from CO ($GgCO_2e$)	Total Emissions ($GgCO_2e$)
2018	581898.33	3520.48	14.55	0.42	234.72	3770.18
2019	694899.00	4204.14	17.37	0.51	280.30	4502.32
2020	806773.33	4880.98	20.17	0.59	325.43	5227.17
2021	734017.07	4440.80	18.35	0.54	296.08	4755.77
2022	14857.93	89.89	0.37	0.01	5.99	96.27

2.11.5 Cropland (CRT 4.B)

2.11.5.1 Cropland Remaining Cropland

Minor emission decline from 2,999.91 to 2,994.96 Gg CO_2-e between 2018 and 2022 (Figure 2-36).

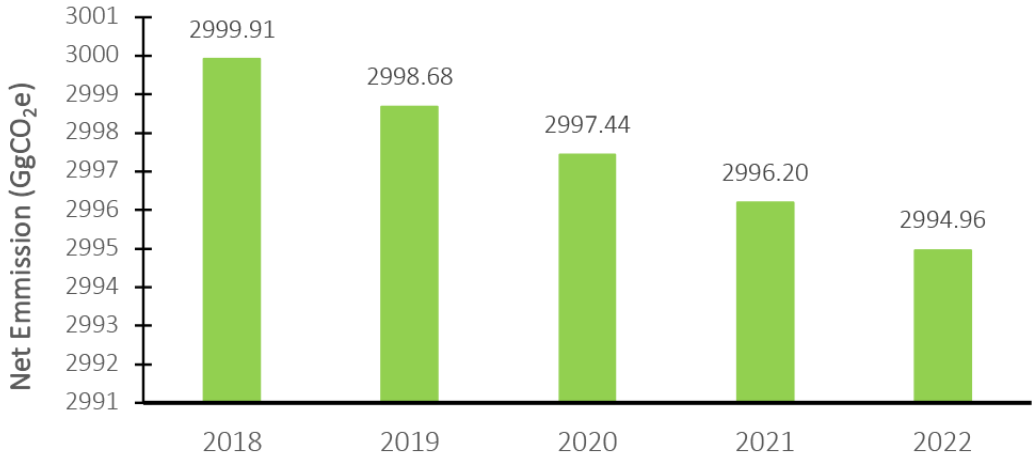


Figure 2-37: Net emissions from Cropland remaining Cropland

2.11.5.2 Land Converted to Cropland

Area and emissions declined yearly. Emissions dropped from 181.63 to 148.61 Gg CO_2-e (Table 2-55 & Table 2-56).

Table 2-55: Annual Area (hectares) for Land Converted to Cropland

Year	Forestland converted to cropland	Wetlands converted to cropland	Total
2018	269913.6	108490.0	378403.6
2019	257645.3	103560.0	361205.3
2020	245377.0	98630.0	344007.0
2021	233108.7	93700.0	326808.7
2022	220840.0	88770.0	309610.0

Table 2-56: Annual net emissions (GgCO2e) for land converted to cropland

Year	Forestland converted to cropland	Wetlands converted to cropland	Total
2018	129.56	52.08	181.63
2019	123.67	49.71	173.38
2020	117.78	47.34	165.12
2021	111.89	44.98	156.87
2022	106.00	42.61	148.61

2.11.5.3 Biomass Burning in Cropland

Emissions rose slightly, reaching 1,778.67 GgCO2e in 2022 (Table 2-57).

Table 2-57:Annual area burnt and net emissions for burning biomass in cropland

Year	Area burnt (ha)	Emissions from CO_2 ($GgCO_2e$)	Emissions from CH_4 ($GgCO_2e$)	Emissions from N_2O ($GgCO_2e$)	Emissions from CO ($GgCO_2e$)	Total Emissions ($GgCO_2e$)
2018	300430.00	1664.38	2.97	0.08	101.37	1768.80
2019	300849.13	1666.70	2.98	0.08	101.51	1771.27
2020	301268.25	1669.03	2.98	0.08	101.65	1773.73
2021	301687.38	1671.35	2.99	0.08	101.79	1776.20
2022	302106.50	1673.67	2.99	0.08	101.93	1778.67

2.11.6 Grassland (4.C)

2.11.6.1 Grassland Remaining Grassland

Emissions dropped from 814.15 to 777.78 Gg CO_2-e (Figure 2-37).

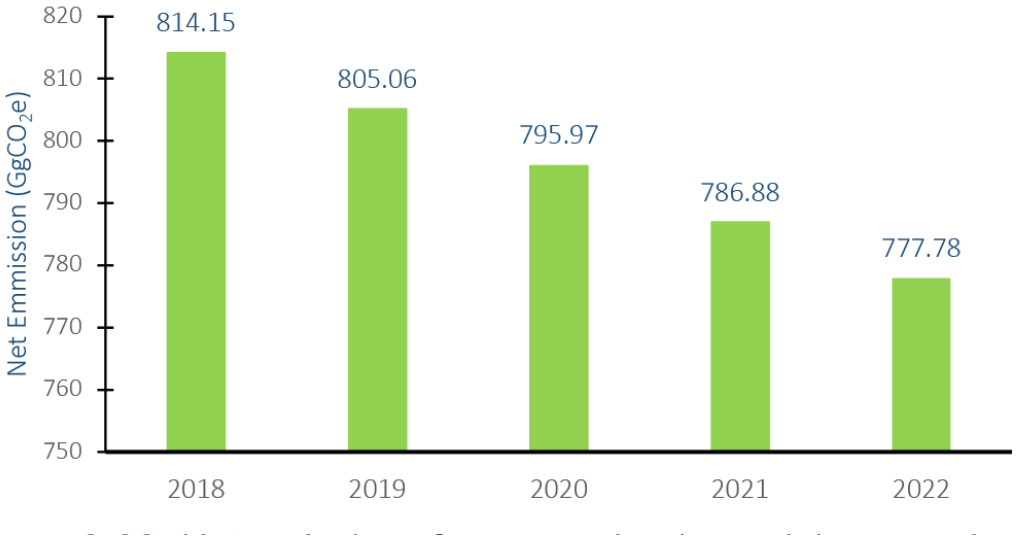


Figure 2-38: Net emissions from grassland remaining grassland

2.11.6.2 Land Converted to Grassland

Conversions and emissions decreased (Table 2-58).

Table 2-58: Cumulative area and net emissions for land converted to grassland

Year	Cumulative area (ha) of forestland converted to grassland	Emissions ($GgCO_2e$) forestland to grassland
2018	18770.0	51.77
2019	17917.5	49.42
2020	17065.0	47.07
2021	16212.5	44.71
2022	15360.0	42.36

2.11.6.3 Biomass Burning in Grassland

Steady decline in emissions from 747.48 to 182.75 $GgCO_2e$ (Table 2-59).

Table 2-59: Annual area burnt and net emissions for burning biomass in grassland

Year	Area burnt (ha)	Emissions from CO_2 ($GgCO_2e$)	Emissions from CH_4 ($GgCO_2e$)	Emissions from N_2O ($GgCO_2e$)	Emissions from CO ($GgCO_2e$)	Total Emissions ($GgCO_2e$)
2018	121842.67	705.47	1.74	0.05	40.21	747.48
2019	106024.63	613.88	1.52	0.05	34.99	650.44
2020	75312.08	436.06	1.08	0.03	24.86	462.02
2021	59913.83	346.90	0.86	0.03	19.77	367.56
2022	29789.00	172.48	0.43	0.01	9.83	182.75

2.11.7 Wetland (CRT 4.D)

2.11.7.1 Wetland Remaining Wetland

Gradual increase in emissions from 3,763.59 to 3,814.20 $GgCO_2e$ (Figure 2-38).

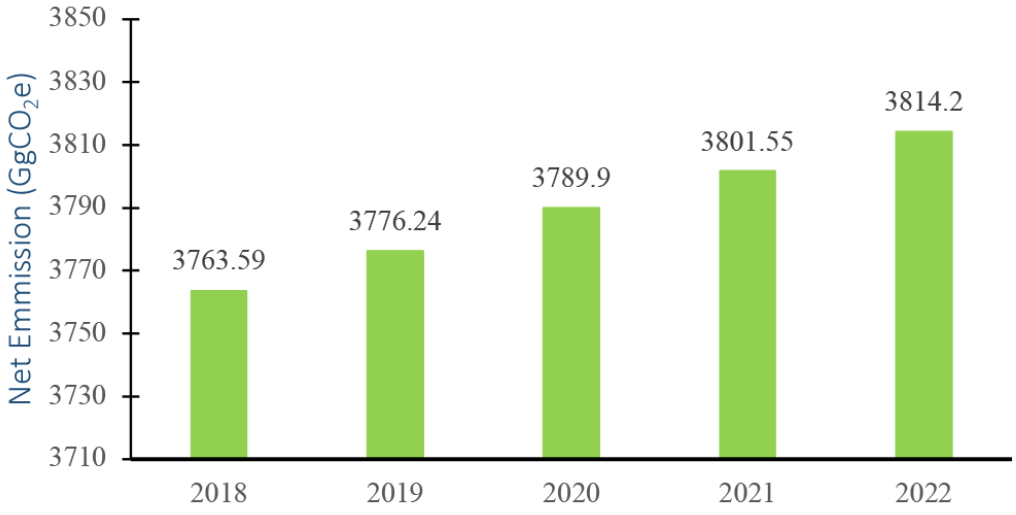


Figure 2-39: Net emissions from wetland remaining wetland

2.11.7.2 Land Converted to Wetland

Emissions increased from 522.31 to 551.86 $GgCO_2e$ (Table 2-60).

Table 2-60: Cumulative area in hectares and net emissions for land converted to wetland

Year	Cumulative Area (ha) forestland converted to wetland	Emissions ($GgCO_2e$) forestland to wetland
2018	38236.7	522.31
2019	38777.5	529.70
2020	39318.3	537.09
2021	39859.2	544.48
2022	40400.0	551.86

2.11.8 Settlement (4.E)

2.11.8.1 Settlement Remaining Settlement

Table 2-61: Area gain and net emissions of sparse woody vegetation, settlements remaining settlements

Year	Area gain (ha)	Net emission ($GgCO_2e$)
2018	1443	19.71
2019	1440	19.67
2020	1447	19.77
2021	1425	19.47
2022	1475	20.15

2.11.8.2 Land Converted to Settlement

Emissions dropped slightly to 38.27 GgCO2e by 2022 (Table 2-62).

Table 2-62: Cumulative area in hectares and net emissions for land converted to settlement

Year	Cumulative Area (ha) forestland converted to settlement	Emissions ($GgCO_2e$) forestland (Miombo) to settlement	Emissions ($GgCO_2e$) forestland (Pine plantation) to settlement	Emissions ($GgCO_2e$) forestland (Eucalyptus plantation) to settlement	Total Emissions ($GgCO_2e$) forestland to settlement
2018	2563.3	31.16	1.32	7.07	39.55
2019	2542.5	30.91	1.31	7.01	39.23
2020	2521.7	30.66	1.30	6.95	38.91
2021	2500.8	30.40	1.29	6.90	38.59
2022	2480.0	30.15	1.28	6.84	38.27

2.11.9 Other Land (4.F)

No emissions reported due to lack of significant activity.

2.11.9.1 Harvested Wood Products (4.G)

Emissions fluctuated, peaking in 2019 at 149.4 $GgCO_2e$, then declining to 90.2 $GgCO_2e$ in 2022 (Figure 2-39).

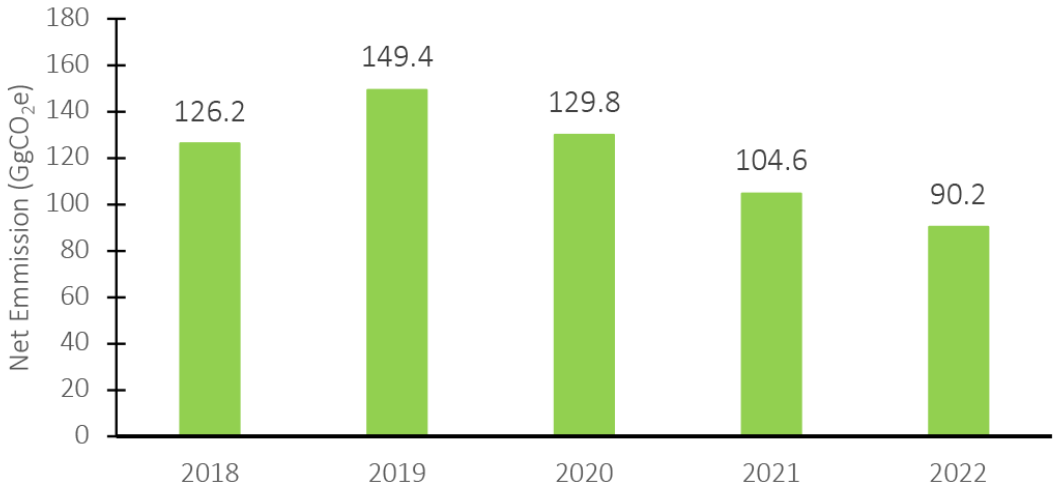


Figure 2-40: Net emissions from harvested wood products

2.11.10 Uncertainty Assessment

Lowest uncertainty was in cropland (0.20%), highest in grassland (6.05%). Overall uncertainty for the FOLU subsector was 4.16% (Table 2-63)

Table 2-63: Uncertainty assessment by category in FOLU Sub-sector

No.	Category	Uncertainty (%)
1	Forestland	4.92
2	Cropland	0.20
3	Grassland	6.05
4	Wetland	0.64
5	Settlement	0.69
Overall		4.16

2.11.11 Areas that need improvement

Malawi's FOLU sector plays a significant role in GHG emissions reporting. Improving LULUCF reporting requires addressing gaps in data, methodology, and institutional frameworks for each category: forestland, cropland, grassland, wetland, and settlements. Here are the potential areas of improvement for each category:

1. Forestland
    - Incorporate and improve tracking of biomass loss due to charcoal production.
    - Improve reporting on community woodlots, natural regeneration, and forest conservation efforts.
2. Cropland
    - Implement better methodologies to track soil organic carbon changes
    - Enhance reporting on emissions from biomass burning and promote residue management practices.

3. Grassland
    - Improve assessment of land degradation due to overgrazing and unsustainable livestock management.
    - Enhance monitoring of emissions from grassland burning, particularly in savanna ecosystems.
4. Wetlands
    - Establish monitoring systems for methane fluxes from dambos and floodplain ecosystems.
    - Strengthen tracking of deforestation and restoration projects along Lake Malawi and coastal areas.
5. Settlements
    - Enhance data collection on household charcoal and firewood consumption, as well as alternative energy adoption.
    - Incorporate carbon sequestration from urban tree planting and green spaces in emission reporting.
6. General Cross-Cutting Improvements
    - Shift from default Tier 1 emission factors to country-specific factors where possible.
    - Strengthen institutional and technical capacity for data collection, analysis, and reporting.
    - Align LULUCF reporting with Malawi's Nationally Determined Contributions (NDCs) and climate action plans.
    - Leverage local knowledge for improved data collection in remote areas.
    - Enhance appropriate archiving of data for easy retrieving and use

2.12 Waste

2.12.1 Overview of the sector and background information

According to the United Nations, about 56.2 % of the world population was living in urban areas in 2020 (UNDESA, 2020). For the least developed countries (LDC), urban population was 34.6%. In Malawi, only 16 percent of the population resided in the urban areas of the country in 2018; urban areas refer to the four major cities of Blantyre, Lilongwe, Mzuzu and Zomba, towns, Bomas, and gazetted town planning areas (National Statistical Office, 2018). The rate of urbanisation is high in the low-income countries like Malawi as people migrate to the cities in search of jobs and better quality of life. However, lack of planning for urbanisation often results in a number of social, economic and environmental challenges (UNHABITAT, 2023). One of the environmental challenges associated with urbanisation is waste generation and its management (Gondwe et al).

Solid wastes are generally categorized into municipal solid waste (MSW), sludge, industrial and other wastes. MSW includes household waste, garden(yard) and park waste, commercial and institutional waste. Sludge includes materials from domestic and industrial wastewater treatment plants, whereas industrial waste includes organic solids from construction debris, and the other waste includes clinical, hazardous and agricultural wastes. Municipal solid waste mainly comprises food waste, organic waste from gardens and parks, paper, cardboard, wood, textiles, rubber, leather, plastics, metal, and glass (pottery and Chinaware), among many others (IPCC, 2006). Studies on waste generation have been carried out in the past. However, waste generation data in Malawi has not been done systematically over the years. Although there have been a numbers of studies in waste characterization and management, none of the researches have done detailed proximate analysis in the IPCC format (NCST, 2014; JICA, 2019; Gondwe, Chiotha, Mkandawire, Munthali, & Kawiya, 2019b). Therefore, a default waste composition suggested by IPCC (2019) was applied (Figure 2-40).

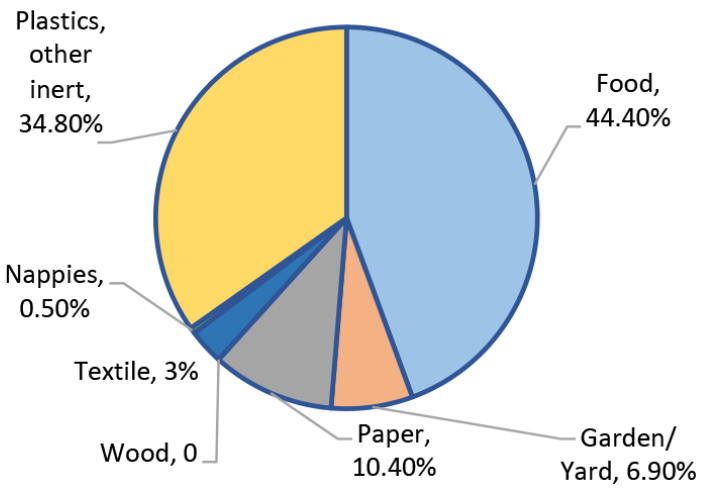


Figure 2-41: Composition of waste going to solid waste disposal sites

In terms of waste generation rates, a few studies were done but the data could not be generalized due to limitation in sample size (Gondwe, Chiotha, Mkandawire, Munthali, & Kawiya, 2019b; NCST, 2014). In Malawi, the waste generation, composition and management is affected by social, economic, technical and regulatory/ policy factors. Although Malawi is seeing an increasing number of individuals and organisations collecting, recycling and reusing wastes, the majority still consider wastes as valueless material resulting in uncontrolled dumping. Waste collection services are available only to planned high and middle-income groups who constitute about 30% of the population. In addition, it has been shown that solid waste generation rates and composition depend on income levels especially in cities and other urban areas (Gondwe, Chiotha, Mkandawire, Munthali, & Kawiya, 2019b; NCST, 2014). The economic capacities by the local authorities are low. Resource limitations further affect the local councils' ability to procure the minimum numbers and diversity of basic waste handling and transporting equipment, engineered waste management sites and laboratory facilities for waste characterisation. Furthermore, at regulatory level, local councils are delegated to handle and manage wastes but without associated budgetary support.

Table 2-64 and 2-65 show national statistics on waste disposal types and type of toilets accessed by different population categories.

Table 2-64: Statistics on waste disposal type by population category (%)

Population category	Type of waste disposal						
	Waste bin	Waste pit	Burning	Public heap	Other	None	Total
Malawi	3.8	59.2	4.9	8.5	1.4	22.2	100
Rural	2.1	58.6	4.9	8.6	1.3	24.5	100
Urban	12.4	62.2	5.2	7.8	1.9	10.5	100
Northern Region	8.1	63.9	0.7	2.1	1.7	23.5	100
Central Region	3.1	59.5	5.7	10.7	1.1	19.9	100
Southern Region	3.2	57.6	5.4	8.2	1.6	24.0	100

Table 2-65: Statistics on access to and type of toilet facility by population category (%)

Population category	Access to improved toilet	Type of toilet facility						
		Flush toilet	VIP latrine	Pit latrine with slab	Pit latrine without slab	None	Other	Total
Malawi	35.4	2.3	1.2	31.7	54.7	8.9	1.2	100
Rural	29.3	0.4	1.2	27.7	59.1	10.2	1.4	100
Urban	65.5	11.7	1.3	52.5	32.0	1.9	0.6	100
Northern Region	43.7	2.7	0.6	40.4	46.6	9.3	0.4	100
Central Region	38.0	2.3	0.5	35.2	52.7	8.6	0.7	100
Southern Region	30.2	2.1	2.0	26.0	58.8	9.0	2.1	100

Source: Adapted from the Fifth Integrated Household Survey (IHS 5), NSO (2020)

By 2020, the report showed that 59.2% of Malawians used rubbish pits as main means of disposal of wastes. Access to improved toilet facilities was at 35.4%. Even for the urban areas, less than 12% had access to flush toilets (National Statistical Office, 2020).

Sources of data for the waste sector were from 31 urban areas including published data in the literature and online sources. Malawi specific waste generation of 0.18Kg per capita was used following updated 2019 IPCC guidelines refinement. As per the same refinement, urban population which is 16% of the total national population was used in the GHG emission estimation.

2.12.2 Source category description

The sources of emission from waste sector are shown in Table 2-66.

Table 2-66: Sources of CH_4 emission from waste sector

Emissions sources	Sources included	Method	Emission factors reference
5.A.1.a.ii	Solid waste disposal – unmanaged shallow sites	Tier 1	IPCC (2006) Table 3.2
5.A.1.b.	Solid waste disposal – uncategorised sites	Tier 1	IPCC (2006) Table 3.2
5.C.2.	Open burning – solid waste	Tier 1	IPCC (2006) Table 5.1
5.D.1.a.i	Domestic wastewater – centralized treatment	Tier 1	IPCC (2006) Table 6.2
5.D.1.a.ii	Domestic wastewater – septic systems	Tier 1	IPCC (2006) Table 6.2
5.D.1.a.iii	Domestic wastewater – latrines	Tier 1	IPCC (2006) Table 6.2

2.12.3 Total GHG Emissions by category and gas type- time series 1994 to 2022

2.12.3.1 Emission factors

The summary of emission factors applied in the waste sector are shown in Table 2-67.

Table 2-67:Source emission factors for waste sector

Emissions sources	Sources included	Tier-1 Default Emission Factor / Parameter	Emission factors reference
5.A.1.a.ii	Solid waste disposal – unmanaged shallow sites	Methane Correction Factor (MCF) = **0.4**	IPCC (2006) Table 3.1
5.A.1.b.	Solid waste disposal – uncategorised sites	MCF = **0.6**	IPCC (2006), Table 3.1
5.C.2.	Open burning – solid waste	CH_4 EF = 6,500 g CH_4 / tonne MSW (wet weight) N_2O EF = 150 g N_2O / tonne waste Oxidation factor for CO_2 = 58% of carbon input	IPCC (2006) Tables 5.2 & 5.6

5.D.1.a.i	Domestic wastewater – centralized treatment	CH_4 maximum producing capacity (Bo) = 0.0 kg CH_4 / kg BOD + MCF varies by treatment pathway; N_2O EF (effluent discharge) = 0.005 kg N_2O-N / kg N	IPCC (2006), Chapter 6, Table 6.2 & Section 6.3.1.2
5.D.1.a.ii	Domestic wastewater – septic systems	MCF for septic systems = 0.5 (used in combination with Bo above) N_2O EF=0.3 kg/ person/year	IPCC (2006), Chapter 6
5.D.1.a.iii	Domestic wastewater – latrines	MCF for latrines = 0.1 CH_4 EF calculation uses that with Bo; N_2O EF =0.06kg CH4/kg BOD	IPCC (2006), Chapter 6

Figure 2-41 shows GHG emissions in the waste sector by category type for the period 1994 to 2022.

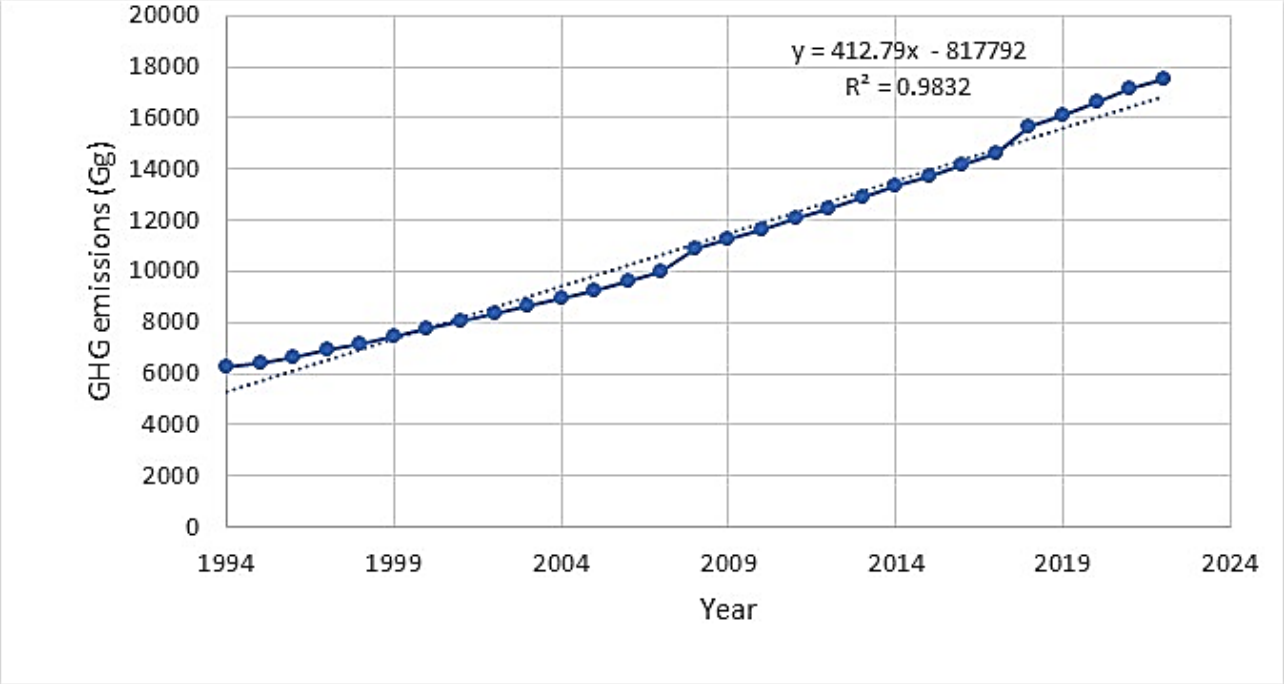


Figure 2-42: Total GHG emission in waste sector for 1994 to 2022

The analysis shows that the emissions were growing at an average rate of about 413 Gg per annum, starting at 6474 Gg of CO_2e in 1994 to 17548 Gg of CO_2e in 2022. The steady increase in the emissions was mainly driven by rapid increase in population which is growing at 2.8% per annum and stagnation of infrastructure and operation budget to support waste management activities.

Figure 2-42 shows total GHG emissions by gas type contributions.

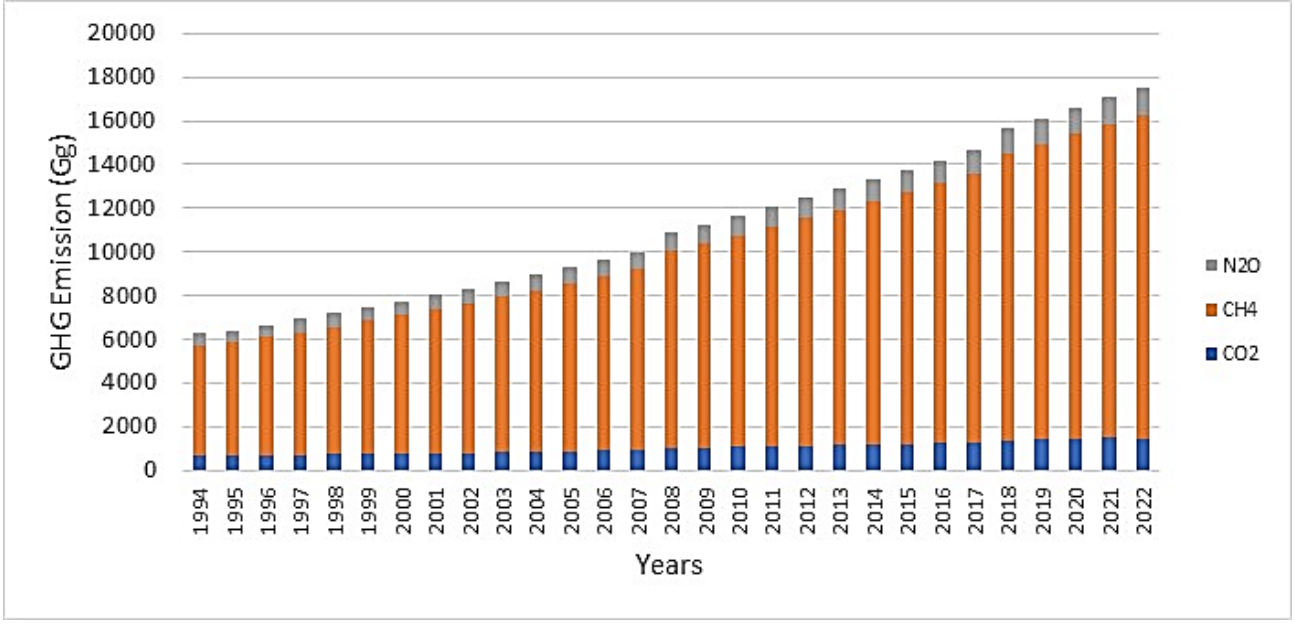


Figure 2-43: GHG emissions for waste sector by gas type for 1994 to 2022.

The analysis of emissions by gas type based on CO_2 cumulative for the period 1994 to 2022 shows that the contributions were 9.2%, 83.1% and 7.7% for CO_2, CH_4 and N_2O respectively. Emission of CH_4 was driven by anaerobic digestion of biodegradable waste materials in unmanaged dumpsites accelerated by lack of waste management facilities.

2.12.4 Category-specific Emissions

Figure 2-43 shows emissions in the key categories in the waste sector covering Solid Waste Disposal (4A), Incineration and Opening Burning of Waste (4C) and Waste water Treatment and Discharge (4D). GHG emissions from Biological Treatment of Solid Wastes (5.B.) were not estimated due to lack of data.

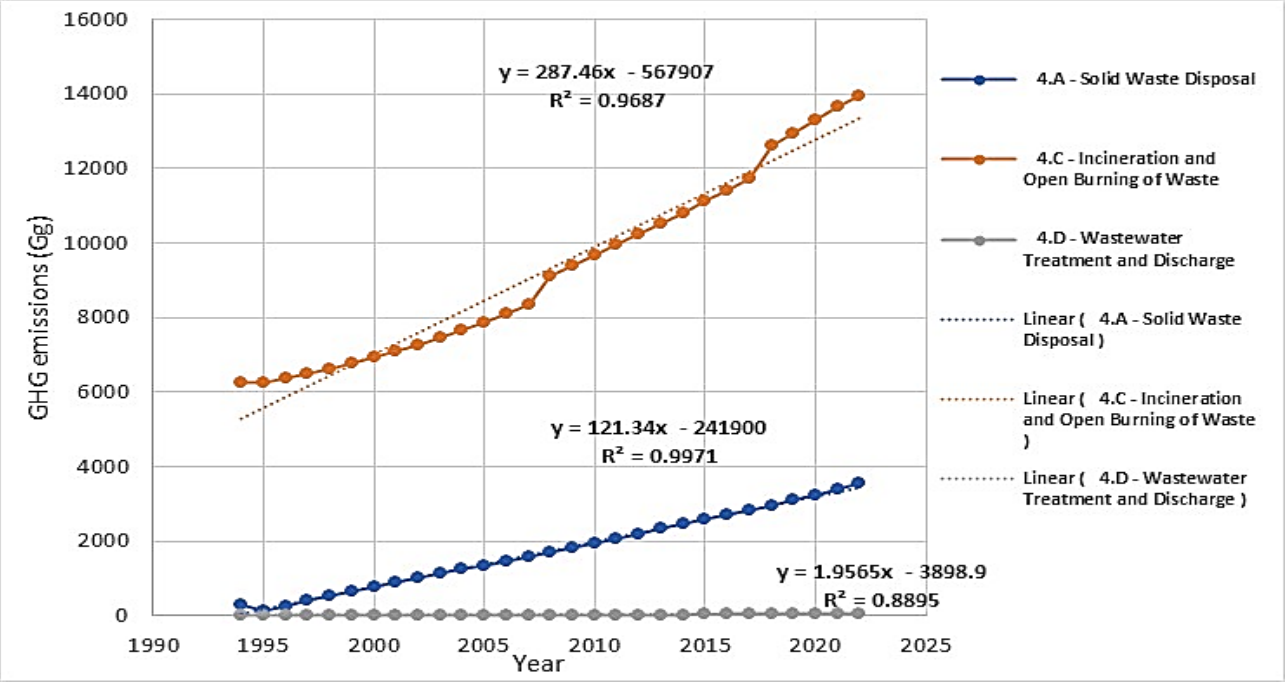


Figure 2-44: GHG emissions for waste sector by category for 1994 to 2022

The cumulative total of over the period 1994 to 2022 was 321822 Gg CO_2e . In terms of contributions by category type were as follows: Incineration and Open Burning (84%), Solid Waste Disposal (15.7%) and Waste Water Treatment and Discharge (0.3%).

i. Solid waste disposal

Solid waste disposal refers to a practice of disposing solid wastes from generation to the final disposal destination at SWDS. The waste may be separated or mixed. The disposal site may be engineered facility and unmanaged. The waste is dumped and left at the site without any management. In this situation, there is both aerobic decomposition of the top layers of waste and anaerobic decomposition of the layers below. The CO_2 produced in the MSW can be of both biogenic and fossil origin. The N_2O emissions from SWDS, by anaerobic digestion of organic matter, and mechanical–biological (MB) treatment is considered insignificant (IPCC, 2006).

Between 1994 and 2022, GHG emissions from Solid Waste Disposal grew from 294.3 Gg to 3544 Gg, with an average growth of 121 Gg per annum. The slow growth in GHG emissions in the category was mostly driven by the low waste collection in the urban areas which is estimated to be at 30%. Table 2-68 shows the activity data for solid waste disposal.

Table 2-68: Activity data for solid waste disposal

Year	Population (people)
1994	1094235
2000	1212774
2010	1688940
2017	2051865
2018	2204146
2019	2264081
2020	2325248
2021	2386770
2022	2448639

ii. Incineration and Open Burning of Waste

Incineration and open burning of waste are important sources of GHG emissions. Incineration refers to the combustion of solid or liquid waste in controlled incineration facilities. Incineration of hazardous and medical waste is not reported in this communication because of inadequate activity data. Open burning of waste refers to combustion of unwanted materials in open dump sites. It also includes burning of uncollected wastes at source practiced by households and institutions.

From the analysis, Incineration and Open Burning of Wastes grow from 6262 Gg CO_2e in 1994 to 13933 Gg CO_2e in 2022, giving an average growth of 287 Gg CO_2e per annum. The GHG emissions in this category is mostly driven by increasing urban population, low waste collection and the uncontrolled burning of wastes at open dumpsites. Table 2-69 shows the activity data for *Incineration and Open Burning of Waste.*

Table 2-69: Activity data for Incineration and Open Burning of Waste

YEAR	Total Amount of Waste open-burned (Gg Waste)						
	Food waste	Garden and park	Disposable nappies	Paper and cardboard	Wood	Textile	Rubber and leather
1994	17490.25	2718.08	196.9623	4096.81584	0	1181.774	1825.98233
2000	19384.99	3012.532	218.29946	4540.62866	0	1309.797	2023.79312
2010	26996	4195.325	304.00907	6323.38855	0	1824.054	2818.38292
2017	32797.01	5096.833	369.3357	7682.18256	0	2216.014	3424.00786
2018	35231.07	5475.098	396.74624	8252.32169	0	2380.477	3678.12326
2019	36189.07	5623.978	407.53463	8476.7202	0	2445.208	3778.1394
2020	37166.76	5775.915	418.54455	8705.72664	0	2511.267	3880.20933
2021	38150.12	5928.735	429.61847	8936.06407	0	2577.711	3982.8725
2022	39139.05	6082.419	440.75502	9167.70442	0	2644.53	4086.11638

iii. Wastewater treatment and discharge (5.D)

Wastewater treatment and discharge is liquid waste that is channelled to a treatment plant through open or closed sewer system. The wastewater treatment may be domestic or industrial in nature. In Malawi however, some sewer systems are mixed. In terms of infrastructure, there are four plants in Blantyre (3 domestic and 1 mixed), one plant in Lilongwe (mixed), one plant in Zomba (domestic) and no plant in Mzuzu. Emissions from Wastewater treatment and discharge is influenced by per capita protein intake. It should be noted that the sewer system capacity is low and no new infrastructure has been constructed in recent years. Most of new residential areas and institutions have isolated septic tanks.

Between 1994 and 2022, GHG emissions from Waste Water Treatment and Discharge grew from 11 Gg CO_2e to 71 Gg CO_2e, with an average growth of 1.97Gg CO_2e per annum. The slow growth in GHG emissions in the category was mostly driven by the low infrastructure capacity to treat domestic and industrial wastes.

Table 2-70: Number of people accessing different types of waste water treatment technologies

YEAR	Population - P (Capita)/ Waste water treatment technologies		
	Sewered	Septic Tank	Improved Latrine
1994	100984.3	151198.43	224178.6058
2000	101582.8	184277.84	407679.6087
2010	138230.2	275705.38	894746.677
2017	177440.4	379192.34	1673462.453
2018	184236.1	397540.59	1816988.538
2019	191408.5	417011.99	1970671.301
2020	198969.8	437659.1	2135180.291
2021	206847.8	459348.86	2310271.856
2022	215078	482183.55	2496829.913

2.12.5 Time-series consistency and recalculations

In order to produce credible time series in the waste sector, 2006 IPCC guidelines were used together with 2019 refinement for default per capita municipal solid waste generation. Malawi per capita MSW generation is pegged at 0.18kg and methane emission factor for MSW for unmanaged shallow solid waste dumpsite is 0.4 were used. Recalculations have been done because we have added new data sources, e.g. per capita protein intake in the wastewater treatment and discharge. Also added uncategorised solid waste disposal in this assessment. Population increase over the years has contributed greatly to the data volume compared to the last national communications.

2.12.6 Planned Improvements for the Waste Sector

During the analysis of the waste sector, GoM has experienced several challenges in various area that would require improvements over time. These include but not limted to the following:

i. There is a lack of continuous collection of activity data in the waste sub-sectors. To improve this, data collection personnel should be trained and capacitated to collect and submit the same as part of their monthly reports to responsible offices;

ii. Malawi needs to undertake studies to come up with country specific waste emission factors and this will require resources;

iii. There is need to invest in waste management infrastructure and facilities (engineered waste collection and treatment facilities, waste collection truck, weigh bridges and waste water treatment plants) in the growing industrial and urban areas. With such facilities, data quality could be improved and uncertainties reduced;

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3.0 TRACKING PROGRESS MADE IN IMPLEMENTING AND ACHIEVING MALAWI'S NATIONALLY DETERMINED CONTRIBUTIONS UNDER ARTICLE 4 OF THE PARIS AGREEMENT

3.1 National Circumstances and Institutional Arrangements

3.1.1 National Circumstances

In line with paragraph 59 of the MPGs, "*Each Party shall describe its national circumstances relevant to progress made in implementing and achieving its NDCs under Article 4 of the Paris Agreement, including: Government structure; Population profile; Geographical profile; Economic profile; Climate profile; and Sector details*", the following national circumstances for Malawi are presented.

3.1.1.1 Government structure

The Government of Malawi is a democratic republic with a multi-party system, featuring a presidential head of state and a unicameral legislature. Governing the country is based on the Malawi constitution. Before, Malawi was a British Protectorate and it got independence from Britain in 1964. From 1971 to 1994, the country was governed based on one-party state principle. Multiparty Democracy reintroduced in 1994. The country has Central Government and Local Government system. The Central Government is made up of three branches that have separate powers: executive, legislative, and judicial. The Executive Branch comprises of The President, who is both head of state and head of Government, and is elected by popular vote. The President appoints a Cabinet, which advises and supports the President. The Office of the President and Cabinet (OPC) provides support and oversight leadership in the public service, according to the Government of Malawi.

The Legislative Branch of Government of Malawi is the National Assembly, a unicameral legislature. The National Assembly is responsible for making laws, providing an oversight role on the Executive Branch of the Government, and representing the people of Malawi. It is the supreme legislative body and holds the ultimate power over other political bodies in the country. The National Assembly used to consist of 193 Members of Parliament (MPs), but from 2025 elections, the number of MPs will be 229 following re-demarcation and the subsequent increase in number of constituencies by the Malawi Electoral Commission. Members of Parliament are directly elected by the people in single-member constituencies using the first-past-the-post system. The Legislative Branch is led by the Speaker of Parliament, who is elected by the MPs. Members of Parliament serve five-year terms, unlimited.

Judicial Branch (or Judiciary), as another arm of the Government is made up of lower courts (subordinate courts), a High Court, and a Supreme Court of Appeal. The judicial system is based on the English model. The Judiciary is headed by The Chief Justice, who is also the head of the supreme court. It is independent of the Executive and Legislative branches. The Judiciary's main functions include interpreting and applying the law, resolving disputes, and reviewing government actions for conformity with the Constitution. The Judiciary aims to provide access to justice for all citizens and offers various services to facilitate this.

Local Government in Malawi is governed based on mandate enshrined in the Constitution (1994), the Local Government Act (1998), and the National Decentralization Policy (1998). The country operates a single-tier local government system; and it comprises of 28 district councils, 4 city councils, 2 municipal councils, and 1 town council. Local authorities are responsible for local governance and development. The local Government affairs are under the Ministry of Local Government. Following the enactment of the Local Government Act and coming up of Decentralization Policy, most of the Government Departments have incorporated decentralization, which helps in managing activities related to implementation of Government development activities, such as projects related to implementation of NDCs measures at local levels. Local Governments play a crucial role in development, because they act as a bridge between citizens and the Central Government structure. They are responsible for promoting local development, including infrastructure and economic growth, and ensuring effective service delivery to citizens. Local Governments also facilitate citizen participation in development initiatives, promoting accountability and responsiveness.

Despite having governance structures in place, Malawi has experienced more environmental damage (forest degradation and deforestation) in the multiparty democratic era than during the one-party era, manifested by unabated cutting down of trees for charcoal and individuals selling charcoal that is displayed openly along the main roads. This could point to challenges in regulation and enforcing of laws during this democratic era.

3.1.1.2 Population profile

Population of Malawi, in 2024, was estimated to be around 22.216 million people and is growing at a rate of 3% per year (Statista, 2025). With a land area of 94,280 km^2, this gives a population density of close to 240 people per km^2, placing the country among African countries with high population density: Rwanda, 561 people per km^2, Burundi, 560 people per km^2; Nigeria, 261 people per km^2; and Uganda 257 people per km^2 (Wordometer, 2025). Spatially, 44% of the population lives in the south, 43% in the centre, and 13% in the north. Only 16% of the population live in the urban areas while the rest, 84%, live in the rural areas. Women comprise 51% and men 49% of the population (World Bank, 2025). About half of the population is 18 years or older.

Average life expectancy is approximately 63 years as of 2023, which is still below the average life expectancy for Africa, which is estimated at 64.5 years in 2023 (World Bank, 2025).

High population density would lower investment cost to implement some of the NDC measures cost per unit of people served. For example, in a densely populated township, the distribution cost of grid-based electricity supply per unit number of people is lower. Also, a high population would provide market to NDC measures that are implemented using market approach, for example, biomass cookstoves. On the other hand, high population density exerts pressure on natural resources (like trees and forests) for a livelihood. For example, charcoal trade in Malawi, which could erode gains in the emission reduction realized from implementation of NDC measures. Further, population profile where majority are in rural areas (where most of trees and forests degradation and deforestation take place), make implementation of NDC measures that result in arresting forest degradation and deforestation meaningful. Implementation of such measures is likely to be supported by key stakeholders like development partners.

3.1.1.3 Geographical profile

Malawi is a landlocked country, located in southern-eastern Africa, nestled along the southernmost part of the East African Rift Valley System. The country is bordered by Tanzania to the north and northeast, Mozambique to the south, southwest, and east, and Zambia to the west. Stretching about 910 kilometres in length and ranging from 60 to 161 kilometres in width, Malawi covers a total area of 118,484 square kilometres. Of this, 80% of square kilometres) is land, while the remaining 20% is water taken up by the vast Lake Malawi. Malawi is divided into three main regions: Northern, Central, and Southern regions, each with distinct geographical and cultural characteristics. The Northern Region, known for its highlands and mountains, including the Nyika Plateau, has Mzuzu as its administrative and commercial centre. The Central Region, dominated by the capital city Lilongwe, is a hub of political and economic activities and is experiencing rapid urbanization and infrastructure development. The Southern Region, the most densely populated, includes the commercial capital Blantyre and Zomba, the former capital city, known for its attractive plateau.

Being a landlocked, the country faces logistical and transportation challenges, which affect implementation of projects. Most of the imported goods and materials come via Beira and Dar es Salaam ports in Mozambique and Tanzania respectively. With logistical and transportation challenges, timely completion of power plants construction to implement NDCS measures related to hydropower and solar PV would be affected, making projects longer to construct and relatively expensive. Currently, the Government of Malawi is prioritizing rail transport, demonstrating it through investment in the Nacala Corridor. The Nacala Corridor has started to be used in transporting oil from Nacala port into the country, Lilongwe (NOCMA,

2024). However, being a demonstration project, it is hoped that the Government and other business partners will increase usage of the Corridor as one of the important import routes. Doing so could lower transportation costs.

3.1.1.4 Economic profile

The economy continues to face serious difficulties. Malawi is one of the least developed countries, with a GDP per capita of 602.3 USD in 2023 (World Bank, 2024). The country faces several chronic challenges including poverty, reliance on donor funding, limitation on foreign dominated currency, and vulnerability to climate shocks. This scenario would limit the buying power for energy products related to NDCS measures. According to the World Bank and reported by Lloyds Bank, in 2023, real GDP grew by just 1.6% year-on-year, constrained by limited access to inputs due to foreign exchange shortages and the effects of Tropical Cyclone Freddy (Lloyds Bank, 2024). Forex challenges would also delay completion of projects, and would therefore affect implementation of project based NDCS measures like large-scale hydropower and grid connected solar PV.. In 2024, the real GDP growth slowing to 1.8% amid a severe drought and persistent foreign exchange constraints. Real GDP is projected to grow modestly by 2% in 2025, supported by a partial recovery in the agricultural sector. However, growth in the industrial and services sectors is expected to remain subdued due to ongoing foreign exchange shortages, which continue to limit the import of production inputs. In 2026, GDP growth is forecast at 2.4%.

The economy of Malawi is a predominantly agricultural-based one, with the sector contributing about 30.4% of GDP, 80% of export revenue, and 61.7% of employment (Lloyds Bank, 2024). Agriculture remains the greatest contributor to employment. Tobacco is the most important export crop providing most of forex, followed by tea, sugar, and coffee. Agricultural sector is dominated by rain-fed, which is vulnerable to droughts and flooding. The other economic sectors are mining, tourism and industry. Despite poor showing on economic performance, the country is endowed with several policy documents to turn around the economic situation of the country. For example, The Government of Malawi has come up with Agriculture, Tourism and Mining (ATM) Strategy to recover and boost the country's economy, in line with the overarching economic development policy, The MW 2063. Through the ATM Strategy (which is budgeted), the Government supports investments in various agricultural projects such as mega farms for increased production in the agricultural sector. Mega farms require enormous amounts of chemical fertilizer for example urea, which increases GHG emissions in the agriculture sector. Also, the Government is promoting irrigation on large scale through the same ATM Strategy. Commercial irrigation requires energy to power irrigation pumps. This provides opportunity to apply off-grid solar in irrigation, providing opportunity for implementation of NDCs measure on off-grid solar PV.

The growth rate for agriculture industry in 2022 was recorded at 0.9% from 3.8% recorded in 2021. This positive but slow growth was largely attributed to the adverse weather conditions experienced in 2022 as the country was hit by Tropical cyclones, Anna, Gombe, Dumako and Freddy which affected crop and animal production. The cyclones also affected large-scale agriculture, such as tobacco and sugarcane production. The industry's growth rate for 2023 was estimated at 0.8%, a slight decline in performance compared to 2022. The country experienced unfavourable weather conditions in form of Tropical Cyclone Freddy (TCF) and incessant rainfall which affected crop and animal production. This resulted in poor production in the main crops such as soybean. According to the 2023 Post-Disaster Needs Assessment (PDNA) report, losses caused by TCF to the crop and livestock industry were estimated at USD55.01 million and USD3.04 million, respectively, across all the 16 affected districts. Furthermore, the northern region was affected by dry spells, which undermined rice production. In addition, the government experienced operational challenges in the procurement and distribution of affordable inputs prior to, and during the farming season. This had a detrimental impact on small-scale agriculture, hence affecting production.

Tourism sector is considered a priority economic sector in the country's long-term development plan, the Malawi 2063. The sector contributed 6.7% to GDP in 2024 (MCCCI, 2024). However, it is affected by climate change impacts through destruction of infrastructure such as access roads to tourism sites such as national parks and game reserves, loss of biodiversity that attract tourists, and increased illegal livelihood activities on protected sites arising from surrounding communities as part of climate change coping endeavours. In 2024, rising water levels in Lake Malawi disrupted activities of most hotels along the Lake leading to closure of notable hotels. Also, prevailing economic environment of higher macroeconomic imbalance evidenced by rising fuel and food costs has not only affected the operational costs for businesses in the sector but also reduced demand for accommodation services. Higher inflation has eroded the buying power of consumer income thereby reducing the amount of income allocated towards domestic tourism. Therefore, NDCS measures related to adaptation would find relevance and supported.

Mining sector is among the sectors prioritized in the ATM Strategy to contribute significantly to economic development. Government has established a public company to spearhead mining trade in the country, called The Malawi Mining Investment Company (MAMICO). The company, launched in February 2025, is a body corporate established with the mandate of promoting the optimal development of the mining sector and maximization of national revenue and social benefits. MAMICO aligns with national development goals, notably the MW2063, which highlights mining as a priority sector under the Industrialization pillar. Previously, from 2009 to 2014, the mining sector contributed a significant share (around 10%) to the GDP, from the Kayelekera Uranium Mine in Karonga District (north of Malawi).

However, since 2014, the uranium mine went into care and maintenance phase due to a depressed international uranium market. In 2021, Lotus Resources Limited of Australia, bought Kayelekera Uranium Mine from Paladin Africa Limited; the company started that it is ready to start uranium mining in the third quarter of 2025 (Lotus Resources Limited, 2024). In the years 2000s, the country has registered several mining interests in rare earth minerals, the country being one of the countries endowed with rare earth mineral resources. Kangankunde in Balaka District and Songwe Hill in Phalombe District are key examples of areas with notable rare earth mineralization in Malawi. Kangankunde project, implemented by the Lindian Resources (an Australian Company), is one of the largest rare earth deposits in the world, and mining activities are stated to commence in 2026 (Times Malawi Limited, 2024). The planned extractive mining activities require firm energy supply, which is currently limited. Therefore, implementation of NDCS measures related to large scale hydropower and grid connected solar PV would provide firm energy for mining activities.

3.1.1.5 Climate profile

Scientific evidence in Malawi shows increase in the frequency, intensity and magnitude over the last two decades of extreme weather events (GoM, 2016). Further, it is also reported that Malawi is progressing to a warm climate system with increase in average temperatures. The country has witnessed increased incidence of extreme temperatures (heatwaves), and has high levels of unpredictability with respect to onset and duration of precipitation. All these points to climate change. The warm climate increases the cooling load during summer, and thus increases energy demand for heating ventilation and air-conditioning (HVAC) systems especially in urban areas. Malawi is vulnerable to impacts of climate change; particularly to floods, droughts and strong winds associated with tropical cyclones. Most of the drought episodes that Malawi experiences are caused by the El Nino and the Southern Oscillation phenomena, with serious impacts on crop and livestock production. Additionally, the country experiences long dry spells that occasionally disrupt the rainfall season and cause crop failure. The pattern of rainfall results in the seasonality of crop production, and forces farmers to stay idle during the dry season. This gives basis for the Government and other stakeholders to prioritize irrigation, which require considerable large amounts of energy, and off-grid solar PV are favored in this situation. Flooding, which occurs on annual basis, significantly impact power production by damaging hydroelectric power stations which are located along Shire River. The damage caused power outages and reduced electricity generation, impacting the national grid and causing disruptions to economic and social activities. The Government is diversifying power generation sources as one way of adapting to impacts of climate change by power sector. Therefore, implementation of NDCS measures on large scale hydropower that are away from Shire River would get support from Government and other development partners.

3.1.1.6 Sector details

Malawi's revised NDCS identifies agriculture, energy, industrial processes and product use (IPPU), forestry and other land use (AFOLU), and waste as sectors for emission and removal of greenhouse gases. This section presents details that are necessary for tracking NDCS implementation. It starts with presenting on agricultural sector, then energy, IPPU, FOLU, and Waste. In third national communication (TNC), agriculture accounted for by far the largest share of the total emissions excluding FOLU (5.07 million tCO_2e, 54% of total), followed by Energy (2.34 million tCO_2e, 25% of total) and waste (1.67 million tCO_2e, 18% of total). Emissions from IPPU represented just 0.24 milliontCO_2e, equivalent to around 3% of total emissions in 2017 (mainly associated with calcination CO_2 emissions from minerals production). Emissions from livestock, predominantly methane from enteric fermentation in cattle, represented the largest emissions source category, followed by N_2O emissions from managed soils in crop production. Following these agriculture sources, major sources included CO_2 emissions from fossil fuel use in transport, which accounted for 11% of the total, and methane emissions from unmanaged waste disposal site (dumps), which accounted for 13% of the total. Dependence on chemical fertilizer coupled with support from Government for small-scale household farmers to access chemical fertilizer, increases N_2O emissions. This would affect achievement of emission reductions in the agriculture sector.

The energy sector is an important sector in the social and economic development of any country. In Malawi, the energy supply sub-sector is characterized by predominant supply of biomass energy in form of firewood and charcoal, which are is sourced from trees and forests unsustainably. Modern form of power, electricity contributes less than 3% to the energy supply mix. Almost all of electricity is generated from hydropower plants that are in the Shire River, south of the country. The installed hydropower electricity is around 400 MW. While hydropower is a renewable energy resource, generation of hydropower electricity in Malawi is challenged by impacts of climate change that damage the power infrastructure, such as flooding and droughts. The power sector is one of the sectors that is vulnerably to climate change in the country. The Government plans to develop other power systems away from Shire River to diversify sources of electricity.

Malawi's energy supply mix is dominated by biofuels, mostly fuel wood and charcoal. Other biofuels are bagasse used in generation of electricity used at sugar producing companies (Illovo Nchalo, and Illovo Dwangwa), as well as fuel-grade ethanol which is produced by Presscane Limited and Ethanol Company Limited . The other energy sources are petroleum products (petrol, diesel, aviation fuels and liquified petroleum gas (LPG), which are wholly imported. A considerable share of energy is also supplied from renewables: hydropower and solar radiation, which are mostly into generation of electricity both on-grid and off-grid. Finally, coal is also a

form energy supply used mostly in tobacco processing and beverage industries for supplying process steam. A significant amount of coal used in the country is mined in the northern part of the country. Some of the coal is imported into the country from neighboring countries, mostly from Mozambique. The Government plans to construct a 350 MW coal powered thermal power plant in Kam'mwamba in Neno District (southern part of Malawi), with Electricity Generation Company to source financing for the project. If this coal powered project materializes, coal will contribute a significant share in the energy supply mix. According to the 2020 energy balance produced by the ministry of energy, the energy supply mix for a total of 4902 kToE was as follows: biofuel 85.6%, petroleum products 10.2%, hydropower and solar radiation 3.3%, and coal 0.9%. There are plans to import electricity once the Mozambique-Malawi Interconnector Project finalizes, that will add electricity supply of 150 MW.

In terms of energy consumption sub-sector, the household sector consumes the largest share of energy supplied at 80%. Industry and transport sectors both consume 9% each while other sectors (commercial and agriculture) account for about 2% of the total energy use by the consumers . Energy consumed in the mining sector is quite minimal, though it would pick up when planned mining projects materialize. Electricity is used in all economic sectors, but the main demand are from the food and tobacco and services (or commercial) sectors which are estimated consume over two-thirds of the electricity supplied to business. Petroleum products namely (petrol, diesel, aviation fuels and LPG are mostly consumed in the transport sector, with the road transport (petrol and diesel) dominating, followed by civil aviation (aviation fuels; aviation gas and jet kerosene), then rail and waterborne navigation. The manufacturing and construction (in the category of other sectors) also consumes petroleum products for self-generation of electricity and shaft power to run machines/plants such as those in the construction sector.

Malawi's mining sector is in its infancy stage compared to neighboring countries like Zambia and Tanzania. It is mainly into quarrying and small-scale mining of precious stones like gold, which cause environmental degradation. Small-scale mining of gold is regulated, but the country finds challenges in controlling the illegal mining activities, which have created gullies along river banks and other areas. In the early 2010s, mining activities contributed significant contributions to countries GDP, mainly from Kayelekera Uranium Mining in Karonga District, which is now under care and maintenance. Malawi is reported to possess relatively huge deposits of rare earth minerals, which could be used as critical minerals in producing components used in renewable energy industry. Also, it is reported that there are prospects of oil in the Lake Malawi, but exploration for it has not yet started. Mining sector would be among major energy consumers in the near future, favouring implementation of NDCS measures on grid-connected hydropower and solar energy.

Malawi faces a decrease in tree and forest cover due to deforestation. This could lead to desertification, if it is not controlled. The forest cover was 47% in 1975, 36% in 2005 (Mauambeta, et al., 2010) and 33% in 2015 (FAO, 2015). The deforestation rate is at 2.8% per year, thus losing about 250,000 ha of forest cover per year (GOM, 2016). The human activities are the major causes of deforestation and forest degradation, such as expansion of farming land and other land uses, extensive biomass harvesting for household fuel and tobacco curing energy supply, selective tree felling for timber and curios, uncontrolled forest fire (which is also blamed on arsonists, especially in industry forest like Viphya Plantations), and tree debarking for herbal medicine and honey harvesting from trees. Deforestation and forest degradation are exacerbated by population pressure, poverty and limitations in alternative livelihoods.

3.1.2 Institutional Arrangements

Government of Malawi has put in place robust national planning process involving pillar, enabler, sector and district level coordination structures that are coordinated by the National Planning Commission (NPC) for medium to long term plans and strategies, and the Ministry of Finance and Economic Affairs, and Public Sector Reforms (MOEPD&PSR) through sector working groups (SWGs) that track the short term implementation of sector priorities aligned with the goals of the MW2063, The MW2063. Implementation of NDCS measures falls under Environmental Sustainability enabler for achievement of Malawi 2063. Given the cross-cutting nature of environmental sustainability matters, there is a National Steering Committee on Climate Change (NSCCC) and the joint Technical Committee on Climate Change and Disaster Risk Management (TCCC&DRM) that define multi-year pillar and enabler priorities as well as advising Government on the resources required for meeting the defined Vision priorities within their respective pillars and/or enablers. The NSCCC and TCCC&DRM shall receive policy and implementation oversight from the NPC through the Enabler Coordination Group on Environmental Sustainability (ECGES). The NSCCC comprises all key ministries and departments and provides strategic direction and inter-ministerial coordination on national climate change policy including Malawi's NDCS. Figure 3-1 summarizes the institutional arrangements for tracking of NDCS implementation in a transparent manner.

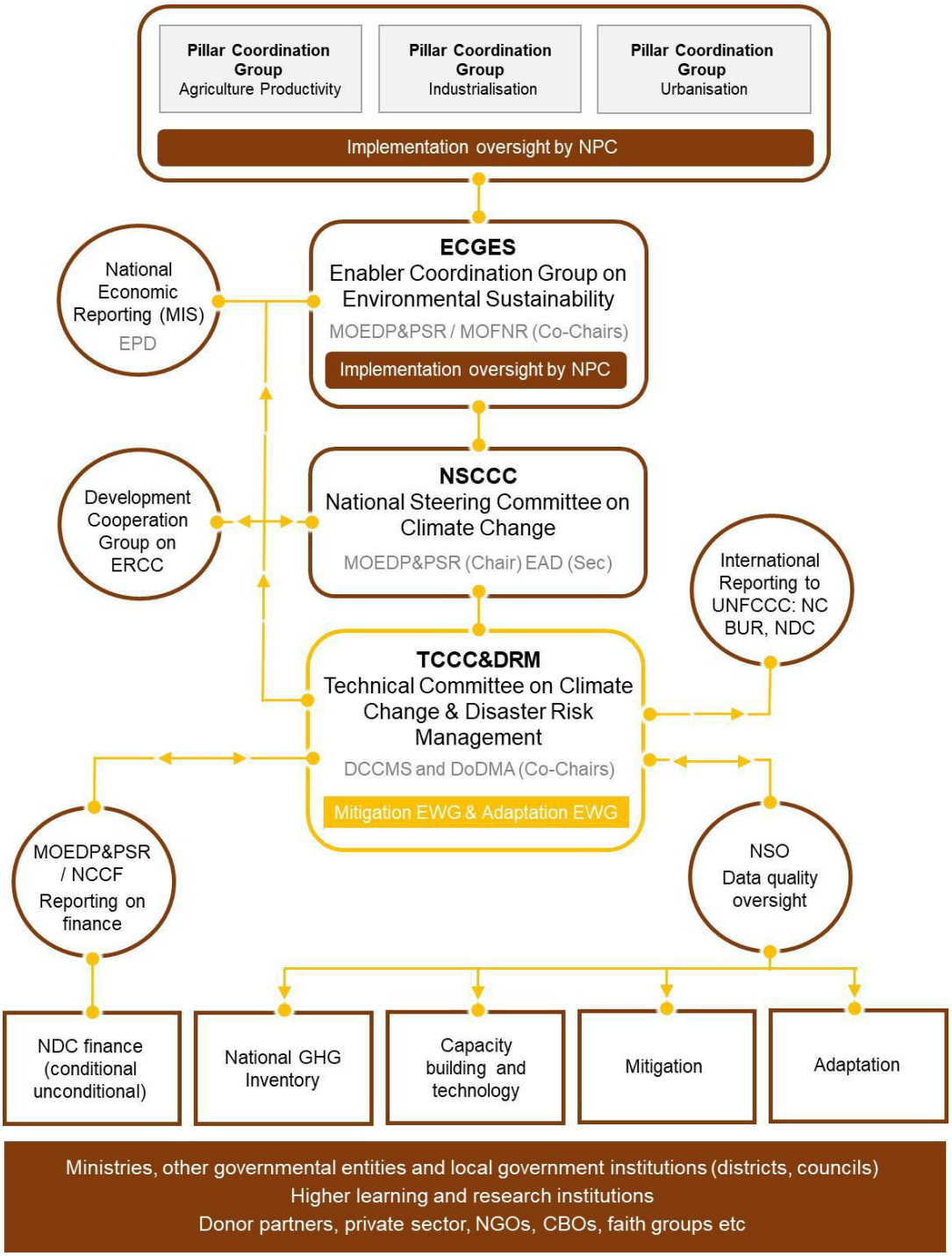


Figure 3-3-1: Institutional arrangements for tracking Malawi's NDCS implementation

In relation to MPG paragraph 61, the institutional arrangements available in Malawi to track progress made in implementing and achieving its NDCS measures are presented and explained in Table 3-1. Basically, the two Government departments listed in the table are mandated to firstly assess impacts of any project that can affect the environment and climate system in Malawi, before the project can proceed to construction stage. The institutions are also involved in monitoring and reporting impacts of such projects on environment and climate system. These arrangements therefore, are central in tracking progress made in implementing NDCS measures.

Table 3-3-1: Institutional Arrangements to track progress made in implementing Malawi's NDCS under article 4 of Paris Agreement

Arrangement/Institution	Role in tracking progress made in implementing and achieving its NDCS measures
Environmental Affairs Department in the Ministry of Natural Resources and Climate Change	1. It is a focal point for handling all of climate change related activities in Malawi, including implementation of NDCs measures. It is a requirement of the Government that all climate change activities are recorded and reported to EAD 2. EAD is the authority in policies on environment and climate change management. The institution provides policy guidance to public and private organizations/companies that implement NDCS measures. Documentation of engagements in policy guidance provides useful information on tracking of progress made in implementing the NDCs 3. Thirdly, the EAD performs the role of supervision, monitoring and coordination over all matters relating to the environment, natural resources and climate change management. This provides space to track and record progress in implementing NDCs 4. EAD has a unit to record and archive data related to project they carryout and reported to them, such as those related to NDCS implementation.
Malawi Environmental Protection Agency (MEPA)	1. MEPA is a newly institution, established by the Environment Management Act (2017) with the mandate as the principal agency for the protection and management of the environment and sustainable utilization of natural resources in Malawi. 2. One of the functions of MEPA review and approve environmental and social impact assessment, strategic environment environmental assessments and other relevant environmental assessments in accordance with Environment Management Act (2017). In this, NDCS measures such as those involving large scale hydropower projects and grid connected solar PV undergo assessment of it impacts including its GHG and non-GHG impacts. 3. It also the function of MEPA to supervise, monitor and coordinate over all matters relating to the environment, natural resources and climate change management. 4. Further, MEPA is mandated to prepare and publish a National State of the Environment and Outlook Report every five (5) years and annual report on the status of the environment. The process of preparing the report involves analyzing impacts that projects on the environment and climate system of Malawi. This provides space for projects related to NDCS implementation to have its impact evaluated and published for dissemination, helping to track its implementation progress.

Malawi as a Party recognizes that participation in Internationally Transferred Mitigation Outcomes (ITMOs) is on voluntary basis. In accordance with Article 6 of the Paris Agreement, Parties participating in must apply a robust accounting system to avoid double counting, and must ensure proper governance structure to oversee ITMOs transaction and to ensure transparency in reporting ITMOs in BTRs. In terms of accounting for ITMOs, Malawi has adopted a GHG Inventory

Management System, where data providers for quantifying mitigation outcomes (emission reductions and removals) are identified and engaged. These would isolate data for tracking implementation of Malawi's NDCs and data for ITMOs from the various carbon trading projects in Malawi. The EAD has a separate unit for managing ITMOs in Malawi. Among others, this unit is responsible for estimating carbon credits from carbon trading application projects in Malawi, using 2006 IPCC Guidelines for National Greenhouse Gas Inventories. There is need for capacity enhancement to measure and validate emissions and removals for proper management of ITMOs.

Malawi as a Party to Paris Agreement, therefore, the country is legally allowed to participate in cooperative approaches in the implementation of its NDCs such as the ITMOs under Article 6 of the Paris Agreement and is designated to coordinate and prepare GHG Inventories, NDCs and their revisions, and BTRs. Adjustments and accounting for ITMOs with respect to these reporting documents is also handled by the EAD. In addition, Malawi has developed and launched a Carbon Market Regulatory framework to guide in engagement in international carbon market. The framework, among others provides for the following key guidance:

a. The Ministry responsible for Climate Change Management Authorize and oversee all proposed projects.
b. A Carbon Registry System will document and manage all carbon credit projects.
c. Project developers are required to submit a Mitigation Activity Idea Note (MAIN), detailing project objectives, alignment with Malawi's NDCS priorities, proposed technologies, financial and technical requirements, and a monitoring, reporting, and verification plan.
d. Upon positive evaluation of the MAIN, the Ministry issues a Letter of No Objection.
e. Developers must then submit a Mitigation Activity Design Document for each project, accompanied by an administration fee, which undergoes validation, Positive examination, Authorisation, Mopnitoring, verification and Reporting.
f. Projects must adhere to guiding principles, including environmental integrity, transparency, sustainable development, and generating social and economic co-benefits.
g. Regarding the upcoming auction scheduled for July 16, 2024, aligned with the Paris Agreement principles of multilateral trust and leadership:
h. 12.5% of auction proceeds will directly support Malawi's environmental, climate, and carbon initiatives.
i. Additional proceeds will be allocated to local entrepreneurs, ensuring reinvestment in Malawi's sustainable development.

The GoM is also reviewing all existing carbon credit projects to align with the new framework. In terms of structures that would help track progress and impacts of carbon credits, The Government has established the Malawi Carbon Market Registry that will document, account and keep track of transactions related to carbon market project in Malawi. the government will also conduct corresponding adjustments and conduct initial, Annual and regular reporting to the UNFCCC. Further to that, the Government has established the National Planning Commission, (NPC) an office that tracks development projects in the country in relation to achievement of MW2063 (Malawi's overarching development strategy). The Malawi 2063, implemented via medium terms strategies or implementation plans, has prioritized projects that create enabling environment for thriving of economic and industrial activities. Some of these projects are on transitioning to low-emission development in the power sector, for example. With NPC in place, carbon trading projects, would therefore be tracked accordingly. Furthermore, trading of carbon is being identified by the Government of Malawi as one of the revenue generation to bolster the economy with proceeds from carbon markets bieing reflected in the national budget. Through this regulatory framework, Government of Malawi has a proper platform for managing carbon projects and markets in Malawi. Lastly but least, Malawi is developing legislation and regulations for the carbon trading landscape that was commissioned in 2022. The content of the legislation and regulations is under design. The legislatory framework is expected to cover the following aspects:

a. Monitoring, reporting, and verification mechanisms.
b. A carbon credit registry.
c. An oversight agency for carbon credit trade.
d. Registration requirements for businesses involved in carbon trade.
e. Mandated benefit-sharing agreements with minimum ratios.
f. Renegotiation of revenue sharing for existing projects

In terms of information on institutions, legal, administrative and procedural arrangement for supporting domestic implementation, monitoring, reporting, archiving of information and stakeholder engagement related to implementation and achievement of NDCs in relation MPG paragraph 62, Table 3-2 and Table 3-3 present the information.

Table 3-3-2: Institutions for domestic implementation, monitoring, reporting, archiving of information and stakeholder engagement related to implementation and achievement of NDCs

Arrangement/Institution	Role
Ministry of Energy	1. Oversees the energy sector and establishes energy policies and sets strategic direction for the sector. 2. Policy guidance in implementation of NDCS measures related to energy 3. Ensuring there are effective energy legislation and policy frameworks in place 4. Supervision, monitoring and coordination over all matters relating to NDCS measures related to energy 5. Established an IPP framework for private sector development in the renewable energy sector, to provide a conducive environment and framework for awarding and implementing renewable energy projects in Malawi. 6. Data source on GHG and non-GHG impacts of NDCS implemented measures
Ministry of Finance and Economic Affairs	1. provides sovereign guarantees to Independent Power Producers for the development of power generation projects, 2. is responsible for negotiating the implementation of such power projects in Malawi.
Directorate of Road Traffic and Safety Services	1. Policy guidance in implementation of NDCS measures related to road transport, for example modal-shift 2. Supervision, monitoring and coordination over all matters relating to road transport. 3. Data source on GHG and non-GHG impacts of NDCS implemented measures
Renewable Industry Association of Malawi (REIAMA)	1. Implementation of NDCS measures related to renewable energy, such as grid connected solar PV, and largescale hydropower 2. Data source on GHG and non-GHG impacts of NDCS implemented measures
Electricity Supply Corporation of Malawi (ESCOM)	1. Implementation of NDCS measures related to supply and distribution of electricity e.g efficient electric motors 2. Data source on GHG and non-GHG impacts of NDCS implemented measures
Electricity Generation Company	1. Implementation of NDCS measures related to supply and distribution of electricity e.g efficient electric motors 2. Data source on GHG and non-GHG impacts of NDCS implemented measures
Department of Forestry	1. Policy guidance in implementation of NDCS measures related to energy 2. Supervision, monitoring and coordination over all matters relating to NDCS measures related to energy 3. Data source on GHG and non-GHG impacts of NDCS implemented measures

Ministry of Agriculture,	1. Policy guidance in implementation of NDCS measures related to agriculture 2. Supervision, monitoring and coordination over all matters relating to NDCS measures related to agriculture 3. Data source on GHG and non-GHG impacts of NDCS implemented measures
National Planning Office,	1. Tracking progress in implementation of NDCS measures 2. Data source on GHG and non-GHG impacts of NDCS implemented measures 3. Archiving of archiving of information and stakeholder engagement related to implementation of NDCS
National Statistical Office,	1. Data source on GHG and non-GHG impacts of NDCS implemented measures 2. Archiving of archiving of information and stakeholder engagement related to implementation of NDCS
City Councils (Mzuzu, Lilongwe, Zomba and Blantyre)	1. Supervision, monitoring and coordination over all matters relating to NDCS measures related to waste 2. Data source on GHG and non-GHG impacts of NDCS implemented measures
Council for Non-Governmental Organizations in Malawi (representing all local non-governmental organizations in Malawi)	1. Advocacy on implementation of NDCS measures 2. Advisory role on implementation of NDCS measures 3. Implementation of NDCS measures 4. Data source on GHG and non-GHG impacts of NDCS implemented measures
Universities and other Research Institutions (	1. Analysis of GHG and non-GHG impacts of NDCS measures 2. Implementation of NDCS measures
Malawi Energy Regulatory Authority (MERA)	1. Regulating energy sector, thus regulating implementation of NDCS measures related to energy, for example-grid connected solar PV and large-scale hydropower 2. Data source on GHG and non-GHG impacts of NDCS implemented measures
Ministry of Trade and Industry	1. Tracking progress of NDCS implementation related to industrial processes and product use 2. Implementation of NDCS measures on industrial processes and product use 3. Data source on GHG and non-GHG impacts of NDCS implemented measures
National Water Resources Authority (NWRA)	1. Regulation and management of water resources and issuance of permits for hydro power projects.
The Ministry of Lands	1. Facilitates the acquisition of land for energy infrastructure development.

Table 3-3-3: Policies related to domestic implementation, monitoring, reporting, archiving of information and stakeholder engagement related to implementation and achievement of NDCs

Type of Instrument	Exact name of Instrument	Role
Policy	Malawi 2063	1. This is the overarching long-term development Policy for Malawi. 2. Aims to transform Malawi into a wealthy and self-sufficient nation by 2063 3. Has environmental sustainability as one of the key enablers for achieving Malawi 2063 developmental objective 4. All development policies, strategies and projects (including NDCS measures) are designed to achieve Malawi 2063. 5. Arrangement for tracking progress of implementation of Malawi 2063 development activities is in place, managed by the National Planning Commission
Programme	National Energy Compact for Malawi	1. It sets out Malawi's vision and commitment to increasing access to electricity, promoting clean cooking solutions, and increasing the share of renewable energy by 2030.
Policy	Nacional Climate Change Management Policy of 2016	1. Provides a strategic framework for addressing climate change impacts and promoting sustainable development. 2. It focuses on integrating climate change considerations into all economic sectors, emphasizing adaptation, mitigation, technology transfer, and capacity building. 3. It aims to align Malawi's climate change management efforts with international agreements like the UNFCCC and |Paris Agreement.
Policy	National Energy Policy of 2018	1. The energy policy of 2018 gives strategic direction on implementation of NDCS measures related to energy. 2. The policy promotes renewable energy and universal access to affordable and clean energy for all Malawians in line with SDG 7. 3. The policy creates space for private sector participation in the energy market, which encourages implementation NDCS measures that designed as conditional implementation in the form of direct investment, public private partnerships (PPPs), independent power producers (IPPs) or other participation vehicles. 4. The policy is currently being reviewed. The review process gives opportunity for tracking of the GHG and non-GHG impacts of energy projects some of which are NDCS implemented measures.

Policy	National Forestry Policy of 016	1. This policy provides strategic direction for all actions related to forest management in Malawi, including NDCS measures on mitigation and adaptation related to forestry 2. It aims to sustainably manage forest resources for the benefit of the nation, addressing issues like deforestation, climate change, and biodiversity conservation 3. Promotes community-based conservation and sustainable utilization of the forest resources through promoting communal and individual ownership of forests
Strategy	National Charcoal Strategy (2017 to 2027)	1. Presents a framework of actions to promote clean cooking through promotion of efficient cookstoves and use of alternative fuel for cooking to control deforestation and its related impacts 2. Aims to address linked problems of deforestation and high demand for household cooking fuel 3. Seeks to move Malawi towards a diversified, sustainable, and regulated household energy sector while mitigating deforestation and its associated impacts. 4. Provides a suitable environment for implementation of NDCS measures related for fuelwood cookstoves
Strategy	Renewable Energy Strategy, 2017	1. Gives direction on increasing share of renewable energy in electricity generation mix, particularly through off-grid and mini-grid systems in order to improve energy access and reduce reliance on traditional biomass. 2. The strategy focuses on promoting private sector investment, expanding mini-grids, and encouraging the sustainable use of biomass.
Strategy	Malawi National Electrification Strategy	1. presents a guidance on expansion of grid and off-grid electricity interventions to support achievement of National Energy Policy.
Strategy	Malawi Integrated Resource Plan	1. Presents implementation tool to guide and facilitate investments in the energy sector
Administrative	National Cookstove Steering Committee	1. Oversees initiatives and other cleaner cooking interventions to implement the Malawi Cleaner Cooking Energy Compact, which sets ambitious universal clean cooking target for 2030. 2. Advocates cleaner cooking sector in line with the country's policies and vision. 3. Members of the committee include NGO's working in the energy sector, academia and research institutions chaired by the Ministry of Energy.

Regulatory and Informative	Independent Power Producer (IPP) Framework for Malawi	1. The IPP Framework provides interested parties with a clear understanding of how to invest in Malawi's power sector, includes structures and processes covering IPP Roles, Responsibilities and Rules of Engagement. 2. It also covers step-by-step IPP Framework Solicitation Processes including for Solicited IPP (SIPP) procurement and Unsolicited IPP procurement (UIPP). 3. It also provides information on the process for project evaluation, including steps such as risk assessment and due diligence, technical evaluations, tariff structures and analysis, and financial evaluation.
Regulatory	Energy Laws, as follows Energy Regulation Act 2004, Electricity Act 2004 Electricity Amendment Act 2016	1. MERA is mandated under the Energy Regulation Act 2004, together with the Energy Regulation Bylaws to regulate the energy sector as well as approve energy tariffs etc. 2. Electricity Act 2004 and the Electricity Amendment Act 2016 provide a requirement for a licence from MERA for generation, transmission, distribution, importation, exportation, system and market operation, single buyer, and distribution licence. 3. Under the Electricity Amendment Act 2016, MERA has the power to issue further system and market operation, single buyer, and distribution licences to other applicants other than ESCOM.

Despite having institutional arrangements for domestic implementation, monitoring, reporting, archiving information and stakeholder engagement related to the implementation of NDCs under article 4 of the Paris agreement, there are some challenges are those that prevent their full realization of benefits to NDCS implementation. Some of the challenges those related to policies and other arrangements that do not complement each other; limitation of financial resources to implement activities related to supervision and monitoring; and limited awareness about the available instruments and institutions.

3.2 Description of Malawi's nationally determined contribution under Article 4 of Paris Agreement, including updates

Description of Malawi's NDCs Measures in relation to Decision 18/CMA.1 paragraph 64 and definitions to understand the NDCs measures (Decision 18/CMA) is hereby presented. The revised NDCS for Malawi has 34 mitigation measures, including those from Forestry and Other Land Use (FOLU) sector. FOLU sector 4 measures, namely; afforestation (protective forests, woodlots and urban forests), riparian restoration, agroforestry, and sustainable forest and landscape management. Means of implementation of the measures is based on the source of financing. The measures that would be implemented from domestic generated financial resources are unconditional measures, while those that would be implemented with financial resources from international support are conditional measures. Table 3-4, shows that the energy sector has almost half of the measures (grid connected hydropower, grid connected large scale solar PV, off-grid small scale solar PV systems, grid connected wind power,) are fully conditional measures: However, only one measure (efficient charcoal production) is a fully unconditional measure, and the rest of the measures are both conditional and unconditional. In general, for mitigation NDCs, including FOLU, 14 measures out of 34 require full international support to be implemented. This overdependence on international support is somewhat a challenge in the implementation because the support is conditional. Referring to the revised NDCS report for Malawi submitted in 2021 (GoM, 2021; UNFCCC, UNFCCC NDC submitted reports, 2021), the total budget for implementing mitigation measures (including FOLU) over the implementation period (2015 to 2040) is 41,782 million USD (representing 79% of the budget), from which 32,808 USD is budgeted to be contributed from international support (conditional), and 8,974 USD is to be sourced from domestic resources.

Table 3-3-4: Description of Malawi's Mitigation NDCS measures

NDCS Measure	Aim of the measure	Sector	Means of Implementation	
			Conditional	Unconditional
Grid-connected hydropower generation	To displace GHG emissions from the current diesel-electric generators and from planned coal-fired thermal power plants that will produce electricity (Kam'mwamba and Salima coal-fired thermal power plants)	Energy	100%	-
Grid connected large scale solar PV	To displace GHG emissions from the current diesel-electric generators and from planned coal-fired thermal power plants that will produce electricity (Kam'mwamba and Salima coal-fired thermal power plants)	Energy	100%	-

Off-grid small scale solar PV systems	Installation of PV systems for domestic solar heating and lanterns, resulting in avoided GHG emissions from kerosene and unsustainable charcoal use.	Energy	100%	-
Grid connected wind power	To displace GHG emissions from the current diesel-electric generators and from planned coal-fired thermal power plants that will produce electricity (Kam'mwamba and Salima coal-fired thermal power plants).	Energy	100%	-
Clean Coal technology – High efficiency coal-fired power plant	high efficiency coal-fired power plant Installation of highly efficient super ultra-critical coal plant, result sing in reduced GHG emissions from coal use in electricity generation.	Energy	100%	-
Efficient charcoal production.	Production of charcoal to meet energy demand using less wood feedstock through use of efficient kilns, resulting in reduced CH_4 and N_2O emissions	Energy	-	100%
Clean Coal technology-Carbon Capture and Storage (CCS)	Carbon Capture and Storage (CCS) Deployment of carbon capture to sub-critical coal power stations in the north of Malawi with permanent geological storage within in-situ coal seams.	Energy	100%	-
Power Factor Correction	Reduced generation of reactive power at power plants resulting in reduced GHG emissions from reduced fossil fuel combustion to generate reactive power.	Energy	100%	
Modal shift: private to passenger transport	To increase share of passenger transport from around 10% at present to around 30% in 2040, reducing GHG emissions from gasoline and diesel use.	Energy	70%	30%
Modal shift: road to rail freight	To increased use of rail under the National Transport Master Plan, resulting in reduced diesel consumptions and GHG emissions from road freight transport.	Energy	50%	50%

Increasing ethanol blending with gasoline as a transportation fuel	Achieving an average national blend rate of 20% ethanol, resulting in reduced GHG emissions from gasoline consumption in road transport.	Energy	50%	50%
Blending biodiesel with diesel as a transportation fuel	Commercial production of biodiesel fuel reaching 55 million litres and resulting in reduced GHG emissions from diesel consumption in road transport.	Energy	50%	50%
Improved charcoal cookstoves - rural households	Deployment of efficient charcoal cookstoves to urban households; increasing from 20% to 30% efficiency thereby reducing demand for charcoal and CH_4 and N_2O emissions	Energy	-	100%
Improved firewood cookstoves - rural households	Introduction of 2 million improved high efficiency wood stoves, resulting in carbon sink preservation through reduction in use of unsustainable biomass fuel.	Energy	-	100%
Use of efficient barns for tobacco curing	Reduced demand for fuelwood required in tobacco curing from 2025-2040 by use of efficient barns, resulting in reducing CH_4 and N_2O emissions from fuelwood combustion.	Energy	-	100%
Increased use of rice husk ash (RHA) in blended cement	Reduction in demand for cement in construction industry through; increased blending in cement production resulting in reduced calcination emissions from domestic clinker production.	Industrial Process and Produce Use	100%	-
Earth stabilised blocks (ESBs) as building materials	Wider promotion of ESBs as materials within institutional and domestic building projects to replace cement stabilised blocks within construction, reducing emissions from cement production.	Industrial Process and Produce Use	100%	-
Alternative low carbon cement processes	Potential use of emerging lower-carbon cement production processes such as *belite ye'elimite-ferrite* (BYF) clinker with reduced GHG emissions compared to conventional process.	Industrial Process and Produce Use	100%	-

Support industries involved in carbon capture utilisation and storage (CCUS)	Support for companies assessing, developing or implementing CCUS from suitable facilities, resulting in stored or avoided CO_2 emissions	Industrial Process and Produce Use	100%	-
Landfill gas (LFG) utilisation	Generation of up tp 95 GWh of electrical power from landfill gas extraction, collection and utilization applied to sanitary landfills, resulting in reduced CH_4 from landfill sites and avoided CO_2 from displacement of fossil-based electricity use.	Waste	100%	-
Waste Reduction Practices	Solid and water waste reduction practices at household, institutional and industry level to reduce waste generation, resulting in reduced CH_4 and CO_2 emissions.	Waste	Not quantified	
Waste to Energy (WtE)	Installation of waste to energy incinerators to generate up to 250 GWh of electricity per year in Lilongwe and Blantyre, achieving reduced CH_4 emissions from landfill sites and avoided CO_2 from displacement of grid power.	Waste	100%	-
Waste-water treatment and reuse	Rehabilitation and construction of sewerage network and wastewater treatment plants in Lilongwe, Blantyre, Mzuzu and Zomba, achieving a reduction in CH_4, and N_2O emissions from waste-water and sewage.	Waste	100%	-
Conservation agriculture: crop residue and rotation	Support and implementation of the planned expansion targets for crop residue and crop rotation to improve soil conservation, resulting in increase of soil carbon stock and improved crop yields.	Agriculture	50%	50%
Conservation agriculture: conservation tillage	Support and implementation of the planned expansion targets for conservation tillage to improve soil conservation, resulting in increase of soil carbon stock and improved crop yields.	Agriculture	50%	50%

Promotion of efficient fertiliser use and manure management	Improved fertiliser management through increased use of organic waste in soil fertilizers and compost manure, increasing carbon stock retention in soils, and reduced N_2O emissions from mineral N-fertilizer use	Agriculture	40%	60%
Improved rice management practices	Deep organic fertiliser application and improved biomass and fertilizer management in rice and nitrification inhibitors application, resulting in reduced N_2O emissions from mineral N fertilizer use.	Agriculture	70%	30%
Improved livestock husbandry	Improved livestock husbandry through expansion of new fodder area under Brachiaria and Napier, reducing CH_4 emissions from enteric fermentation and increasing biomass carbon stock.	Agriculture	40%	60%
Improved livestock and breed management	Improved breeding management to increase meat and milk yields, including through species replacements, encouragement of semi-intensive feeding system and diversification, resulting in reduced CH_4 emissions from enteric fermentation.	Agriculture	70%	30%
Improved farm management	Establishing biogas digesters, promotion of collective farms, improved manure management and promotion of slurry systems, resulting in reduced or avoided N_2O and CH_4 emissions	Agriculture	10%	90%
Afforestation (protective forests, woodlots and urban forests)	Production and planting of native Eucalyptus and Pinus trees in 45,000 Ha of areas, with potential to be scaled-up to 600,000 Ha with international support, based on NFLRS targets.	Forestry and Land Use	93%	7%
Ripairan restoration	Around 36,000 Ha of native species and bamboo to be planted within riparian zones and we4 mtland borders to enable higher ecological productivity and sustainable harvesting.	Forestry and Land Use	Not quantified	

Agroforestry	Targeted planting of an additional 25 trees/ha on 155,000 Ha of crop fields, equivalent to 20% of total arable land, 31,784 Ha of village forest areas; and expansion of new fruit area on 27,000 Ha to achieve at least a 10% tree cover. Scaled-up potential for all agroforestry types estimated at 700,000 Ha.	Forestry and Land Use	1%	99%
Sustainable forest and landscape management	Production and planting of native trees in conservation areas, and protection of areas with tree-site matching species for a total of up to 132,000 ha, with potential to be scaled up to around 600,000 Ha with international support, based on NFLRS targets.	Forestry and Land Use	85%	15%

Malawi's NDCS covers the following GHG gases, carbon dioxide (CO_2), methane (CH4), and nitrous oxide (NO2). NDCS measures are from four sectors, namely: energy, industrial processes and product use (IPPU), Agriculture and Waste. Referring to Figure 3-2, energy sector dominates the number of mitigation measures (15) representing a share of 44% of the total measure, seconded by agriculture (7) representing 20%. IPPU, Waste and FOLU each has 4 measures representing a share of 12%. This shows that Malawi's NDCS-mitigation is energy-centred.

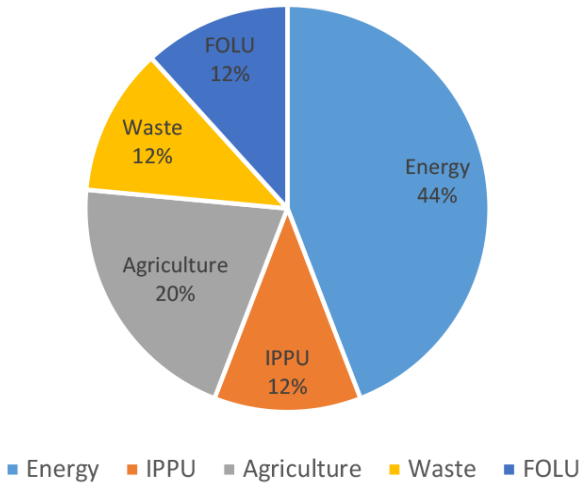


Figure 3-32: Share of number of sectoral mitigation measures over all mitigation measures

Accordingly, with energy sector dominating list of NDCS measures, a 35,994 million USD (representing 86%) of the total implementation budget for mitigation measures, is for implementing energy-related mitigation measures. Energy measures are project-based that require relatively huge capital to construct and commission. Malawi, as with the case with other least developed

country, faces challenges in financing mitigation and adaptation measures due to limited domestic budget for the implementation of climate actions, and the limited involvement of private sector investment in environment and climate change activities. In response to these factors, Malawi has come up with a resource mobilization strategy which identifies sources of finance and strategies to fund and support the prioritized measures.

As indicated in the updated Malawi's NDCs submitted to UNFCCC in 2021 (UNFCCC, 2021), NDCS mitigation contribution takes the form of a reduction in GHG emissions relative to a business-as-usual (BAU) emissions baseline over the period to 2040. The base year in the updated NDCs analysis is 2017 because the 2017 GHG inventory was the most recent during updating of the initial NDCs was the 2017 GHG inventory, extracted from Malawi's Third National Communication (TNC) (GoM, 2021). Target year for Malawi's NDCS is 2040, thus, modelling of the emission pathways was from 2017 to 2040. The reference year is also the target year. In the base year (2017), GHG emissions were assessed to be 9.3 million tCO_2e as in TNC report (GoM, 2021). Modelling of emission pathways in the absence of updated NDCs measures, also known as business-as-usual scenario (BAU), show emissions rising from 9.3 million tCO_2e in 2017 to 34.6 million tCO_2e in 20240. Emissions under mitigation scenarios are those described when NDCS measures are implemented. Emission reduction resulting from mitigation with additional measures is defined '*total contribution*' or contribution from all '*NDCs measures*'. When describing emissions pathways in the absence of NDCs measures (BAU scenario) and when NDCs measures are implemented as planned (Mitigation scenario), assumptions are made. In general, for the energy sector, assumptions were on increased emissions from planned coal-fired thermal power plants and from diesel generators for production of electricity, increased demand for wood fuel, and increased demand for transport services and hence for liquid fossil fuel (petrol and diesel). Further, it was noted that there would be increased agricultural productivity as well as industrial productivity up to 2040. Details on assumptions and other modelling metrics used to project emission pathways and under BAU, mitigation with measures and mitigation without measures scenarios are in the submitted updated NDCs report for Malawi.

The summary of emission pathways (scenarios) without emissions from FOLU as detailed in updated NDCs, is presented in Table 3-5 for the base year (2017), 2020, 2030 and 2040 (the target year). Table 3.5, under business as usual scenario, shows emissions increasing steadily from 9.33 million tCO_2e to 10.71 million tCO_2e in 2020, 19.25 million tCO_2 in 2030, and 34.61 million tCO_2e in 2040, the target year. Further, emissions under mitigation for all NDCS measures are also increasing from 9.33 million tCO_2e in 2017, to 10.68 million tCO_2e in 2020, 12.78 million tCO_2 in 2030, and 16.92 million tCO_2 in 2040 the target year. Therefore, if all NDCS measures are implemented, there will be emission reductions (contribution) as follows: 0.03 million tCO_2 in 2030, 6.47 million tCO_2e in 2030, and 17.69 million tCO2e by the target year of 2040.

Table 3-3-5: NDCS emission reduction scenarios and relative reductions against business as usual scenario excluding emissions from FOLU

Emissions under different Scenario *Emission reduction under difference scenario*	**Emissions for the particular year in million tCO2e** **(Emission reduction for the particular year in million tCO2e)**			
	2017	2020	2030	2040
Emission under Business as Usual (BAU)	9.33	10.71	19.25	34.61
Emission under unconditional NDCS measures	9.33	10.7	18.07	32.56
Emission under conditional contribution NDCS measures	9.33	10.69	13.96	18.97
Emissions under all NDCS measures	9.33	10.68	12.78	16.92
Emission reductions from unconditional NDCS measures only	*0*	*0.01*	*1.18*	*2.05*
Emission reductions from conditional NDCS measures only	*0*	*0.02*	*5.29*	*15.64*
Total emission reductions for all NDCS measures	*0*	*0.03*	*6.47*	*17.69*
Relative contribution (relative emission reduction) to BAU				
Unconditional contribution	0%	0.1%	6%	6%
Conditional contribution)	0%	0.2%	27%	45%
Total contribution	0%	0.3%	34%	51%

Furthermore, Table 3-5 shows that conditional measures result in more contribution (15.64 million tCO_2e) than unconditional measures (2.05 million tCO_2e) because Malawi's NDCS is premised on international support to implement most of its measures. If that support is not provided as planned, it is difficult for Malawi to achieve its NDCS target of reducing 17.7 million tCO_2e by 2040 hence need for a prudent resource mobilization strategy international financial support. Also, mainstreaming of NDCS measures in national policies and strategies should be supported. In addition, from Table 3.5, the Malawi contribution (emission reduction) by the target year, is 51% emission reduction relative to BAU emissions in 2040. This is a higher emission reduction ambition, compared to initial NDCS submitted in 2015. This target is made up of 6% from unconditional NDCS measures and 45% from conditional NDCS measures. Table 5 also shows that much of absolute amounts of reduction is more noticeable after 2030 than before 2030.

Emissions from FOLU were not considered because of its high uncertainties and large variations noted from different FOLU GHG inventories conducted the same period (GoM, 2021). In summary, sectoral contributions (emission reduction after implementation of NDCS measures) by the target year (2040) presented in Figure 3-3 shows that energy sector would contribute 15.1 million tCO2e reduction by 2040, representing above 85% of the total contribution (17.7 million tCO_2e). Other sectors combined would contribute the remainder (2.6 million tCO_2e) reaffirming that Malawi's NDCS is energy based.

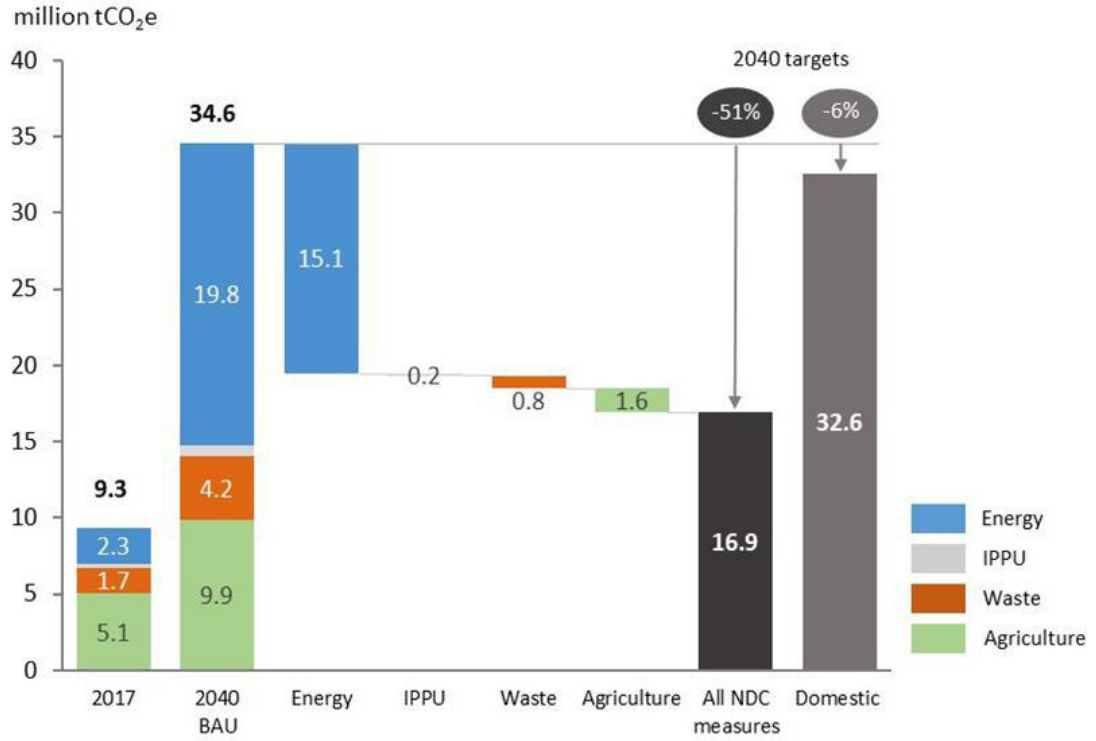


Figure 3-3-3: Summary of GHG emissions under business as usual and mitigation scenarios, with sectoral reductions with respect to implementation of NDCS measures for base year (2017) and target year (2040) for each sector

The dominanct contribution from the energy sector stems from actions to reduce emissions that would come from coal-fired thermal power plants at Kam'mwamba (300 MW) and in Salima (120 MW) as well as from the diesel electric generators that were installed and planned to be installed to provide extra electricity generation in future. At the time of compiling this BTR, the coal-power plants construction and installation works had not yet strted, being projects still requirening financing.

Malawi is participating in ITMOs via carbon credits that are traded on the carbon market, with independent verification of the credits and their adherence to the rules of the respective standards to avoid double counting related to global assessment of NDCS effects. The country has established arrangements that are consistent with Article 6, paragraph 2, guidance and relevant decisions of the conference of parties serving as a meeting of members to Paris Agreement (CMA)for tracking ITMOs. Related information on Malawi's internationally transferred mitigation outcomes is presented in the attached Malawi's Initial Report. Further, the country has no any update or clarifications of previously reported information to present such as those related to GHG inventory, methodologies on emission reduction estimation, and use of cooperative approaches. In this NDCs reporting phase, Malawi is engaged in sale of carbon through Hestian Innovation Limited, although other organizations have expressed interest to invest in carbon trading. The programme, developed by Hestian, is based on extensive work since 2008 specifically on cleaner cooking in Malawi, where the technology promoted is designed and developed to meet local user needs and preferences. Gradually

the *Chitetezo Mbaula* is becoming 'business as usual' in communities where it has been adopted and the Program is promoting a shift away from open fire cooking to efficient, cleaner and more cooking sustainable practices. The Programme that is on ITMOs is not limiting Malawi's efforts to achieve their NDCs. Specifically, the Programme was authorised having considered the technical recommendations from the country's Mitigation Expert Working Group (MEWG) as the Article 6 Technical Advisory Unit. Secondly, there is transfer of knowledge, skills and expertise with local experts coming from this Programme, which would enable Malawi enhance its NDCs implementation.

3.3 Information necessary to track progress made in implementing Malawi's Nationally Determined Contribution under Article 4 of the Agreement

3.3.1 Indicators for Tracking Progress

Decision 18/CMA.1, in paragraphs 65 to 97, mandates parties to provide information for tracking progress and achievement of their NDCs. Before providing this information, it is important to recognize that BTR submitted by Parties to Paris Agreement, among others, is intended to track progress on implementing their NDCs and progress tracked done using indicators, which can be quantitative or qualitative depending on its nature. Decision 18/CMA.1 (MPGs) does not provide a definition of an indicator but guides that the indicator must be self-determined by the Party (Malawi), must be relevant for the NDCs implementation, and may be quantitative or qualitative. The indicator is simply a measure used to assess and evaluate status of a project that is implemented. The indicator not only tells the status of the project implementation, in this case NDCs implemented measures, over a given period of time, it also specifies whether or not associated policy objectives are being met and quantitative targets reached. Where these are not being achieved, the indicator discusses the reasons for this. For BTR, the process for tracking starts with identifying the indicators followed by production of information on each of the identified indicator for reference points, levels, baselines, and base year. Further, the most recent information (that is for the reporting years) for each of the identified indicator is provided for the BTR NDCs tracking reporting years, which is 2 years. This reporting period of 2 years, considering that GHG Inventory has to cover 2 years prior to reporting of BTR, gives reporting period for NDCs Tracking as 2021 and 2022. When the current information is provided, the fourth step is to compare the second and third step to track progress made in implementing NDCs.

For Malawi's NDCs, for the type of NDCS target chosen (the absolute GHG emission reduction of 17.7 million tCOe2 relative to baseline emission in 2024), the indicator for NDCS implementation is the absolute amount of GHG emissions (million tCO2e) reduced in the current year expressed as the difference between the business as usual scenario presented in the NDCs document (baseline) and the current emission as per latest GHG inventory. The updated NDCS measures for Malawi are mostly in the energy sector with mitigation out being reduction in GHG emission, and thus, all measures are grouped together and progress assessed using an umbrella indicator of absolute GHG emission reduction relative to the baseline (BAU emission). The emission during the baseline formulation (BAU scenario) were calculated using Tier 1 methodology, following the 2006 IPCC Guidelines for conducting national GHG inventories. The base year being 2017 and the emission reduction is zero. Target year is 2040 and the emission reduction for the target year is 17.7 million tCO2e. Reference years are reporting years for the BTR, in this case, 2021 and 2022. The reference levels are

the baseline emissions (BAU) in 2021 and 2022. Between base year and reference year, emissions under BAU are provided, as extracted from the updated NDCS document for Malawi. Projection of the planned absolute GHG emission reduction when all NDCS measures are implemented is presented, in relation to BAU emissions (baselines) and under implementation of NDCS measures, is presented in in the last row of Table 3-3.

Table 3-6, (BAU scenario) shows baselines were were constructed from extrapolation of data in submitted 2021 updated NDCS (NDCS.2) in Microsoft excel while . Further, Table 3-6 shows that GHG emissions when all NDCS measures are implemented to be 10.89 and 11.1 million tCO2e in 2021 and 2022 respectively. These are reference emissions in the NDCS tracking. Under BAU scenario, the emissions in 2021 and 2022 were 11.564 and 12.418 million tCO2e, giving a planned reduction when all NDCS measures are implemented (domestically and internationally supported NDCs) as 0.674 million tCO2e and 1.318 million tCO2e in 2021 and 2022 respectively. Domestically implemented measures are planned to reduce 0.127 and 0.244 million tCO2e in 2021 and 2022 respectively.

Table 3-3-6: Projection of absolute emission reductions in relation to emission pathways (business as usual and under implementation of NDCS measures

Inventory Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2028	2030	2032	2034	2036	2038	2040
GHG emissions without NDCS measures (BAU Scenario)	9.33	9.79	10.25	10.71	**11.564**	**12.418**	13.272	14.126	14.98	15.834	17.542	19.25	22.322	25.394	28.466	31.538	34.61
GHG emissions with only domestic supported NDCs measures	9.33	9.79	10.24	10.70	**11.437**	**12.174**	12.911	13.648	14.385	15.122	16.596	18.07	20.968	23.866	26.764	29.662	32.56
GHG emissions with domestic and international supported NDCs measures (all NDCS measures)	9.33	9.78	10.23	10.68	**10.89**	**11.1**	11.31	11.52	11.73	11.94	12.36	12.78	13.608	14.436	15.264	16.092	16.92
Reductions (domestic support)	0.000	0.003	0.007	0.010	**0.127**	**0.244**	0.361	0.478	0.595	0.712	0.946	1.180	1.354	1.528	1.702	1.876	2.050
Reductions (domestic plus international support)	**0**	**0.01**	**0.02**	**0.03**	0.674	1.318	1.962	2.606	3.25	3.894	5.182	6.47	8.714	10.958	13.202	15.446	17.69

Recent information for the identified indicator (absolute emission reduction relative to the baseline emission) is obtained from the recent GHG inventory for years 2021 and 2022. The calculated current inventory from 2017 to 2022 is presented in Table 3-7.

Table 3-3-7: Comparison between GHG emissions for reference years (during NDCS.2 estimation) and current GHG Inventory for reporting years of 2021 and 2022

Inventory Year	Energy (Gg CO2e)	Industrial Processes and Product Use (Gg CO2e)	Agriculture (Gg CO2e)	Waste (Gg CO2e)	Total (Gg CO2e)	Total emission in the Current Inventory (million tCO2e) (million tCO2e)	Total Emission Under Mitigation scenario where all NDCS-2 measures implemented (million tCO2e)	Relative difference between emissions when all NDCS-2 measures are implemented and actual emissions (%)
2017	1,366.32	89.38697	4,056.55	14,631.92	20,144.18	20.144	9.33	-116%
2018	1,629.07	107.5394	4,489.38	15,635.91	21,861.90	21.862	9.78	-124%
2019	1,693.66	146.0092	4,258.79	16,125.19	22,223.65	22.224	10.23	-117%
2020	1,859.69	179.4682	4,638.31	16,622.88	23,300.36	23.300	10.68	-118%
2021	1,697.86	194.8529	5,113.06	17,124.02	24,129.79	24.130	10.89	-122%
2022	1,810.16	188.3158	5,714.96	17,547.87	25,261.30	25.261	11.1	-128%

In relation of MPG 64, comparison of recent information for the indicator with information on reference points is presented in Table 3-7. From Table 3-7, it can be seen that emissions are above the reference emissions (mitigation scenario with all NDCS-2 measures implemented) for reporting years of 2021 and 2022. Tracking of NDCS implementation in terms of relative reduction in GHG emissions is given by the equation (1). If the relative reduction, as in equation (3-1) is positive, then the current emissions (from GHG Inventory) are less than what was described in the NDCS-2 as mitigation scenario when all NDCS measures are implemented. This indicates good progress in NDCS implementation. However, if the relative emission is negative, it means that the actual emission levels are higher than those described in NDCS-2 mitigation scenario. This shows that NDCS implementation is not progressing well.

$$\text{RD}\ (\%) = \left(\frac{E_{MIT,NDCS.2,y} - E_{Inventory,y}}{E_{MIT,NDCS.2,y}}\right) \times 100 \qquad \textbf{(3-1)}$$

Where RD is relative difference between emissions when all NDCS-2 measures are implemented and actual emissions

$E_{MIT,NDCS.2,y}$ is the GHG emission under mitigation scenario where all NDCS measures are implemented for the inventory year y, as estimated in NDCS.2

$E_{Inventory,y}$ is the actual GHG emission for the inventory year y, as estimated the BTR GHG Inventory Chapter for inventory year, y.

Table 3-7 shows that actual GHG emissions in 2021, and 2022 (from latest GHG inventory) are higher than emissions under mitigation scenario, as described in NDCs-2, when all measures are implemented, for all the years.

Further, it can be seen that relative difference between emissions when all NDCs-2 measures are implemented and actual emissions are -122%, and -128% of the emissions under NDCs-2 mitigation scenario. Further analysis of emissions as in Table 3-7 shows that actual emissions are more than double the emissions described when all NDCs-2 mitigation scenario, and that the differences in emissions are increasing. This shows that Malawi is not making any progress for achieving emission reduction of of target 17.7 million tCO2e in 2040 relative to the BAU emission in 2040. This result was discussed during stakeholder consultations and it was stated that the problem could be on estimation of GHG emissions from the Waste Sector in the most current GHG Inventory (for this BTR). It was noted that Waste emissions could have been overestimated.

3.3.2 Methodologies and Accounting Approaches

In line with MPG paragraph 74 "*Each Party shall provide a description of each methodology and/or accounting approach used, as applicable for:* (a) *Target(s), as described in paragraph 64 above; (b) The construction of baselines, as described in paragraph 64 above, to the extent possible; (c) Each indicator identified in paragraph 65 above*", emissions of gases covered in Malawi's NDC-2 creation of its indicator, target and construction of baselines, were estimated basing on the 2006 IPCC Guidelines for national greenhouse gas inventories. Tier 1 of the methodology (use of IPCC default emission factors) was employed because of absence of country specific emission factors in all the key categories. Malawi plans to use its country specific emission factors in its second BTR for some key categories in energy- road transport and other sector-biomass different sectors. The country was implementing a GEF supported Project on "*Capacity Building Initiative for Transparency (CBIT)*" to develop emission actors in these key categories. Emissions of the covered gases (CO_2, CH_4 and N_2O) were aggregated using the 100-year time-horizon global warming potential on the basis of the values stipulated in the Fifth Assessment Report of the IPCC. The methodologies, including assumptions, employed in estimating GHG reductions from implemented measures and their projected emission reductions, are presented in Section D.

During this BTR reporting period, Malawi was involved in cooperative approaches (under Article 6.2 of the Paris Agreement) where some of its CO2e reduced were traded involving ITMOs. The accounting approach applied by the Gold Standards applied in certification of carbon credits from Malawi), to ensure adherence to its core-principles of avoidance of double counting, environmental integrity, transparency, accuracy, consistency, comparability, and completeness.

3.3.3 Contribution from Land Use, Land-Use Change and Forestry

Contribution from Land Use, Land-use Change and Forestry (LULUCF) was estimated in Malawi's NDCS.2 to be equal to 59.8 million tCO2e through a range of LULUCF interventions covering an area of up to 2 million hectares, of which 22% is unconditional and 78% is conditional (GoM, 2021). However, uncertainties in estimation of emission reductions were considered to be too high, qualitatively, and thus, contributions from LULUCF were not considered in Malawi's NDCS-2 but were recommended to be considered contributions. Therefore, in reference to MPG 77 (c) *"Contribution from the LULUCF sector for each year of the target period or target year, if not included in the inventory time series of total net GHG emissions and removals, as applicable"*, information that was used to track progress of NDCS-2 implementation, did not include contribution from LULUCF.

3.3.4 Cooperative Approaches that Involve the Use of Internationally Transferred Mitigation Outcomes

The Paris Agreement Article 6.2 allows parties to pursue, on voluntary basis, cooperative approaches that involve the use of ITMOs towards NDCs, promote sustainable development and ensure environmental integrity and transparency, including in governance, that shall apply robust accounting to ensure, inter alia, the avoidance of double counting, consistent with guidance adopted by the Conference of the Parties serving as the meeting of the Parties to this Agreement. Accordingly, MPG paragraph 77 (d) directs that "*Each Party that participates in cooperative approaches that involve the use of internationally transferred mitigation outcomes towards an NDCS under Article 4, or authorizes the use of mitigation outcomes for international mitigation purposes other than achievement of its NDCS, shall also provide the following information in the structured summary consistently with relevant decisions adopted by the CMA on Article 6; (i) The annual level of anthropogenic emissions by sources and removals by sinks covered by the NDCS on an annual basis reported biennially; (ii) An emissions balance reflecting the level of anthropogenic emissions by sources and removals by sinks covered by its NDCS adjusted on the basis of corresponding adjustments undertaken by effecting an addition for internationally transferred mitigation outcomes first-transferred/transferred and a subtraction for internationally transferred mitigation outcomes used/acquired, consistent with decisions adopted by the CMA on Article 6; (iii) Any other information consistent with decisions adopted by the CMA on reporting under Article 6; (iv) Information on how each cooperative approach promotes sustainable development; and ensures environmental integrity and transparency, including in governance; and applies robust accounting to ensure inter alia the avoidance of double counting, consistent with decisions adopted by the CMA on Article 6".*

As pointed out in section 3.3.4 abopve, Malawi is involved in ITMOs under carbon credit trade arrangement. During the reporting period of NDCS-2, the following information is provided in line with MPG 77 (d).

3.3.4.1 Malawi's Engagement in cooperative approaches in the reporting period 2021-22

Between 2021 and 2024, Malawi took part in ITMO activities by issuing and trading carbon credits. These ITMOs have not been used to track Malawi's progress in meeting its NDCs goals, in line with rule on Corresponding Adjustments. So far, there are only a few ITMO projects in the country namely: Hestian Innovation Limited, EKI Energy Services, and Burn ECOA Capital but with the creation of a conducive environment for carbon trading, the number of ITMO projects is expected to grow. Hestian Innovation Limited has provided clear, verifiable data on the number of carbon credits issued and traded. During the reporting period, all authorised ITMO projects focused on cleaner cooking solutions. They involve replacing traditional three-stone open fire stoves with efficient cookstoves or using alternative fuels instead of firewood and charcoal. Firewood and charcoal are viewed as non-renewable sources of biomass energy.

Promoting clean cookstove initiatives has important co-benefits. They help reduce exposure to household indoor air pollution; they help reduce expenditure on fuel, protect forests and reduce environmental damage. Therefore, ITMO projects play a key role in achieving these goals. This aligns with the ITMO requirement of additionality. ITMO projects also support the Government of Malawi's focus on clean cooking as a national priority, as detailed in the Energy Compact for Malawi, 2021. In the Compact, there is a target of reaching all households with cleaner cooking by 2030, with an associated target of reducing firewood consumption and associated emissions by 40%.

According to ITMO trading rules, Malawi is entitled to receiving a share of the proceeds from ITMO sales. This funding can support NDCS implementation and other environmental and climate-related activities. In addition, ITMO projects can create jobs and bring in the much-needed foreign exchange through the sale of carbon credits. Government of Malawi has prioritized carbon trading as one of the sources for alternative income generation. The Government encourages carbon trading and has set-up structures to make sure that carbon trade projects properly guided. For example, The Government has established a new agency to oversee carbon trading, aiming to leverage the country's potential in the carbon market, for details, kindly refer to information in section 1.6.

Malawi has provided detailed information about the mitigation activities, their authorization status and the authorization and first transfer of any of their issued mitigation outcomes. The Initial Report is accessible on the Centralised Accounting and Reporting Platform (CARP)[4]. Quantitative data about the authorized projects and any action in relation with Article 6 such as authorization, transfer, use, etc.

4 https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement/cooperative-implementation/carp/reports#Initial-reports-and-updated-initial-reports

is contained in the annual reports in the digital format, also accessible on the CARP (Annual Information Reports). The project activity in

Malawi and the detailed information contained in the Initial Report and the in the Tables 3-8, 3-9, 3-10, and 3-11. Table 3-8 provides an overview of the projects that intend to become authorized under Article 6. The resulting corresponding adjustments are calculated using the single year / averaging method as indicated in the Initial Report (Refer to the attachment).

Table 3-3-8: Projects intending to become authorized under Article 6

ID	Project Title	Sector	Activity Type	Owner	Standard	Standard ID
002	EKI Energy Services					
003	Burn ECOA Capital					
004					Swiss Standard	n./a.
005					Swiss Standard	n./a.

Table 3-3-9: Projects authorized under Article 6

ID	Project Title	Cooperative approach	Sector	Activity Type	Owner	Standard	Standard ID	Authorisation of project	ITMOs authorised	First Transfer
		If available	Common Nomenclature	Common Nomenclature[1]	As per IR					Common Nomenclature
006	GS Biomass Energy Conservation Programme				Hestian	Gold Standard	11677	8. 11. 2023[2]	1,552,755	Issuance

Table 3-3-10: ITMOs authorised under Article 6 (refer to Table 2 for project title) in reporting period

ID	Project Title	ITMOs authorised		ITMOs first transferred		Identification underlying standard – 2021		Identification underlying standard – 2021		Authorisation of ITMOs
		2021	2021	2021	2022	First ID	Last Unit ID	First ID	Last Unit ID	date
006	GS Biomass Energy Conservation Programme	989,219	563,536	989,219	563,536	Block ID start	Block ID end	Block ID start	Block ID end	N.A
Total		989,219	563,536	989,219	563,536					

Table 3-3-11: Corresponding Adjustments (averaging method) in t CO2e for CTF Table 4

ID	Project Title	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	Elapsed years	1	2								
006	GS Biomass Energy Conservation Programme	989,219	563,536								
Aggregate issued MOs		989,219	1,552,755								
Average CAs to be reported		989,219	776,377								

3.3.4.2 Authorised Mitigation Activities

C4.2.1 0001 GS Biomass Energy Conservation Programme

Detailed project information in relation to integrity of the project and the methodology, as well as how the risk for a net increase of emissions is addressed, is discussed in the initial report (refer to the attachment). Additional information about the compliance with the carbon standard can be found at the standard's website as follows:

Standard: Gold Standard

Project ID: GS11677 - GS Biomass Energy Conservation Programme

Project Documentation: https://registry.goldstandard.org/projects/details/3915 and https://assurance-platform.goldstandard.org/project-documents/GS11677

Hestian Innovation Limited is the project developer of a project on biomass conservation that involves promotion of household cookstove. The mitigation outputs are emission reduction of non-CO_2 GHG emissions (CH_4 and N_2O) from use of improved/efficient cookstoves and CO_2 removals through trees and forests that are conserved. Through a Letter of Authorisation granted on Nov 8th 2023, Government of Malawi through the Ministry of Natural Resources and Climate Change has allowed the organization to market the carbon credits as ITMOs. The LoA states that the generated credits, Table 3-12, are not used for Malawi's NDCS and that Government of Malawi is to receive 12.5% share of proceeds. Out of the issued credits reported in Table 4 the vintages 2021 and 2022 will be reported as authorised and first transferred, and subtracted from total GHG reduction from the NDCS.

Table 3-3-12: Issued carbon credits to Hestian Innovation Limited as of May 2025

Year	tCO_2e issued under GS11677
2021	989,219
2022	563,536
2023	207,295
2024	18,425
Total	1,778,475

Source: Hestian Innovation Limited data provided in May 2025

The Hestian Project on biomass conservation is to reduce emissions and increase removals up to 2031. A carbon credit is equal to one metric ton of carbon dioxide equivalent (CO2e) emissions reduced or removed from the atmosphere. Hestian Innovation Limited reports that actual trading of the carbon credits by started in 2024, with 103,412 credits sold in 2024 on the CTX Trading Platform. Therefore, under this ITMOs, by the time of compiling this BTR, out of 1,778,475 credits issued, 1,675,063 credits (equivalent to 1.675 million tCO_2) remain to be traded under the international carbon market, less 2% of credits paid to Gold Standard as share of proceeds.

The methodology used to compute reduced emissions on improved cookstoves project by Hestian Innovations Limited involved quantifying

the difference in emissions levels between 3-stone open fire stoves (baseline technology) and the improved cookstoves (the mitigation technology). The programme of activities (PoA), Gold Standard PoA 11677, transitioned from UNFCCC Clean Development Mechanism PoA 10182, and applies methodology AMS-II.G. ver. 12 - Energy efficiency measures in thermal applications of non-renewable biomass and has been audited by UN accredited independent auditors and the credits , detailed above, have been issued by the Gold Standard Foundation in 2021 and 2025.

Information from the most recent monitoring report dated 23/7/2024 revealed that the programme was reaching 237,032 households in Malawi, all of whom claimed to be saving time on sourcing of fuel. The programme created 759 jobs, and was saving 199,071 tonnes of wood per annum, resulting in an estimated $47 savings per household per annum. This demonstrates role of carbon trading in job creation and environmental management, subsequently contributing to achieving developmental objectives stipulated in MW 2063.

3.3.4.3 Projects that are not yet authorized

The following subsections presents projects that have not yet obtained authorization to trade as ITMOs.

C4.3.1 ITMOs via EKI Energy Services

Malawi reported to have registered ITMOs project is with EKI Energy Services, a private company that is yet to implement an improved cookstove project with a potential to generate credits as ITMOs. The company will distribute 50,000 improved cookstoves[5] expected to reduce 1.4 million metric tonnes of carbon dioxide equivalent (making a total tradable carbon credit of 1,400,000tCO2eq[6]. The company, based in Nashik in India, stated in 2024 that it had already distributed 25,000 improved cookstoves in Malawi[7]. While the Ead reported in early 2025 Government has made commitment through offering the company a Letter of Authorization to implement the project, Monitor and Verify and report in readiness for positive examination and issuance. Issuance and Corresponding Adjustments to this project has not yet been done.

C4.3.2 ITMOs via Burn ECOA Capital

BURN Manufacturing, a Kenya based company that manufactures clean cookstoves and is into carbon credit project developing will invest in the distribution of clean clean cookstoves to generate carbon credits for trading in Malawi. The organization applied for and and received a ex-Ante Letter of Authorization from the GoM through Ministry of Natural Resources and Climate Change to implement the project. The specific technologies are natural and forced draft biomass stoves, and electric induction cooking suites. The company plans to distribute

5 https://www.outlookbusiness.com/economy-and-policy/eki-energy-services-to-distribute-25000-cookstoves-in-malawi

6https://www.outlookbusiness.com/economy-and-policy/eki-energy-services-to-distribute-25000-cookstoves-in-malawi

7 https://www.outlookbusiness.com/economy-and-policy/eki-energy-services-to-distribute-25000-cookstoves-in-malawi

2 million of these technologies by 2028 across Malawi. In 2024, the company committed to establish a factory in Lilongwe City to produce the technologies. Apart from reducing emissions and enhancing removals (hence carbon credits), this project will help decrease indoor air pollution, and create employment. It is reported that company would be in Malawi for a period of 5 years. The first phase of the project by BURN is is estimated to reduce about 3,000,000 carbon credits (thus, 3,000,000 metric tonnes of CO_2e) as ITMOs dependent on independent verification and positive examinantion by Government. However, the Project has just started being implemented and soon it will enter the monitoring Verification and Reporting phase.

3.3.4.4 Article 6.2 initial report (AIR) for Malawi

An Article 6.2 initial report (AIR) is a mandatory submission by countries participating in cooperative approaches under Article 6.2 of the Paris Agreement. This report provides detailed information on the cooperative approach being undertaken, including authorization arrangements, tracking systems, and how it contributes to the participating country's Nationally Determined Contribution NDCs. The initial report is submitted prior to or in conjunction with the first transfer of ITMOs. The MNRCC through the EAD - Government of Malawi, prepared the Article 6.2 Initial Report prior to Authorization to the UNFCCC, in June 2025, and is attached as an Appendix to this BTR Report.

From Malawi's AIR, it is seen that the country is making an ambitious plan to increase in trade in ITMOs through the Biomass Energy Conservation Program beyond 2024. The projected (expected) GHG mitigation from cooperative approaches is presented in Table 3-13, as extracted from Malawi's Initial Report. Since the emissions traded under ITMOs come from improved cookstoves, the net emission reduction that can be reflected in Malawi's NDCs is found by subtracting expected emission traded under cooperative approach from absolute emission reduction from improved cookstove. This has been done and is reported in Section D2.4.3.

Table 3-3-13: Expected GHG mitigation from the cooperative approach

Year	Net GHG emission reductions (tCO_2e)	Net GHG emission reductions (million tCO_2e)
2021	989,219	0.989
2022	563,536	0.564
2023	207,295	0.207
2024	18,425	0.018
2025	1,000,000	1.000
2026	1,000,000	1.000
2027	1,000,000	1.000
2028	1,000,000	1.000
2029	1,000,000	1.000
2030	1,000,000	1.000
Total	7,778,475	

3.3.4.5 Governance of ITMOs in Malawi

As a Party, Malawi recognizes that participation in ITMOs is on voluntary basis. In accordance to Article 6 of the Paris Agreement, Parties participating in ITMOs must apply a robust accounting system to avoid double counting, and must ensure proper governance structure to oversee ITMOs transaction in Malawi and to ensure transparency in reporting ITMOs in BTRs. In terms of accounting for ITMOs, Malawi has adopted a GHG Inventory Management System, which data providers for emission reduction and removal sources are identified and engaged. These would isolate data for tracking implementation of Malawi's NDCS and data for ITMOs from the various carbon trading projects in Malawi. The office of Environmental Affairs Department has a separate unit for managing ITMOs in Malawi. Among others, this unit is responsible for estimating carbon credits from carbon trading application projects in Malawi, using 2006 IPCC Guidelines for National Greenhouse Gas Inventories. There is need for capacity enhancement to measure and validate emissions and removals for proper management of ITMOs in Malawi.

The GoM has put arrangements for management of ITMOs. Firstly, Malawi is a Party to Paris Agreement, therefore, the country is legally allowed to participate in cooperative approaches such as the ITMOs. There is an established EAD that coordinates and prepares GHG Inventories, NDCs and their revisions, and BTRs. Adjustments and accounting for ITMOs with respect to these reporting documents is handled by the EAD. In addition, the country has developed framework to guide in engagement in international carbon market. The Government has established the National Planning Commission, the office that tracks development projects in the country in relation to achievement of MW2063 (Malawi's overarching development strategy): ITMOs via carbon trading projects would therefore be tracked accordingly. Furthermore, trading of carbon is being identified by the Government of Malawi as one of the revenue generation to bolster the economy (and expected proceeds from carbon Malawi are reflected in the national budget), and is subsequently developing the Carbon Market Regulatory Framework, which has been approved by the cabinet Further, in terms of regulatory set-up in Malawi, The Government is developing Climate Change Act, which is in final stages of consultations (on the draft).

3.3.5 The Structured Summary

The structured summary is central to any Party's reporting of the information necessary to track progress in implementing and achieving its NDCs prenting the Party's reported information in a uniform and consistent manner, which assists external stakeholders, including other Parties and the international community, in viewing each Party's progress towards meeting its NDCS targets. The MPGs define the content of the structured summary. Note that in addition to the specific reporting requirements for the structured summary set out in paragraph 77(a)-(d), the structured summary must also provide

the information stipulated by paragraphs 65–76, such as indicators, definitions, methodologies and accounting approaches. Most of the reporting elements related to the structured summary is described in sections above on indicators, methodologies and accounting approaches, contribution from the LULUCF sector and use of ITMOs. The structured Summary is presented in the Appendix in form of CTF Tables.

3.3.6 Mitigation Co-benefits of Adaptation actions and economic diversification plans

In relation to MPG paragraph 78. *"Each Party with an NDCS under Article 4 that consists of adaptation actions and/or economic diversification plans resulting in mitigation co-benefits consistent with Article 4, paragraph 7, of the Paris Agreement shall provide the information necessary to track progress on the implementation and achievement of the domestic policies and measures implemented to address the social and economic consequences of response measures*", as it has been pointed out earlier under description of NDCS measures, Malawi's NDCs also include adaptation actions, which have mitigation co-benefits outcome. GHG emission reduction from such co-benefit outcomes were not been quantified in the NDCS.2. On the other hand, in NDCS.2 all listed mitigation measures with identified adaptation measures mapped to them, but again, adaptation effects from mitigation actions have not been quantified. In this NDCS.2 implementation period, qualitatively, mitigation effects (GHG reduction) from implementation of adaptation measures have been achieved, as described in Table 3-14. Mitigation benefits from other adaptation actions have not been reported because of limitation in information.

Table 3-3-14: Mitigation co-benefits from adaptation actions

Adaptation Action	Mitigation co-benefit
Climate proof infrastructure	Protection of assets that promote low carbon development, thus enhancing emission reduction. Low carbon development infrastructure refers to creation of physical structures and systems that minimize carbon emissions, promote energy efficiency, and support a transition towards a low-carbon economy. For example, access roads to energy crop plantations/sugarcane plantation for ethanol production, and bridges/barrages that control water levels for hydropower production. Transport infrastructure including roads and bridges are vulnerable to climate induced flooding in Malawi. In the implementation period of NDCS.2 (2017 to 2024) construction of climate proof infrastructure include the Liwonde barrage on Shire River in Machinga District, which was upgraded to enhance its water storage capacity and regulate water flow for hydropower generation and other water uses along the Shire River in 2018. Upgrading of the barrage assists in sustainable and efficient hydropower generation, helping to achieve emission avoidance from use of diesel power generators. The other mitigation benefit from climate proof as an adaptation is in use of renewable energy in powering some infrastructure associated with climate change adaptation, for example use of solar PV energy in irrigation systems. Irrigation with use of solar PV pumps is implemented in most parts of Malawi that face climate induced water shortages; mostly in the lower Shire districts of Chikwawa and Nsanje. These districts greatly suffer from impacts of droughts and flooding and are among climate change hot spots in Malawi. Within the NDCS.2 implementation period, projects funded by non-governmental organizations and Government of Malawi have installed solar water pumps in water-stressed areas like Chikwawa and Nsanje. For example, UNICEF installed of 45 solar powered water systems targeting schools and healthcare facilities, as well as nearby communities, reaching an estimated 135,000 people in the period of 2017 to 2020 period (UNICEF, 2020). Using solar energy, GHG emissions from use petrol power water pumps, which would have been used in water supply, has been avoided as communities have access to water.
Flood management	Malawi is prone to climate induced disasters from flooding, some of which destroy transport and power infrastructure. The destruction of these systems, as already stated, limited low carbon development activities. The Government of Malawi is implementing several measures and projects to manage floods. For example, The Government is implementing a multi-sectoral Malawi Resilience and Disaster Risk Management Project (MRDRMP), a three Year- Project, from 2021 to January 2024. It is being implemented by government ministries, departments and agencies including the Ministry of Water and Sanitation sources (MWS), Department of Disaster Management (DODMA), various departments in the Ministry of Agriculture (MoA), district councils, PMU and all potential beneficiaries. It also involves the participation of other service providers on the ground involved in flood risk management under the Shire River Basin Project. Further, multiple hydropower projects, including the Mpatamanga Hydro Power Project, commencement of construction work starts in 2025, are designed to not only generate electricity but also to regulate river flow and mitigate flood risks. Furthermore, dam rehabilitation and sediment management at existing plants like Kapichira Hydropower contribute to both energy security and flood resilience.

Smart Agriculture, livestock and fisheries	Use of renewable energy in Smart Agriculture, makes a direct mitigation benefit from Smart Agriculture as an adaptation action. In Malawi, solar water pumping is a key technology for smart agriculture, enabling farmers to irrigate their land more efficiently and sustainably. These projects, often supported by international and local non-governmental organizations, are also helping to improve food security, livelihoods, and economic opportunities for smallholder farmers. As already stated, use of solar energy instead of petrol to power water pumps avoids GHG emissions. Further, use of biogas technology from livestock waste help to reduce methane emissions. During the NDCS.2 implementation period, private companies have ventured in generating gas from biogas reactors that use waste from animal husbandry. One of such organisations is ECO Gen. EcoGen, a Malawian start-up, is transforming animal waste into biogas and bio-fertilizer, providing farmers with sustainable energy and farming solutions. This initiative reduces reliance on firewood and chemical fertilizers, offering a cleaner, more affordable alternative. EcoGen's biogas systems, particularly their portable domestic digesters, are becoming increasingly popular across Malawi, including among cattle and pig farmers. A study by Kulugomba and others found out that Malawi had a biogas installation of 343 biogas systems in Malawi with all of them using livestock waste as feed material, 92 of the were installed by EcoGen (Kulugomba, et al., 2023). Most of these biogas systems have been installed during NDCS.2 implementation period. Biogas, is mostly used for cooking, and the substrate is used as organic manure. Therefore, this adaptation action in livestock agriculture as they get manure for fertilizer application and conservation of moisture, trees saved from using biogas saves tress and enhances carbon removal.
Integrated watershed management through afforestation and reforestation	Apart from treating and restoring degraded catchment through afforestation and reforestation, one of the outcomes of this mitigation outcome is enhanced forest cover, thus, achieving carbon removal. Government of Malawi, through its Ministry of Natural Resources, Energy and Mining, in 2017, developed the National Forest and Landscape Restoration Strategy, and Landscape Restoration Opportunities Assessment for Malawi. These policy measures provide ambitious, nationwide programme for land restoration, focusing on: (1) agricultural technologies (e.g. agroforestry); (2) community forests and woodlots (restoring and managing cover on customary common lands); (3) forest management (restoring and managing reserves, natural forests and plantations); (4) soil and water conservation (stabilising soils and increasing infiltration through terracing, check dams etc.); and (5) river and stream bank restoration (natural regeneration and tree planting along 'in-stream' buffer zones. The ambition is to restore 4.5 million hectares of degraded landscapes by 2030 at an estimated cost of US$ 385 million (US$ 86/hectare) (GoM, 2017). This strategy is implemented through support from international and domestic support. For example, Germany Government provided support that resulted in a total of 5,000 hectares of land being restored in Ntcheu District in the period of 2021 to 2024 (FAO, 2024). Further, The Government of Malawi implements the annual National Tree Planting Programme with the goal of restoring forests and land to secure food production. While the program faces challenges such as livestock damage, dry spells, and floods affecting tree survival, a percentage of trees survive and the programme has positive impacts such as benefits like job creation and reforestation of degraded areas. Verifiable numbers of trees planted and are surviving are hard to get.

In relation to MPG 79 *"Each Party shall report the information referred to in paragraphs 65–78 above in a narrative and common tabular format, as applicable. Such common tabular formats should accommodate all types of NDCS under Article 4, as appropriate"*, CTF tables are attached to this BTR report.

3.4 Mitigation policies and measures, actions and plans, including those with mitigation co-benefits resulting from adaptation actions and economic diversification plans, related to implementing and achieving a nationally determined contribution under Article 4 of the Paris Agreement

Paragraph 80 of the MPGs mandates that *"Each Party shall provide information on actions, policies and measures that support the implementation and achievement of its NDCS under Article 4 of the Paris Agreement, focusing on those that have the most significant impact on GHG emissions or removals and those impacting key categories in the national GHG inventory. This information shall be presented in narrative and tabular format"*. The NDCS.2 for Malawi presents a list of measures, some of which the Government of Malawi and other stakeholders including internal partners have implemented. All of the measures are of project type of action, and their aims and information on implementation details are already presented in Table 1. Since the measures are many and that some are not implemented, a prioritization process was conducted to identify measures that would be reported on. Methodology used to prioritize the measures was as follows. Firstly, factors to be used selection were identified and given equal weighting. Three factors were identified, as follows: availability of data (targeting those measures those that are implemented); those that have potential for GHG reduction/removal; and those from affect emissions from key categories according to GHG inventory from Third National Communication (TNC). This is the criteria for selection/prioritization where all the three factors had to be satisfied. The second step in the prioritization methodology was to select the measures. The selection was done by the consultant and two Government officials from Environmental Affairs Department. Four measures prioritized for analysis, and were large scale hydropower, grid connected solar PV, off-grid solar PV, and biomass/fuelwood cookstoves. All measures are from the Energy Sector and cover the following greenhouse gases: carbon dioxide (CO2), methane (CH4), and nitrous oxide) (N2O). These measures are analyzed, including estimation of GHG reduction, in the following subsections:

3.4.1 Grid-connected hydropower generation

Grid-connected hydropower generation is one of the measures reported in 2021 revised NDCS for Malawi, that would significantly contribute to achievement of emission reduction targets in 2040. Among other reasons, the NDCS on grid connected electricity was prioritized to mitigate the would-be GHG emissions in the power sector from the planned coal-fired power stations at Kam'mwamba and Pamodzi. This NDCS measure was also prioritized to reduce emissions from diesel-powered electric generators. There is a share of electricity generated using diesel fuel especially by the EGENCO and the auto-generators for example the anticipated resumption of Kayelekera Uranium Mining in Karonga District which used diesel generators to generate electricity for the mining activities. In the absence of grid-based electricity, it is expected that mining projects in the pipe-line would also generate part of the electricity for their mining operations using diesel generators.

However, despite completing conducting Environmental and Social Impact Assessment (ESIA) and technically designing these two coal-powered power plants, actual construction works have not yet started reportedly due to lack of financing. The Kam'mwamba coal power plant (300 MW), which was initially planned to be financed from a loan from Export and Import Bank of the People's Republic of China[8]. The project, whose construction was expected to start by 2016, was scheduled to start feeding 10% of its output into the national grid by 2019 and the balance of 90% by 2021. However, this Chinese financing did not materialize and Government of Malawi started looking for alternative financing. It is now one of power projects by EGENCO to diversify sources of power away from Shire River[9]. EGENCO planned to have Kam'mwamba power project completed in 2024, but financing is not yet secured. Kam'mwamba thermal power plant project is listed as a priority flagship project in Malawi 2063 Implementation Strategy 1 in the period 2021 to 2030[10] as one of the economic infrastructures to be developed to support industrial activities.

Pamodzi coal-powered plant (120 MW) was planned to be installed at Chipoka in Salima District, by Intra Energy Corporation (IEC), a committed developer. Its construction permit was granted in 2016. However, IEC cancelled project[11] in 2023 and another developer is not found. Inability of construction of Kam'mwamba and Pamodzi coal-fired power plants therefore affects business as usual scenario (BAU) GHG emission projections, from which the 2040 NDCS target for Malawi was based. Further, Malawi expects that securing financing for coal-fired power plants from international community would be difficult because many funding organizations are not willing to provide finance to a GHG-emitting power project such as the coal-fired power plant. Since tracking of progress and target for the 2021 revised Malawi NDCS is based on a dynamic baseline target, subsequent revision of NDCS would into consider such changes to produce a revised plausible future emission scenario from the power sector.

With respect to planned NDCS activities (refer to Table 3-15), there has been progress pertaining to grid-connected hydropower during this step implementation period (2017 to 2024). During this period, there has been activities on planned grid-based hydropower projects with the aim of increasing the installed electricity capacity for Malawi, and diversifying grid electricity generation away from the Shire River. During the period, there has been feasibility studies (technical and financial) on the potential grid-based hydropower potential sites in the country. There has also been activity with respect to designing the listed grid-based hydropower plants. Furthermore, there have

8 https://www.engineeringnews.co.za/article/malawi-tedzani-2016-02-19

9 https://www.egenco.mw/portfolio/full-images-left-sidebar/

10 https://npc.mw/wp-content/uploads/2021/11/MIP-1-WEb-Version-8-November-2021-Fast-view.pdf

11 https://www.gem.wiki/Pamodzi_power_station

also been activities related to securing of financing to develop these power projects. According to the 2021 revised NDCS for Malawi, grid-connected hydropower has a target of adding an extra 410 MW by 2030.

Table 3-3-15: Activities for Grid-connected hydropower NDCS for period (2017-2024)

Activity	Status
Review and update (as needed) hydropower component of Malawi's IRP (2015 - 2035) by 2021	This activity has not been done
Mobilize resources for project preparation studies for priority grid-connected hydropower projects by 2022	Resources for preparation for priority projects have been done, as discussed in the following sections
Initiate project preparation studies for priority grid-connected hydropower projects by 2023	Project preparation studies for priority projects have been done, as discussed in the following sections
Complete and approve project preparation studies for priority grid-connected hydropower projects by 2024	Priority grid connected projects have been identified and feasibility studies conducted. These projects are discussed in the following sections.
Secure funding (financial close) for priority grid-connected hydropower projects and commence development by 2025	Securing of funding for priority grid connected projects in in progress

All of the listed grid-based hydropower projects, discussed and tracked in the following sub-sections, belong to EGENCO a state-owned power generating company. The feasibility studies financed by international organizations, for example World Bank and Africa Development Bank. This gives firm assurance of attainment that these projects will be materialized as planned. From Table 3-316, activity on NDCS grid-connected hydropower pertaining to Review and update (as needed) hydropower component of Malawi's IRP (2015 - 2035) by 2021, has not been carried out. As part of tracking the NDCS, the following sub-sections present on prioritized grid-connected hydropower projects and their statuses, starting with description of the grid-connected hydropower projects that have been prioritized by the Government of Malawi.

In general, most of planned energy projects aimed at increasing national installed power capacity, is enough to meet its national development activities as stipulated in the Malawi 2063, are hydropower-based. Prioritization of hydropower projects in Malawi's integrated energy resource master plan does not come as a surprise. Firstly, Malawi has relatively large hydropower capacity to generate power to the grid to meet national power demand and for export. Secondly, hydropower projects are favored by international development partners and financing institutions because of their being a renewable energy source for generating electricity. Prioritized hydropower projects reported in this initial Biennial Transparency Report (BTR), are planned to be financed from domestic and international sources. Domestic sources include those from EGENCO and through Public Private Partnerships, where the private are local based institutions. This is stated in the 2021

revised NDCS. The international sources include international based power companies and other organizations/institutions that would want to investment in the power sector in Malawi. All of the activities (currently studies, designs and documents preparation for seeking for funding) for prioritized hydropower projects are monitored by the Ministry of Energy, which also provided policy and strategic guidance. Further, Government of Malawi has produced strategic documents and created power sector regulatory framework to create an enabling environment to attract funding to develop the planned grid-connected hydropower projects.

Despite having a characteristic of relatively small operational cost compared to other power generation technologies, initial investment cost for a hydropower project per MW of installed is high compared to other power generation technologies like coal-fired electric power station and solar PV. Process of acquiring financing for such a high initial investment project and the project that is associated demanding works to satisfy environmental and social mitigation requirements, a large-scale (grid-connected) hydropower project take long period of time to construct and commission. In the following sub-sections, description and status of grid-connected hydropower projects that that are being implemented in the country are presented. As it can be seen from the following presented projects, all of the grid-connected hydropower projects are waiting for construction. The positive observation is that the Government and development partners support these grid-connected hydropower projects because they are aligned with the objective of the Malawi 2063. In Malawi 2063, first implementation strategy, known as Malawi 2063 Implementation Plan 1 (MIP1) for the period 2021 to 2030, identification of hydropower sites for increased energy generation and access is listed as one of the activities to be carried[12].

3.4.1.1 Extension of Wovwe Small Hydropower Plant

Extension of Wovwe Hydropower Plant is one of the grid-connected projects that is currently implemented by the EGENCO, a state-owned. The existing Wovwe Hydropower Plant is of installed 4.5 MW, being installed in 1995. It is located along the Wovwe River in Karonga District, northern part of Malawi. Wovwe hydropower plant is of run-of-river type. It is the only grid-connected hydropower plant that is located away from Shire River[13]. The plant, using impulse turbine, gets water flow from rivers/streams originating from Nyika Highlands, with an effective head of more than 100 m. In 2024, EGENCO carried out a feasibility study, with own financial and human resources, to find out if the plant could be extended in terms of power generation. The feasibility study showed that the Wovwe plant could be expanded to

12 https://npc.mw/wp-content/uploads/2021/11/MIP-1-WEb-Version-8-November-2021-Fast-view.pdf

13 Shire River is the outlet from Lake Malawi. Hydropower stations are located in the middle part of the river. Thus, they are all located in the southern Malawi. Installation of hydropower away from Shire Rover is one of the power sector adaptation measures because the Shire River suffers from climate related flooding which affects hydropower production

generate a further 4.5 MW. This would make the Wovwe plant generate 9 MW in total, which is enough to supply almost half of the electricity load in the northern region of Malawi because electricity demand for entire northern region is currently at around 20MW. The status of the project is that full technical and economic feasibility studies and technical designs of the plant are completed. As at the time of reporting this BTR, the project was at financing stage. This is the Project that EGENCO has committed to develop using own funds. Considering amount of work required for a constructing a hydropower project, it is unlikely that constriction of the project could be completed by the end of 2025.

Expansion of Wovwe Hydropower project to generate 9 MW that would serve the northern region, is long overdue. The extra power would help to connect a considerable number of unconnected households in the northern region. There are planned extractive mining activities in the northern region that would benefit from this power; directly showcasing productive use of electricity leading to economic development. Furthermore, it would help consumers in the northern region access reliable electricity because grid-electricity from hydropower stations located in the Shire River become more unreliable in the northern part of Malawi than the rest of the country due to frequent breakdowns of power infrastructure, exacerbated by long distance of transporting electricity from hydropower power stations.

Government of Malawi plans to diversify power generation sources so that the country does not rely on hydropower stations located in the Shire River only. This is clearly stated in the Integrated Resource Planning (IRP) of 2017. Hydropower plants installed along the Shire River suffer damage from flooding of the river, which carry silt and debris from a heavily deforested and harvested land of the Shire River catchment area. Therefore, extension of Wovwe hydropower plant would demonstrate a country's resolve on power supply diversification.

3.4.1.2 Mpatamanga Hydropower Project

Mpatamanga Hydropower Project is scheduled to be constructed at Mpatamanga Gorge, along the Shire River, in southern Malawi. The hydropower plant will be installed at a location that is between Tedzani and Kapichira Hydropower Power stations. The gorge was identified as one of the potential sites along the Shire River to harness further hydropower to feed to the grid. Initially, a feasibility study revealed that the project would generate 358 MW. A recent (2024) feasibility study validated the initial study and showed that a generation potential 361 MW could be realized. By the time of reporting the initial BTR, Mpatamanga Hydropower Project had the status of having the feasibility studies (technical and financial) and ESIA completed. Process of securing financing started and Ministry of Energy expects that the financial closure to be concluded by end of 2025. Technical design of the hydropower plant is completed. Initial works on the project site has started (for example construction of Baily Bridge is done) in readiness for actual construction works in 2026. Assuming financing is

secured as planned, The Mpatamanga Hydropower Project is expected to be commissioned by 2031. A 361 MW installed capacity from this grid-connected hydropower project alone, once commissioned, will contribute more than 85% of the grid-based hydropower NDCS target of 410 MW by 2040. Also, in Malawi 2063, MIP 1, development of Mpatamanga Hydropower Project is listed as a highly priority project under economic infrastructure. This means therefore, that Malawi and other partners have to put to special attention to have Mpatamanga Hydropower project completed as planned.

The project is being developed through a Public Private Partnership Model of which EGENCO will hold a 30% shareholding capacity on behalf of the Government of Malawi. A special purpose vehicle, Mpatamanga Hydro Power Limited (MHPL), was established in 2022 to develop, finance, construct, own and operate the hydropower project[14]. The other partners include the World Bank's International Finance Corporation (IFC), Scatec ASA, and EDF International. The Mpatamanga Hydro Power Limited is currently owned by SN Malawi BV (owned by Scatec ASA and its partners British International Investment (BII) and Norfund), and EDF International (owned by EDF SA) each owning 50%. The planned ownership structure for MHPL is EDF 27.5 % and Scatec and its venture partners 27.5%, Government of Malawi GoM 30 % and IFC 15% of the Project. The project is to be developed on a Build-Own-Operate-Transfer (BOOT) basis by MHPL and the GoM. MHPL will be responsible for developing, constructing and operating the project for a period of 30 years, after which period it will be transferred to (GoM) for continued operations. Once commissioned, Mpatamanga Hydropower Station will significantly increase Malawi's power generation capacity, contributing to enhancing energy security and generation of renewable energy in Malawi (hence avoiding GHG emissions from the energy sector) some of which would be exported. Export of excess electricity from renewable energy would help directly reduce GHG emissions in countries away from Malawi, in cases where this electricity replaces electricity generated from non-renewable energy industries, for example, the coal fired thermal power plants. The country has potential to export electricity using the arrangements of Southern African Power Pool[15], with already the Malawi-Mozambique interconnection project about to be operationalized in 2025. In order to prepare for this, The Government of Malawi, through its Malawi Energy Regulatory Authority has come up of Market Rules for the Malawi Electricity Market[16]. By the time of writing this BTR (May 2025), the World Bank provided financing of Mpatamanga Hydropower Project amounting to 350 million USD in form of a grant[17]. Therefore,

14 https://www.egenco.mw/350mw-mpatamanga-hydro-power-plant-contract-signed/

15 https://times.mw/malawis-power-export-potential-at-150m-european-union/

16 https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.egenco.mw%2Fdownload%2F69%2Fresources%2F3960%2Fmarket-rules-for-the-malawi-electricity-market.pdf&psig=AOvVaw1a9QjCiHACcDEYMgmt57T0&ust=1745570599486000&source=images&cd=vfe&opi=89978449&ved=0CAQQn5wMahcKEwiIh6muo_CMAxUAAAAAHQAAAAAQBA

17 https://www.worldbank.org/en/news/press-release/2025/05/15/malawi-afe-world-bank-approves-grant-financing-for-landmark-358-5-megawatt-mpatamanga-hydropower-storage-project

Mpatamanga Hydropower Project, being a priority project, the NDCS target related to grid-connected hydropower will likely be achieved in 2040 and Malawi is progressing well to achieve it.

3.4.1.3 Kholombidzo Hydropower Project

Just like the Mpatamanga Hydropower Project, Kholombidzo Hydropower Project is one of firm hydropower generation projects planned by the Government of Malawi. It is also listed as a highly prioritized project in the MW 2063 Implementation Strategy for the first period (2021 to 2030) as one of the key economic infrastructures to be developed. Kholombidzo Hydropower Project is planned to be constructed along the Shire River, after the Liwonde Barrage, along the Kholombidzo Falls. The technical and financial feasibility studies were carried out in 2013, with support from African Development Bank. The technical feasibility study showed that a firm power capacity of 210 MW could be generated at this hydropower scheme. The technical designs of the power station also developed. By the time of reporting this initial BTR, the Kholombidzo Hydropower project construction works are yet to be started despite being planned to commence them in 2018 and be completed in 2021[18]. The reason is that the financing is not yet secured. The Government of Malawi is expecting financing arrangement from independent power producer (IPP) alone or through engagement with them through the Public Private Partnership (PPP) arrangements. However, the Government prefers the PPP arrangement[19] . The Ministry of Energy reports that the project will be implemented using a build-own-operate and transfer (BOOT) model with a thirty years long concession period. Further, the Government of Malawi plans to have a Special Purpose Vehicle (SPV) to oversee the implementation of the project.

3.4.1.4 Fufu Hydro Power Project

Fufu hydropower project is located in the Northern Region of Malawi, on South Rukuru River in Rumphi District. Fufu Project is also a planned grid-connected hydropower project, but the project is not included in MIP 1, as one of the key economic infrastructure key priority projects. Despite not being included in MIP 1, Fufu Hydropower Project would be convenient power supply source for the northern region. This is so because the region is prone to poor quality electricity supply that come due to challenges with long-distance-transmission of electricity from hydropower stations located in the Shire River in the southern part of Malawi. Technical and economic feasibility studies for Fufu hydropower project are already conducted, in 2016. The studies show that a firm electricity generation capacity of 146 MW is possible[20].

18 https://nation1514.rssing.com/chan-25972360/article7740.html

19 https://mitc.mw/invest/index.php/investment-opportunities/investment-projects/projects-energy/108-kholombidzo-power

20 https://mitc.mw/invest/index.php/investment-opportunities/investment-projects/projects-energy/109-fufu-hydro-electric-power

Fufu Hydropower Project is designed as designed as a pumped-stage hydropower plant. Pumped-storage hydropower plants have advantages over other hydropower plants because apart from generating electricity, they generated electricity when not needed in form of potential energy of water. When more electricity is needed, for example, during the peak hours, the potential energy of water is released to generate electrify using the same turbines. Fufu hydropower project would therefore provide relatively quick response to fluctuating electricity demand, helping to stabilize the grid, which is currently compromised by the grid-feed-in of variable solar PV electricity. However, in general, pumped storage hydropower project is associated with higher investment cost compared to the traditional hydropower stations. Of course, the actual investment cost is site specific. The financial feasibility study of Fufu Hydropower project revealed investment cost of US$702.5[21] million for a firm power output of 261 MW[22]. In relative terms, this is much higher compared to the conventional hydropower projects. This could probably explain why Fufu was prioritized as one of the power projects to be done in MPI 1.

Apart from Fufu Hydropower Project being a reliable source of electricity supply in the northern region, and its grid-stabilizing characteristics, it would also provide opportunity to diversify sources of electricity away from Shire River, which suffers from impacts of climate (flooding). Shire River is also sensitive to water levels in Lake Malawi, a water source that is projected to affected by impacts of climate change. Therefore, construction of Fufu hydropower station could be one of the climate change adaptation measures in the hydropower sub-sector. However, the positive attributes about Fufu hydropower project are not investor-attractive characteristics to construct the hydropower plant. Of course, Fufu hydropower project is listed as one of the viable projects for investment in the energy sector by Malawi Investment and Trade Centre (MITC). The Government through the Ministry of Energy need to continue wooing private investors for a possible PPP arrangement to development the power plant. The project is planned to be implemented through public-private partnership, with the construction period spanning for 5 years commencing in 2024[23]. The Ministry of Energy indicates that the project would be implemented following a build-own-operate and transfer (BOOT) model. By the time of reporting this BTR, a Special Purpose Vehicle (SPV) to oversee the implementation of the project is yet to be established.

21 https://mitc.mw/invest/index.php/investment-opportunities/investment-projects/projects-energy/109-fufu-hydro-electric-power#:~:text=A%20Bankable%20feasibility%20study%20conducted%20for%20the,project's%20Net%20present%20Value%20is%20US$123%20million.

22 https://www.energy.gov.mw/hydropower/

23 https://www.energy.gov.mw/portfolio-item/fufu-hydropower-project/

3.4.1.5 Songwe Hydropower Project

Songwe Hydropower Project is one of the outputs of the Songwe River multipurpose dam that is planned to be constructed jointly by Malawi and Tanzania. The dam would stabilize the meandering Songwe River, which serves as a boundary between Malawi and Tanzania. Songwe River drains its water into Lake Malawi, also known as Lake Nyasa. Feasibility study, environmental and social impact assessment, and the technical designs of the plant layout were conducted in 2017. The studies showed that the project is both technical and economic viable. The firm power generation capacity is 180 MW to be shared equally between two countries. Thus, power generation from Songwe Hydropower Project for Malawi is 90 MW. Construction worked were expected to start in 2022 with costs between two countries, planned to 5 years to complete[24]. This power project is one of priority projects by both countries. The Ministry of Energy reports that a bi-national company, called SONGWECOM has been established by Malawi and Tanzania to plan, implement, and manage the project on behalf of both nations.

The status report provided by the Songwe River Basin Development Programme in 2008, in preparation for financial support by African Development Bank stated that the Project had conducted a second feasibility study from 2012 to 2015 to update the 2003 one[25]. The second feasibility study for the project recommended, that out of three flood control dams that would be constructed, the lower dam would be the one where the hydropower generation would be incorporated with a planned generation capacity of 180 MW. However, by the time of preparing this BTR, construction works had not yet started. It is likely that this project would require another feasibility study to update the 2015 design data. With interest from development partners, including the African Development Bank (AfDB), the World Bank, and the Global Environment Facility (GEF), it is likely that the project will be constructed. The partners and the two governments view Songwe multipurpose dam project as a model for sustainable, transboundary resource management. The Government of Malawi has prioritized this project in the MIP1 as one of the flagship projects under economic infrastructure, with duration implementation being 2016-2063.

3.4.1.6 Chasombo and Chizuma Hydropower Project

Chasombo hydropower project is another hydropower-connect project that is planned to be constructed during the revised NDCS implementation period. The Project is located on the Bua River, in Nkhotakota district in the central region of Malawi. According to Ministry of Energy, technical and financial feasibility studies for the project were conducted lately, in 2024. The studies show that is feasible, both technically and financially. Environmental and Social Impact Assessment

24 https://www.energy.gov.mw/songwe-dam-and-hydropower-plant/

25 https://ilejedc.go.tz/storage/app/uploads/public/5b2/fe2/754/5b2fe275431d2616024163.pdf

(ESIA), were also conducted. The project aims at generating 50 MW. There is another proposed grid-connected hydropower project close to Chasombo on Bua River, known as Chizuma. Feasibility studies were also conducted for Chizuma hydropower project. The Ministry of Energy intends to explore combining Chasombo and Chizuma into one power plant with an aggregate capacity of 83 MW. Increase hydropower capacity of Malawi and diversify power generation away from the Shire River. Again, as with other grid-connected hydropower projects, Government of Malawi prefers to develop the project through a Public-Private Partnership (PPP) arrangement, following a build-own-operate-transfer model. A Special Purpose Vehicle (SPV) is yet to be established to oversee the project's implementation.

3.4.1.7 Estimation of emission reduction/avoided from Gird-connected hydropower projects

All of the discussed six grid-connected hydropower electricity projects discussed in subsection D1 are all in the stage of securing financing except Mpatamanga Hydropower Project has had financing secured and construction is set to start in 2025 (World Bank, 2025). Hydropower projects take long to construct; accordingly, the revised NDCS activities for this implementation period (2017 to 2024) are focused on studies and securing financing. Finances for conducting studies have been sourced, with technical designs of most of the projects done. The GoM continues to engage potential investors to invest in the power sector with almost all of the grid-connected projects listed in the Malawi Trade and Investment Centre list of opportunities to invest in Malawi. MTIC is a trade and inward investment promotion agency, established to promote Malawi as an ideal destination for trade and investment in Africa and beyond. MITC operates as a One-Stop Service Centre for business start-ups as mandated by the Investment and Export Promotion Act of 2012.

The NDCS target for the grid-connected hydropower projects is a total of 410 MW by 2030. Unless construction of hydropower projects with large capacity starts this year or next year (2026), realization of this NDCs target would be difficult to achieve. The Government of Malawi is therefore, recommended to do more in securing financing to construct the planned hydropower projects accordingly. In case the projects are constructed, GHG avoided and reduced would come from the saving of fossil fuels that is used to generate electricity in Malawi and the region, since with Malawi will be able to trade excess power with the region using Southern African Power Pool. Estimation of the GHG reduced is done using fuel and energy generation technologies will be replaced by the grid-connected hydropower projects. The methodology and its assumptions used in this BTR in estimating GHG to be reduced is described in the following section.

3.4.1.7.1 Methodology and assumptions in estimating GHG reduction for Gird-connected hydropower NDCS measure

As stated in the NDCs report, grid-connected hydropower projects will reduce emissions from the planned coal-fired electric power plants, and from the diesel electric generators. In other words, grid-connected hydropower projects will replace electricity that would be generated from these thermal plants that use fossil fuels. GHG emissions in the power sector depends on the fuel and on the electricity generation technology (type of the power plant). In the case of coal fired electric power plant, the technology used is a typical thermal power plant operating on Rankine power cycle technology. A coal-fired thermal power plant operating using Rankine power cycle has typical efficiency values generally lower than 50%, thus, a considerable amount of coal is not directly converted into electrical energy, it is lost to the environment as per second law of thermodynamics. However, this loss of energy in coal would also contribute to increased emissions. If the power plant is inefficient, it will be associated with increased levels of emissions per unit electricity generated. The coal to be used for electricity generation would be sourced locally in Malawi and outside (especially Moatize in Mozambique). The CO_2 emission factor of such coal is not yet established. Thus, tier 1 methodology of estimating emissions would be used: where default emission factors are used, such as those published by the Intergovernmental Panel on Climate Change (IPCC).

Default emission factor for coal was obtained from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, under stationary combustion in the sub-category of energy industries – Electricity generation, where fuel is coal[28]. Assuming sub-bituminous coal (which s available in Malawi and in Mozambique), the default emission factor for CO_2 is 96,100 $kgCO_2/TJ$. Emission factors for methane (CH_4) and nitrous oxide (N_2O) are relatively small and are not included in estimation in the electricity generation using coal.

Efficiency of the thermal power plant determines amount of coal or any fuel needed to produce the required amount of electricity. Further, it is required to produce emission factor of coal-fired power plant, per unit of electric energy produced (for example MWh). It is better to do so in order to estimate CO_2 emissions using its emission factor and amount of electric energy produced in a given time (usually a year). Since the emission factor from IPCC is provided as $kgCO_2/TJ$, the emission factor in terms of tCO_2/MWh can be converted. Emission factor in tCO_2/MWh for coal in electric power plant could then in the same units with electricity grid emission factor. The thermal efficiency is introduced to include the increased amount of coal (or any fuel) due to lowering in efficiency to generate unit electric power. Equation (2), on thermal power plant emission factor ($kgCO_2/MWh$) is formulated accordingly (to be used to for coal and diesel in electric power generation). This approach was used by in calculation of emission factors in power sector in Indonesia[29].

28 https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf

29 https://www.jcm.go.jp/id-jp/methodologies/66/attached_document1

$$\text{Thermal Power Plant Emission Factor} = \text{Emission Factor of Fuel Source}\left(\frac{\text{kgCO}_2}{\text{TJ}}\right) \times 10^{-3}\left(\frac{\text{t}}{\text{kg}}\right) \times \frac{3.6\times10^{-3}}{\eta_t}\left(\frac{\text{TJ}}{\text{MWh}}\right) \quad (2)$$

Thermal efficiency of a typical coal fired power plant is around 45%[30], though with modern coal pulverization technologies, the efficiency could reach 55%. But the pulverization technologies increase investment cost, and it is unlikely that the coal-fired power plant in Malawi would use ultra-advanced coal combustion technologies. Once the emission factor in kgCO2/TJ is found and the thermal efficiency is known, equation (2) can be used to find the emission factor of the power plant in tCO_2/MWh.

To estimate CO_2 emissions using equation (2) in tCO_2/MWh, there is a need to estimate electric energy generated by the hydro-electric power plant in MWh (whose electricity production replaces electricity from thermal-electric power plant. Planned installed power for all grid-connected discussed in section 3.4.1 are presented in Table 3-17. Power plants do not operate at rated capacity all the all the time. Also, they may operate at less than rated capacity due to limited in resources and or responding to lowering demand for electricity. A plant capacity factor is usually introduced to consider actual energy generated relative to energy that would be generated if power plant was being run at 100% rated power over the time. Capacity factor of the proposed grid-connected hydropower projects are provided in some designs, while capacity factor for other projects are assumed.

Table 3-3-17: Electric energy generated from grid connected hydropower planned projects

Grid-connected Project	Planned Capacity (MW)	Availability	Capacity factor	MWh
Wovwe expansion	4.5	0.9	0.5	17,739.0
Mpatamanga	361	0.9	0.49	1,394,600.8
Kholombidzo	210	0.9	0.65	1,076,166.0
Fufu	261	0.9	0.49	1,008,284.8
Songwe	90	0.9	0.77	546,361.2
Chasombo and Chizuma	83	0.9	0.5	327,186.0
Total				4,370,337.80

Further, power plants do not operate all the time; at other times the plant is down for aa scheduled maintenance procedure. A plant availability factor is introduced to consider amount of time the plant is available to generate power. The availability factor for hydropower plants varies significantly. However, proposed hydropower projects would be providing base load, except the Fufu which would provide peaking load, but since it is a pumped storage hydropower plant, it would operate most of the time. Base load electric power plants are generally run almost all the time. Therefore, a conservative figure of

30 https://www.sciencedirect.com/science/article/abs/pii/S0196890415007657

90% availability factor for the proposed hydropower plant is assumed. The number of hours the plant would generate power in a year is therefore the product of availability factor and the number of hours in a year (8760 hours). The electric energy (in MWh) generated is the product of installed capacity, capacity factor and the number of hours the plant generate power. The electric energy (MWh) is calculated for all the grid-connected electricity and listed in Table 3.

The emission factor for a coal-fired electric power plant is calculated from Equation (1) taking the emission factor of coal in $kgCO_2/TJ$ as 96,100 and thermal efficiency as 45%, the emission factor in tCO_2/MWh is 0.7688, as demonstrated in the following solved equation.

$$\text{Coalfired Thermal Power Plant Emission Factor} = 96{,}100 \left(\frac{kgCO_2}{TJ}\right) \times 10^{-3} \left(\frac{t}{kg}\right) \times \frac{3.6 \times 10^{-3}}{0.45} \left(\frac{TJ}{MWh}\right) = 0.7688 \left(\frac{tCO_2}{MWh}\right)$$

Since the emission factor in tCO_2/MWh, and the energy in MWh are calculated, estimation of emission reduction from grid-connected hydropower is possible. Apart from replacing electricity generated from coal-fired power plants, the grid-connected hydropower projects would replace electricity generated from diesel electric generators. Therefore, there is need to estimate the MWh from diesel electric generators and the diesel generator emission factor, using equation 1. For stationary combustion in energy industries, diesel has a default IPCC emission factor, in $kgCO_2/TJ$ of 74,100. The efficiency of diesel electric generator is around 40%[31] if operated in the designed optimum operating range, usually up to 80% of total load capacity. Therefore, the emission factor for diesel electric generator in tCO_2/MWh is 0.6669, as exemplified in the following calculation.

$$\text{Diesel Generator Emission Factor} = 74{,}100 \left(\frac{kgCO_2}{TJ}\right) \times 10^{-3} \left(\frac{t}{kg}\right) \times \frac{3.6 \times 10^{-3}}{0.40} \left(\frac{TJ}{MWh}\right) = 0.6669 \left(\frac{tCO_2}{MWh}\right)$$

3.4.1.7.2 Potential emission reduction from grid-connected electricity projects

Emission reduction will be achieved when grid-connected power would replace electricity from coal-fired power plants and diesel electric generators. However, the grid-connected hydropower plants are also associated with emissions themselves, which are estimated using grid-emission factor. Therefore, to calculate the potential emission reduction from grid-connected hydropower, it is required to find the next emissions reductions. This can be achieved by subtracting grid emission factor from the power plant emission factor

31 https://www.genpowerusa.com/blog/diesel-generator-vs-gas-generator-which-is-more-efficient/#:~:text=How%20Efficient%20are%20Diesel%20Generators?,deciding%20which%20generator%20to%20buy.

From UNFCCC harmonized grid emission factor database, the grid-emission factor for hydroelectric power for Malawi is 0.243 tCO_2/MWh[32] . Therefore, the net emission factor for coal-fired power plant is 0.5258 tCO_2/MWh and for a diesel electric generator is 0.4239 tCO_2/MWh. Since energy from grid-connected electricity (MWh) is calculated, the share of this that would replace electric energy from coal fired power plants and diesel generator can be assumed to be 90% coal and 10% diesel (because diesel generators are mostly for peaking purposes). The emission reduced are calculated and presented in the following Table 3-18. The total GHG reduced is 2,253,389.83 tCO_2.

Table 3-3-18: GHG reductions from the NDCS measure on grid-connected hydropower projects

Name of grid connected hydropower project	MWh from hydropower	Energy replaced from coal	Energy replaced from diesel generators	GHG reduction from coal power plants (tCO_2) Emission factor = 0.5258 tCO_2/MWh)	GHG reduction from diesel power plants (tCO_2) Emission factor = 0.4239 tCO_2/MWh	Total GHG reduced (tCO_2)
Wovwe expansion	17,739.0	15,965.10	1,773.90	8,394.45	751.96	9,146.41
Mpatamanga	1,394,600.8	1,255,140.68	139,460.08	659,952.97	59,117.13	719,070.10
Kholombidzo	1,076,166.0	968,549.40	107,616.60	509,263.27	45,618.68	554,881.95
Fufu	1,008,284.8	907,456.28	100,828.48	477,140.51	42,741.19	519,881.71
Songwe	546,361.2	491,725.08	54,636.12	258,549.05	23,160.25	281,709.30
Chasombo and Chizuma	327,186.0	294,467.40	32,718.60	154,830.96	13,869.41	168,700.37
Total						2,253,389.83

The emission reductions from this NDCS measure related to grid-connected electricity would be spread out up to 2040 according to the discussed realistic time they would be commissioned, as presented in Table 3-19. Wovwe expansion project is likely to be commissioned in 2027 with funds from EGENCO, Mpatamanga in 2030 with funding from local and international, Kholombidzo is likely to be commissioned in 2035, Chisombo and Chizuma in 2037, while Fufu is likely to be commissioned in 2038. Songwe Hydropower project is likely to be commissioned in 2040 with funding from Malawi, Tanzania and international organization.

32 https://unfccc.int/sites/default/files/resource/Harmonized_Grid_Emission_factor_data_set.xlsx

Table 3-3-19: Grid-connected hydropower projects, likely year of commissioning and correspond GHG reduced

Name of grid connected hydropower project	Year likely to be commissioned	Total GHG reduced (tCO_2)	Total GHG reduced – cumulative (tCO_2)
Wovwe expansion	2027	9,146.41	9,146.41
Mpatamanga	2030	719,070.10	728,216.51
Kholombidzo	2035	554,881.95	1,283,098.46
Chasombo and Chizuma	2037	168,700.37	1,451,798.83
Fufu	2038	519,881.71	1,971,680.54
Songwe	2040	281,709.30	2,253,389.84
Total by 2040		2,253,389.83	

It is a requirement to project how the indicator will be changing over the entire NDCS period. For the grid-connected electricity, as an NDCS measure, the realistic year of implementation/commission is 2027 with Wovwe Expansion., contributing 9,146.41 tCO_2. Total GHG emissions for the other years is taken as cumulative emissions, calculated from Table 3-19. The progression of the indicator (total GHG reduced) is therefore presented in Figure 3-4.

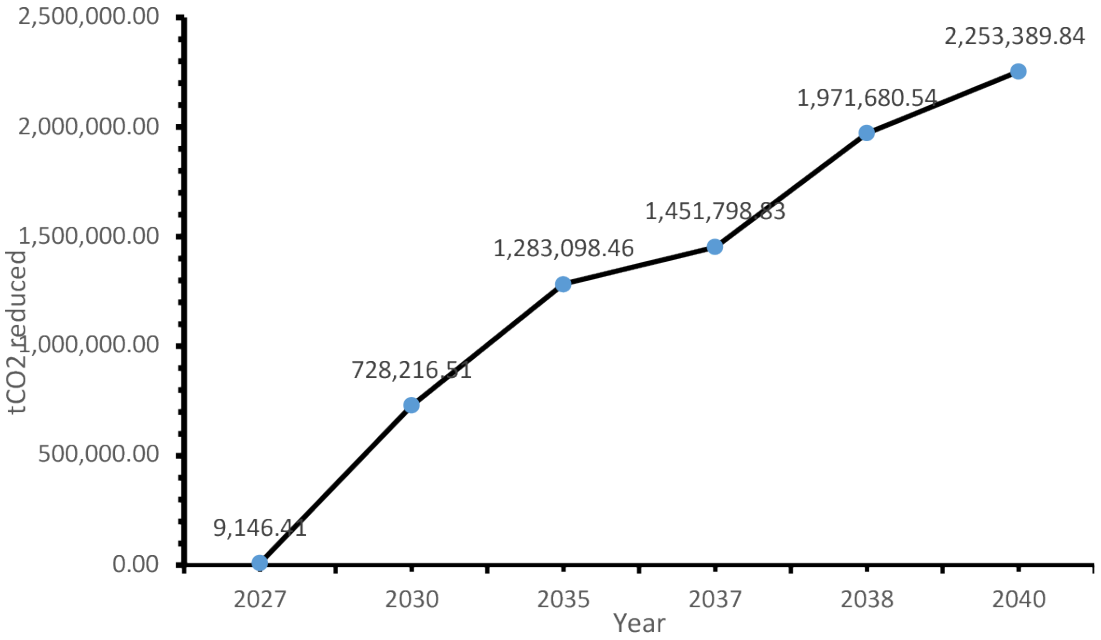


Figure 3-01: Projection of Indicator (Total GHG reduction) on grid-connected hydropower from 2027 to 2040

The cumulative GHG reduction by 2040 (2.25 million tCO_2e) represents a share of 13% of the NDCS target (17.7 million tCO_2e) for Malawi for both unconditional and conditional measures.

3.4.2 Off-grid small scale solar PV systems

A typical solar home system comprises a solar PV panel, battery, radio, light bulbs and phone charger. By placing the solar PV panel in sunlight during the day, the solar energy can be stored (in a small battery) and used to power lights and small appliances. Unpublished sources and expert opinion state that Malawi has achieved a lot in terms solar home system installations arising from projects and individual installations. Solar Home Systems (SHS) are off-grid energy solutions on household level. They use one or more solar panels (PV modules) to generate electricity for lightning and appliances such as radios or TVs. SHS usually operate at 12 Volt direct current for low power DC appliances and include a charge controller (distributes power and protects the batteries and appliances from damage) and at least one battery (stores energy for use when the sun is not shining). SHS for larger appliances come with an inverter to change the current. During this NDCS implementation period, coordination plan among stakeholders including donors is developed through a special unit (Rural Electrification Unit) in the Ministry of Energy in the office of the Director of Electricity, and new off-grid small scale solar PV systems have been installed throughout the country.

In Malawi SHS, just like other categories of off-grid solar PV systems, are difficult to monitor and record because there are various players that are involved, but not coordinated. These players include the Government of Malawi, non-governmental organizations, individuals (households and institutions), and numerous renewable-energy based industries. The other players are the institutions such as the energy sector-wide regulating authority, the Malawi Energy Regulatory Authority (MERA), the Malawi Bureau of Standards (MBS), Malawi Revenue Authority (MRA), and an association of renewable energy industries, named renewable energy industries association of Malawi (REIAMA). These institutions form important part of institutional framework for off-grid solar PV market in Malawi. It is important therefore that these activities of these institutions are well coordinated and inform each other to create a vibrant solar PV off-grid in the country where data for monitoring, reporting and verification purposes is systematically collected and archived.

Off-grid solar PV is considered as one of the firm sources of power to electrifying rural areas that are far away from the main ESCOM grid. However, the off-grid solar PV has had challenges such as the sector having unregulated market landscape, suppliers not having accountability on quality and poor service, users/consumers affordability constraints, difficulties in sourcing solar PV system parts locally, and management of the resulting e-waste resulting from off-grid solar PV components. Despite the challenges, Malawi has registered a booming of solar home systems (SHS) especially for as small-scale solar PVs for lighting. The Government of Malawi has put in place policies and strategies to promote off-grid solar PV energy. Some of these are Malawi Renewable Energy Strategy that sets the country to achieve an

electrification level of 45% in 2030 where off-grid solar PV via private sector/industries is mentioned as one of the significant technologies to be promoted to achieve this target. One of the implementation strategies to achieve the target is Government increasing level of affordability of solar PV components through removal of import taxes and excise duties on all renewable energy components.

3.4.2.1 Numbers of Solar Home System Installed in Malawi

MERA, being the energy-sector wide regulator has mandate to regulate the renewable energy industry, both for solar home systems, small-scale solar PVs, mini-grids and large-scale solar PVs (grid connected). Important details on regulation would provide useful data to track the progress of the off-grid solar PV NDCS. However, installation and trade/market on solar home systems and small-scale solar PVs are unregulated, and no reliable data is available. Because these are done at individual level purchasing them from off the-shelf (shops) or are brought into the country through unchartered routes, and inability of MRA and MBS to record some small-scale solar energy components at entry points into Malawi. Solar mini-grids are regulated. The NDCS on off-grid solar PV has a target of 50,000 of additional off-grid PV SHS / lanterns by 2025. Information to estimate SHS was aided from literature on Government based projects, with Ministry of Energy officials validating the estimates.

According to the June 2024 World Bank Report on its the project it finances on Malawi Electricity Access Project (MEAP), which was approved in 2009, in 2024, the MEAP registered 115,000 connections of which one-third was from SHS since the restructuring of the project ed in 2022[33]. This means that by closing of the reporting date of 30 June 2024, over 38,000 SHS were installed through MEAP. This was achieved through the NgweNgweNgwe Fund[34] (established in May 2023), administered through the Ministry of Energy where five solar companies were contracted to install at least 244,500 SHS of Tier 1 category. According to the Project, Tier 1 category of SHS are those of a solar lantern that meets Tier 1 on the multi-tier framework (MTF) for a household, if it provides at least 1,000 lumen-hours (lm-hr) / day and sufficient energy to keep a well-used mobile phone operational. Through interviews with some of the contracted companies (Zuwa Energy Limited and Green Impact Technologies), it was established that provision of after-sale services and repairing of defunct SHS systems were done, monitored by the Ministry of Energy.

Also, the number of SHS will also increase during the implementation phase of this NDCS from the 2025 approved The Government of Malawi sustainable energy financing application to the World Bank. This is the project, titled Accelerating Sustainable and Clean Energy Access Transformation in Malawi (ASCENT-Malawi) Project with implementation period from 2025 to 2030[35]. The project will be

33 https://documents1.worldbank.org/curated/en/099050724110519939/pdf/P1643311e2468709c1b43a14253e502c6d8.pdf

34 NgweNgweNgwe is a term in vernacular Malawian language of Chichewa meaning *"having light all night"*

35 https://projects.worldbank.org/en/projects-operations/procurement-detail/OP00350240

implemented by Ministry of Energy and Electricity Supply Corporation of Malawi (ESCOM). The general project development objective is to increase clean and sustainable energy access in Malawi, aligning with ASCENT's Program Development Objective of increasing clean and sustainable energy access in Eastern and Southern Africa. The ASCENT project has five components but, the Malawi component will implement the following components: Off-grid Connection through Solar Home System (SHS); Energy Access for Schools and Health Facilities; and Clean Cooking Solutions, respectively; and on Technical Assistance and Capacity Building. With respect to off-grid connection through SHS, the ASCENT Project will expand the deliverables of the NgweNgweNgwe Fund under the MEAP to provide solar home systems (SHS) to over 800,000 households contributing towards a 70% electricity access level by 2030[36]. Therefore, with only these two projects (MEAP and ASCENT) achievement of the NDCS on off-grid SHS target of 50,000 of additional off-grid PV SHS / lanterns by 2025 is on track and will be exceeded.

Further, the other renewable energy projects on solar PV give data on numbers of SHS that are installed in Malawi. A report from the USAID Solar Home System Kickstarter Programme in Malawi show that a number of SHS have been installed in Malawi. The report states that for the period of 2019 to 2022 over 108,000 SHS were sold[37] through the market activities of 4 renewable energy-based companies that were awarded to implement the programme: The four grant winners (national and international) were SolarWorks, VITALITE, Yellow, and Zuwa Energy. In 2019, Power Africa launched the "Solar Home System Kick-Starter Program for Malawi" to expand energy access in order to grow the private sector. Kick-Starter grantees have measurably increased their presence in Malawi and are still actively growing their operations following the end of the grant program in the country, and attract qualified international solar home system players into the Malawian market.

The other regulated and documented off-grid solar -PV installation that can be tracked towards achievement of the NDCS on off-grid solar installations are the solar PV mini-grids, presented as follows.

3.4.2.1.1 Estimation of emission avoided/reduced from use of Solar Home Systems

Most of the solar home systems are used for lighting, almost all of them are used in off-grid communities. SHS are also used in grid-based communities where electricity supply is unreliable for provision of lighting and phone charging. The power rating for each of the SHS vary because the SHS depends on application, for example on lighting, entertainment, and phone charging. In Malawi, power rating of SHS typically range from 6W to 55W[38]. Taking the average of 30W for each

36 https://times.mw/250-million-clean-energy-project-rolls-out-mid-year/

37 https://sun-connect.org/wpcont/uploads/PA021SBM.pdf

38 https://www.mphamvu-now.info/home-solar-systems/

of SHS, and typical time usage of 4 hours per day (thus, 1460 hours in a year) according to an expert opinion from e renewable energy expert based in Ministry of Energy, the annual electricity consumption from SHP can be calculated. Firstly, verifiable information from installed SHP is used, which basically indicates minimum number of installations in the country. This information is collected from the above discussed status of SHS in Malawi. Total power installed from SHS is then calculated from the product of power wattage of a SHS (30 W) and number of installed SHS, as presented in Table 17.

A SHS, being part of Solar PV systems are known for their durability and long-lasting performance. On average, a solar PV system can last between 25 and 30 years[39]. However, their efficiency will gradually decline over time, typically at a rate of about 0.5% to 1% per year[40]. This information is considered when calculating number of SHS installed and their contributions towards renewable energy power supply for Malawi up to 2040, being target year for Malawi's NDCS. This means that SHS installed in 2019 would still be in used up to 2040, thus accumulative installation totals can be determined. SHS installation per year (annual installation rate) has increased tremendously in Malawi, for example a study done in Lilongwe revealed that annual installation rate increased from 1% in 2010 to 12% in 2020[41]. It is also assumed that since these project-based SHS are disseminated through market-approach, the numbers after end of the project would grow by an annual rate equal to the installation rate: which is assumed to be an average of 5% nationally (guided by the Lilongwe SHS installation rate and from an expert opinion). The calculations of the installed SHS and energy in MWh (power in MW multiplied by number of hours) from it are presented in Table 3-20.

39 https://sunshinesolar.co.nz/how-long-does-solar-last/#:~:text=On%20average%2C%20a%20solar%20PV,%25%20to%201%25%20per%20year.

40 https://sunshinesolar.co.nz/how-long-does-solar-last/#:~:text=On%20average%2C%20a%20solar%20PV,%25%20to%201%25%20per%20year.

41 https://sunshinesolar.co.nz/how-long-does-solar-last/#:~:text=On%20average%2C%20a%20solar%20PV,%25%20to%201%25%20per%20year.

Table 3-3-20: Number of installed solar home systems and energy generated from installed solar home systems

Project	2019	2020	2021	2022	2023	2024	2025	2026	2028	2030	2032	2034	2036	2038	2040
ASCENT	0	0	0	0	0	0	133,333	266,667	533,333	800,000	882,000.00	972,405.00	1,072,076.51	1,181,964.36	1,303,115.70
USAID Solar Home System Kickstarter Programme	27,000	54,000	81,000	108,000	113,400.00	119,070.00	125,023.50	131,274.68	144,730.33	159,565.19	175,920.62	193,952.48	213,832.61	235,750.46	259,914.88
Malawi Electricity Access Project	0	7,600	15,200	22,800	30,400	38,000	39,900.00	41,895.00	46,189.24	50,923.63	56,143.31	61,898.00	68,242.54	75,237.40	82,949.23
Total	27,000	61,600	96,200	130,800	143,800	157,070	298,257	439,836	724,253	1,010,489	1,114,064	1,228,255	1,354,152	1,492,952	1,645,980
Power from SHS (W)	810,000	1,848,000	2,886,000	3,924,000	4,314,000	4,712,100	8,947,705	13,195,090	21,727,587	30,314,665	33,421,918	36,847,664	40,624,550	44,788,566	49,379,394

Projection of the indicator for tracking NDCS measure, in terms of kW of electricity installed is presented in Figure 3-5. It can be seen that the power installed from solar home systems is increasing steadily from 2019 to 2024 and then from 2025 to 2040 during which period planned instalments and an application of growth rate of 5% is employed

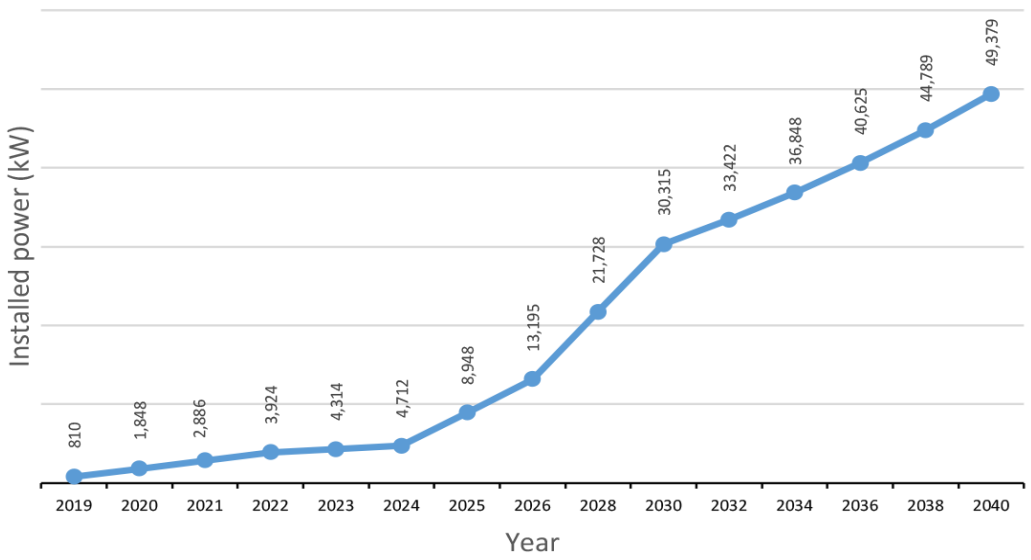


Figure 3-0-2: Installed power from solar home systems

Emission reduction from SHS systems, just like in grid-connected hydropower, is calculated from knowledge of energy that the SHS systems substitutes. Ideally SHS provides power for lighting, phone charging, powering radio and TVs. Most of the SHS are installed in areas without access to grid-connected electricity, and the services that use SHS are not provided before SHS installations. However, it can be estimated in terms of avoided emissions from use of SHS. For the case of lighting (almost all of SHS are used for lighting), in off-grid communities in Malawi, baseline lighting technologies include a mix of traditional and modern sources. Traditional methods like candles, kerosene lamps, and torches are still used. While torches use chemical batteries (non-renewable source of energy), kerosene and candles are not only non-renewables, but also emit GHGs: candles are made of kerosene wax. Therefore, it can be modelled that SHS will substitute kerosene in provision of lighting services in off-grid rural areas. Taking kerosene lamp as stationary combustion, the default emission factor for CO_2 is 71,900 kg CO_2/TJ[42], obtained from 2006 IPCC Guidelines in Table 2.2 on default emission factors for stationary combustion in the energy industries (kg of greenhouse gas per TJ on a net calorific value basis). However, the technology for lighting using kerosene can be using a wick-based lamp or a lantern. The latter is more common in Malawi currently. Kerosene lamps, as sources of light, are highly inefficient with about 0.59% of input used to generate light while the rest are spent as heat. According to the Joint Crediting Mechanism (JCM), the emission factor for kerosene lamp as used in CDM Methodology is 6.8tCO_2/MWh[43]. The CO_2 emissions are then calculated from the product of emission factor (tCO_2)/MWh) and energy (MWh). The calculated values are presented in Table 3-21.

42 Table 2.2 Stationary Combustion in the 2006 IPCC Guidelines available on https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf

43 https://www.jcm.go.jp/ke-jp/methodologies/30/methodology_file#:~:text=2.2%20Calculation%20method%202:&text=CO2%20emission%20factor%20of%20the%20lighting%20from%20kerosene%20lamps.,monitoring%20in%20the%20project%20activity.

Table 3-3-21: CO_2 emission reduction from solar home systems

	2019	2020	2021	2022	2023	2024	2025	2026	2028	2030	2032	2034	2036	2038	2040
Power from SHS (W)	810,000	1,848,000	2,886,000	3,924,000	4,314,000	4,712,100	8,947,705	13,195,090	21,727,587	30,314,665	33,421,918	36,847,664	40,624,550	44,788,566	49,379,394
Energy (MWh)	1,182.60	2,698.08	4,213.56	5,729.04	6,298.44	6,879.67	13,063.65	19,264.83	31,722.28	44,259.41	48,796.00	53,797.59	59,311.84	65,391.31	72,093.92
Emissions reduction tCO_2e)	8,041.68	18,346.94	28,652.21	38,957.47	42,829.39	46,781.73	88,832.82	131,000.86	215,711.48	300,963.99	331,812.80	365,823.61	403,320.53	444,660.89	490,238.63

Solar home systems, despite having relatively smaller capacity to reduce emissions (for example, 8,041.68 tCO_2 in 2019, and projected 490,238.63 tCO_2 in 2040), have greater social benefits compared to grid-connected solar energy systems. SHP provide lighting and communication services, which are need for social development, and for enhancement of businesses in off-grid communities. It is expected that as economic status of rural households increase, SHS installations will increase from household self-installations.

3.4.2.2 Solar PV Mini-grids in Malawi

A mini-grid can be defined as a standalone energy system producing electricity to an off-grid community. Mini-grids can be grouped in terms of energy source, for example a solar PV mini-grid, a hydropower mini-grid, and a diesel generator mini-grid. In Malawi, the majority of mini-grids are of solar PV and hydropower (not hybrids). There have been examples of hybrid mini-grids of solar PV and wind in the country. These are the early mini-girds installed by the Government of Malawi with support from GEF during the UNDP/GEF project on Barrier Removal to Renewable Energy in Malawi (BARREM). Under BARREM Project, in 2004, Government installed 3 solar PV-wind hybrid mini-grids in Thyolo (Kadzuwa), Nkhotakota (Chagunda) and Mzimba (Elunyeni), but these are all not functioning now [44].

Most of the solar based mini-grids are in operational state by the time of reporting the first BTR. The challenges encountered are that most of them depend on international support in terms of parts for repair. Also, mini-grids operators complain about logistical challenges to bring into the country mini-grid parts/components from outside Malawi despite the fact that import duties are waived on such components. Training in mini-grids is happening in the country, but still more critical skills in design and manufacture of parts and components are lacking, exacerbating the challenges of relying on imports of such parts/components. Through mini-grids assessment using snow-balling techniques, the available solar pv mini-grids in Malawi, which are operated in off-gird mode, by the time of initial BTR report are as follows.

3.4.2.2.1 Mthembanji solar PV mini-grid

Mthembanji solar PV mini-grid, and is located in Dedza District has an installed capacity of 12 kW and supports more than 70 consumers since 2020 and the demand for off-grid power is increasing. It is owned and operated by United Purpose Malawi with technical support from University of Strathclyde. It was funded by Scottish Government International Development Program under Rural Energy Access through Social Enterprise and Decentralization (EASE) project. It was initially implemented/operated by the project support from 2018 to 2023. But after 2023, it is operated as an independent entity with technical support from United Purpose (an international NGO), under social enterprise business model. As it is typical of all solar PV based

44 https://strathprints.strath.ac.uk/64868/1/Eales_Unyolo_2018_Renewable_Energy_Mini_grids_in_Malawi.pdf

mini-grid in Malawi, installation of this plant faced number of barriers due to lack of local capacity, supply chain issues, and regulatory hurdles. However, the mini-grid has data management and smart metering system and is well monitored by Ministry of Energy and regulated by MERA. The Mthembanji mini-grid has brought positive social and economic benefits to the community. It is still in operation by the time of reporting in the first BTR for Malawi.

3.4.2.2.2 Sitolo Solar PV mini-grid

Sitolo mini-grid is located in Mchinji District, installed and operated by Community Energy Malawi with support from UNDP/GEF. It was commissioned in 2018, with an installed capacity of 80 kW. It is the largest solar PV mini-grid power system in Malawi. The off-grid solar power system supports a community (Sitolo) with 750 consumers/ customers in a cluster of 3 villages, who include maize mills, agro-processing local activities and shops, as a well as households for lighting. The mini-grid demonstrate productive use of solar energy and the demand for off-grid power is increasing. Technical challenges with inverters were reported, and the mini-grid in operational state by the time of reporting the first BTR. Just like Mthembanji solar mini-grid, Sitolo solar PV mini-grid is well regulated and monitored renewable energy power plant.

3.4.2.2.3 Mwalija solar PV mini-grid

Mwalija Solar PV minigrid is based in Chikwawa District. The project was funded by European Union and installed in January 2019 with support of Practical Action, Hivos, Environment Africa, and CARD (Churches Action in Relief and Development)[45]. However, the minigrid was destroyed by floods in 2021 and is not in operational by the time of report the first BTR. The installed capacity for the dysfunction mini-grid is 55 kW. There is potential to refurbish the off-grid power system.

3.4.2.2.4 Oleole solar mini-grid

This solar mini-grid, with installed capacity of 30 kW is in Chikwawa District in the Oleole Community. Just like Mwalija, this mini-grid was also developed with support from CARD and got damaged by the 2021 floods. This demonstrates the need to make power system resilient to impacts of climate change. The Oleole minigrid can be refurbished to continue generating much needed installed power to off-grid community of Oleole, just like it is for the Mwalija solar PV mini-grid. However, this would need an external support which is relatively not easy to get.

3.4.2.2.5 Nyamvuwu solar mini-grid

The Nyamvuwu solar mini-grid is located in Nsanje District, servicing the off-grid community of Nyamvuwu. It has an installed capacity of 30 kW, and a considerable number of the consumers are the irrigation farmers; thus, the power system is used for productive purposes. Just

45 https://cesetproject.com/sites/default/files/Fieldwork%20visit%20CES%20project%20Malawi_October%202023.pdf

like Mwalija mini-grid, this mini-grid was also developed with support from CARD. However, the mini-grid is not operational because under the MAREP program, Nyamvuwu is not grid-connected and most of the household customers have shifted to using the grid electricity, making the power system more available for irrigation. This shows that the system displaces petrol for irrigation of crops, contributing directly to GHG emission reduction.

3.4.2.2.6 Chimombo Solar PV mini-grid

This minigrid is also located in Nsanje. Just like Nyamvuwu, Oleole, and Mwalija, Chimombo mini-grid was constructed with the support from CARD. The four mini-grids implemented by CARD, in 2019, were funded by the European Union under the Sustainable Energy for Rural Communities project. It has an installed capacity of 15 kW, and provides electricity to the Chimombo off-grid community.

3.4.2.2.7 Rural Off-Grid Energy Kiosks

Energy kiosk is an approach used to provide electricity to low-income households especially in the rural areas. In Malawi, most of the kiosks are solar PV and serve off-grid communities. In 2022, the number of solar PV kiosks in Malawi were estimated to be around 10 (refer to an example shown in Figure 3-6).



Figure 3-03: A picture showing an example of solar PV energy kiosk that will be used for small scale irrigation and water supply, battery charging, lighting: constructed by RENAMA in Thyolo District

The pioneer work was done by Renewable Malawi (RENAMA), who with support from Scottish Government installed demonstrational solar pv kiosks at Bvumbwe (in Thyolo District) and at Dzenje Primary School (in Phalombe District). In Malawi, by the time of report this BTR, there were now over 10 solar kiosks stationed in the rural areas[46]. During the period of the 2021-2024 NDCS implementation phase, a number of projects have implemented these off-grid energy kiosks. For example, in 2024, EKO Energy supported construction of a 10-kW solar PV plant in Thyolo District, including a 10-kWh battery pack[47]. The system provides power to the local schools and also powers an energy kiosk, making energy more easily accessible for many people.

46 https://cesetproject.com/sites/default/files/An%20Overview%20of%20CES%20in%20Malawi_Nov21.pdf

47 https://www.ekoenergy.org/wp-content/uploads/Climate-Fund-leaflet-2024-RENAMA-Malawi.pdf

3.4.2.3 Estimation of emission reduction from solar off-grid power systems

Solar off-grid power installed power system other than SHS serve a larger community through a mini-grid. The systems described above (section 2.2). Sitolo mini-grid contributes 80kW and was commissioned in 2018. The four mini-grids commissioned in 2019 (Mwalija, Oleole, Nyavuwu and chimombo) altogether constructed 130 kW. Mthembanji contributes 12 kW, commissioned in 2020, and Energy Kiosks contribute 10 kW of off-grid electricity, installed in 2022. A Table 3-22 is created to analyze the installations, assuming an 8 hours operation in a day (typical design operating hours for a solar system, reflecting a capacity factor of 33%), energy collected in a year with an annual availability factor of 90%, the energy collected from solar off-grid projects can be calculated. Details of power and energy collected are calculated and presented in Table 3-22, which are calculated from number of installations as discussed already.

Table 3-3-22: Power and energy from installed solar off-grid power systems

	2019	2020	2021	2022	2023	2024	2025	2026	2028	2030	2032	2034	2036	2038	2040
Total kW	210	222	222	244	244	244	244	256	282	311	343	379	417	460	507
Energy MWh	551.9	583.4	583.4	641.2	641.2	641.2	641.2	673.3	742.3	818.4	902.3	994.8	1,096.7	1,209.1	1,333.1

Solar PV off-grid of such sizes are used for cooking, small-scale irrigation, lighting, phone-charging, and radio. These services have different power requirements and without solar PV energy, the services would have to be obtained mainly from firewood for cooking, petrol for pumping, and kerosene for lighting. Information about these off-grid solar PV is that they are mostly used for lighting and other productive uses such as irrigation, and welding. Corresponding emission reduction are calculated from the fuel that the off-grid solar PV would substitute, in this case petrol and kerosene. Biomass have a net zero CO_2 reduction. If it is assumed that alternative energy to off-grid solar is in the ratio of 3:1 for petrol and kerosene, it is possible to estimate reduction in CO2 emissions. The emission factor for petrol powered water pump is to be determined first. Petrol pump uses an internal combustion engine with a thermal efficiency of around 20%[48] . The default CO_2 emission factor for petrol is 69300 kg/TJ, from IPCC. Using equation 1, the petrol pump emission factor is calculated as 1.2474 tCO_2e/MWh.

Thermal Power Plant Emission Factor

$$= \text{Emission Factor of Fuel Source} \left(\frac{\text{kgCO}_2}{\text{TJ}}\right) \times 10^{-3} \left(\frac{\text{t}}{\text{kg}}\right) \times \frac{3.6 \times 10^{-3}}{\eta_t} \left(\frac{\text{TJ}}{\text{MWh}}\right)$$

$$\text{Petrol Pump Emission Factor} = 69300 \left(\frac{\text{kgCO}_2}{\text{TJ}}\right) \times 10^{-3} \left(\frac{\text{t}}{\text{kg}}\right) \times \frac{3.6 \times 10^{-3}}{0.2} \left(\frac{\text{TJ}}{\text{MWh}}\right)$$

$$= 1.2474 \text{ tCO2e/MWh}$$

48 https://www.greencarreports.com/news/1091436_toyota-gasoline-engine-achieves-thermal-efficiency-of-38-percent

The calculated estimate avoided GHG emission from implementation of solar off-grid power systems are presented in Table 3-23. The avoided emissions in 2021 and 2022 are 727.75 and 799.87 tCO2e respectively. The projected emissions avoided are 1,020.86 and 1,662.88 tCO2e in 2030 and 2040 respectively.

Table 3-3-23: Estimated energy production and avoided GHG emissions by solar-off-grid power systems systems

	2019	2020	2021	2022	2023	2024	2025	2026	2028	2030	2032	2034	2036	2038	2040
Energy MWh	551.9	583.4	583.4	641.2	641.2	641.2	641.2	673.3	742.3	818.4	902.3	994.8	1,096.7	1,209.1	1,333.1
Emission tCO2	688.42	727.75	727.75	799.87	799.87	799.87	799.87	839.87	925.95	1,020.86	1,125.50	1,240.87	1,368.05	1,508.28	1,662.88

3.4.3 Grid connected large scale solar PV

3.4.3.1 Status of grid-connected large-scale solar PV in Malawi

Malawi is well endowed with solar radiation for generation of solar PV electricity, which can be fed into the national electricity grid. Generation of electricity from solar energy is one of the strategic focuses of the Government of Malawi to ensure availability of power for economic development. ESCOM electricity grid is able to allow independent power producers feed their generated power into the grid above a threshold. Large-scale power stations are those defined to generate power of at least 10 MW – which can be grid connected or stand alone with its own min-grid system. Previously, there was no large-scale grid-connected solar power project. With enabling the environment for private sector participation in the power market, for example through favorable energy sector-wide policy of 2018, putting in place regulatory system, power purchase agreements, the first implementation period of NDCS (2021 – 2025), saw a number of negotiated large-scale solar projected installed and commissioned, presented as follows.

i. Installation of the 60 MW Salima Solar PV power station by JCM Solar company of Germany and commissioned. This plant was commissioned in 2021;

ii. Installation of 20 MW solar PV power systems installed by JCM company at Golomoti in Ntcheu District, commissioned in 2022;

iii. Serengeti Energy installed 21 MW Solar PV, and commissioned in 2023 in Nkhotakota; and

iv. Votalia Company installed 40 MW of solar PV in Dwangwa in 2023.

Addition of solar PV electricity has enabled Malawi to decommission diesel power electric generators of 78MW installed capacity, contributing to avoiding related carbon emissions from the electricity generation industry. The Ministry of Energy reported that installation of battery-based energy storage system in Lilongwe would be commissioned in mid-2025. This battery storage power system will enable Ministry of Energy to integrate more solar PV based electricity to the grid.

At a time of reporting this BTR, Press Corporation Malawi Limited was negotiating with Ministry of Energy to install 50 MW solar PV electricity in Lilongwe. Also, Atlas Energy company was negotiating to install 20 MW to be installed in Balaka. These two projects would put 70MW of electricity into the grid by 2027.

A summation of installed and commissioned grid connected large scale solar PV give an installed capacity of 141 MW (by 2024). Together with planned installed of 70MW, there would be at least 210 MW of grid-connected large-scale PV by 2027. Therefore, grid-connected large-scale solar PV as an NDCS measure, is progressing well and would surpass the target of 200MW before its NDCS target year of 2030.

3.4.3.2 Estimation of emission reduction from grid-connected solar PV

The grid-connected solar PV intervention was designed to address the critical shortage of power supply and displace expensive diesel-electric generators. Indeed, as stated already, all of the diesel electric generators are decommissioned with coming in or grid-connected solar electricity. Therefore, the emissions avoided are those that would have been emitted by the diesel generators for the same electricity energy provided by the solar energy system. In order to estimate this, we have to establish the emission factor of the diesel generator, using the following equation.

Thermal Power Plant Emission Factor

$$= \text{Emission Factor of Fuel Source} \left(\frac{\text{kgCO}_2}{\text{TJ}}\right) \times 10^{-3} \left(\frac{\text{t}}{\text{kg}}\right) \times \frac{3.6 \times 10^{-3}}{\eta_t} \left(\frac{\text{TJ}}{\text{MWh}}\right)$$

$$\text{Diesel Generato Emission Factor} = 74100 \left(\frac{\text{kgCO}_2}{\text{TJ}}\right) \times 10^{-3} \left(\frac{\text{t}}{\text{kg}}\right) \times \frac{3.6 \times 10^{-3}}{0.4} \left(\frac{\text{TJ}}{\text{MWh}}\right)$$

For diesel, the emission factor from IPCC guidelines is 74 100 kg CO_2/JT. The thermal efficiency of diesel generators is around 40%. Using the equation gives emission factor of diesel generator as 0.6669 tCO_2/MWh.

Energy in MWh can be estimated from solar availability factor and capacity factor. It is assumed that the solar PV would be operational for an average of 7 hours a day, and 90% of the year. This gives emission of 92,012.19 tCO_2 and 122,682.92 tCO_2, as in Table 3-24.

Table 3-3-24: GHG avoided from grid-connected solar PV installed systems

	2021	2022	2023
JCM Salima	60		
JCM Golomoti	-	20	
Serengeti	-	-	21
Votalia	-	-	40
Installed per year (MW)	60	20	61
Cumulative (MW)	60	80	141
MWh	13,7970	183,960	324,229.5
tCO_2 reduced	92,012.19	122,682.92	216,228.65

3.4.4 Improved Biomass Cookstoves (Charcoal and Firewood)

Improved biomass cookstove (for charcoal and firewood), goes together with clean cooking. It is therefore important to look at the status of clean cooking in Malawi, where units of biomass cookstoves are discussed.

3.4.4.1 Status of Clean Cooking in Malawi and Projects

Clean cooking, others call it modern cooking, is a relatively new intervention in the country, mostly implemented by projects led by/supported by non-governmental organizations working on environmental and climate management. Most of the clean cooking interventions has been on policy measures, cooking-fuel switch and stacking, and demonstration of higher-tier stoves for fuelwood. It is now the plan of the Government of Malawi to transition to clean cooking as a way to manage environmental and climate related challenges. The transitioning is exemplified by inclusion of clean cooking related mitigation measures in the revised Malawi's NDCs submitted to UNFCCC Secretariat in 2021. The cooking restated NDCs are introducing high efficiency firewood and charcoal cookstoves. There are also projects in clean cooking implemented by Ministry of Energy, Development Partners and Other non-governmental organizations.

Most of the clean cooking projects have been implemented by development partners and non-governmental organizations. According to 2023 Malawi Multi-Tier Framework Survey, high-tier biomass cookstoves are mostly (65%) distributed for free, and the rest (35%) for sale. Those distributed for are for demonstration purposes mainly by non-governmental organizations (mostly) and the Government of Malawi. Those higher-tier biomass stoves that are sold are mostly sold at subsided prices, supported by international non -governmental organizations to induce market for the stoves. Some of the projects on clean cooking are listed as follows, detailing what they are doing in 2024 on going.

a. UK Government and USA Government are implementing a project called Modern Cooking for Healthy Forest (MCHF) Programme. The programme is for 5 years, from 2019 to 2026 and focusses primarily on reducing the consumption of illegal, unsustainably harvested charcoal which is mainly focussed in urban areas. It is implemented in the districts of Mzimba, Salima, Dedza, Nkhatabay and Lilongwe, by a company known as Tetra Tech. The company works together with other non-governmental organizations as subcontractors namely: Centre for Environmental Policy and Advocacy (CEPA), Lilongwe Wildlife Trust (LWT), mHub, Winrock International and World Resources Institute (WRI).

b. EU through EnDev Country Programme. They provide subsidies to companies selling efficient cookstoves and modern fuel cookstoves so that these stoves are sold at cheaper prices to increase uptake and use. There is also the EnDv Core Project that supports market-based energy access through cooking solar energy interventions covering the entire country, working with micro and small-scale energy service companies.

c. the Norwegian Government Energy for Development Programme for Malawi will also look at alternative energy for cooking,

d. Centre for environmental policy and Advocacy (CEPA), Oxfam and Civil Society Network on Climate Change (CISONECC) working on the "Promoting equitable access to clean energy" – which promotes clean cooking technologies stoves among other energy projects.

The ministry of energy has also been involved in distribution of clean cooking technologies with the help of development partners as follows: From 2022 to 2024, the Ministry of energy with support from the Japanese Government under the Japanese Supplementary Budgets (JSB), distributed LPG stoves in Lilongwe and Zomba in 2022 to 2024 to reduce deforestation in the Bua River catchment area through limiting usage of charcoal and firewood. Most of the work they do is to demonstrate use of higher-tier fuelwood stoves so that communities can shift from open fire stoves to these stoves. They also support creation/stimulation of market for efficient stoves by subsidizing the stoves so that households buy them at relatively cheaper prices. Further, they provide international expertise to build capacity in high-tier stoves and help in GHG emission reduction calculations for carbon trading. The development partners also introduce use of alternative cooking fuels, for example LPG with their stoves so that households are able to stack fuel for cooking and lessen pressure on charcoal and firewood.

3.4.4.2 Estimation of emission reduction from implementation of efficient biomass cookstoves

Efficient biomass stoves, also known as improved biomass stoves are improved version from the traditional inefficient 3-stone open fire stoves. The 3-stone open fire stoves are still widely used, with a thermal efficiency of around 10%[49], meaning that a considerable amount of wood energy is lost and that a lot more wood is needed to cook a unit amount of food. Improved biomass cookstoves usually have efficiencies of more than 20%[50], thus switching from 3-stone to improved cookstove could save wood energy by more than 50%, which is quite significant for a country like Malawi that relies more than 90% of its cooking energy from biomass. Numbers for biomass cookstoves are difficult to get, because of limitations in data collection on stoves. There are several players involved in distribution of efficient biomass cookstoves in the country, including Ministry of Energy (formerly known Department of Energy Affairs), NGOs, and lately companies that want to trade in carbon market. There are conflicting numbers of stoves that are reported to be in Malawi, possibly because there is lack of tracking and recording of information related to implementation of wood fuel cookstoves. The most reliable information is those from the Ministry of Energy, reporting that up to 2 million improved cookstoves were distributed in Malawi by October 2020 through a presidential decree in 2013 to intervene to control deforestation through popularizing use of efficient biomass cookstove[51]. A committee, National Cookstove Steering Committee was formed to oversee implementation to achieve the target. However, data from ex-ant data from Malawi Energy Compact document data on available improved biomass cookstoves in 2020 that are less than the 2 million reported to have been achieved. Since the Malawi Energy Compact was validated through a rigorous process, this BTR uses the data from this source.

Estimation of emission reduction from wood fuel cookstove over use of 3 stone-open fire cookstoves used methodology described in AMS-II.G, Energy efficiency measures in thermal applications of non-renewable biomass, version 5.0. This is a small-scale methodology used to quantify greenhouse gas emission reductions from projects that introduce energy-efficient technologies (for example cookstoves, ovens, dryers, or other heating devices) for heating or cooking using non-renewable biomass. Non-renewable biomass is biomass that is not harvested sustainably. These projects typically involve replacing or retrofitting existing, inefficient biomass-fired devices with more efficient ones. Emission reductions are calculated by comparing the biomass consumption of the old, inefficient devices with the new, efficient ones. Under AMS-II.G version 5, emission reduction for introduction of efficient woodfuel cookstoves were estimated using the following equation

49 https://www.sciencedirect.com/science/article/pii/S0973082620303215

50 https://rippleafrica.org/wp-content/uploads/2025/03/Ripple-Africa-Non-Technical-Summary_VPA.pdf

51 https://www.energy.gov.mw/cooking-energy-2/

$$ER_y = B_{y,savings} \times f_{NRB,y} \times NCV_{biomass} \times EF_{projected\ fossil\ fuel} \times N_{y,i}$$

Where

ER_y is emission reductions during the year y in tCO2e, which is to be estimated

$B_{y,savings}$ is quantity of woody biomass that is saved in tonnes per wood fuel stove. This value is taken as 2.168 tonnes/device/year from a similar CDM Project in Nkhatabay, Malawi[53]

$f_{NRB,y}$ is fraction of woody biomass saved by the project activity in year *y* that can be established as non-renewable biomass. This has a value of 0.81 as obtained from UNFCCC CDM website as a default Malawi specific value available on the CDM website as approved by CDM EB and the Malawi DNA[54].

$NCV_{biomass}$ is net calorific value of the non-renewable woody biomass that is substituted. The Net calorific value. From 2006 IPCC Guidelines for conduction of GHG inventory, default for wood fuel taken as 0.0156 TJ/Tonne.

$EF_{projected\_fossilfuel}$ is emission factor for the substitution of non-renewable woody biomass by similar consumers. The value is taken as is 81.6 tCO2/TJ. This is a default value provided in AMS-II.G.

$N_{y,i}$ is number of project devices of type *i* operating in year *y*

Using data on stoves from Malawi Energy Compact, the emissions are calculated using equation above and the parameters given. The emissions from cookstoves are presented in Table 3-25.

Table 3-3-25: Number of wood fuel cookstoves and their emission reductions

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Percentage of households with access to Improved Cookstoves	22.43	23.8	23.61	23.43	23.24	23.5	24.57	26.64	28.71	30.79	32.86	34.93	37
	0.2243	0.238	0.2361	0.2343	0.2324	0.235	0.2457	0.2664	0.2871	0.3079	0.3286	0.3493	0.37
Households	3,984,929	4,096,507	4,211,209	4,329,123	4,450,339	4,574,948	4,703,047	4,834,732	4,970,104	5,109,267	5,252,327	5,399,392	5,550,575
Number of improved cookstoves	893,820	974,969	994,266	1,014,314	1,034,259	1,075,113	1,155,539	1,287,973	1,426,917	1,573,143	1,725,915	1,886,008	2,053,713
Emissions reduction (tCO2)	1,998,061.79	2,179,464.07	2,222,602.81	2,267,416.35	2,312,002.10	2,403,328.17	2,583,113.48	2,879,159.10	3,189,758.12	3,516,635.55	3,858,143.24	4,216,018.31	4,590,909.61
Emissions reduction (million tCO2e)	2.00	2.18	2.22	2.27	2.31	2.40	2.58	2.88	3.19	3.52	3.86	4.22	

52 https://cdm.unfccc.int/UserManagement/FileStorage/EBP7TRMDAZ3LGXNC4H2UI0WF1JVQO6

53 https://cdm.unfccc.int/DNA/fNRB/index.html

3.4.4.3 Estimation of Emission from cookstoves considering ITMOs transferred

The ITMOs first transferred are from biomass conservation using efficient stoves (refer to section C4.4). According to MPG 77 (d,ii) "An emissions balance reflecting the level of anthropogenic emissions by sources and removals by sinks covered by its NDCS adjusted on the basis of corresponding adjustments undertaken by effecting an addition for internationally transferred mitigation outcomes first-transferred/ transferred and a subtraction for internationally transferred mitigation outcomes used/acquired, consistent with decisions adopted by the CMA on Article 6"; actual emissions from NDCS measure on improved biomass cookstoves and their projections, are the estimated emission reduction (in Table 25) less the amount of ITMOs transferred. Net GHG emission reductions and their projection from improved cookstoves considering ITMOs transferred are presented in Table 3-26.

Table 3-3-26: Net GHG emission reductions and their projection from improved cookstoves considering ITMOs transferred

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Emissions reduction (million tCO_2)	2.00	2.18	2.22	2.27	2.31	2.40	2.58	2.88	3.19	3.52	3.86	4.22	4.59
ITMOs (Million tCO_2e)	-	-	-	0.989	0.564	0.207	0.018	1.000	1.000	1.000	1.000	1.000	1.000
Net Emissions reduction from improved cookstoves (million tCO_2e)	2.000	2.180	2.220	1.281	1.746	2.193	2.562	1.880	2.190	2.520	2.860	3.220	3.590

3.4.5 Analysis of emission reduction from all implemented NDCS measures

During the NDCS-2 implementation period, measures involving solar PV and improved biomass cookstoves have been implemented and emissions reductions have been estimated (refer to sections D2). The emissions reductions in 2021, 2022, and 2023 are summarized in Table 3-27. As it can be seen from, emissions reduction from implemented NDCS-2 measures are increasing, from 1.4 million tCO2e (representing 7.9% of absolute emission reduction of 17.7 million tCO2e by 2040) in 2021, 1.91 million tCO2e in 2022 (representing 10.8%), and 2.45 million tCO2e in 2023 (representing 13.8 million tCO2e). This shows contribution to emissions reduction. However, since the emissions, as per GHG emissions inventory conducted as part of this BTR submission, the current emissions (2021 and 2022) are far above emission described by NDCS-2 with all measures implemented.

Table 3-3-27: Summary of emission reductions in NDCS-2 from measures in solar PV and improved cookstoves

	2021	2022	2023
Solar Home Systems (tCO_2e)	28,652.21	38,957.47	42,829.39
Off-grid power systems (mini-grids) (tCO_2e)	727.75	799.87	799.87
Grid connected solar (tCO_2e)	92,012.19	122,682.82	216,228.65
Total on solar PV measures in tCO_2e	121,392.15	162,440.16	259,857.91
Total on solar PV measures in million tCO_2	0.121	0.162	0.260
Improved cookstoves million tCO_2e	1.281	1.746	2.193
Total emission reduction on NDCS measures million tCO_2	1.40	1.91	2.45

3.5 Summary of greenhouse gas emissions and removals

In line with MPG 91 *"Each Party that submits a stand-alone national inventory report shall provide a summary of its GHG emissions and removals. This information shall be provided for those reporting years corresponding to the Party's most recent national inventory report, in a tabular format"*. Malawi has submitted national inventory of its greenhouse emissions and removals as a chapter in this first BTR.

3.6 Projections of greenhouse gas emissions and removals

The projections on greenhouse gas emissions and removals are derived from NDCS-2. The emission without measure scenario are those emission under business as usual scenario. "Emissions with measures" are those under domestic implemented NDCS measures. "Emissions with additional measures" are those that are implemented with international support. The projections are presented in Figure 3-7.

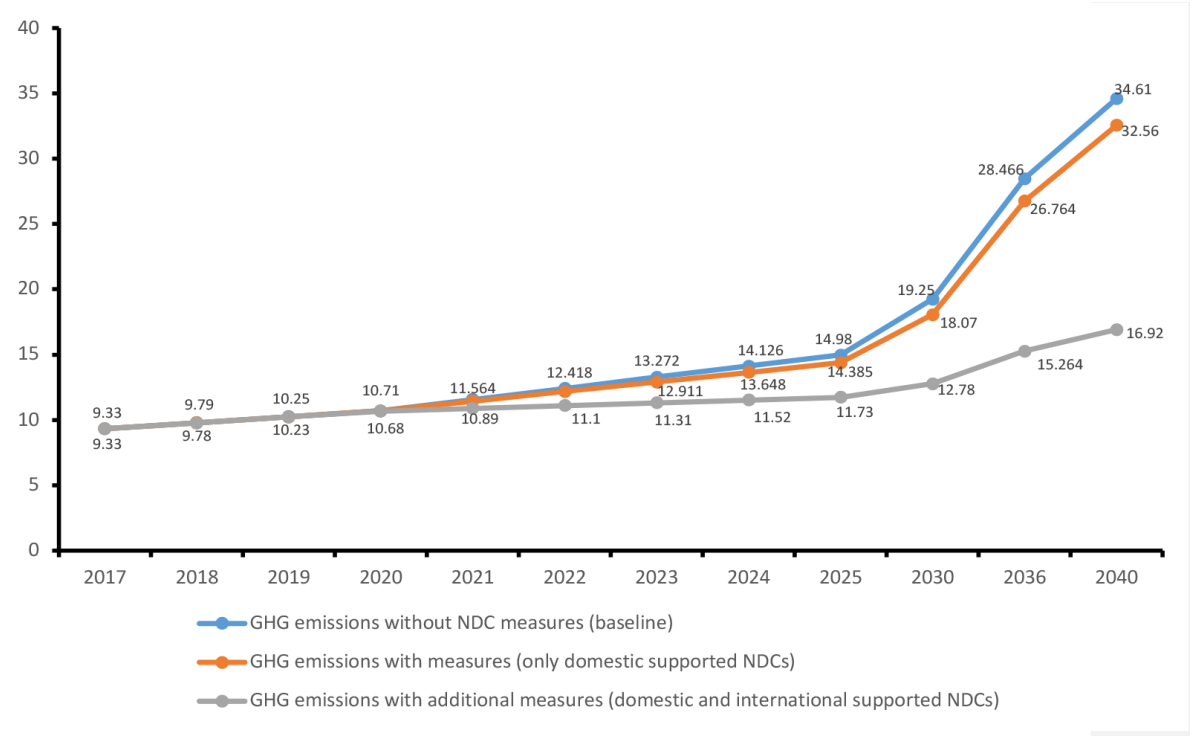


Figure 3-0-4: Projections of greenhouse gas emissions and removals

Emissions without measures are increasing, from 13.272 million tCO2e in 2023, to 19.25 million tCO2e in 2030, and 34.61 million tCO2e in 2040. On the other hand, emissions with measures emissions raise from 12.911 million tCO2e in 2023 to 18.07 million tCO2e in 2030 and to 32.56 million tCO2e in 2040. With additional measures, the emission projections are much reduced compared to emission without measures: the emissions are 11.31 million tCO2e in 2023, 12.78 million tCO2e in 2030, and 16.92 million tCO2e. This means that international support is crucial for Malawi to meet its NDCS target by 2040.

3.7 Other information

In line with MPG 103 *"Each Party may provide any other information relevant to tracking progress made in implementing and achieving its NDCS under Article 4 of the Paris Agreement"*, Malawi has developed the following tools to help in tracking NDCS implementation: Malawi NDCS score-card; NDCS implementation plan, and resource mobilization strategy. However, the following are the challenges that limits implementation of NDCS measures: financing challenges; limited collaboration among NDCS stakeholders, and limited awareness on NDCS measures especially at local level.

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4.0 INFORMATION RELATED TO CLIMATE CHANGE IMPACTS AND ADAPTATION UNDER ARTICLE 7 OF THE PARIS AGREEMENT

4.1 Institutional Arrangement for Climate Change

In line with the UNFCCC, the EAD is the Focal Point of all Climate Change activities in Malawi. However, the actual implementation of various adaptation projects/activities is done by the respective players, including: MDAs, NGOs, CSOs, private sector, academia, faith-based organizations, and developmental partners. The institutional arrangement shown in Figure 1-1 provides information on a general setup for climate change management in the country, comprising several committees. GoM (2021), including:

a. the Cabinet Committee - it enables all arms of government to coordinate their actions;

b. the Parliamentary Committee - serves to assist in lobbying for the passing of environment related policies and legislations in the national assembly; and

c. the National Technical Committee on Climate Change (NTCCC) and the Natural Resources Sector Working Group (NRSWG) - provides oversight over the institutional coordination framework.

The NSCCC is chaired by the Principal Secretary (PS) for MoEPD. Public sector members of the NSCCC include PSs for: Ministry of Economic Planning and Development (MoEPD); Ministry of Water and Sanitation; Ministry of Agriculture (MoA); Ministry of Lands, Housing and Urban Development; Department of Disaster Management Affairs; Ministry of Local Government; Ministry of Transport and Public Works; Ministry of Health and Ministry of Energy. Other members include representatives from development partners, civil society and private sector.

The Government of Malawi adopted a Decentralization Policy in 1996 to devolve authority for managing development projects and programmes at district level. The District Council is the focal point for district level policy and programme development, implementation, monitoring and evaluation. All projects and programmes under the National Climate Change and Investment Plan (NCCIP) at District level are overseen by the District Council for strategic direction, inter-sectoral coordination and policy guidance, overseeing implementation of policy decisions, endorsement of consolidated annual work plans and budgets, and monitoring of progress.

The District Executive Committee (DEC), headed by the District Commissioner (DC), provides overall leadership of the NCCIP at the district level. The DEC is composed of technical staff drawn from Government Departments, civil society organizations and other stakeholders. The DEC provides technical direction in the management of NCCIP programmes and projects. It is

directly responsible for facilitating the formulation and implementation of District Development Plans. Under the NCCIP, each DEC has sub-committees for the key sectors including the District Environmental Sub-Committee (DESC) which is responsible for issues of environmental management, Climate Change (CC), forestry and other natural resources. The secretariat to the DESC is in the Directorate of Planning and Development that is able to ensure that Climate Change issues are mainstreamed throughout the District's programmes.

The DESC is responsible for preparing consolidated Annual Work Plans and Budgets for review and approval by the DEC and in turn by the District Council. It is also responsible for conducting physical progress and policy reviews in addition to facilitating the formulation of new policies. Implementation of NCCIP projects and programmes at area level is channelled through the Area Development Committee (ADC) headed by the Traditional Authority. At village level, it is done through the Village Development Committee (VDC) headed by the Group Village Headmen (GVH). In cases where sector specific committees for particular projects exist, implementation of the projects is done by the ADC and VDC in collaboration with the committee. Communities overseen by the GVH are not only responsible for implementation of the NCCIP projects Area Development Committee meeting and programmes but also beneficiaries.

For community based Natural Resources Management (NRM) projects, early warning systems, monitoring of environmental indicators and payment for environmental service projects, the NCCIP promotes Co-Management arrangements between Government and communities. In enhancing Private Sector, Development Partners and Civil Society Organizations (CSOs) partnerships with communities, the NCCIP promotes the private-social partnerships aimed at driving community development projects and programmes such as REDD+. Effective and efficient extension systems are promoted in order to benefit from the private-social and public-private partnerships.

4.2 Legal Framework for Climate Change

Malawi's legal framework on climate change is based on policies and laws that have been developed over the years to address these matters. The legal framework spells out who has powers in terms of the development and adoption of various laws and policies. Section 5 of the Constitution of Malawi states that any act of Government or any law that is inconsistent with the provisions of this Constitution shall, to the extent of such inconsistency, be invalid. Section 7 explains that the executive branch of government is responsible for the initiation of policies and legislation, and for the implementation of all laws which embody the express wishes of the people of Malawi, and which promote the principles of this Constitution. Therefore, the responsibility on development of policies and legislation on climate change lies with the Executive Branch of Government through Ministries, Departments and Agencies (MDAs).

Climate Change has been addressed broadly under the Constitution of Malawi. Section 13 of the Constitution states that the State shall actively promote the welfare and development of the people of Malawi by progressively adopting and implementing policies and legislation aimed at achieving various goals, including managing the environment responsibly in order to prevent the degradation of the environment, provide a healthy living and working environment for the people of Malawi, accord full recognition to the rights of future generations by means of environmental protection and the sustainable development of natural resources, and conserve and enhance the biological diversity of Malawi [Section 13(d) of the Constitution of Malawi]. The Constitution of Malawi further states that the Government of Malawi has to progressively adopt and implement policies and legislation aimed at governing in accordance with the law of nations and the rule of law, and actively support the further development thereof in regional and international affairs. This guidance by the Constitution of running affairs in line with law of nations and regional and international developments enabled Malawi to sign the United Nations Framework Convention on Climate Change (UNFCCC) [Adopted on 9th May 1992 and entered into force on 21st March 1994] on 10th June, 1992 and ratified on 21st April, 1994. The Convention sets out the basic legal framework and principles for international climate change cooperation with the aim of stabilising atmospheric concentrations of greenhouse gases (GHGs) to avoid "dangerous anthropogenic interference with the climate system".

The country also adopted Electricity Act [Chapter 73:01 of the Laws of Malawi] and this legislation states that an electricity licence shall be subjected to various conditions including implementation of environmental impact mitigation measures by the licence holder. To protect the environment further, Malawi also passed the Noxious Weeds Act [Chapter 64:02 of the Laws of Malawi] (NWA). The NWA make provisions for the eradication of noxious weeds in order to protect the environment. Section 3 of NWA states that it is the duty of every person responsible under the law to clear or cause to be cleared any noxious weeds growing or occurring on the land in respect of which he or she is responsible. It shall further be the duty of any person to report forthwith to the nearest known weed inspector the occurrences of any

noxious weeds on any land in respect of which such person is responsible. Section 10 of NWA guides that no person shall throw any noxious weed or the seed of such noxious weed into any river or stream, or on to any road or land and anyone doing that shall be prosecuted.

Malawi also adopted the Environment Management Act [No. 19 of 2017 of the Laws of Malawi] (EMA) which provides for conservation and management of the environment in Malawi and prescribes environmental standards. This is to protect the environment and the atmosphere so that people live a good life and in a good environment, thereby reducing adverse impacts of climate change. This legislation also outlines the conservation and management of biological (genetic) resources. Section 3(1) of EMA puts an obligation on every person to take all necessary and appropriate measures to protect and manage the environment, to conserve natural resources and to promote sustainable utilization of natural resources in accordance with the Act and any other written law or policy relating to the protection and management of the environment or the conservation and sustainable utilization of natural resources. Under section 54(1) of EMA, the lead agency in protection of environment, Environment Protection Authority (in this case the "Malawi Environment Protection Agency", MEPA), shall, in consultation with lead agencies, develop guidelines and prescribe measures for the control and management of factors affecting climate change. Section 52(2) of EMA states that the guidelines and measures to manage factors affecting climate change should identify activities, practices and substances that cause climate change, and measures for reducing or eliminating their effects, prescribe measures for the reduction of greenhouse gas emissions from any sector, prescribe measures to enhance greenhouse gas sinks and promote assessment and monitoring of the potential impact of climate change on the functioning of ecosystems, vegetation sinks and net carbon sinks. Section 52(3) of EMA puts an obligation on "Environment Protection Authority" to commission national studies on activities, practices or substances that cause climate change and develop necessary policy and legislation for effective control, management and monitoring of such activities, practices or substances. However, it has to be mentioned that matters of climate change are inherently addressed through the Environment Management Act (EMA), 2017..; and that the Government of Malawi is currently (2025) developing the Climate Change Management Bill which will specifically address issues pertinent to climate change management in the country.

The National Resilience Strategy (NRS) was developed in 2018, but it spans over the period 2018 to 2030. The NRS is a medium-term goal, aimed at starting the transition from recurrent humanitarian appeals to protective and productive investments targeting food insecure and poor households while strengthening markets, infrastructure, and economic growth supported. This is being done through strong institutional coordination and multi-sectoral planning and implementation, under the guidance of four (4) pillars, namely:

a. Resilient agriculture: The outcome for this is increased real farm-based household incomes through crop and livestock diversification, irrigation farming, market development, improving strategic grain reserves, drought risk reduction, and increasing access to farm inputs;

b. Catchment protection and management: Forest and landscape restoration, Payment for Ecosystem Services, sustainable energy, forest-based enterprises;

c. Risk reduction, flood control, early warning and response; and

d. Human capacity, livelihoods and social protection: shock responsive social support, livelihoods and nutrition.

Under policy, Malawi developed and adopted the Malawi 2063, which highlights environmental sustainability as one of the cross-cutting enablers required to achieve a more inclusive, wealthy, and self-reliant nation. In 2016 Malawi developed the National Climate Change Management Policy (NCCMP) which provides strategic direction on integrating climate change into development planning through adaptation, mitigation, technology development and transfer, and climate finance. The Malawi National Adaptation Plan Framework was adopted in 2021 to align efforts to address climate change, with an overarching goal of reducing communities' and ecosystems' vulnerability to the effects of climate change through adaptation and mitigation, technology transfer, and capacity building. The stocktaking recommended the following thematic areas to be considered for the medium- and long-term adaptation planning horizon of the NAP process, namely: improving access to energy sources; increasing resilience of food production systems; improving weather and climate forecasting; improving agriculture to ensure farmers are moving from subsistence to commercialization; promoting catchment management practices; integrated water resource management to encourage large scale commercial irrigation; population change and human settlements; civic education and adult literacy; infrastructure development; inclusiveness of gender, disability and other socially excluded vulnerable groups in the implementation of climate change adaptation interventions; monitoring of climate: adequate database and easy access for all people; development of collaborative wildlife management; and education, science and green technology. In 2021, Malawi adopted NDCs which demonstrates the commitment of the Government of Malawi to meeting its obligations towards addressing the challenges of climate change. The NDCS articulates areas of priority for climate change management through both mitigation and adaptation measures needed to address challenges of climate change. The NDCS commits to a combined unconditional and conditional contribution of 51 percent reduction in GHG emissions by 2040 emanating from the energy, agricultural, waste, and industrial sectors. The NDCS also identifies ten strategic adaptation actions across three pillars: (1) institutional framework; (2) knowledge, technology, and financing; and (3) resilience of the most vulnerable. In addition, Malawi has also developed additional policies such as National Environmental Policy, National Environmental Health Policy, National Energy Policy, National Forest Policy, National Agricultural Policy, National Irrigation Policy, and National Water Policy which contribute to various strategies of management of

environment and mitigating factors on issues of climate change. In fact, all the sectors discussed in this chapter (i.e., agriculture, water, human health, energy, fisheries, tourism, infrastructure, forestry, and wildlife) have policies and strategies and regulatory frameworks that directly or indirectly address climate change adaptation.

The EAD in the MNRCC is the focal point for climate change issues in Malawi. The EAD is responsible for preparing and implementing environmental policies and relevant legislation. It is also responsible for enforcing the regulations and providing guidance on environmental issues, including climate change. EAD, in collaboration with the Department of Climate Change and Meteorological Services (DCCMS), is responsible for coordinating climate change issues in Malawi.

At the community level, climate change issues are addressed by a number of committees, key among which is the Village Natural Resources Management Committee (VNRMC), which mostly focuses on the protection of the environment in order to promote climate change mitigation and adaptation; and it is mandated to do this through established By-laws.

Malawi 2063 (MW2063): is a long-term development blue-print for Malawi that succeeded the Vision 2020. It is anchored on three key pillars, namely: Agriculture Productivity and Commercialization; Industrialization; and Urbanization. MW2063 is operationalized by the first 10-year Implementation Plan (MIP-1) which spans the period 2021 to 2030. The MIP-1 has identified priority areas under the key pillars which will set Malawi on a path to actualize MW2063. Under Pillar1: Agriculture Productivity and Commercialization, whose objective is to have an optimally productive and commercialized agriculture sector, the following areas will be focused; (a) Agriculture Diversification, (b) Irrigation Development, (c) Anchor farms, (d) Agriculture Inputs, (e) Agriculture mechanization, (f) Structured Markets, (g) Agriculture Research, Innovation and Dissemination. Agriculture production in Malawi is highly vulnerable to the vagaries of climate change.

National Climate Change Management Policy (2016): aims to guide and coordinate the formulation, implementation, monitoring and financing of climate change programmes in Malawi. The Policy further promotes climate change adaptation, mitigation and capacity building for sustainable livelihoods through the adoption of green economy measures for the country. The Policy has identified six (6) priority areas and these include: climate change adaptation; climate change mitigation; capacity building, education, training and awareness; research, technology development and transfer and systematic observation; climate financing; and cross-cutting issues (includes gender considerations, population dynamics and HIV and AIDS.

Environment Management Act (2017): the Act provides for the protection and management of the environment; conservation and sustainable utilization of natural resources. The Act further provides for control and management of factors affecting climate change through development of guidelines and prescription measures.

4.3 Impacts, Risks and Vulnerabilities

It was stressed in Malawi's Third National Communication (GoM, 2021) that science is now unequivocal as to the reality of climate change; and that anthropogenic activities are its principal cause (Smith, 2001; Epstein, 2002; Boko *et al*., 2007; IPCC, 2007). Adverse impacts of climate change are mostly felt in the world's poorest countries which oftentimes have low adaptive capacity, particularly countries in sub-Saharan Africa, including Malawi, where most people are at immediate risk of this phenomenon. Failure to respond to adverse impacts of climate change will aggravate poverty (Tadross *et al*., 2009). In Malawi, adverse of impacts of climate change mostly manifest themselves in the frequent occurrence of hydro-meteorological disasters that take place in the country, particularly the occurrence of floods, droughts, strong winds.

With a human population of approximately 21 million people, Malawi is vulnerable to a range of climate related natural hazards, common among which include: floods, droughts, and strong winds. "Losses and Damages" incurred from natural disasters caused by hazards highlighted above have had significant and serious repercussions on the country's economy and the well-being of the citizenry, with the poorest and most vulnerable communities often being the hardest hit (GoM, 2021). During the year 2020, Malawi was ranked number 163 out of 182 countries on the Notre Dame Global Adaptation Index (ND-GAIN) Index (World Bank, 2022). The ND-GAIN is a free, open-source tool that measures a country's vulnerability to climate change and its ability to adapt. The frequency and severity of extreme weather events in Malawi are projected to increase in the future, making the country even more vulnerable to climate-related disasters. Climate change is likely to exacerbate the country's existing social and economic inequalities, particularly for vulnerable groups such as women, children, the physically challenged, and the poor. The poorest households are disproportionately affected by climate change, and climate shocks will further reduce their incomes and may push the affected people into dire poverty.

Malawi's Country Climate and Development Report (CCDR) of 2022 (World Bank, 2022) showed that climate change impacts would result in very large annual GDP losses, as high as 20 percent under the business as usual (BAU) scenario, and 11 percent under Aspirational Development (ASP). Results for the ASP scenario showed how much damage would be reduced by the policies and investments envisioned in the Malawi 2063, as the economy shifts away from the vulnerable agriculture sector, and infrastructure is built to higher and resilient standards.

Of late, Malawi has been experiencing an increase in the frequency and magnitude of climate related disasters; and as stated in the preceding discussion, these disasters are mostly caused by a spectrum of hydro-meteorological hazards. Since 1980, more than 50 disasters associated with hydro-meteorological events, including cyclones, floods, landslides and mudslides, and droughts have been reported in Malawi, affecting millions of people (GoM, 2023). About seven (7) disasters associated with severe rainfall events (floods, landslides, and storms) have happened in the last decade alone, depicting an incremental upward trend in terms of the number of

people affected. The losses associated with disasters are equivalent to 5 percent of Malawi's GDP (GoM, 2016). From 2015 to 2023, Malawi experienced the following disasters: severe floods in 2015; El Nino and Southern Oscillation (ENSO) phenomena induced drought episode in 2016, resulting in estimated losses of $500 million - approximately a 1.7 percent reduction in the country's GDP; catastrophic events caused by Cyclones Idai and Kenneth in 2019; Tropical Storm Ana and Cyclone Gombe in 2022; and Tropical Cyclone Freddy in 2023, which affected over 2.5 million people, causing over 600 fatalities, economic damage estimated at $506.7 million and substantial agricultural losses. In between 2019 and 2023, diseases such as Covid-19 pandemic and the countrywide cholera outbreak had severe impacts on Malawi's economy, although the causes of these pandemics have not been proven to be directly linked to climate change. The disasters highlighted above have had negative impacts on the social, productive and infrastructure sectors as well as the macro economy and overall human development of the country. As a result, Malawi has slipped into delicate economies in the recent past due to the grievous, persistent, and alternating disasters (GoM, 2023).

Recurrent climate related disasters in Malawi have had far-reaching impacts and consequences on various sectors of social economic development, including agriculture, water, energy, health, infrastructure, housing, and education. Past experience has shown that disasters undermine the stability of livelihoods among the most vulnerable communities in the country, and cause serious setbacks to development and poverty reduction efforts by the Government of Malawi (GoM, 2023). Furthermore, disasters pose a serious threat and challenge to Malawi's attainment of the United Nations Sustainable Development Goals (SDGs) and the Malawi 2063. According to the assessment report by the United Nations Economic Commission for Africa (UNECA, 2015), hazards that are commonly experienced in Malawi include: floods, strong winds, droughts, disease outbreaks, pest infestation (fall armyworm), economic disturbances, civil strife, and earth tremors and landslides. Among these, floods, droughts, strong winds, pest infestation and disease outbreaks occur on a frequent basis. In the last decade, the intensity and frequency of these disasters has been increasing.

The severity of destruction and the degree of misery wrought by climate related natural hazards that frequently affect Malawi cannot be overemphasised. Suffice to say that deaths, injuries, damage to property and infrastructure, destruction of crops and livestock, disruption of essential services, malnutrition, food insecurity, etc., are a hallmark of disasters. It is obvious from the above-mentioned litany of adverse effects of climate related disasters that a wide spectrum of sectors is adversely impacted by these events in the country, hence the need to put in place appropriate anticipatory adaptation strategies in order to counter adverse impacts, risks, and vulnerabilities associated with these hydro-meteorological phenomena. In principle, risk may be defined as the expected losses (of lives, persons injured, property damaged and economic activity disrupted) due to a particular hazard for a given area and reference period. The unit of measure of risk could be the number of fatalities or value of damaged property. Risk is mathematically expressed as:

Climate risk = Hazard × Exposure × Vulnerability,

where:

Hazards are climate-related events like floods, droughts, heatwaves, or sea-level rise;

Exposure is the presence of people, assets, or ecosystems in areas that could be affected; and

Vulnerability is the degree to which those exposed systems are susceptible to harm;

UNFCCC technical papers and adaptation frameworks distinguish between Current Climate Risks (Based on historical climate variability and extreme events) and Future Climate Risks (Projected impacts under different climate scenarios).

4.4 Analysis of Existing Temperature and Rainfall Data

Malawi experiences a tropical continental climate, with the rainfall season commencing in November and ending in April. Studies done by McSweeney *et al.* (2008) showed a temperature increase of 0.9°C between 1960 and 2006 for Malawi, an average increase rate of 0.21°C per decade. The increase in temperature has been most rapid in December-January-February (DJF) and slowest in September-October-November (SON). Daily temperature observations show an increase in the frequency of hot days and nights in all the seasons. The frequency of cold days and nights has significantly decreased in all the seasons, except in SON. Observed rainfall over Malawi does not show statistically significant trends. Also, there are no statistically significant trends in the extremes' indices calculated using daily precipitation observations (McSweeney *et al.*, 2008).

Studies done by the Government of Malawi and Irish Aid in 2018 (Irish Aid, 2018; GoM, 2018) show that climate trends observed from temperature data across Malawi depict an increase in temperatures of 0.9 °C between 1996 and 2017, an average increase rate of 0.21°C per decade. The increase in temperature has been most rapid in August-November (early-summer) and slowest during December-February (mid-summer). The frequency of hot days and hot nights has increased in all seasons. The average number of hot days increased by 30.5 days per year from 1996-2017, particularly in summer. The average number of hot nights has increased by an additional 41 days per year over the same period. Generally, these findings are in agreement with results of climate change scenario analysis done by McSweeney *et al.* (2008).

In terms of rainfall, long-term trends of precipitation in Malawi do not show statistically significant trends in total rainfall amount (GoM, 2018). Analysis of trends in monthly rainfall across Malawi show that most regions experienced decreasing but non-significant rainfall trends over the period 1996-2017. Decreases are evident for annual and seasonal rainfall and for the months of December to March. However, the highest rainfall months of January and February show increasing trends in rainfall amounts. Daily precipitation observations show that despite observed decreases in total rainfall, the proportion of rainfall falling in the two events has increased at an average rate of 2.6 percent, and 5-day annual rainfall maximum have increased by 8.4 mm per decade, with largest increases observed in March (GoM, 2018). During the compilation of the "Situation Analysis Report" for the review of the National Water Policy (2023), long-term rainfall data for 14 stations were analysed using a linear trend analysis (GoM, 2021). The analysis was done by computing annual rainfall departures from the long-term averages for the period 1960 to 2019 (60 years). The analysis revealed the following: ten stations showed a decreasing trend in annual rainfall, three showed no trend while one station showed an increasing trend in rainfall. Table 4.1 shows the list of the 14 rainfall stations, and Figures 4.4 to 4.13 show rainfall trends for some of the stations.

Table 4-1: Annual rainfall trends for selected 14 stations from 1960 to 2019

No.	Station	Rainfall Trend
1	Chitipa	Decrease
2	Karonga	Decrease
3	Mzuzu	Decrease
4	Chelinda Nyika Plateau	Decrease
5	Nkhata Bay	Decrease
6	Mzimba	Decrease
7	Nkhotakota	Decrease
8	Chitedze	Decrease
9	Dedza	No trend
10	Liwonde	No trend
11	Zomba	Decrease
12	Chileka	No trend
13	Chikwawa	Decrease
14	Makhanga	Increase

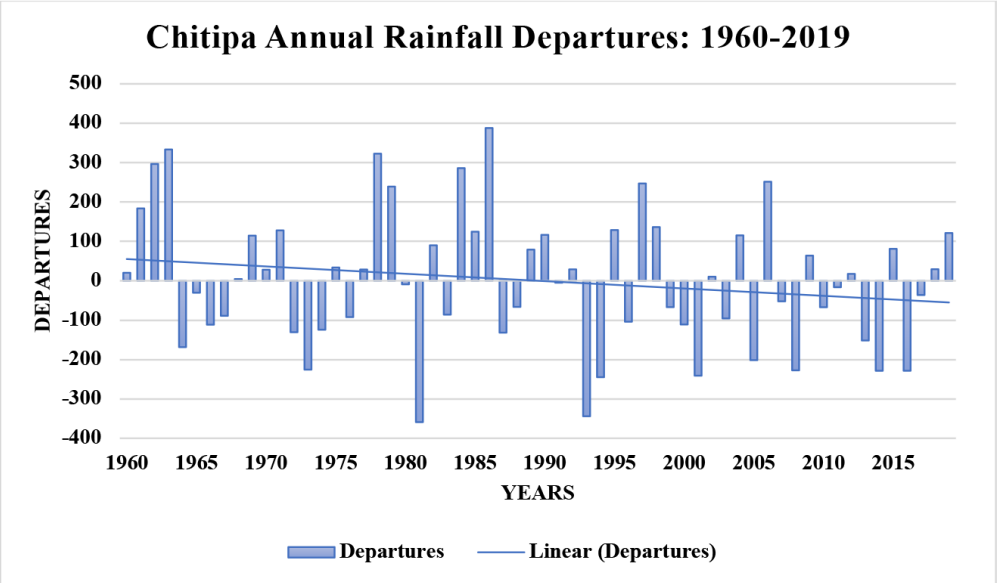


Figure 4-1: Trend for Chitipa Annual Rainfall Departures (mm): 1960 – 2019

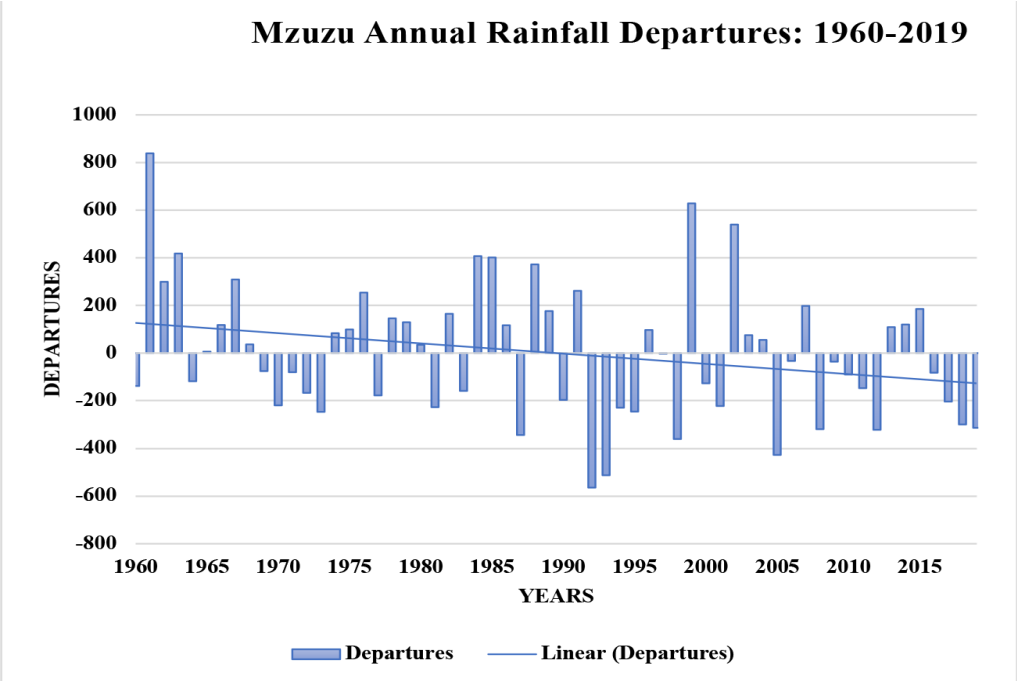


Figure 4-2: Trend for Chitipa Annual Rainfall Departures (mm): 1960 – 2019

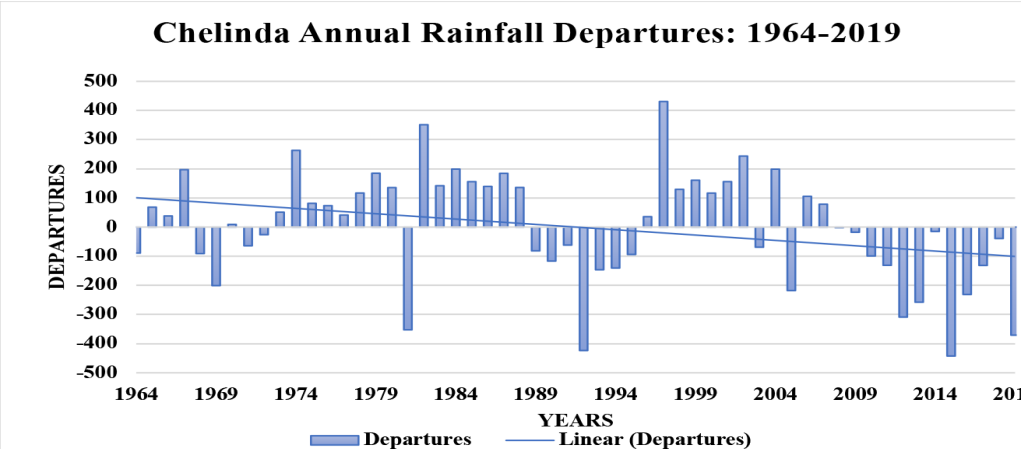


Figure 4-3:Trend for Chelinda Annual Rainfall Departures (mm): 1960 – 2019

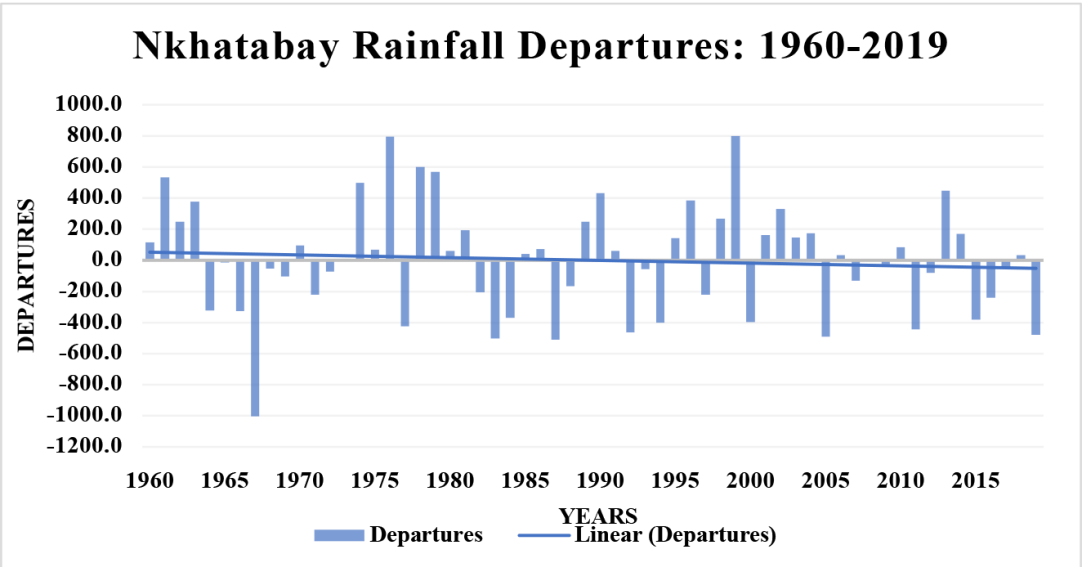


Figure 4-4:Trend for Nkhata Bay Annual Rainfall Departures (mm): 1960 – 2019

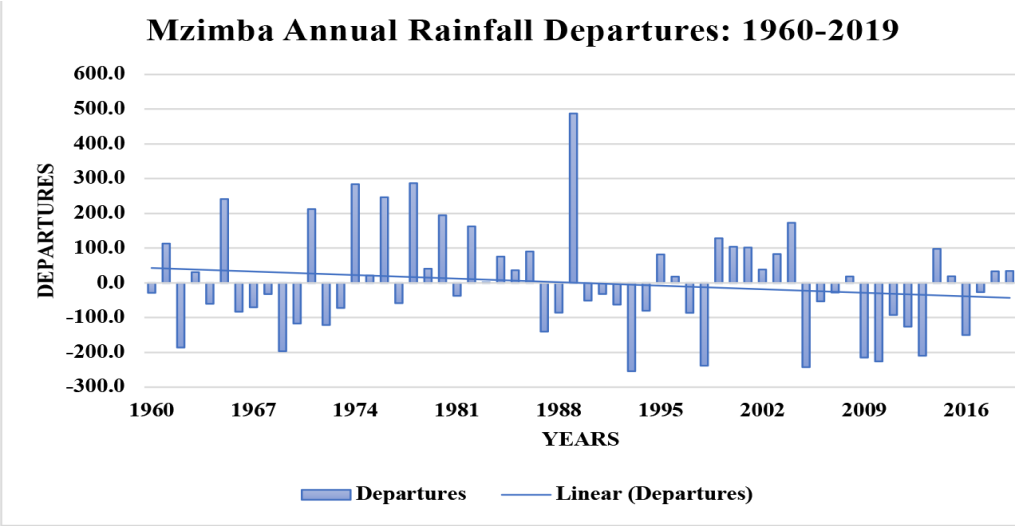


Figure 4-5:Trend for Mzimba Annual Rainfall Departures (mm): 1960 – 2019

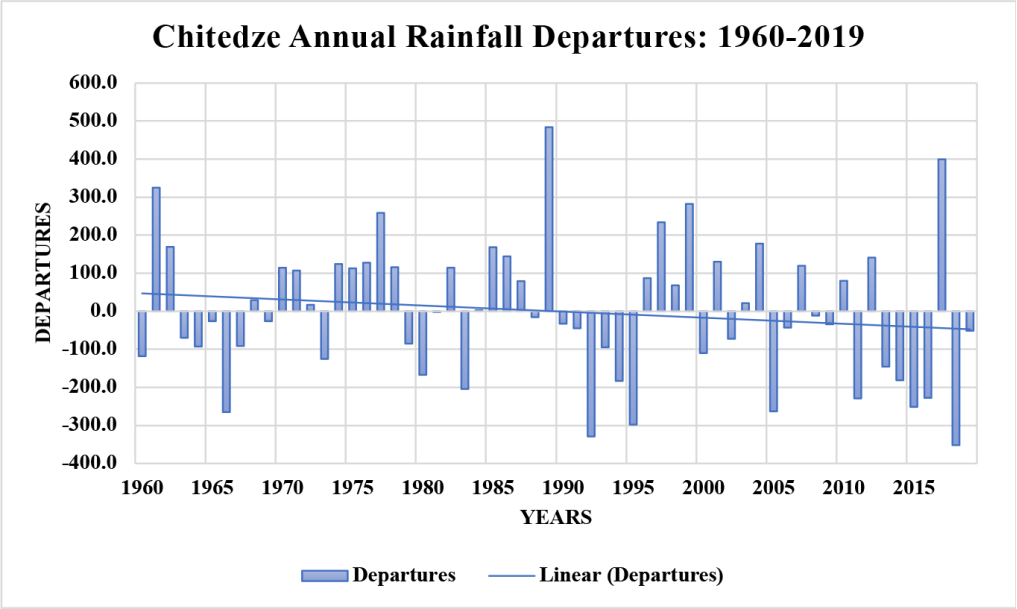


Figure 4-6: Trend for Chitedze Annual Rainfall Departures (mm): 1960 – 2019

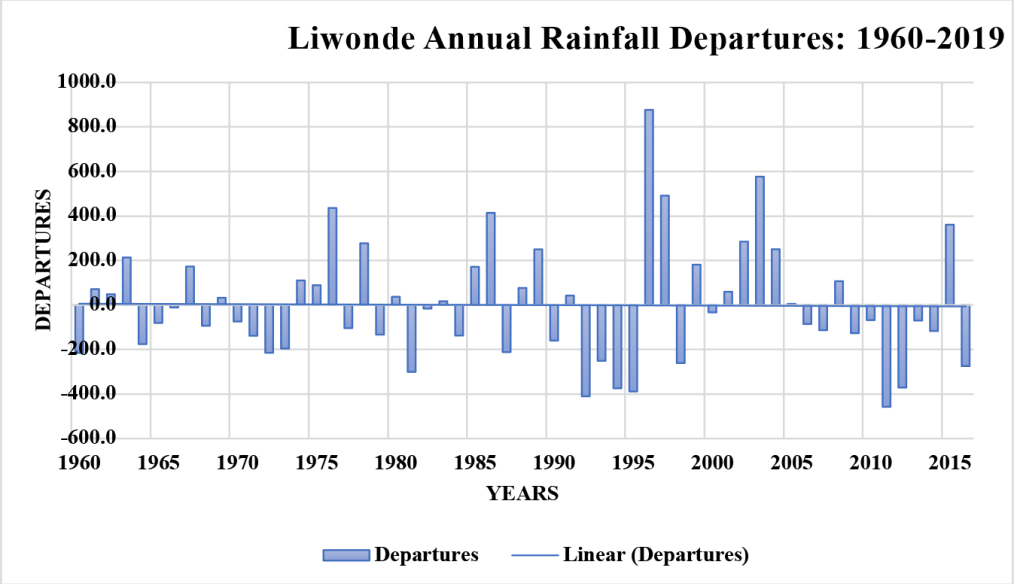


Figure 4-7: Trend for Liwonde Annual Rainfall Departures (mm): 1960 – 2

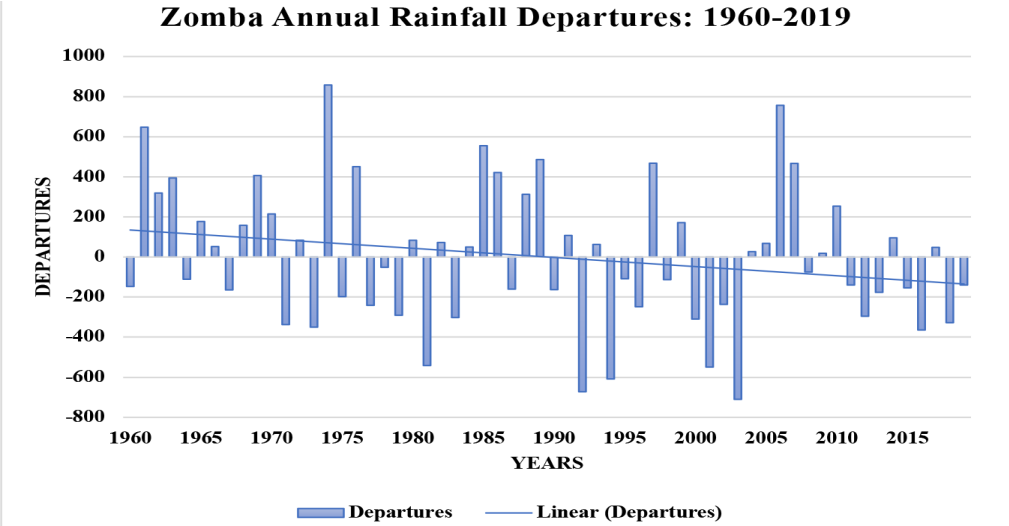


Figure 4-8: Trend for Zomba Annual Rainfall Departures (mm): 1960 – 2019

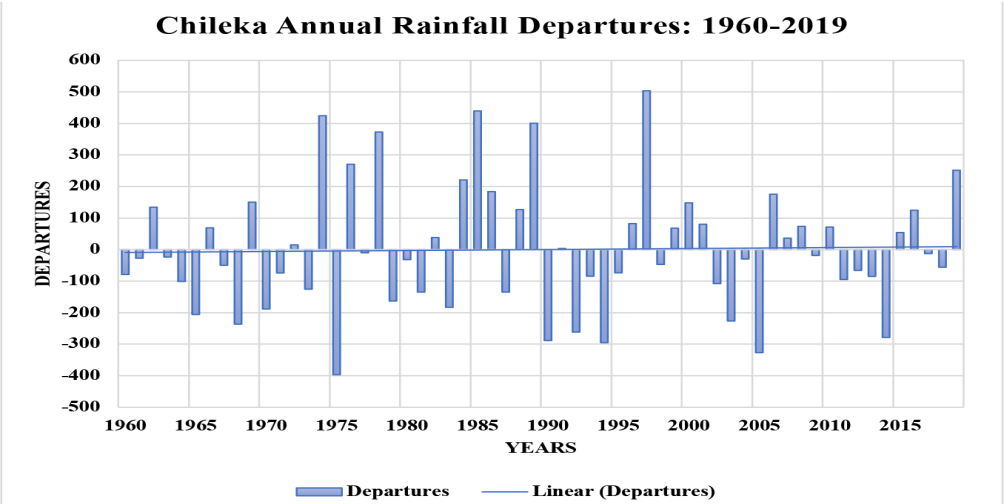


Figure 4-9: Trend for Chileka Annual Rainfall Departures (mm): 1960 – 2019

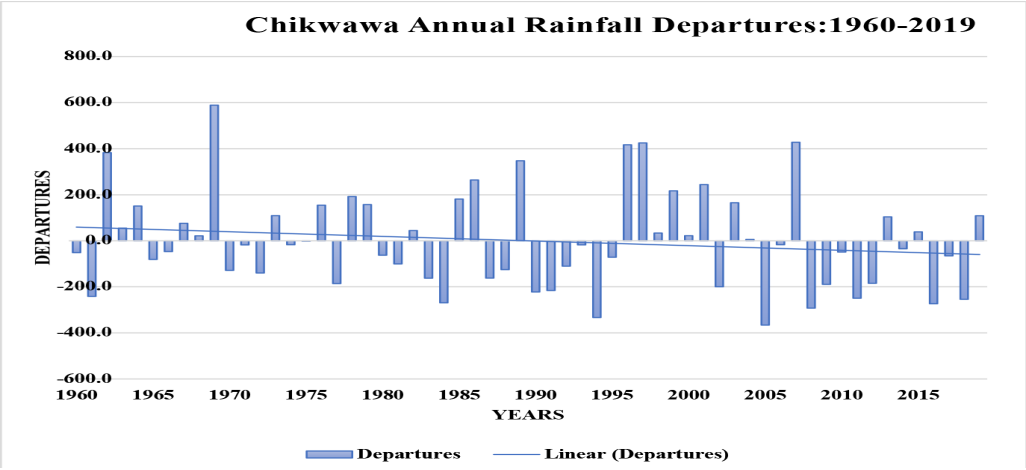


Figure 4-10: Trend for Chikwawa Annual Rainfall Departures (mm): 1960 – 2019

In their study of a detailed rainfall climatology for Malawi, Nicholson *et al.* (2014) delineated the country into four rainfall regions, namely: Regions, 1, 2, 3, and 4 (Figure 4.14), with mean onset, end and duration of the rainy season for individual stations in regions 1–4 shown in Table 4.2

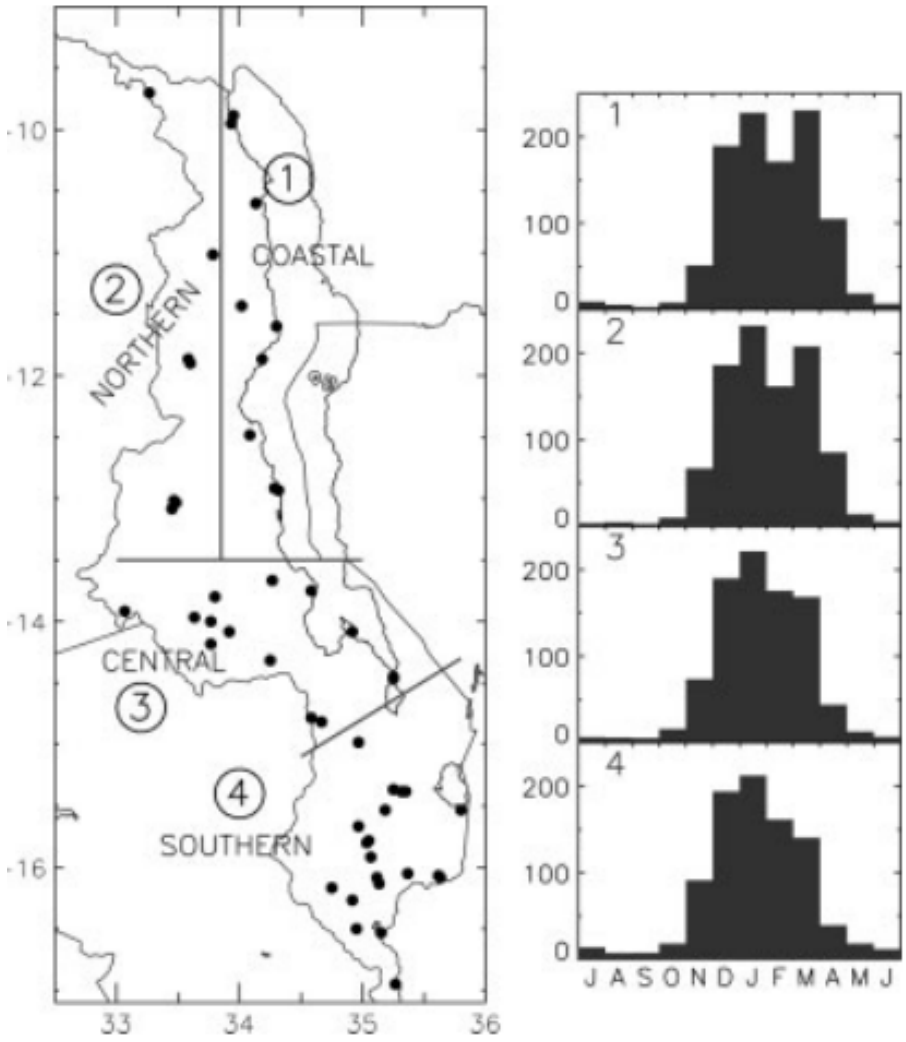


Figure 411:Left: four homogeneous rainfall regions of Malawi and the stations within them. Right: The typical seasonal cycle of rainfall (mm per month) in each.

Table 42:Mean onset, end and duration of the rainy season for individual stations in regions 1–4.

Region	1	1	1	1	2	2	2	2
Station	1	2	3	4	5	6	7	8
Onset	12/4	11/19	11/23	12/1	11/27	12/6	11/27	12/1
End	4/20	4/28	5/8	4/14	4/4	3/19	3/30	3/20
Duration	138	161	167	134	129	104	124	108

Region	3	3	3	3	3	3	3	4	4	4	4	4	4
Station	9	10	11	12	13	14	15	16	17	18	19	20	21
Onset	12/4	12/3	11/28	11/27	11/27	12/4	11/23	11/27	11/15	11/14	11/13	11/29	11/25
End	3/24	4/1	3/21	3/23	3/27	3/19	3/27	3/17	3/17	4/4	4/5	3/13	3/19
Duration	111	120	114	117	122	106	126	111	123	142	144	105	114

4.5 Generation of Future Temperature and Rainfall Scenarios

The DCCMS generated climate change scenarios for temperature and rainfall for eight (8) Agricultural Development Division (ADDs) in the country; and these findings were used in conducting vulnerability assessment of the country to impacts of climate (DCCMS, 2023). Data from 64 rainfall stations and 21 temperature stations across Malawi were used to extrapolate to other parts of the country. The Coupled Model Intercomparison Project 6 (CMIP6) - General Circulation Models (GCMs) were applied to estimate changes in climate elements and ocean circulation for the future by means of Shared Socio-economic Pathways (SSPs). The SSPs represent a range of possible paths the world might take during the coming century from population changes to education, gross domestic product (GDP), economic growth, rate of technological developments, urbanization, greenhouse gas and aerosol emissions, energy supply and demand, to land use changes, etc. The SSPs are designed to work together with the Representative Concentration Pathways (RCPs) that were used in Coupled Model Intercomparison Project (CMIP5) that are based on the radiative forcing levels.

The DCCMS generated future temperature and rainfall based on two scenarios, namely: the Shared Socio-economic Pathway (SSP) 8.5 (SSP8.5), i.e., the high-end scenario; and SSP2.45, the intermediate middle of the road scenario. The analysis covered the whole country, but focused on the eight Agricultural Development Division (ADDs). Details of the analysis are presented in a special report titled: "Climate Projections for the Eight Agricultural Development Divisions in Malawi" (DCCMS, 2023). Major findings of the study showed that temperature is increasing in Malawi, and that the increase is inevitable in the future (Figures 4.15 and 4.16). The rate of increase of temperature during the period 1991-2020 is of the same magnitude as the increase in future under the SSP5.85 scenario (DCCMS, 2023). Maximum temperature increase in the future is between +1.2 and +3.1°C for SSP2.45 while the increase for SSP5.85 is between +1.4 and 4°C. Similarly, minimum temperature may increase between +1.1 and +2.7°C based on SSP2.45 or between +1.9 and +3.7°C for SSP5.85 scenario.

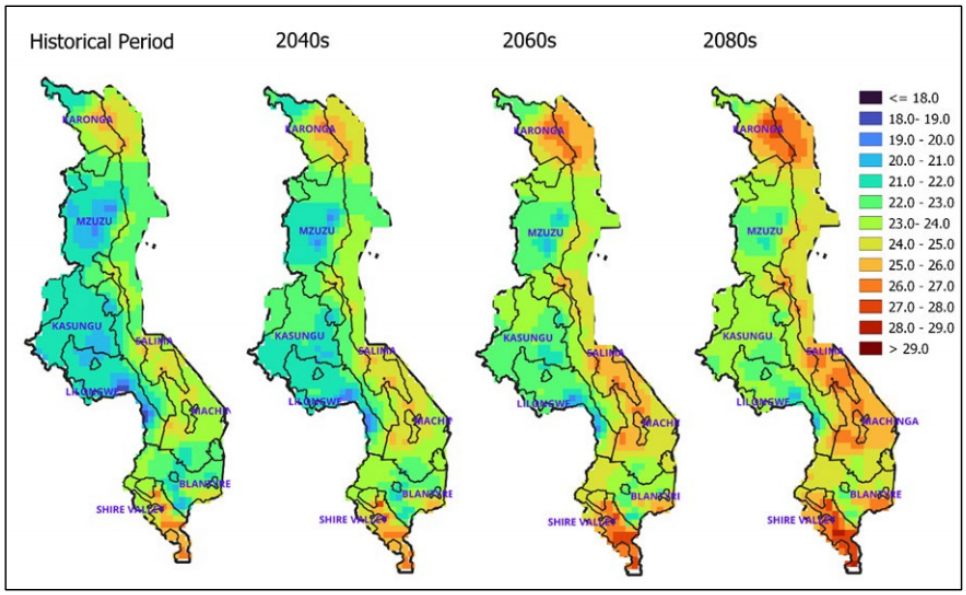


Figure 412: Figure 4.15. Mapped projected mean temperature change for Malawi in the 2040s, 2060s and 2080s, using SSP2.45

Source: DCCMS (2023)

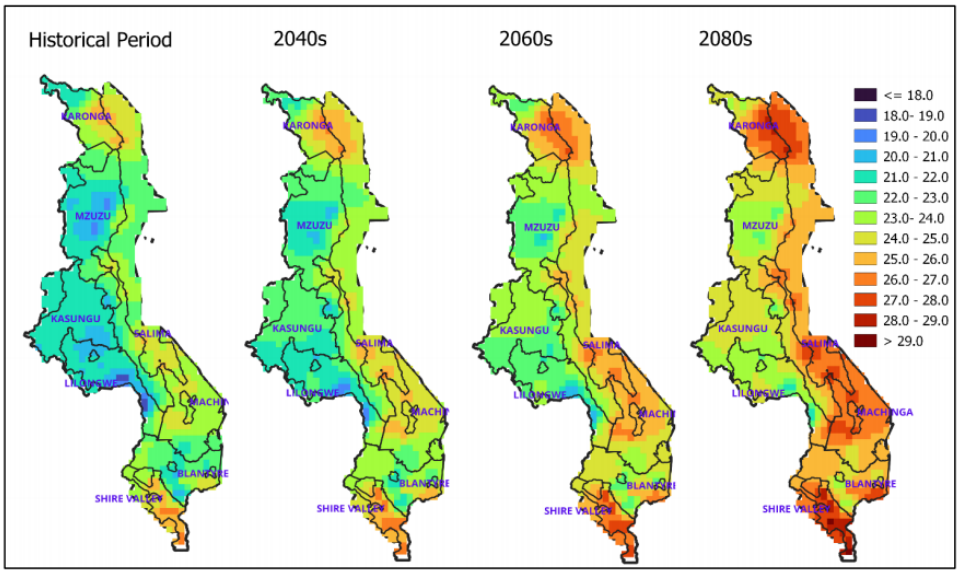


Figure 413: Mapped projected mean temperature change for Malawi in the 2040s, 2060s and 2080s, using SSP5.85

Source: DCCMS (2023)

With this increase in temperature, no ADD will have a mean minimum temperature of less than 15°C in future (DCCMS, 2023). The report further showed that the hottest months have higher temperature increase rate than the coolest months. Similarly, ADDs that experience hottest temperatures are also likely to have higher temperature increase than those with cooler temperatures. Chances for the temperature increase to go beyond the Paris Agreement limit of +1.5°C is between 11 percent and 56 percent during the 2060s, but may increase to greater than 78 percent by the 2080s. For +2°C temperature increase, chances are around 11 percent during the 2060s and may increase to above 44 percent in 2080s in Malawi. This is with reference to 1991-2020 period.

Rainfall changes are insignificant during period the 1991-2020; and there is a high uncertainty among the models regarding future rainfall in Malawi. There is little convergence among the models on the direction of change of future rainfall. However, it was noted that there is a high tendency of positive change during the rainfall season and negative change during the drier months. But still, the changes are usually not significant in most cases (DCCMS, 2023). High positive trends were noted with SSP5.8 scenario. Rainfall exceeding 120 mm is very rare during the period 1990-2020. This is more so with Mzuzu ADD, especially Bolero Station. But future changes are likely to have more intense rainfall than the historical period. The high intense rainfall in the future is noted mainly over Southern ADDs (Figures 4.17 and 4.18).

Temperature and rainfall projections for Malawi highlighted in the preceding discussion using CMIP6 have a lot in common with those obtained from CMIP5 that the Government of Malawi presented in its Third National Communication, where both RCP 4.5 (Intermediate Emission), and RCP 8.5 (High Emission) as described by Moss *et al*. (2013) were employed (Tables 4 and 5). RCP 4.5 and 8.5 are respectively equivalent to story lines B1 and A1F1 in the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC, 2007). RCP 8.5 or Scenario A1F1 is consistent with the following scenarios: (a) three times today's CO_2 emissions by 2100; (b) rapid increase in methane emissions; (c) increased use of croplands and grassland

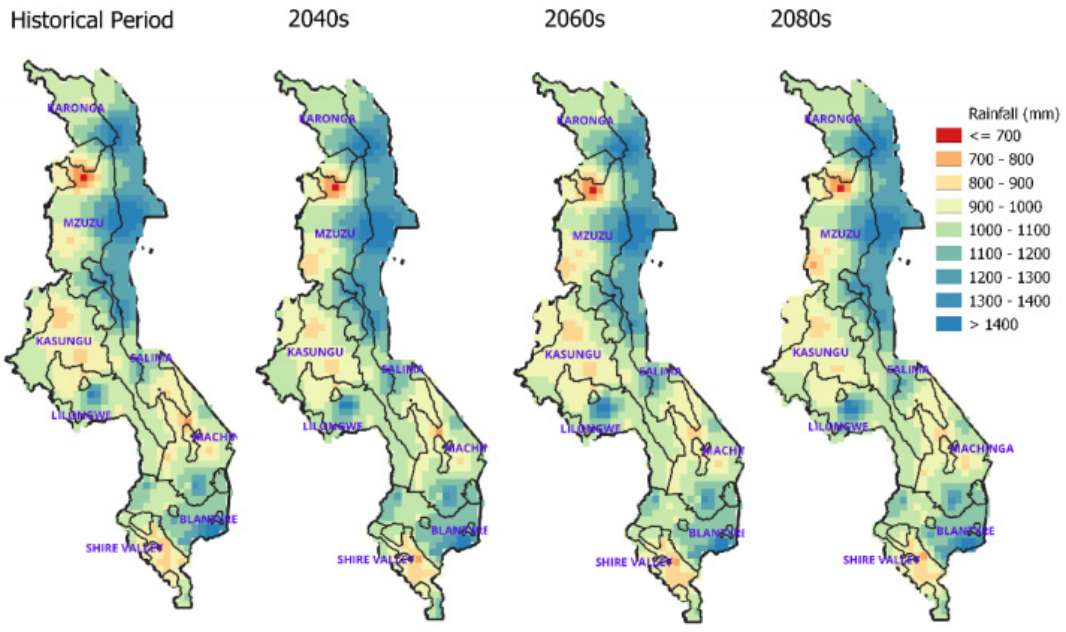


Figure 414: The ensemble annual rainfall mean from 2020s (historical period) to 2040s, 2060s and 2080s based on SSP2.45

Source: DCCMS (2023).

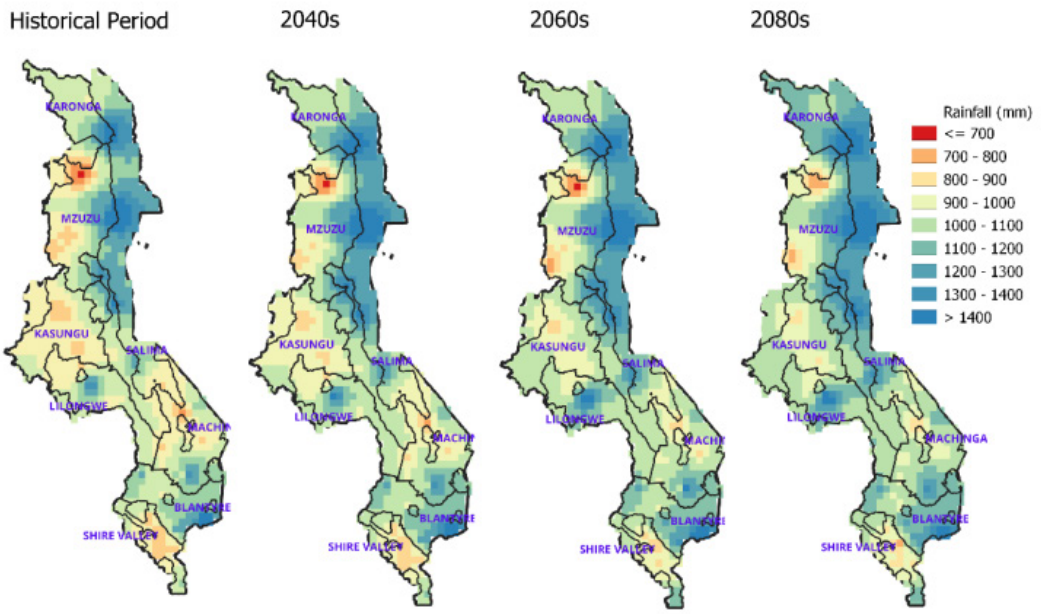


Figure 415:The ensemble annual rainfall mean from 2020s (historical period) to 2040s, 2060s and 2080s based on SSP5.85

Source: DCCMS (2023)

driven by an increase in population growth; (d) a world population of 12 billion by 2100; (e) lower rate of technology development; (f) heavy reliance on fossil fuels; (g) high energy intensity; and (h) no implementation of climate change policies. RCP 4.5, which is comparable to SRES B1 is consistent with the following scenarios: (a) lower energy intensity; strong reforestation programmes; (b) decreasing use of croplands and grasslands due to yield increases and dietary changes; (c) stringent climate policies; (d) stable methane emissions; and (e) CO_2 emissions increase only slightly before decline commences around the year 2040.

Scenario A1B depicts a situation with a balance across all sources, where balance is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end-use technologies. The main finding from the comparison of SRES with scenarios described in AR5 is that the uncertainties as represented by the ranges of main driving forces and emissions have not changed very much. The following conclusions may be drawn from climate change scenario analysis results presented in Tables 4.4 and 4.5 about future expected temperature and rainfall regimes in Malawi using the two RCPs: (a) there is a positive trend in temperature rise, i.e., there will be an increase in temperature in Malawi with climate change; (b) minimum temperatures exhibit a faster rise in temperature with climate change than maximum temperatures; (c) generally, there is an insignificant decrease in rainfall during the OND period, and an increase during JFM; (d) future temperatures will rise by 1.3 °C to 2.6 °C; and (e) El Nino conditions will likely increase climate extremes, resulting in the increased severity, or magnitude/intensity, and frequency of floods, droughts, and strong winds.

What is clear from the description of climate change scenarios for Malawi presented above is that floods, droughts and strong winds will continue to wreak havoc in the country. Thus, the country's vulnerability to the vagaries of severe floods, droughts,

Table 4-3: Temperature Scenarios for CMIP5 (Source: GoM, 2021)

Location	Near Century Period: 2011-2040.	Mid Century Period: 2041-2070.	End Century Period: 2071-2100.
Lower Shire Valley	0.03°C-0.04°C: temperature increase.	1.4°C-2.8°C: temperature increase.	2.5°C-4.2°C: temperature increase.
Shire Highlands	0.034°C: temperature increase (Jun-Dec).	1.0°C: temperature increase.	1.5°C-2.4°C: temperature increase.
Central Areas	0.7°C-0.9°C: temperature increase.	1.3°C: temperature increase.	temperature increase.
Lakeshore Areas	0.8°C-0.9°C: temperature increase.	1.5°C-2.0°C: temperature increase.	2.5°C-3.0°C: temperature increase.
Northern Areas	0.2C-0.9°C: temperature increase.	1.4°C-1.9°C: temperature increase.	1.7°C-2.3°C: temperature increase.

Table 4-4: Rainfall Scenarios

Location	Near Century Period: 2011-2040.	Mid Century Period: 2041-2070.	End Century Period: 2071-2100.
Lower Shire Valley	800 mm – 1000 mm: mean rainfall.	January rainfall to increase by 8% while summer will be drier by 3% to 5%.	Rainfall to decrease by about 15%.
Shire Highlands	1000 mm – 1200 mm: mean rainfall.	Winter rainfall to increase by 15% while summer rainfall will decrease by 10%	Summer rainfall to decrease by 25%.
Central Areas	800 mm -1100 mm: mean rainfall.	October to December rainfall to decrease by 10% to 22%.	October to December rainfall to decrease by 20% to 56%.
Lakeshore Areas	March to April rainfall will increase by 5% to 25%.	Winter rainfall will decrease by 65%.	There will be a general decrease in rainfall by 60%.
Northern Areas	Increase in rainfall by 3% to 8% during the period January to April.	October to December rainfall to decrease by 10% to 36%.	Rainfall to decrease by 56%.

and strong winds should be taken as a serious cause for worry by the Government of Malawi and the citizenry, and hence the urgent need by the country to implement robust anticipatory climate change adaptation strategies in order to avert impending disasters associated with these natural hazards.

In view of the current energy trajectory in Malawi, the A1B Storyline (IPCC, 2007) was selected for the generation of the country's climate change scenarios for temperature and rainfall in studies conducted by the Intergovernmental Authority in Development (IGAD) and ICPAC (IGAD Climate Prediction and Application Centre) in 2007. Results of future climate change scenarios for temperature and rainfall are respectively presented in Figures 4.19 and 4.20 for the years 2030 and 2050.

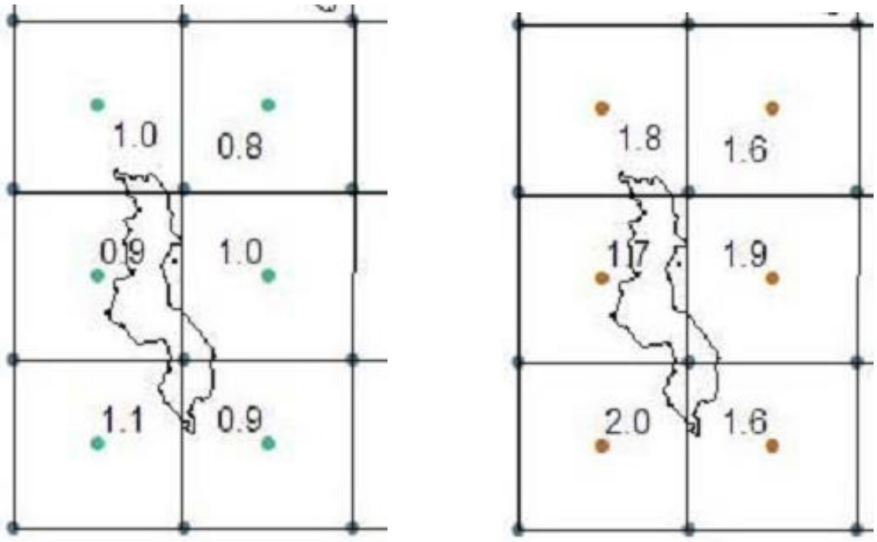


Figure 416:Composite change in mean annual temperature by 2030 (left panel) and 2050 (right panel) in Malawi, using six GCMsGCMs (CSM_98, ECH395, ECH498, GFDL90, HAD295, and HAD300).

Source: IGAD and ICPAC, 2007.

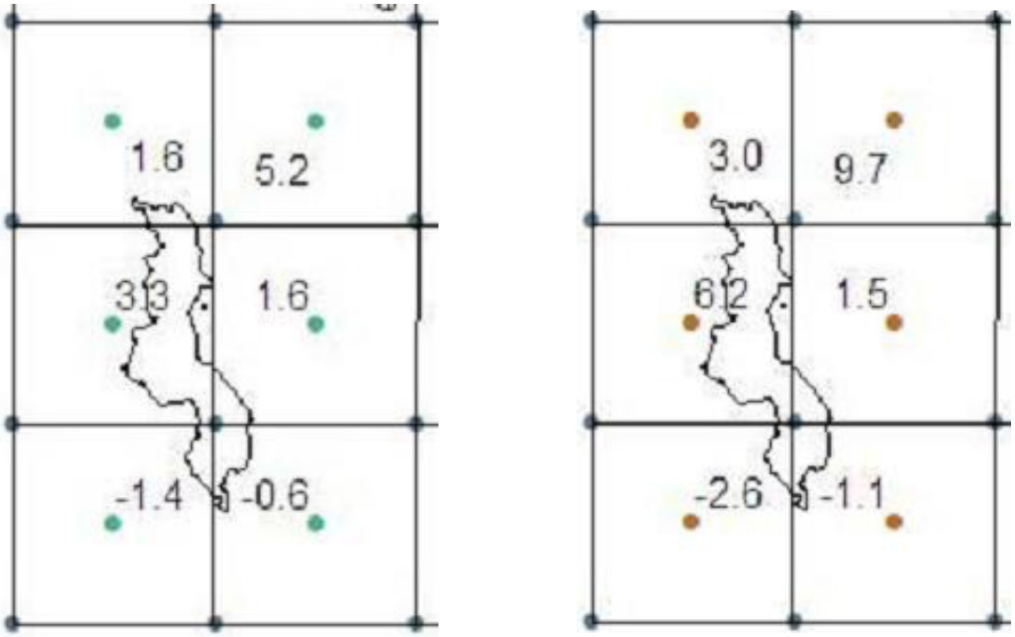


Figure 417: Composite change in mean Annual precipitation by 2030 (left panel) and 2050 (right panel) in Malawi using six GCMs (CSM_98, ECH395, ECH498, GFDL90, HAD295, and HAD300).

Source: IGAD and ICPAC, 2007.

4.6 Agriculture

Malawi largely depends on agriculture for its social and economic development. Agriculture production contributes over 90 percent of foreign exchange earnings. Efforts to diversify the agriculture sector and the economy to other productive sectors such as industry, mining, and tourism have not been effective because of infrastructural and economic challenges. Consequently, the share of other sectors to GDP has increased marginally over the years, forcing the decline in the share of agriculture from 38 percent in 1994 to 28 percent in 2017 (GoM, 2017). The development of agriculture in Malawi is guided by the following policy documents: National Agriculture Policy (2016), National Irrigation Policy and Development Strategy, National Livestock Development Policy (2021-2026), National Seed Policy, Strategic Grain Reserve Management Guidelines, and Malawi Control and Diseases of Animals Act.

Malawi is moving towards profitable commercial farming through specialization of smallholder farm production, output diversification at the national level, and value addition in downstream value chains. However, crop production levels are still low, and so are levels of consumption of fish resources and livestock. With the increased intensification of irrigated agriculture, the country will likely reduce food insecurity and nutrition problems that its citizenry face annually, exacerbated by climate change. It is worth noting that currently, rural households rarely consume foods rich in the seven key food groups comprising carbohydrates, fats, dietary fiber, minerals, proteins, vitamins, and water. Hence cases of malnutrition are still very common, especially during the lean season which spans from December to March.

Malawi's agriculture sector is divided into estate and smallholder sectors. The estate sector mainly concentrates on cash crops (tobacco, tea, sugar, etc.) production while the smallholder sector produces food crops (maize, beans, etc.) for on-farm consumption, with the excess sold for incomes.

With about 1.7 million families involved in small scale farming, most of the agriculture sector policies target smallholder farmers characterised by cultivation on less than one hectare of land, limited access to inputs, unreliable market opportunities and information, and poor infrastructure. Agriculture is highly vulnerable to the vagaries of climate change and climate variability.

4.6.1 Crops: Vulnerabilities, Impacts and Risks

The assessment of crops to adverse impacts of climate change was based on responses of various types of crops to crop-water requirements under various climate change scenarios using models. Vulnerability assessment comprised both cereals and pulses. For cereals, the selected crops were maize, rice and sorghum while pulses included beans, soy beans and groundnuts (Figures 4.21 - 4.30). Model simulation results show that three maize varieties used in the study are sensitive to changes in climate, hence appropriate adaptation strategies have to be put in place in order to grow these crops under climate change scenario. Maize does well in all areas apart from the ADDs of Shire Valley, Salima and Machinga where the environment

is not conducive to its growth and maturity. These ADDs show significant decrease in maize yield, yet those results are not physically important as these ADDs are not traditionally high maize producing areas. It is worth noting that an important decrease does not have the same impact whether it happens in high or low producing area. It is therefore proposed that in these three ADDs, maize cultivation should not be encouraged. It was also noted that the high yielding hybrid maize variety is the most sensitive among the three varieties investigated under the study. It is therefore proposed to grow early maturing varieties of hybrid maize to take advantage of the variability of the rainy seasons. Some observations suggest the shortening of the growing season with climate change, hence hybrid maize might be a solution to food security compared to the other two varieties, namely: local and composite maize verities. In addition, local and composite seeds are scarce, especially the local varieties, and breeding new drought resistant varieties less sensitive to water stress may be worth pursuing. A large decrease in hybrid maize yields is projected in Mzuzu and Blantyre ADDs. The yield functions in the two ADDs were overestimating the historical yields and factor in the amplification of the decreasing effect suggested by future projections. In the case of local and composite varieties, the model fits the historical yields better except in Mzuzu ADD, where it simulates significant increase in future projected yields. Despite a generally poor capacity to represent model results, yield projections in the study area are in conformity with historical yields, albeit with varying degrees of confidence. It is therefore imperative to consider these outputs with caution when it comes to implementing proposed actions to boost maize production in the country.

Both long and short maturing varieties of rice perform poorly in areas outside their niche. This is due to water stress, as the projected rainfall shows a slight decrease and an increased seasonal variability. This variability means that crop water requirements for rice might not be always be met. Consequently, there is a projected reduction in rice yield in most areas across the country including Salima ADD and some parts of Machinga ADD (Zomba) which are high rice producing areas. Given the huge water demand by rice, irrigation may be required even in the suitable areas, particularly where water is readily available (e.g., Lake Malawi for Salima and Karonga ADDs, and Lake Chilwa for Machinga ADD). Therefore, it is proposed to develop large scale irrigation schemes which would take advantage of the current suitability of these ADDs, and adapt to possible future marginal reduction.

Sorghum requires less rainfall compared to other cereals used in this study, hence it performs well in almost all areas with minimal changes. The most significant observation is a marginal increase in projected sorghum yield in the Shire Valley ADD which is one of the traditionally high producing

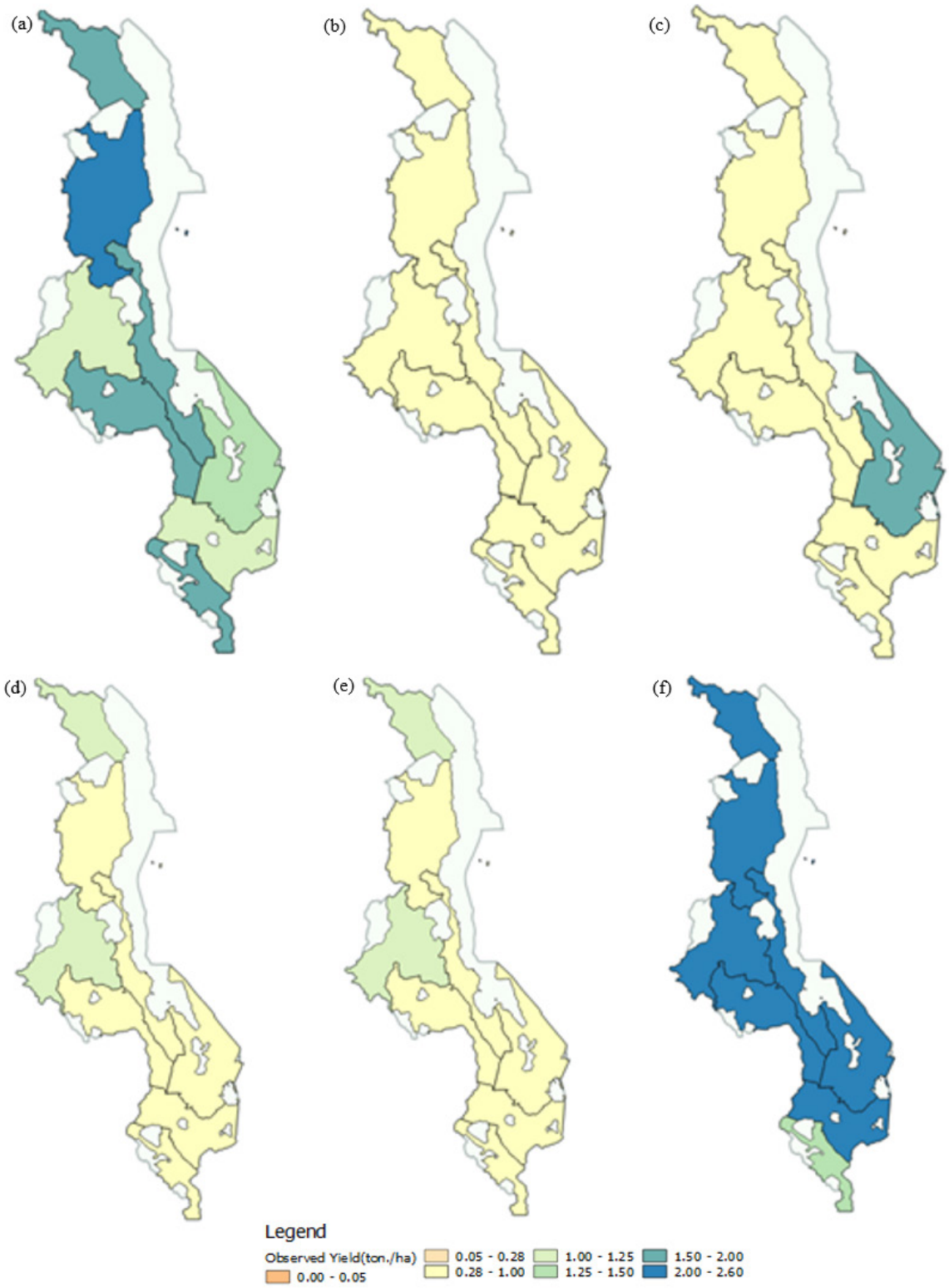


Figure 418:Actual historical yield across ADDs in Malawi where (a) Rice (b) Sorghum (c) pulses (d) local maize (e) composite maize and (f) hybrid maize.

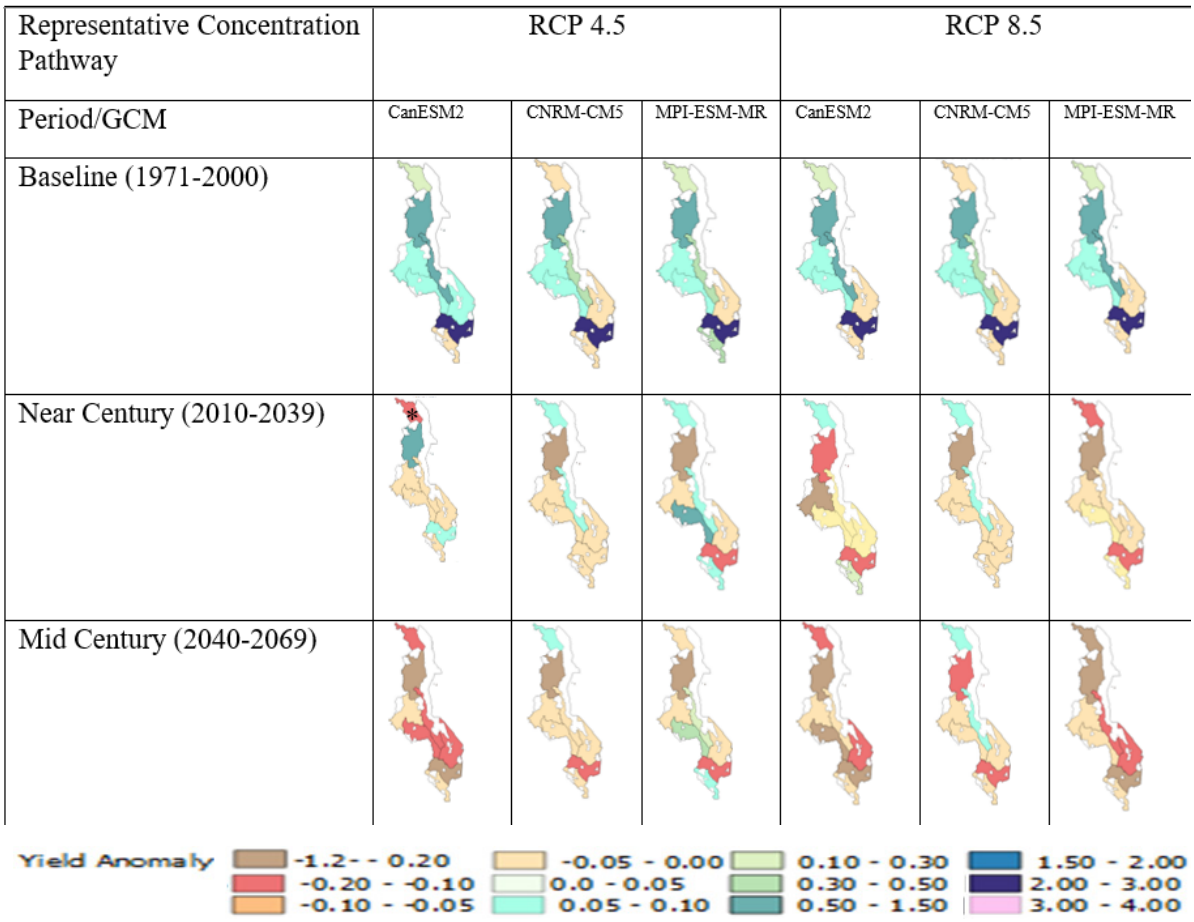


Figure 419:Hybrid maize projected yield anomaly maps across Malawi for three GCMs for different time periods simulated using two RCPs.

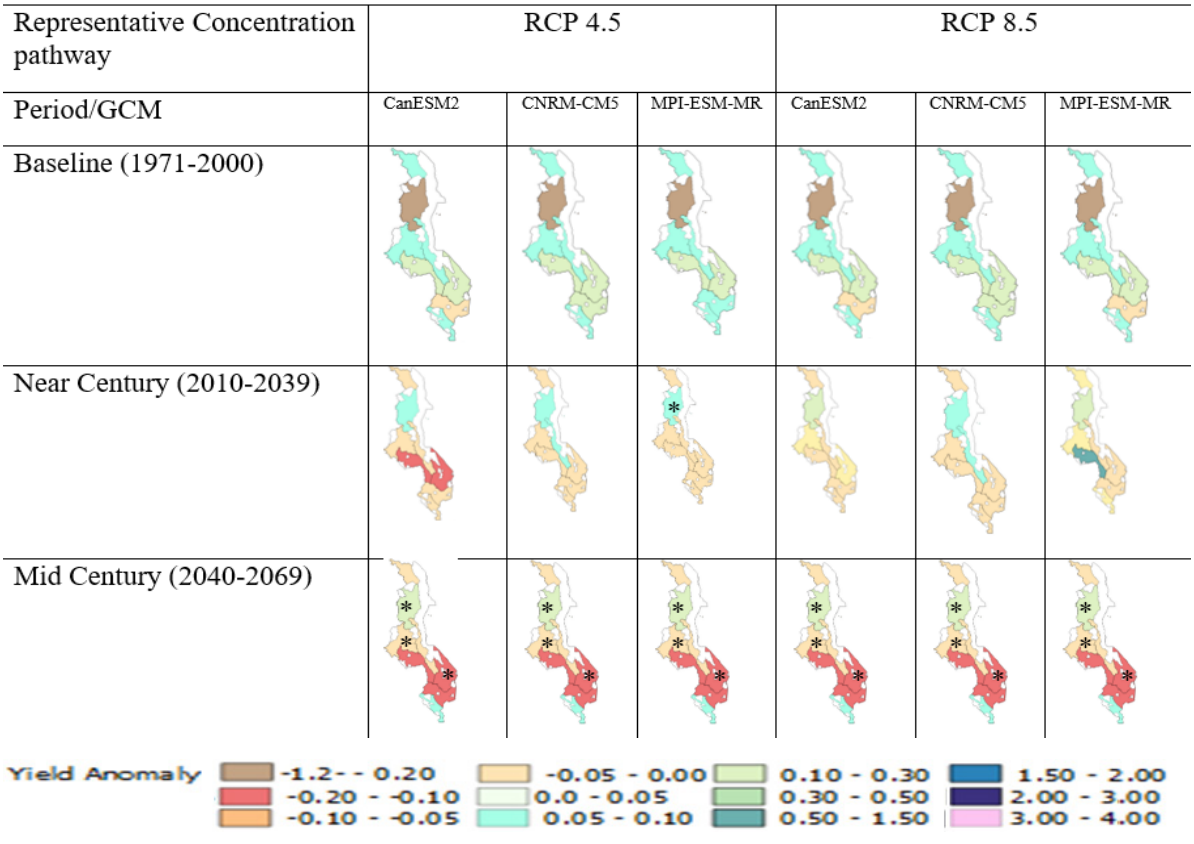
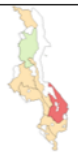
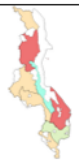
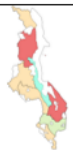
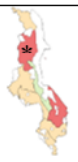
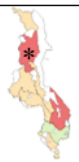


Figure 420: Composite maize projected yield anomaly maps across Malawi for three GCMs for different time periods simulated using two RCPs.

Representative Concentration pathway	RCP 4.5			RCP 8.5		
Period/GCM	CanESM2	CNRM-CM5	MPI-ESM-MR	CanESM2	CNRM-CM5	MPI-ESM-MR
Baseline (1971-2000)						
Near Century (2010-2039)						
Mid Century (2040-2069)						

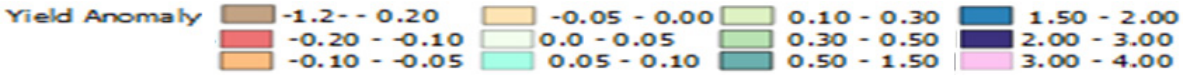
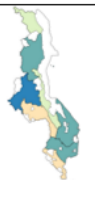
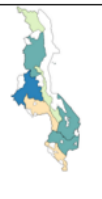
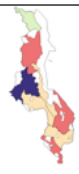
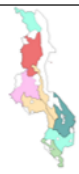
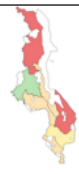


Figure 421: Local maize projected yield anomaly maps across Malawi for three GCMs for different time periods simulated using two RCPs.

Representative Concentration Pathway	RCP 4.5			RCP 8.5		
Period/GCM	CanESM2	CNRM-CM5	MPI-ESM-MR	CanESM2	CNRM-CM5	MPI-ESM-MR
Baseline (1971-2000)						
Near Century (2010-2039)						
Mid Century (2040-2069)						

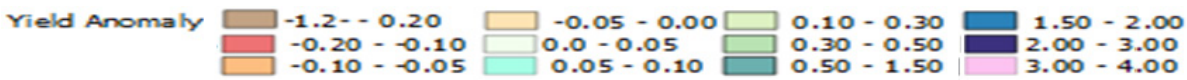
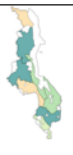
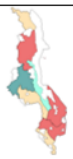
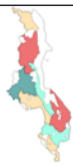
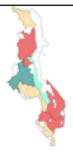
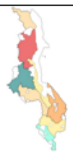
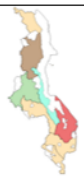


Figure 422: Early maturing rice projected yield anomaly maps across Malawi for three GCMs for different time periods simulated using two RCPs.

Representative Concentration Pathway	RCP 4.5			RCP 8.5		
Period/GCM	CanESM2	CNRM-CM5	MPI-ESM-MR	CanESM2	CNRM-CM5	MPI-ESM-MR
Baseline (1971-2000)						
Near Century (2010-2039)						
Mid Century (2040-2069)						

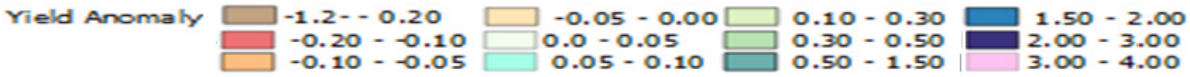


Figure 423: Late maturing rice projected yield anomaly maps across Malawi for three GCMs for different time periods simulated using two RCPs.

Representative Concentration Pathway	RCP 4.5			RCP 8.5		
Period/GCM	CanESM2	CNRM-CM5	MPI-ESM-MR	CanESM2	CNRM-CM5	MPI-ESM-MR
Baseline (1971-2000)						
Near Century (2010-2039)						
Mid Century (2040-2069)						

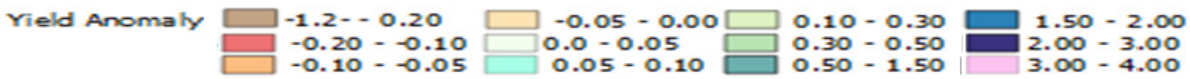


Figure 424: Sorghum projected yield anomaly maps across Malawi for three GCMs for different time periods simulated using two RCPs.

Representative Concentration Pathway	RCP 4.5			RCP 8.5		
Period/GCM	CanESM2	CNRM-CM5	MPI-ESM-MR	CanESM2	CNRM-CM5	MPI-ESM-MR
Baseline (1971-2000)						
Near Century (2010-2039)						
Mid Century (2040-2069)						

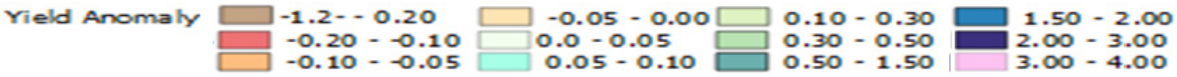
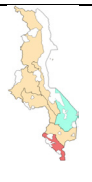
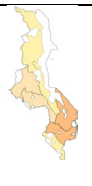


Figure 425:Figure 4.28: Beans projected yield anomaly maps across Malawi for three GCMs for different time periods simulated using two RCPs

Representative Concentration Pathway	RCP 4.5			RCP 8.5		
Period/GCM	CanESM2	CNRM-CM5	MPI-ESM-MR	CanESM2	CNRM-CM5	MPI-ESM-MR
Baseline (1971-2000)						
Near Century (2010-2039)						
Mid Century (2040-2069)						

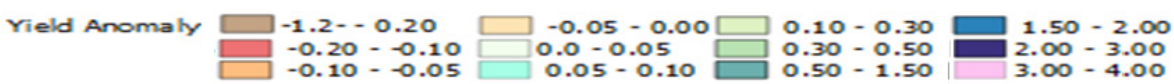
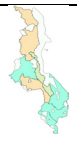
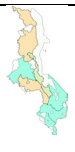
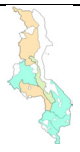
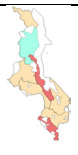
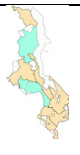


Figure 426: Soy beans projected yield anomaly maps across Malawi for three GCMs for different time periods simulated using two RCPs.

Representative Concentration Pathway	RCP 4.5			RCP 8.5		
Period/GCM	CanESM2	CNRM-CM5	MPI-ESM-MR	CanESM2	CNRM-CM5	MPI-ESM-MR
Baseline (1971-2000)						
Near Century (2010-2039)						
Mid Century (2040-2069)						

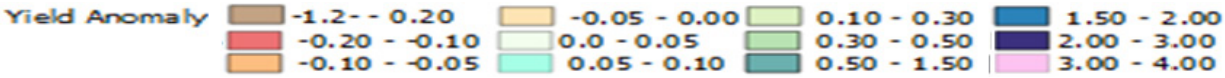


Figure 427:Figure 4.30: Groundnuts projected yield maps across Malawi for three GCMs for different time periods simulated using two RCPs.

areas of sorghum in Malawi. Sorghum also performs well in parts of Machinga ADD (the Lake Chilwa-Phalombe plain), where the projected future yields show a marginal increase for the near century across all the GCMs. Sorghum thrives well in drier and warmer areas as experienced in these areas, which combined with an increasing temperature may explain the positive outcome projected by the models. Where sorghum is currently not a suitable crop, this positive response make sorghum a possible candidate for future suitability. Further research is proposed to ascertain the suitability of different sorghum cultivars to these non-traditional areas.

Generally, pulses seem to be insensitive to climate change as attested by analysis results obtained from this study, as shown by their stability in both near term and mid-century futures. It is worthwhile to follow the general guidelines of climate smart agriculture to maintain the production of pulses, and to allow crop diversification to cushion detrimental effect of climate change and climate variability.

Beans show little sensitivity to changes in temperature or rainfall throughout the country. Albeit a 20 percent projected decrease in beans yield in Machinga ADD was noted, this is not meaningful as Machinga is not associated with high production of beans. The areas favourable for the production of beans in Malawi are usually high-altitude areas like parts of Lilongwe ADD, particularly Dedza and Ntcheu, Kasungu ADD (Dowa and Ntchisi) and Karonga ADD (Chitipa). These areas have shown stable projected yields confirming the lack of

sensitivity of beans to climate change.

Groundnuts are produced in large quantities in Lilongwe ADD, Kasungu ADD, southern parts of Mzuzu ADD and part of Salima ADD (Nkhotakota). There is a general increase of future projected yield, suggesting climate change will be favourable for the production of groundnuts in areas where it traditionally does well. Projections show drastic decrease in areas like Blantyre ADD and Machinga ADD, which is worrisome as there is need to adapt or even to introduce new cultivars to suit the changing climate in these areas. It is therefore advisable to continue the cultivation of groundnuts in areas where it is already acclimatised and refrain from moving to area with less potential, now and into the future.

Soy bean shows little sensitivity to changes in climate in high production areas such as the central region (Lilongwe ADD and part of Kasungu ADD and Nkhotakota). Projections in other parts of the country are of less importance given their current low production. The insensitivity of soy beans to climate change suggests that it can be an alternative crop to grow where the traditional crops may be failing due to climate change. Production of soy beans should be encouraged, also as a cover crop since it fixes nitrogen (nodulation) and can benefit the growth of sensitive crops such as maize, which may be highly affected by climate change. Intercropping of maize and soy beans is proposed as the best combination to adopt under climate change scenario.

Livestock faces multiple impacts of climate change of varying magnitude, ranging from rising temperatures that cascade into heat stress, to livestock feed shortages, scarcity of livestock drinking water, and the spread of parasites and diseases. Increased frequency and magnitude of climate shocks in Malawi, manifested in droughts, floods, heat stress, livestock diseases, have all amplified the risk of climate related shocks on the livestock sector. Animal feed shortages due to frequent droughts and the spread of parasites and diseases to new regions (e.g., previously there was no black leg disease in the Lower Shire Valley but cases emerged due to flooding of 2019) are some of the issues that the Department of Animal Health and Livestock Development (DAHLD) grapples with. It is worth noting that vulnerability of livestock to climate shocks are on the increase. The vulnerability assessment of the livestock sector to impacts of climate change was done using professional experience of the experts.

4.6.2 Adaptation Strategies, Barriers and Gaps

A number of adaptation strategies have been discussed in this section for both crop and livestock production, as well as barriers and gaps that are a hindrance to the successful implementation of adaptation measures for the agriculture sector in Malawi.

Adaptation Strategies

There are a number of strategies that the Government of Malawi has put in place to adapt crop and livestock production sub-sectors to adverse impacts of climate change; and these strategies guide the implementation of a number of adaptation activities in this sector throughout the country. For crop production, these include: promotion of crop diversification, planting drought tolerant crops and early maturing varieties, promotion of irrigated agriculture (e.g., through the Greenbelt Initiative and the Shire Valley Transformation Project), encouraging farmers to adopt agroforestry technologies, promoting the use of manure to enhance soil fertility, promotion of mechanization to reduce drudgery, crop rotation, promotion of farmer field schools (FFS), adoption of smart agriculture, capacity building of all cadres of agriculture staff, promotion of technologies for reducing post-harvest losses, and crop insurance. In addition to the scientific approaches highlight above, communities are also encouraged to complement these adaptation strategies with Local Indigenous Knowledge Systems and Practices (LIKSP). Some of the issues of climate change adaptation strategies highlighted in Malawi's Third National Communication are still valid today.

Most of the strategies that local communities/farmers have applied in response to climate change impacts are mostly short-term coping mechanisms e.g. casual labour, sales of household assets and relying on remittances, hence not necessarily to adapt to impacts themselves. This implies that there is inadequate preparedness, education and public awareness on climate change and its potential impact on social-economics, livelihoods and the environment in general. This nonetheless presents an opportunity for the Government of Malawi and its development partners to invest more in public awareness and education on climate change and its impacts to empower communities to appropriately adapt otherwise they "die".

Further, Local Indigenous Knowledge Systems and Practices that local communities apply to adapt to climate change impacts (e.g. control of pests) have neither been scientifically proven nor documented to enable up-scaling to other communities. This suggests that climate scientists/researchers do not sufficiently involve local communities in their quest to find better adaptation solutions to existing problems. Exclusion of locally generated knowledge in climate science/research/development not only undermines innovative and transformative community-based adaptation, but also inevitably erodes ownership of the 'top-down' interventions developed (Chinseu *et al*., 2019). Hence, greater and active engagement of communities (from inception stage) in science, technology and innovation is imperative to facilitate co-generation of sustainable adaptation options (GoM, 2021).

Crop Diversification and Improved Varieties: Crop diversification is a key adaptation strategy in Malawi aimed at reducing the risks associated with monoculture farming, particularly in the face of unpredictable climatic conditions. By promoting the cultivation of multiple crop types, such as drought-tolerant legumes and cereals, farmers can reduce the likelihood of total crop failure during adverse weather events. The development and dissemination of improved seed varieties that are resistant to drought, pests, and diseases have been prioritised. For instance, drought-resistant maize varieties like ZM 309 and heat-tolerant cassava cultivars are now widely used in many districts, enabling farmers to achieve higher yields even under suboptimal conditions (Ministry of Agriculture, 2021).

Conservation Agriculture: Conservation agriculture has emerged as an effective adaptation measure to address soil degradation and water scarcity exacerbated by climate change. This approach emphasises minimal soil disturbance, crop rotation, and the use of organic mulch to retain soil moisture and enhance fertility. These practices improve soil structure and reduce runoff, which is particularly important in areas prone to floods and soil erosion. Farmers in Malawi's central and southern regions have adopted these practices to sustain productivity during erratic rainfall seasons (FAO, 2020). This method also aligns with Malawi's National Resilience Strategy, which underscores the importance of sustainable land management.

Enhanced Irrigation Systems: Given the increasing unpredictability of rainfall, enhancing irrigation infrastructure is a critical strategy for ensuring crop production stability. Smallholder irrigation schemes, such as treadle pump systems and solar-powered water pumps, have been introduced to enable farmers to irrigate crops during dry spells. Community-managed irrigation projects, such as the Shire Valley Transformation Programme, demonstrate the potential of scalable solutions to mitigate water scarcity risks (World Bank, 2022). Expanding irrigation coverage remains a cornerstone of Malawi's adaptation efforts, as it directly reduces dependence on rain-fed agriculture.

Integrated Pest and Disease Management: Climate change has intensified the prevalence of crop pests and diseases, threatening food security in Malawi. Integrated pest and disease management (IPDM) strategies focus on using environmentally friendly techniques to mitigate these impacts. These include the promotion of biological control agents, development of pest-resistant crop varieties, and the judicious use of pesticides. Farmer Field Schools have been instrumental in training communities on IPDM practices, particularly in addressing invasive species like the fall armyworm (FAO, 2020). Strengthening surveillance systems for early detection of pest outbreaks further complements these efforts.

Soil Fertility Management: Declining soil fertility, aggravated by unsustainable farming practices and climate-induced degradation, necessitates innovative soil fertility management strategies. The use of organic manure, compost, and biochar has gained traction in improving soil health and carbon sequestration. Promoting agroforestry practices, such as planting nitrogen-fixing trees like *Gliricidia sepium* alongside crops, has proven effective in enhancing soil fertility while providing shade and reducing water loss (Muchane *et al.*, 2020). These techniques boost yields and also contribute to long-term soil conservation.

Early Warning Systems and Climate Information Services: To empower farmers to make informed decisions, early warning systems and access to climate information services have been integrated into adaptation strategies. These systems provide real-time weather forecasts, crop advisories, and seasonal climate outlooks, enabling farmers to plan planting and harvesting activities effectively. Platforms such as the Department of Climate Change and Meteorological Services disseminate this information through radio, mobile alerts, and community workshops (Ministry of Natural Resources, 2021). Timely access to such data has enhanced preparedness and reduced vulnerability to climate variability.

Crop Insurance Schemes: To cushion farmers against climate-related risks, crop insurance schemes have been introduced as part of Malawi's adaptation efforts. These schemes provide financial compensation for losses incurred due to extreme weather events, such as droughts and floods. Index-based insurance, which uses weather data to trigger payouts, has been piloted in several districts with promising results. Such financial tools not only reduce economic losses for farmers but also encourage investment in modern farming technologies (UNDP, 2021). Malawi employs Area Yield Index Insurance (AYII) and other insurance schemes as a climate change adaptation strategy, providing financial security to smallholder farmers against crop losses from droughts and floods. Implemented with support from the UN World Food Programme (WFP) and the Adaptation Fund, these initiatives aim to build long-term resilience by ensuring financial stability, enabling farmers to recover from adverse weather, and encouraging the adoption of more resilient agricultural practices.

As stated above, these schemes are weather-indexed, meaning payouts are triggered by predefined weather events like droughts, which are measured by indices rather than individual crop damage. The insurance products protect the value of farmers' purchased inputs, such as seeds and fertilizers, against potential losses. When a triggered weather event occurs, farmers receive financial support to help offset crop losses, ensuring they have resources to continue farming and to recover from the disaster.

For example, The United Nations World Food Programme (WFP), in partnership with the Ministry of Agriculture and the Adaptation Fund, distributed MK 2.2 billion (approximately US$1.3 million) in insurance

payouts to over 36,000 farming households in Malawi . These payouts were aimed at supporting farmers whose crops suffered damage due to climate-induced shocks during the 2023/2024 growing season.

Reduce Post-Harvest Losses and Enhance Food Security: Climate change exacerbates post-harvest losses by increasing the prevalence of pests, diseases, and extreme weather events. A critical adaptation goal is to develop climate-resilient storage facilities and improve supply chain infrastructure to minimize these losses. Efforts include promoting hermetic storage technologies and solar-powered cold storage systems to maintain crop quality and extend shelf life (Ministry of Agriculture, 2021).

Mega Farms Initiative: The Mega Farms Initiative is a transformative adaptation goal aimed at addressing the vulnerabilities of Malawi's agricultural sector to climate change. The initiative seeks to establish large-scale, commercially managed farms that integrate advanced agricultural technologies, resource-efficient practices, and climate-resilient systems. By consolidating resources and expertise, mega farms aim to increase productivity, reduce climate risks, and enhance food security. This initiative aligns with Malawi's National Resilience Strategy (2018–2030) and contributes to the broader goals of the Malawi 2063 vision, which emphasises agricultural commercialization and modernization.

Agriculture value addition and processing: Value addition and processing reduce losses by extending the shelf life of crops and minimizing waste. Technologies such as solar dryers for fruits and vegetables, hermetic storage bags for grains, and improved cold storage facilities for perishable goods have ensured that farmers can preserve their produce longer. For instance, initiatives in districts like Mchinji and Dedza have successfully reduced maize losses through community-level processing facilities that convert maize into flour and other by-products.

The establishment of agro-industrial hubs across Malawi forms a central pillar of the value addition and processing strategy. These hubs serve as centers for processing, packaging, and marketing agricultural produce while creating jobs and fostering economic development in rural areas. Agro-industrial development is particularly beneficial in areas heavily affected by climate change, as it provides alternative livelihoods and reduces reliance on rain-fed farming.

Adaptation in the Livestock sub-sector

In the livestock sector adaptation strategies include improved feeding of the livestock, which is premised on upscaling improved pasture production and feed preservation, selection method of breeding that targets indigenous stocks, vibrant parasite and disease control, and drilling of boreholes as livestock watering points. On rising temperatures causing heat stress, the Government of Malawi is promoting the creation of livestock watering points as well as "build back better" principle for livestock structures with elevated roofs to enhance air circulation and withstand shocks, like floods. The raising of drought tolerant livestock such as goats is highly encouraged. To counter feed shortage, the promotion of livestock feed preservation methods like crop residue preservation, pasture establishment and utilization are promoted. Additionally, use of small-framed livestock such as jersey cows in dairy production is encouraged to match the meagre feed available in the country while optimising productivity. Robust animal/ crop disease surveillance coupled with adequate livestock disease control measures are used to curb the spread of parasites, pests and diseases in livestock and crops.

The National livestock Development policy is the domain covering the adaptation plan within the context of increased contribution of livestock towards adaptation and resilience for sustainable commercially led livestock productivity using climate smart livestock technologies. Livestock adaptation plans hinge on the national resilience strategy. The goal is to promote environmental sustainability so that ecosystems sustainably support livestock development interventions.

Harmonising policies across sectors on climate change for common goal realization is imperative while creation of a Repository Centre as well as website with climate change adaptation initiatives is also of paramount importance. Regular reviews of the NDCs should be done to incorporate emerging adaptation actions for enhanced implementation of proposed adaptation actions enshrined in Malawi NDCs.

4.7 Water Resources

Malawi is generally rich in both surface and ground water resources. Surface water resources comprise a network of rivers (e.g., Shire, Ruo, Linthipe, Bua, Dwangwa, Rukuru, Songwe, Lufilya, Kiwira, Ruhuhu, etc.) and lakes (Lake Malawi, Lake Chilwa, Lake Chiuta), Figure 4.31. The country's drainage system is divided into 17 Water Resources Areas (WRAs), two of which drain outside the Lake Malawi/Shire system, i.e., they drain into Lake Chilwa and Lake Chiuta, Figure 4.32. Water Resources Areas are further subdivided into 78 Water Resources Units (WRUs), as shown in Figure 22.

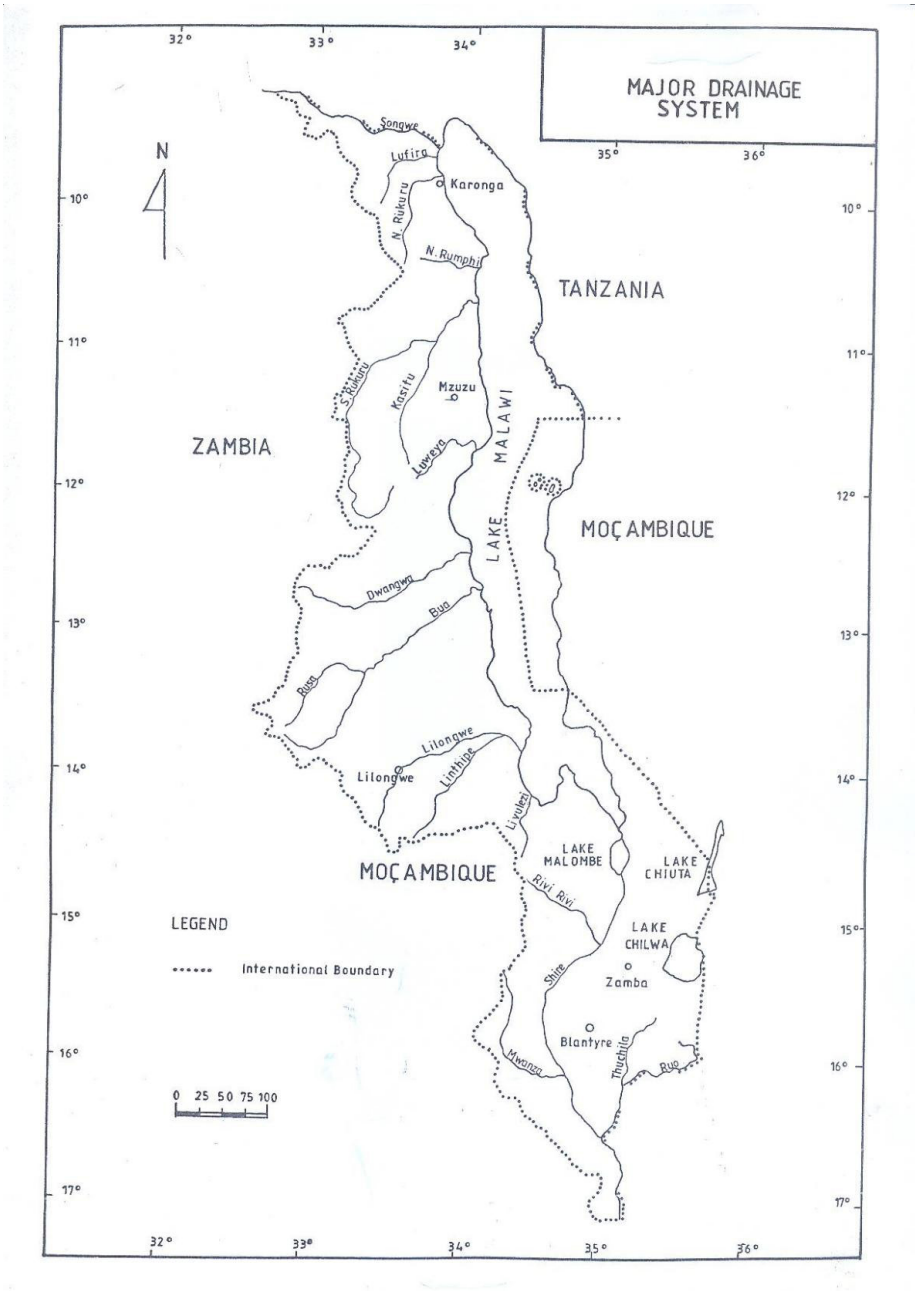


Figure 4-28: Drainage Basin
Source: Water Department/UNDP (1986)

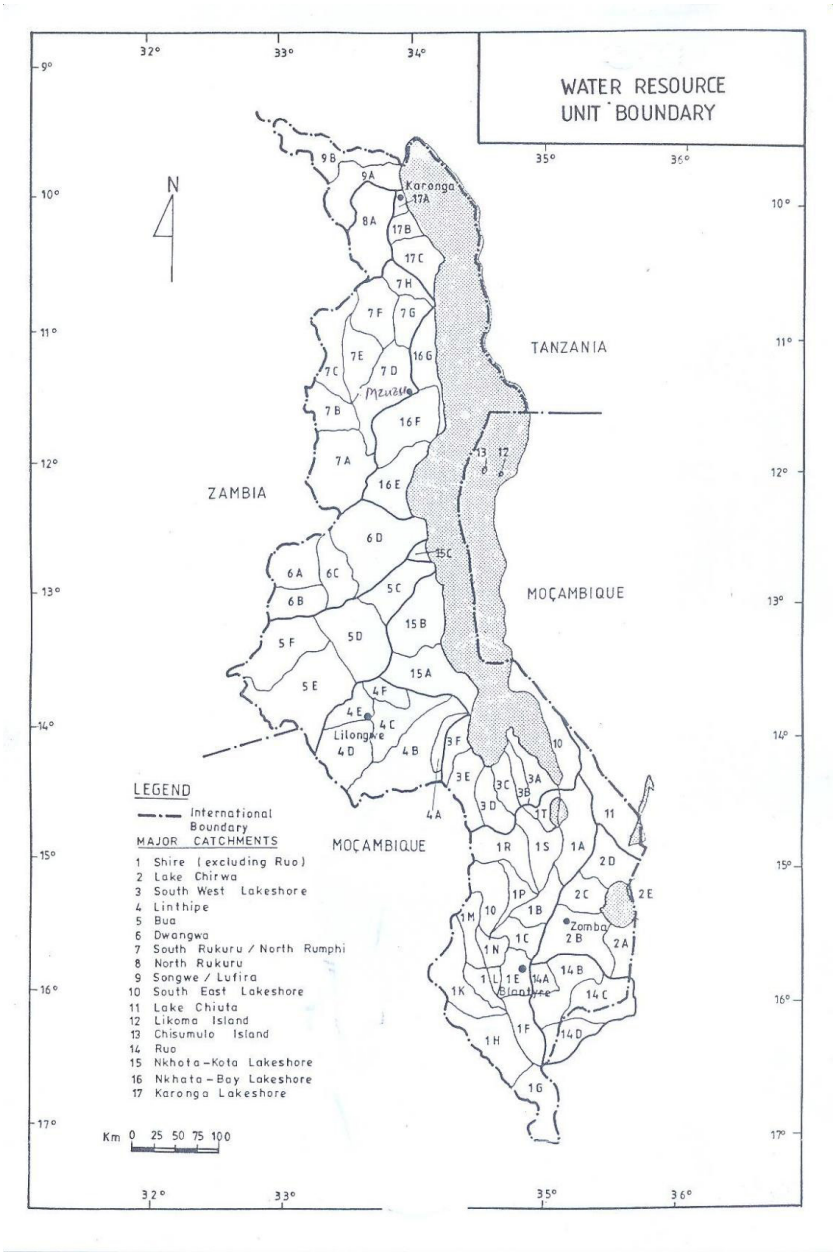


Figure 4-29: Water Resources Units

Source: Water Department/UNDP, 1986

Lake Malawi, with a surface area of about 28,760 km^2, has a great influence on the country's water balance. The mean annual rainfall over the lake is estimated to be 1,549 mm. The total inflow into the Lake Malawi is 927 m^3/s, out of which 400 m^3/s comes from Malawi, 486 m^3/s from Tanzania and 41 m^3/s from Mozambique. The average outflow is 395 m^3/s. The mean lake level is 474.4 m. The only outlet of the lake is the Shire River (Kululanga and Chavula, 1993). Figure 4.33 shows the simulation of lake level fluctuations carried out by Norplan in 1982, and has so far proven to closely mimic the lake's behavior.

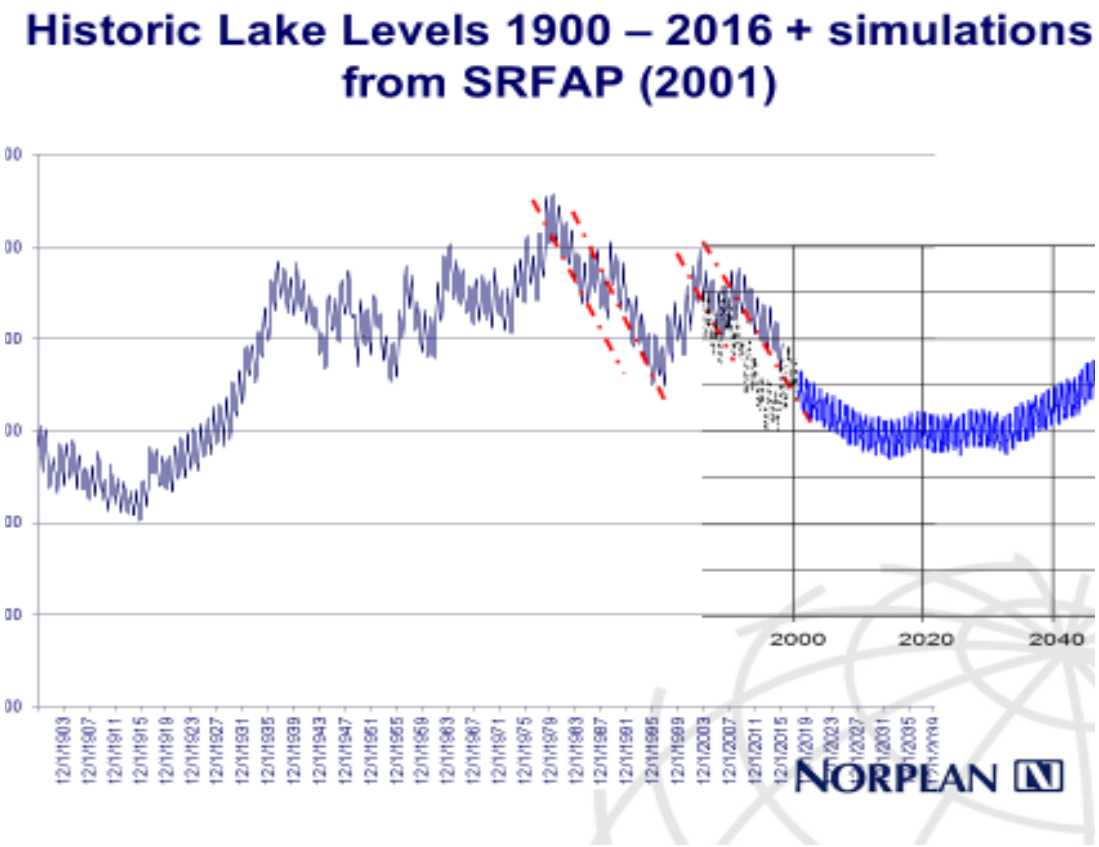


Figure 4-30: Simulation of water level fluctuation of Lake Malawi

The catchment area of Lake Chilwa is estimated to be 5,000 km^2. Most of the rivers that drain their water into Lake Chilwa arise from the northern slopes of Zomba and Mulanje Massifs. All the rivers are perennial in their upper reaches, but they gradually lose their flow and recharge aquifer systems in the Chilwa-Phalombe plains due to the porous nature of the area (Kululanga and Chavula 1993).

The quality of surface water resources is influenced by three major factors, namely: the chemical composition of the parent rocks at the base of the water body or geological formation traversed by the river, agricultural actives taking place in the catchment area, and effluent discharges (including disposal wastes from residential areas and industrial sites).

The hydrochemistry of the majority of surface water resources in Malawi is characterised by alkaline earth (i.e., calcium and magnesium) dominance in the cation group, and by the carbonate system in the anion group. Most of the water may be classified as soft to moderately soft, with hardness less than 100 mg/L of $CaCO_3$. Values of Total Dissolved Solids (TDS) content are generally less than 100 mg/L. Known areas of hard water are confined to the following WRUs: 1C, 1E, 1R, 4E, 4F and part of 5D. The hardness of water in WRUs 1C, 1E, and 1R is attributable to locally occurring outcrops of limestones; whereas in 4E, 4F, and part of 5D the hardness is non-carbonate, but caused by evaporite deposits of gypsum prevalent in dambos.

The biological quality of rivers, especially those flowing through the cities of Blantyre (e.g., Mudi, Chitawira, and Naperi), Zomba (Likangala and Mulunguzi),

Lilongwe (e.g., Lilongwe, Lingadzi), and Mzuzu (e.g., Lunyangwa) is generally poor because of effluent discharges and poor siting of pit latrines. Values as high as 20,000 faecal coliforms per 100 ml have been observed in Lilongwe and Likangala Rivers downstream of the sewage plant during periods when the facility has broken down.

Groundwater resources in Malawi are mostly found in the extensive but low yielding Pre-Cambrian Basement Complex Aquifer (BCA) in plateau areas of the country and in alluvial aquifers along the shores of Lake Malawi, Lake Chilwa, Lake Malombe, Lake Chiuta and in the Upper and Lower Shire Valley (Figure 4.34). In essence, Malawi has three major aquifer systems, and these consist of the extensive but low yielding weathered

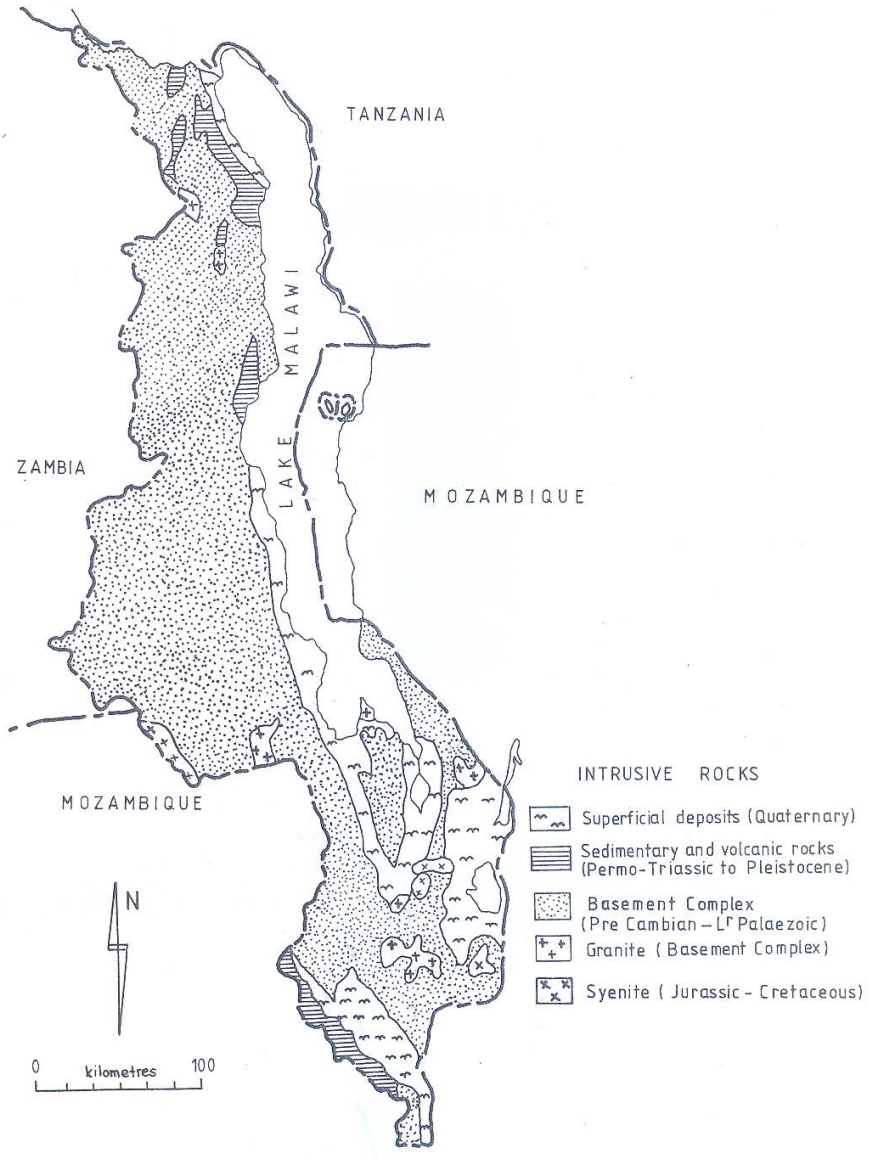


Figure 4-31: Geological Map
Source: Water Department/UNDP (1986)

Precambrian Basement Complex aquifer of the plateau area (1-2 L/s), the high yielding alluvial aquifer of the lake shore plains and the Shire Valley and

the Lake Chilwa - Mphalombe Plain (>15 L/s), and the medium yielding aquifer of the fracture zone in the rift valley escarpment (5-7 L/s). The prolonged in situ weathering of the crystalline basement rocks has produced a layer of unconsolidated saprolite material (Figure 4.35) which is extensively used for groundwater abstraction and forms an important source of water supply for domestic requirements. The weathered zone is best developed over

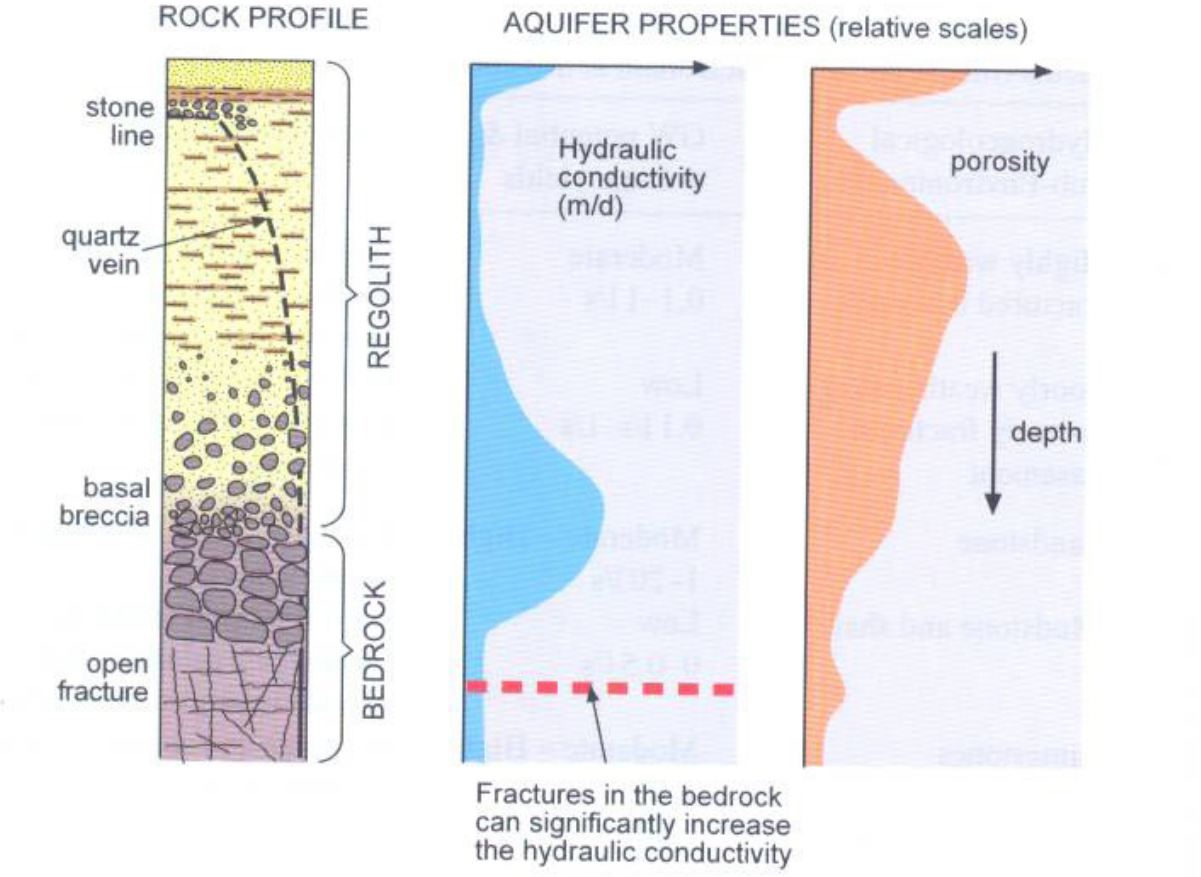


Figure 4-32:Profile of Precambrian Basement Complex Aquifer

Source: Chilton and Foster (1995)

plateau areas where it is commonly 15-30 m thick and locally even thicker (Water Department/UNDP, 1986).

Towards the crest of the escarpment, the uplift associated with the development of the rift valley has resulted in the rejuvenation of rivers and increased erosion, and thus the thickness of the aquifer tends to be reduced in these areas. It also thins towards bedrock outcrops. The saprolite thickness tends to be greatest along fracture zones.

Alluvial aquifers comprise fluvial and lacustrine sediments that are highly variable in character in both vertical sequence and lateral extent. They occur in several basins which, apart from Lake Chilwa, are all located along the rift valley floor, i.e., Karonga Lakeshore, Salima-Nkhotakota Lakeshore, Upper Shire Valley, and Lower Shire Valley.

Most of the lithological logs recovered from boreholes drilled in these areas provide very little information about the successions. The overall impression is that clays usually dominate the sequence, although in many localities

there are significant thicknesses of poorly sorted sands. The sedimentary environment likely to produce the highest groundwater yields are buried river channels and littoral (beach and dune) zones of the lakeshore where deposits are usually coarse grained and well sorted. The Lake Chilwa Basin is different from the other alluvial areas in that it is not located in the bottom of the rift valley floor, but perched on the eastern side of it. The lithological logs suggest that much of the succession is clayey.

Estimates of recharge made from the analysis of flow hydrographs, groundwater level fluctuations, flow nets and catchment balances show that annual groundwater recharge rates range from 15-80 mm (Water Department/UNDP, 1986). However, studies done by Chavula (1989) established that the annual recharge for the eastern side of the Lower Shire Valley alluvial aquifer is greater than 200 mm/year. But the rate of groundwater abstraction still remains very low, and estimates put the figure at less than 1 mm per year (Water Department/UNDP, 1986; Chavula, 1989).

Current estimates show that 65 percent of the human population in Malawi depends on groundwater for domestic water supply (Ministry of Irrigation and Water Development, 2010): about 82.3 percent of the rural population depends on groundwater whereas the figure for the urban population is 19.8 percent. Groundwater usage for irrigation potential is limited by the low yielding aquifers and is generally restricted to small gardens in many dambo areas (Atkins, 2010) and Ngolowindo Irrigation Scheme in Salima District that has a total land area of 17 ha. Kalin *et al*. (2022) stated that there were 85,327 water points in Malawi in 2022.

Bath (1980) and the Ministry of Irrigation and Water Development (Water Department/UNDP, 1986) conducted detailed water quality studies in Malawi in 1980 and 1986, respectively. On a national scale, groundwater quality is generally acceptable for human consumption. In the BCA, groundwater resources are characterised by the dominance of alkaline earths in the cation group and by the carbonates in the anion group (Water Department/UNDP, 1986). Total dissolved solids content values are generally less than 1,000 mg/L and typically around 350 mg/L. Groundwater in the alluvial aquifers is more mineralised than in the basement aquifers. As a result of this, a number of boreholes drilled in alluvial aquifers have been abandoned due to high salinities, notably in the Lower Shire Valley and the eastern part of Bwanje Valley. Chemical parameters of concern include fluoride, sulphate, iron, chloride and nitrate. Groundwaters with fluoride content in excess of 1.5 mg/L are common in the Salima/Nkhotakota and Karonga Lakeshore areas. In these localities, high fluoride content is associated with fault zones and hydrothermal activity in the rift valley. High sulphate groundwater is common in the western part of Dowa District. The high sulphate concentration is thought to be a direct result of progressive oxidation of sulphides rich parent material, probably pyrite and phyrrotite in veins producing sulphuric acid and the subsequent reaction with minerals containing magnesium and calcium.

Chloride rich groundwater resources are common in the Lower Shire Valley and are associated with the dissolution of evaporate minerals and chemical filtration as described by Bath (1980) and Chavula (1989).

In Malawi, the development of water resources is guided by the following key policy documents, namely: National Water Policy (2023), Water Resources Act (2013), Water Works Act, Water Resources Regulations (2018), and National Irrigation Policy. The National Sanitation and Hygiene Policy is now (2025) in its final stages of development.

4.7.1 Vulnerabilities, Impacts, and Risks

The assessment of the water sector to impacts of climate change was done using water balance models in combination with hydrological models under two different climate change scenarios, namely SSP 4.5 and SSP 8.5, in the four Water Resource Areas (WRAs) of North Rukuru in the northern region, Linthipe and Bua WRAs in central region, and the Shire in southern region. Figure 4.36 depicts a typical representation of a water balance scenario at a catchment level.

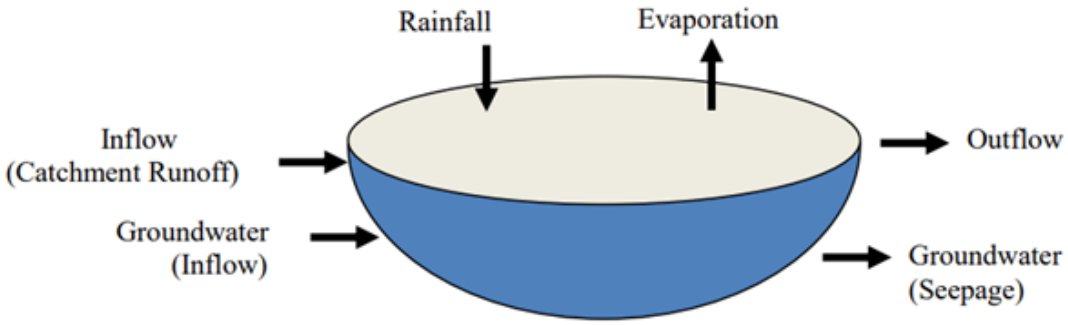


Figure 4-33:Water Balance Parameters

Using hydrological and meteorological datasets, a general water balance equation was developed and expressed as follows:

$$P = R_c + ET_a \pm S_s \pm S_g \pm SMD$$

Where P is rainfall, is catchment runoff, is evapotranspiration, is surface storage, is net groundwater discharge and SMD is soil moisture deficit.

Considering a sufficiently long period of analysis, the changes in surface and groundwater storage may be considered negligible, hence the equation reduces to:

$$P = R_c + ET_a \pm Recharge$$

Figures 4.37 to 4.44 respectively show water balance scenarios for North Rukuru, Bua, Linthipe and Shire River Basins.

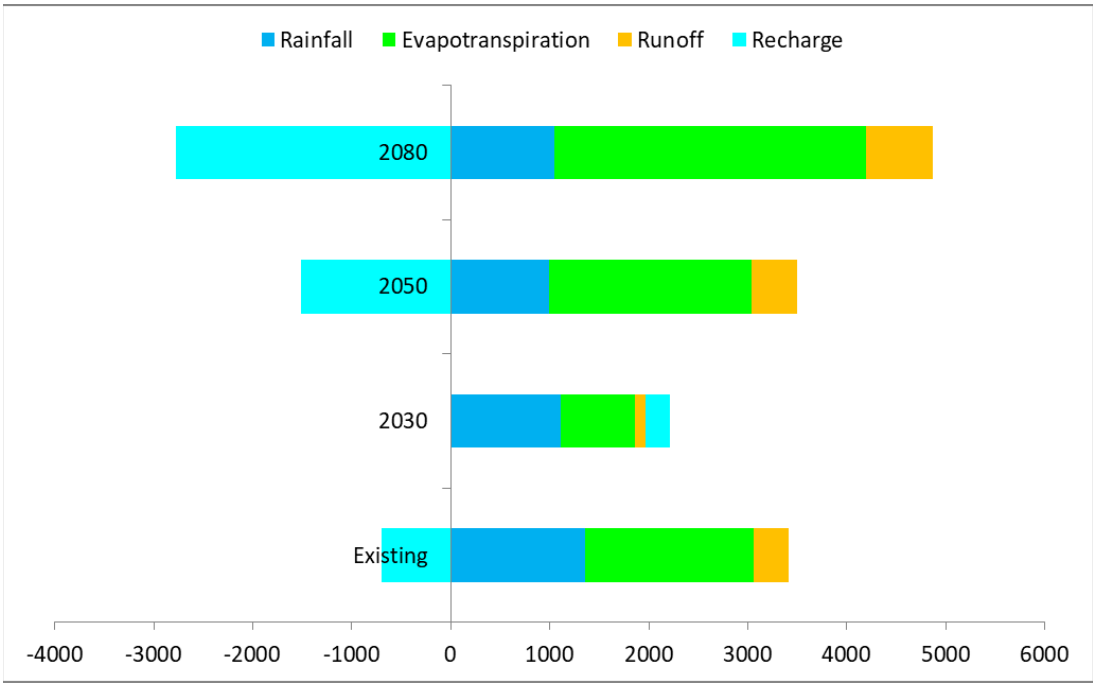


Figure 4-34: Bar chart showing water balance under SSP4.5 climate change scenario

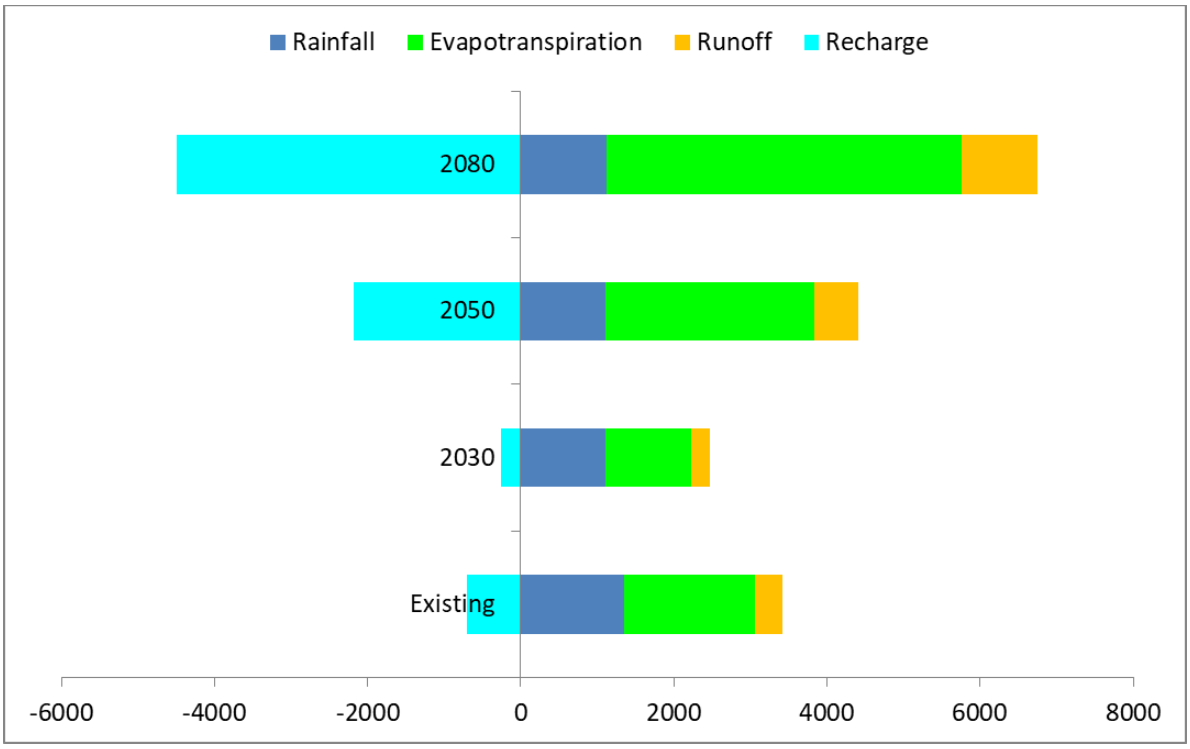


Figure 4-35: Bar chart showing water balance under SSP8.5 climate change scenario

As a summary, the following can be said about water balance parameters for the North Rukuru Basin:

1. **Rainfall**

- In the 2030s and 2050s, rainfall exhibits decreasing trends in the basin, and only starts to increase from the 2050s towards the 2080s period. The inference that may be drawn from this observation is that annual rainfall will be varying in the basin, with the period 2030 to 2050 showing high variability and a decreasing rainfall trend, suggesting the prevalence of drought conditions whilst the 2050 to 2080 period show an increase trend suggesting severe flooding conditions.

2. **Evapotranspiration (ET)**

- Evapotranspiration rates will keep on increasing in the basin because of the increases in temperature. This will have adverse impacts on the growing season of the crops grown in the basin.

3. **Runoff and River Flow**

- The water balance evaluation shows increasing runoff during the wet season, suggesting the prevalence of flooding conditions in the basin, especially in low-lying areas in Karonga district. This is more pronounced over the period 2050 to 2080. However, in the 2030s, runoff is reduced suggesting the existence of water stress conditions that could lead to droughts in the basin.

4. **Storage and Recharge:**

- As shown in Figure 9, in the 2030s and 2050s, the recharge and storage rates are negative. The current growing demands of water resources in the basin for irrigation and domestic use due to population growth is contributing to excessive groundwater abstraction, hence reducing groundwater levels. High rates of urbanization and deforestation is also causing an increase in runoff and reducing infiltration, and hence reducing recharge. High temperatures also influence high evapotranspiration, thereby limiting the potential of recharge in the basin.

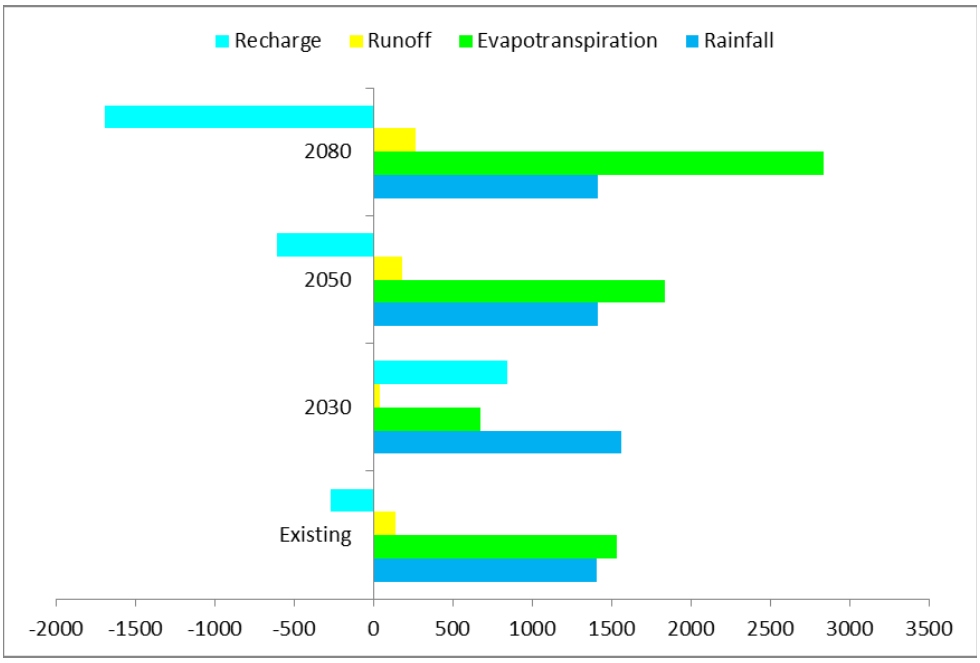


Figure 4-36: Bar chart showing water balance under SSP4.5

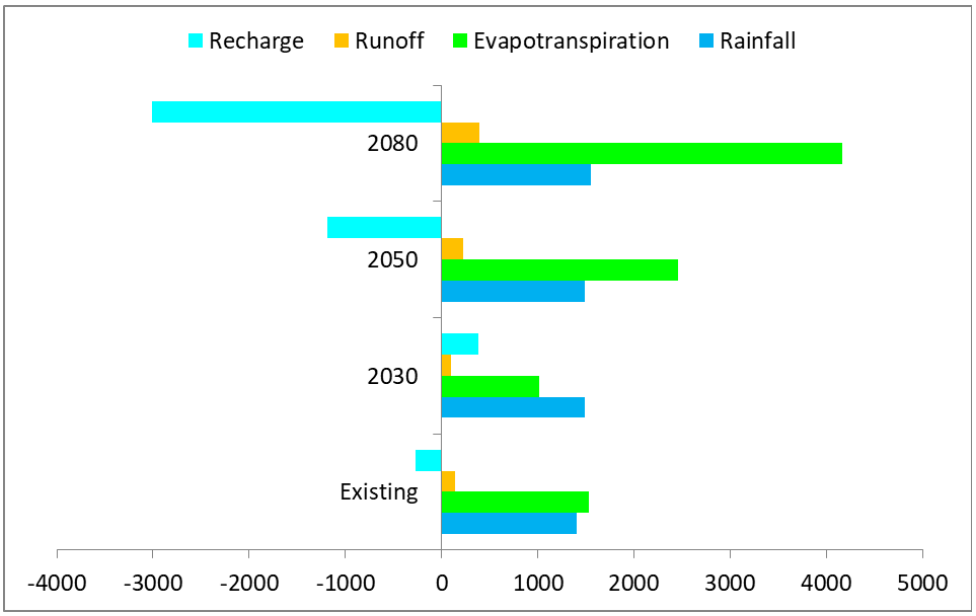


Figure 4-37: Bar chart showing water balance under SSP8.5

In conclusion, the water balance parameters for Bua Basin are summarized as follows:

1. **Rainfall**

- In the 2030s,2050s and 2080s, rainfall exhibits decreasing trends in the basin suggesting increasing drought conditions.

2. **Evapotranspiration (ET)**

- Evapotranspiration rates will keep on increasing in the basin because of the increases in temperature, specifically towards SOND (September, October, November and December). This will have adverse impacts on the growing season of the crops grown in the basin.

3. **Runoff and River Flow**

- The water balance evaluation shows decreasing runoff. With reference to high evapotranspiration and low rainfall, dry spells would be expected, hence reducing recharge during the 2050 to 2080 period. Water stress conditions would prevail during this time.

4. **Storage and Recharge:**

- In the 2030s and 2050s, the recharge and storage rates are negative as compared to the existing conditions. This suggests an increase in water demands due to population growth, industries and domestic uses in the catchment.

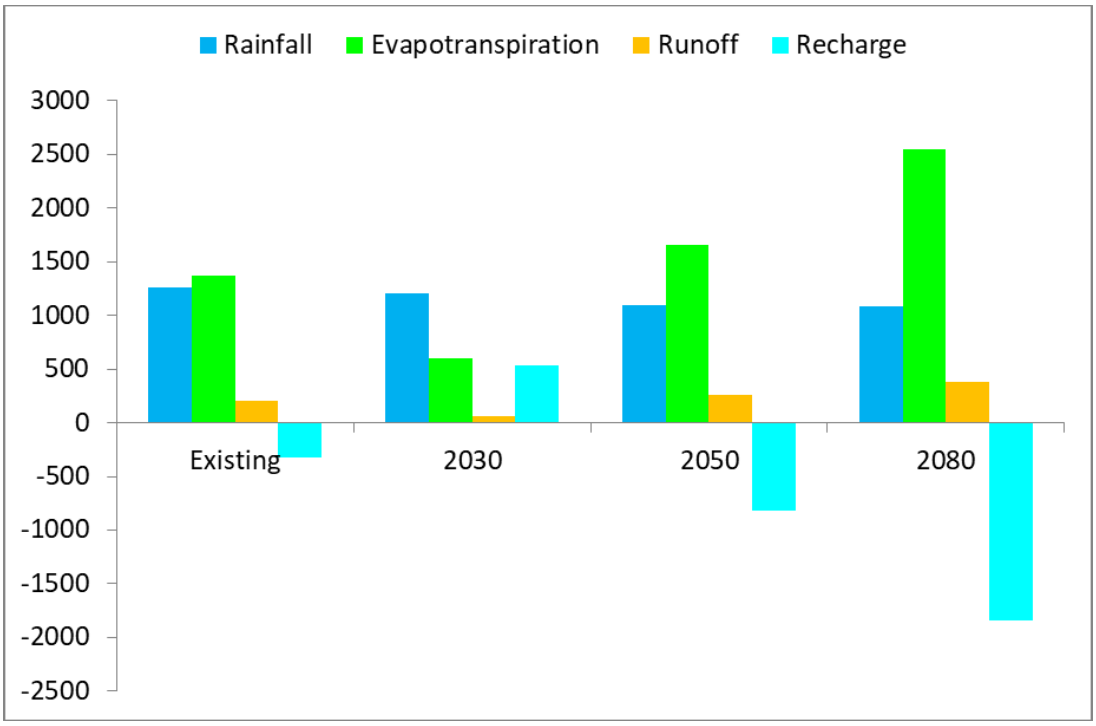


Figure 4-38: Water balance under SSP4.5

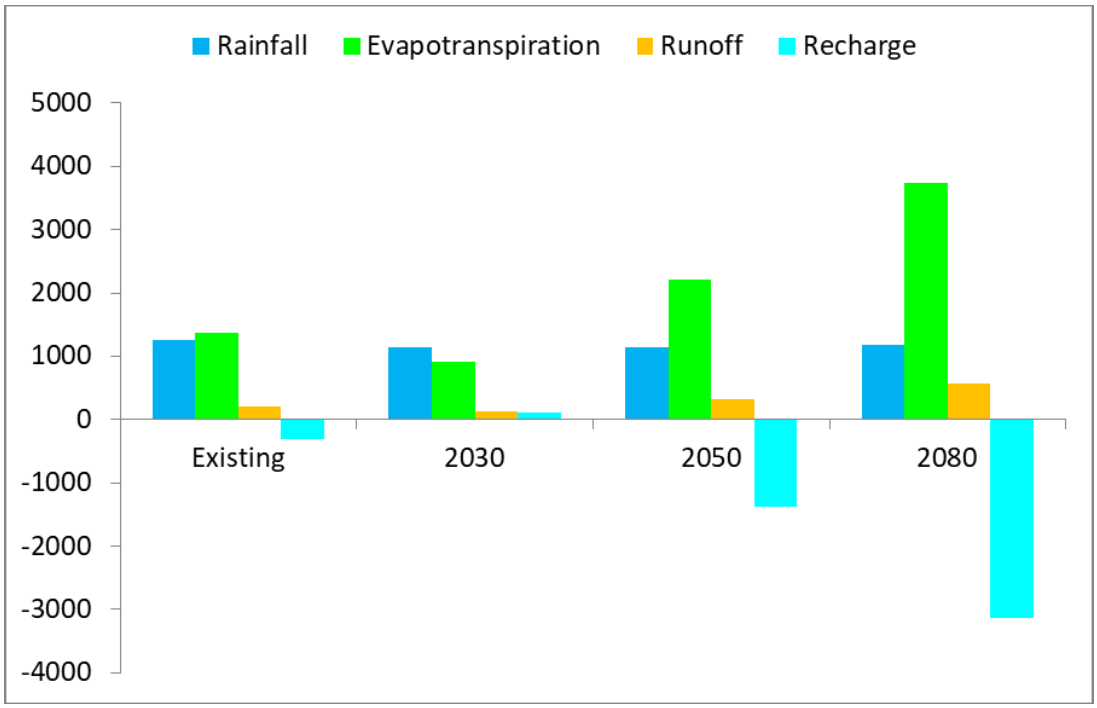


Figure 4-39:Water balance under SSP8.5

In the Linthipe Basin, the following observations are highlighted in the water balance parameters:

1. **Rainfall**

- There is high variability with decreasing trends in the 2030s and 2050s, and some drastic changes in 2050s and 2080s. Droughts and flooding conditions would be highly probable in near and far future scenarios.

2. **Evapotranspiration (ET)**

- The water balance is highly sensitive to ET rates due to increasing trends in temperature. These shifts will limit crop production thereby contributing to lower yields in the catchment.

3. **Runoff and River Flow**

- In lower areas, runoff shows higher values, thereby suggesting flooding conditions while in the dry areas, drought conditions are anticipated with higher severity and durations. There is water deficit in the catchment.

4. **Storage and Recharge:**

- Existing conditions exhibit negative recharge and storage rates just as in the 2050s and 2080s. With high rates of urbanization, population growth and increase in ET, groundwater levels would decrease in the catchment.

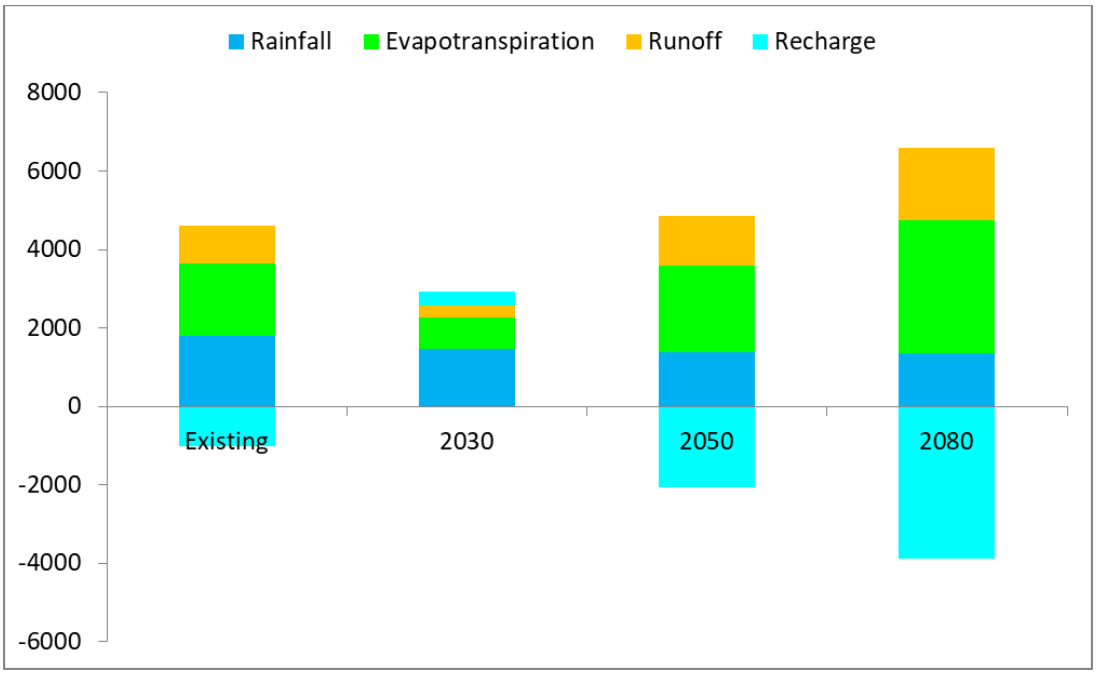


Figure 4-40:Water balance under SSP4.5

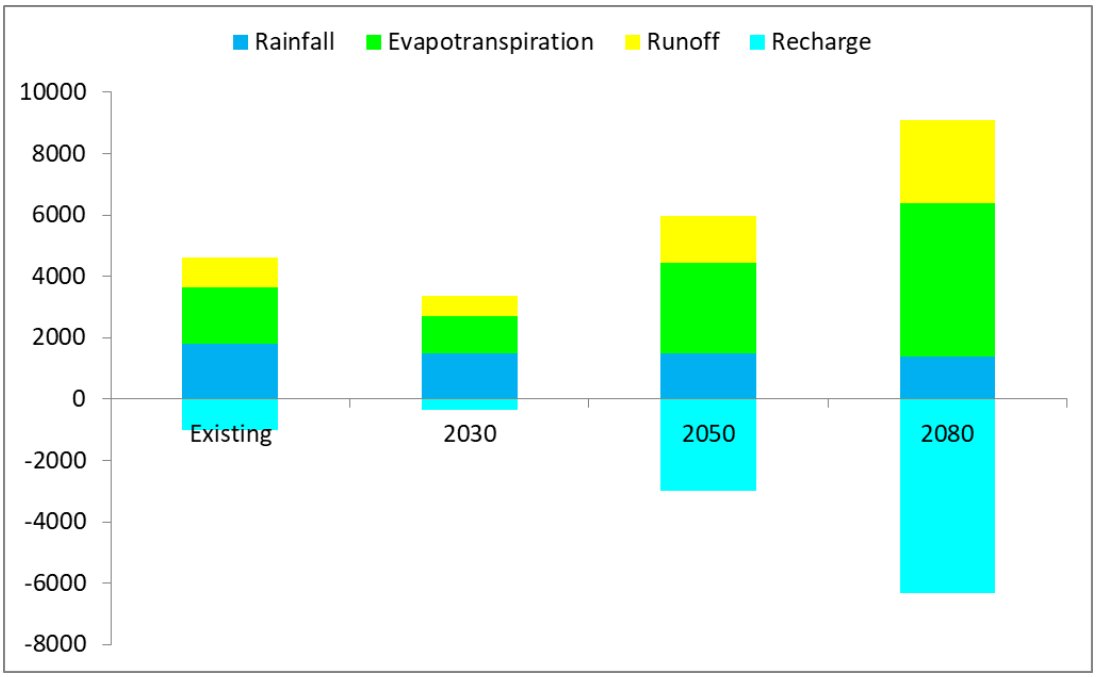


Figure 4-41:Water balance under SSP8.5

In the Shire River Basin, the water balance parameters are summarised as follows:

1. **Rainfall**

- In the 2030s and 2050s, under SSP 4.5, rainfall shows decreasing trends in the basin. This suggests varying drought conditions in the basin in that period. Under SSP 8.5, the basin shows increasing trends of rainfall suggesting flooding conditions in the basin.

2. **Evapotranspiration (ET)**

- Both scenarios project increasing evapotranspiration rates in the basin due to high rates of temperature as the main driver.

3. **Runoff and River Flow**

- Under SSP 4.5, the water balance shows increasing runoff in the wet season, suggesting flooding conditions and drought conditions more pronounced in the dry season. Under SSP 8.5, drought conditions are expected.

4. **Storage and Recharge:**

- Recharge and storage rates are expected to reduce in the basin in both scenarios indicating a limited amount stored for different water users. This would limit water for agriculture, hydropower and water supply.

4.7.3 Adaptation Strategies, Barriers and Gaps

In Malawi, climate change adaptation strategies for water primarily focus on managing water scarcity caused by increasing droughts and floods, including measures like drilling boreholes for rural water supply, constructing storage dams, implementing water harvesting structures, improving irrigation systems, and developing early warning systems for extreme weather events, all while considering demand-side water management practices.

In direct connection with what is highlighted above, a number of adaptation strategies for addressing climate change in the water sector have been proposed by the Government of Malawi to counter the deleterious effects of climate change, and these are presented in both the country's NDCS of 2021 and in the three National Communication reports of 2002, 2011, and 2021 that the Government of Malawi has submitted to the UNFCCC, and these include:

a. Constructing more upstream storage dams to retain surface runoff during the rainy season;

b. Increased sustainable utilization and monitoring of groundwater resources;

c. Avoiding using river banks for agriculture production, both crop and livestock production;

d. Conjunctive use of surface and groundwater resources;

e. Protecting catchment areas through adopting land husbandry practices;

f. Adopting water demand management practices;

g. Leakage monitoring and control in pipe networks to avoid non-revenue water (NRW) losses;

h. Conducting public awareness campaigns regarding the need for implementing water conservation measures;

i. Expanding the network of buoys installed on Lake Malawi for collecting weather data, and for water quality monitoring;

j. Constructing dykes, and diversion structures to minimise flood damage;

k. Improving early warning systems by expanding both manual and telemetry hydrometeorological flood and drought forecasting networks;

l. Delineating flood prone areas through the production of flood zoning maps;

m. Using LIKSP to complement scientific EWS for floods and droughts; and

n. Capacity building of various cadres of stakeholders, ranging from policy makers to technocrats and beneficiary communities.

In addition to adaptation strategies listed above, the Government of Malawi is at present pursuing the following key projects:

a. Constructing the Salima – Lilongwe water project, a grand scheme that will abstract water from Lake Malawi to augment water supply in the City of Lilongwe and its surrounding satellite centers;

b. Constructing infrastructure (intake and main canal) for the Shire Valley Transformation Project, which aims at irrigating 42,000 ha of land in the Lower Shire Valley to boost agriculture production;

c. Developing wellfields for High Yielding boreholes and reticulating them for both urban and rural water supply;

d. Developing the National Sanitation and Hygiene Policy to complement the National Water Policy (2023);

e. Developing plans for Managing Aquifer Recharge (MAR); and

f. Promoting sustainable management of transboundary waters, both surface water and groundwater.

4.7.3 Barriers, Constraints and Gaps

Key barriers to climate change adaptation in the water sector include: limited financial resources, shortage of trained technical personnel and engineers, inadequate infrastructure, poor water resource management practices,, unreliable weather data, high vulnerability of rural communities, and the increasing frequency and intensity of extreme weather events such as floods, droughts, and strong winds which put further strain on existing water systems.

4.8 Human Health

There is concrete scientific evidence that the Earth's climate is changing rapidly. Climate Change is contributing to a variety of health risks, ranging from the direct effects of extreme weather-related events to indirect impacts such as changes in the transmission patterns of major infectious diseases, reduced water resources for domestic consumption, irrigated agriculture and other uses, etc. Malawi is considered high risk country out of 191 countries in terms of vulnerability and lack the capacity to cope with climate change impacts.

In Malawi, climate change induced events are many, including droughts, dry spells, seasonal and flash floods and extreme temperature. Such hazards have important socio-economic consequences towards achieving sustainable development in the country. The impact attributable to environmental risk factors is especially felt among the poor and vulnerable (children, women and rural and people with disabilities). Like many other countries in sub-Saharan Africa, Malawi has high levels of poverty, especially in rural areas where levels are as high as 70 percent are recorded, with female- headed households being the most affected.

Long-term effects of climate change may undermine the attainment of various national targets, including sustainable development goals (SDGs) and the Malawi 2063, if not addressed. In aiming to achieve sustainable development, human health is central. The effects of climate change on human health in Malawi have not been extensively investigated. Further, capacities in the health sector are limited for conducting climate change vulnerability assessments in the country in the face of various climate-induced hazards such as droughts and flash floods and increasing communicable and non-communicable diseases (NCDs). Moreover, there are reports of changing epidemiology of diseases linked to climate change, but these have not been systematically quantified. Therefore, these are not well understood for an effective adaptation strategy towards strengthening national policies and implementation for health systems resilience.

Health services in Malawi are provided by the Government of Malawi, faith-based (not-for-profit) providers, and private (for-profit) providers, with the public sector being the biggest health provider (90%) (MHSP, 2023-2030). The public health system of the country operates at different levels from the tertiary to the primary levels in line with the primary health care system. Malawi is divided into three regions and 31 districts and cities. Health management is done through District Health Offices (DHOs), and other responsible statutory bodies (MHSP, 2023-2030). The country has 4 third-level hospitals, 44 second-level district hospitals, and 1050 health centers, clinics, dispensaries or health posts. In terms of ownership, all third-level hospitals are Government owned and of the second-level hospitals, 26 are Government-owned, and eight are owned by the Christian Health Associations of Malawi (CHAM). Overall, of all 1098 health facilities, Government owned are 52 percent, privately owned are 23 percent and CHAM facilities are 15 percent. These are supplemented by mobile clinics. In 2016, there were a total of 5,090 outreach clinics, 79 per cent of which were owned by Government while CHAM owned 19 percent of these. Also, in the same year, there were 3,542 village clinics, all of which

were owned by the Government.

The guiding principle of the health delivery system in Malawi is to provide equity of access for cost effective quality care in a caring environment. The district is responsible for implementing health promotion, preventive, curative, and rehabilitative services. Administratively, the district health office is responsible for coordinating service delivery at that level. The main activities at health center level are predominantly health promotion and disease prevention which include maternal, newborn and child health, communicable and non-communicable diseases, environmental, water and sanitation, school health and nutrition, and epidemic preparedness (MHSP).

The health care system in Malawi is financed by Government with contributions from the private sector, bilateral and multilateral agencies, NGOs and households. Of the total expenditure spent on health services, households contribute about 20 percent (NHSP). The government continues to invest in low cost high impact primary health care interventions focused on community health and preventive care.

Disease burden in Malawi

Malawi faces a double burden of high communicable diseases and a growing burden of non-communicable diseases (Table 4.6). HIV and AIDs, HIV-TB co-infections, Malaria and Tuberculosis exert a tremendous burden. According to the TB survey of 2014, the burden of TB and TB/HIV in Malawi is among the highest in the southern African region. The HIV prevalence among adults aged between 15-49 years were 14% (16% women vs 12% men) in 2017 and 13.3 percent (15% women vs 13% men) in 2017. NHSP target was to reduce HIV prevalence to 6 percent by 2025 instead of at the current 13.3 percent prevalence.

Table 4-5: Top 10 commonest cases of diseases in Malawi (per 1,000 population)

2013		2014		2015		2016		2017	
Respiratory Infection: non-pneumonia	382	Malaria	394	Respiratory Infection: non-pneumonia	388	Respiratory Infection: non-pneumonia	416	Respiratory Infection: non-pneumonia	452
Malaria	370	Respiratory Infection: non-pneumonia	376	Malaria	316	Malaria	377	Malaria	342
Diarrhoea (non-bloody)	96	Diarrhoea (non-bloody)	97	Diarrhoea (non-bloody)	97	Diarrhoea (non-bloody)	103	Diarrhoea (non-bloody)	106
Muscular skeletal and connective tissue (not trauma)	66	Muscular skeletal and connective tissue (not trauma)	67	Muscular skeletal and connective tissue (not trauma)	67	Muscular skeletal and connective tissue (not trauma)	73	Muscular skeletal and connective tissue (not trauma)	82
Digestive system: (not infectious)	45	Digestive system: (not infectious)	46	Digestive system: (not infectious)	46	Digestive system: (not infectious)	53	Digestive system: (not infectious)	58
Trauma: Other Injuries, wounds	39	Trauma: Other Injuries, wounds	40	Trauma: Other Injuries, wounds	38	Trauma: Other Injuries, wounds	36	Trauma: Other Injuries, wounds	34
Respiratory Infection: pneumonia	36	Respiratory Infection: pneumonia	32	Respiratory Infection: pneumonia	30	Respiratory Infection: pneumonia	28	Skin Diseases (not infectious)	29
Skin Diseases (not infectious)	26	Skin Diseases (not infectious)	26	Sickle Cell Anaemia	30	Skin Diseases (not infectious)	27	Respiratory Infection: pneumonia	28
Eye diseases (infectious)	26	Eye diseases (infectious)	25	Dental Carries	24	Dental Carries	25	Dental Carries	25
Dental Carrie	25	Dental Carries	25	Skin Diseases (not infectious)	24	Throat Diseases	24	Throat Diseases	25

Globally, non-communicable diseases especially cardiovascular diseases, diabetes, cancers, and chronic respiratory diseases cause 23 percent of all deaths in the country with nearly 1 in 5 people dying prematurely from these conditions (WHO, 2019). Estimates of the worldwide incidence and mortality from 27 cancers in 2008 have been prepared for 182 countries as part of the GLOBOCAN series published by the International Agency for Research on Cancer (Hoffmann et al, 2017). The GLOBOCAN results for 20 world regions have summarized the global patterns for the eight most common cancers. Overall, an estimated 12.7 million new cancer cases and 7.6 million cancer deaths occurred in 2008, with 56 percent of new cancer cases and 63 percent of the cancer deaths occurring in the less developed regions of the world. The most commonly diagnosed cancers worldwide are lung (1.61 million, 12.7% of the total), breast (1.38 million, 10.9%) and colorectal cancers (1.23 million, 9.7%). The most common causes of cancer death are lung cancer (1.38 million, 18.2% of the total), stomach cancer (738,000 deaths, 9.7%) and liver cancer (696,000 deaths, 9.2%). Differences in the patterns of cancer occur from region to region are observed (Hoffmann et al, 2017).

Non-communicable diseases (NCDs) which include cancers, diabetes, hypertension, cardio-vascular conditions, road traffic injuries and mental health conditions continue to exert a burden. The major risk factors for NCDs include cigarette smoking, physical inactivity, alcohol consumption, and unhealthy diets.

The total number of NCD cases reported to health facilities increased by 14 percent from 388,120 in 2011 to 441,187 in 2013. Twenty-four (24) percent of Malawian men smoke tobacco, and more than a third of men have hypertension. The most prevalent NCDs in 2013 were hypertension, accounting 41.6 percent of all NCDs cases in 2013 for all ages and asthma was at 22.5 percent. Cervical and breast cancer were lowest at the combined percentage of 0.6 percent of total cases in 2011. However, Malawi is reported to have the fourth highest cervical cancer in the world.

Trauma, including injuries, wounds and their associated impacts also constitute an important health and development challenge in Malawi (WHO, 2023). A review of the top nine NCD showed that deaths from NCDs accounted for 22.6 percent and cause of death by injury was 10.7 percent in 2012.

Data from HMIS and Veterinary Department shows that rabies is prevalent in the country. Studies in Malawi in 2016 showed increasing dog bites and rabies which was then attributed to improved reporting due to changing ecosystem in the country. In addition, the country is prone to outbreaks of anthrax, chicken pox, cholera, dysentery, measles, mumps, and typhoid. However, there are some traces of leprosy being reported but the magnitude is yet to be quantified.

Neglected tropical diseases still plague Malawi. It is endemic to four preventive Neglected Tropical Diseases which include soil transmitted helminths, schistosomiasis, lymphatic filariasis and blinding trachoma. The NTD mapping in Malawi show that out of 10 districts in the country, 57 percent are endemic for schistosomiasis, 40 percent endemic for STH, and 57 percent endemic for lymphatic filariasis. Mass Drug Administration started in 2015 for lymphatic filariasis, schistosomiasis and soil transmitted helminths, having reached coverage of 74 percent above the WHO target of 65 percent. Malawi has adopted the Integrated Diseases Surveillance System (IDSR) strategy for early detection and response to priority diseases in the Country.

4.8.1 Vulnerabilities, Impacts, and Risks

According to Muula and Dzinkambani Kambalame (2024), in Malawi climate change significantly impacts human health primarily through increased occurrences of floods and droughts, leading to higher rates of malnutrition, waterborne diseases like cholera and dysentery, and increased malaria transmission due to altered mosquito breeding patterns; particularly affecting vulnerable populations like infants and young children. The country is prone to floods, droughts, and strong winds, which are expected to increase in frequency and magnitude under climate change scenario. In light of the above, primary risks to human health posed by climate change include increased prevalence of vector-borne diseases like malaria, heightened risk of waterborne illnesses like diarrhea due to flooding and droughts, malnutrition from disrupted agricultural yields, heat stress, and direct injuries from extreme weather events like floods and cyclones, all exacerbated by the country's existing vulnerabilities like poverty and limited access to healthcare. Figure 26 depicts common illnesses associated with climate change.

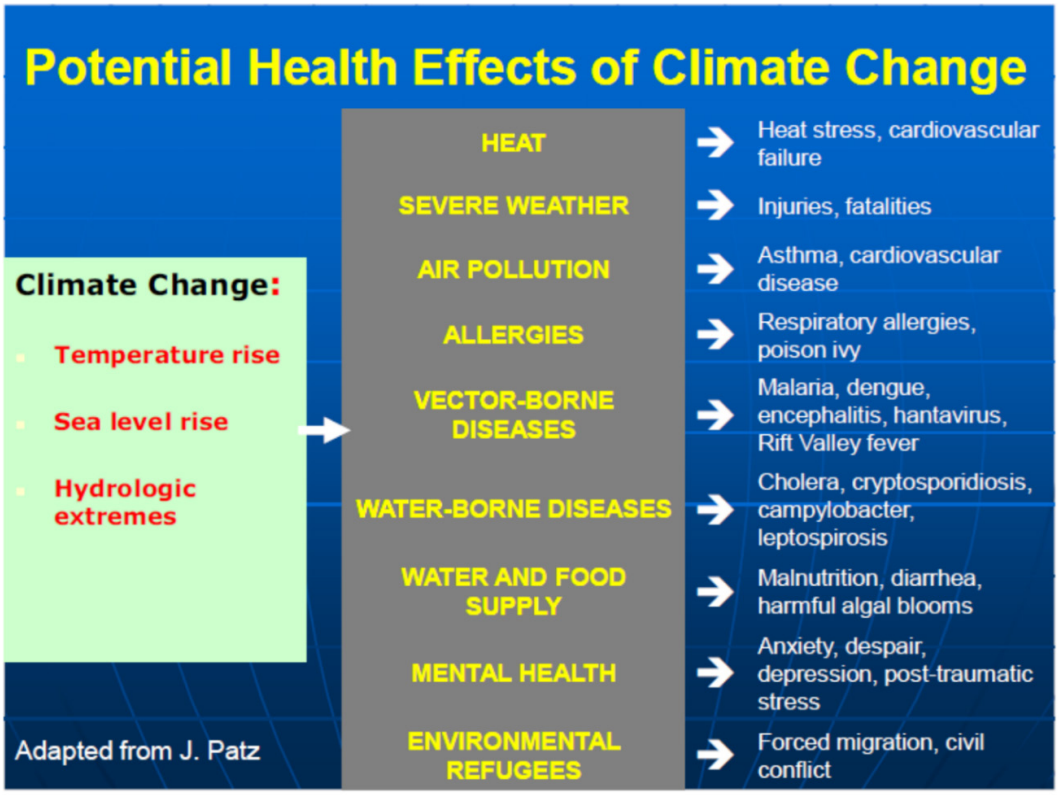


Figure 4-42:Potential Health Effects of Climate Change
Source: Luber (2011)

The impact of climate change on the health sector was assessed for four selected climate-sensitive diseases in Malawi, particularly with respect to infectious diseases (malaria, and diarrhea) and non-communicable diseases (acute malnutrition and depression), namely: Salima, Lilongwe, Zomba and Chikwawa. The districts were purposively selected to represent agroecological-climatic conditions of the country in the Southern Region (Chikwawa and Zomba districts) and the Central Region (Lilongwe and Salima). A statistical analysis was performed on the trend and correlations between two climatic variables, temperature and precipitation and the incidence of malaria, diarrhoea, acute malnutrition and depression. Data used ranged from 2013 to 2023 for most diseases.

Data sources

Three types of data were used for this vulnerability assessment. Table 4.7 provides a summary of all the data used.

Table 4-6: Data used in the vulnerability studies in Malawi

Sensitivity analysis	Future Climate Scenarios
• Health Management Information System (HMIS): 2013-2023 • Meteorology data: 2013-2023	• UNDP climate change country profile, Malawi (rainfall and temperature projections for 2030 & 2050) • NSO projected population data for 2011-2035 • 2050 population projections from United Nations Department of Economic and Social Affairs / Population Division - World Population Prospects

Data analysis

The analysis focused on:

a. Monthly disease cases (malaria, diarrhea, acute malnutrition, and depression) for the period 2013-2023 for the under 5 five-olds; and

b. Meteorological data for the same period (2013-2023): complete data was available for rainfall, minimum temperature and maximum temperature.

The following procedure was adopted in building an optimal model for sensitivity analysis, projecting future risk scenarios and adaptive capacity. Much of the modeling work was informed by a comprehensive desk analysis and literature review of various documents on climatic-sensitivity analysis of health outcomes. Having assembled all the data, the steps listed below were followed:

a. Examine the lag correlation;

b. Fit univariate models of disease and each climatic variable; and

c. Fit multivariate model of each disease and climatic variables.

Impacts of climate change on health

Table 4.8 gives a summary of the disease and climatic variables for the two areas for the period 2013 to 2023. On average, Zomba is wetter and hotter than Chikwawa. The recorded maximum number of malaria cases are relatively higher in Chikwawa than in Zomba, and a similar pattern is observed

Table 4-7: Summary statistics of disease and climatic variables for Chikwawa and Zomba districts

District	Variable	N	Mean	Standard deviation	Minimum	Maximum
Zomba	Malaria	132	11,421	6,377.66	1,057	35,870
	Diarrhoea	132	7,581	1,954.14	2,411	13,037
	Malnutrition	132	422.2	142.71	79	1,920
	Depression	114	9.66	2.16	0	27
	Minimum Temperature	132	14.60	3.36	6.20	18.90
	Maximum Temperature	132	27.20	2.29	22.10	33.10
	Rainfall	120	68.76	92.31	0	393.00
	Humidity	120	70.7	12.5	38.8	88.4
Chikwawa	Malaria	132	14,288	5,069.01	6,971	25,277
	Diarrhoea	132	4,974	1,126.08	2,806	7,680
	Malnutrition	132	20.55	10.92	5	74
	Minimum Temperature	132	14.43	3.42	7.20	18.10
	Maximum Temperature	132	28.68	2.15	25.20	34.20
	Rainfall	132	92.66	116.14	0	330.60
	Humidity	132	61.	10.30	10	80

for diarrhea cases. The incidence rate of malaria and diarrhea in Chikwawa were 5.61 (range: 0.51-20.53) and 3.89 (range: 1.17-6.62) per 1000 persons, respectively. In Zomba, this was comparatively higher, with incidence rate of malaria estimated at 29.14 (range: 13.09-56.02) and that of diarrhea at 10.05 (range: 6.22-15.08).

In the central region, Lilongwe and Salima were selected to study the sensitivity of health outcomes from climate change. Presented in Table 4.9 are summary statistics of disease and climatic variables for the two districts. There is minimal difference in climatic conditions in the two districts. However, the reported incidence of diarrhea, for Lilongwe is much higher than that of malaria. In Salima, malaria was more prevalent than diarrhea, but as low as in Lilongwe. The incidence rate for malaria was 0.96 (range: 0-5.55) per 1000 persons in Lilongwe while in Salima it was 9.92 (range: 0.75-79.33) per 1000 population. The large peak in malaria noted in April 2018 was a direct result of an outbreak epidemic that resulted from heavy rains received between January and February. The incidence rate for diarrhea was similar for the two areas. In Lilongwe it was estimated as 7.11 (range: 2.27- 13.66), whereas in Salima it was 6.96 (range: 2.09- 11.48) per 1000 individuals. Seasonal peaks were observed at the beginning of the year in both districts.

Table 4-8: Summary statistics of disease and climatic variables for Lilongwe and Salima

District	Variable	N	Mean	Standard deviation	Minimum	Maximum
Lilongwe	Malaria	60	107.0	141.59	0	636.0
	Diarrhoea	60	796.0	245.35	260.0	16370
	Minimum Temperature	60	16.01	4.33	7.20	20.70
	Maximum Temperature	60	30.97	2.77	25.10	37.50
	Rainfall	60	54.89	75.32	0	324.60
Salima	Malaria	60	1014	1503.25	75	8336
	Diarrhoea	60	658.4	190.16	208	1177.0
	Minimum Temperature	60	16.61	3.56	10.0	20.60
	Maximum Temperature	60	30.96	2.63	26.80	37.0
	Rainfall	60	82.59	105.76	0	388.30

Correlation between climatic variables and diseases

We then explored the relationship between the selected disease outcomes and climatic variables. Because of sparsity of depression and hypertension data, we pooled the data for the four together and evaluated against national climatic values. The following sections considers each disease separately.

Malaria

Figures 4.46 and 4.47 show plots for malaria. The top panel shows the relationship between malaria and rainfall (top left panel); and malaria with temperature (top right). With minimum temperature and malaria, in Figure 4.46, a moderately positive correlation was observed (r=0.18) at lag 1, but increasing at lag 2 and 3. For malaria and maximum temperature, there was a negative correlation at lag 1 (r=*-0.21*) and lag 2 (r=*-0.18*), but decayed to near zero at further lags. With regards to rainfall, there was a significant lag established at lag 1 (r=0.23), indicating that current malaria risk is somewhat related to a rainfall event that takes place a month earlier. In other words, there is a lead of 1 month before malaria peaks up. Figure 4.47 shows the relationship between malaria and rainfall. No clear association was found between malaria and number of rainfall days.

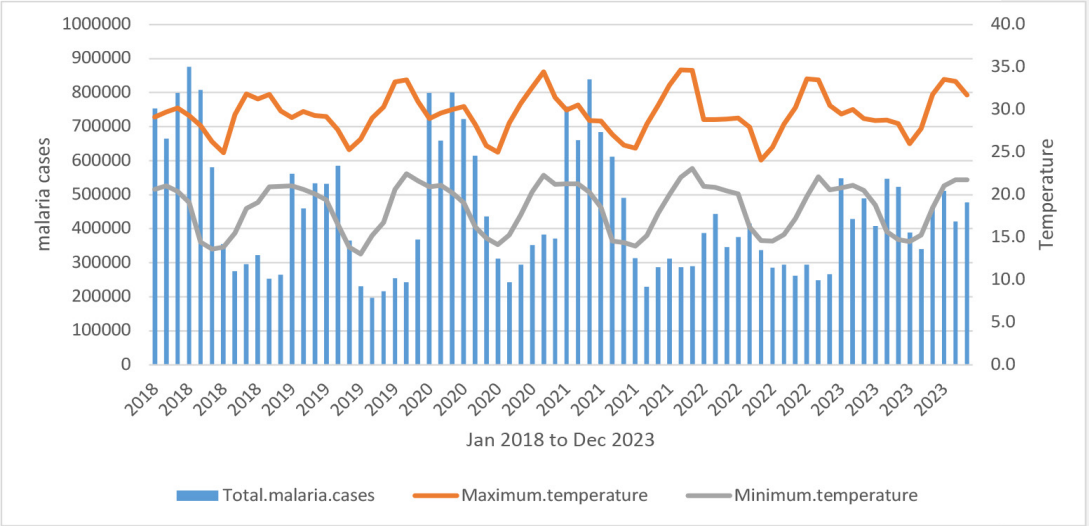


Figure 4-43:Malaria and temperature

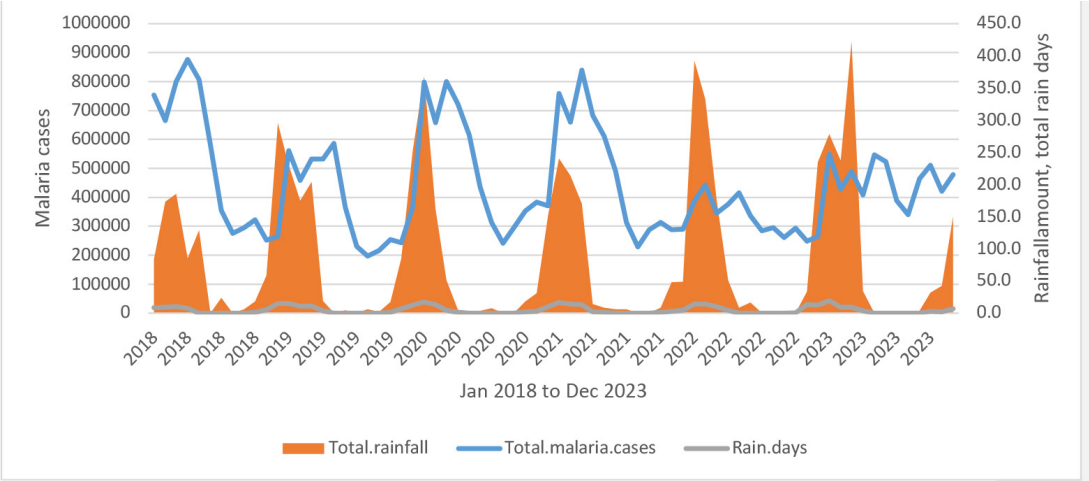


Figure 4-44: Malaria and rainfall.

Diarrhea

Figure 4.48 shows the relation between diarrhea and climatic variables in all districts pooled together. Rainfall and minimum temperature were positively correlated with diarrhea at lag 1 to lag 3, but a negative association with maximum temperature at lag 0 and decreasing at further lags. Presented in Figure 4.49 are time plots for diarrhea and rainfall. The correlation of diarrhea and rain days was strong and positive up to lag 3, (r>0.6).

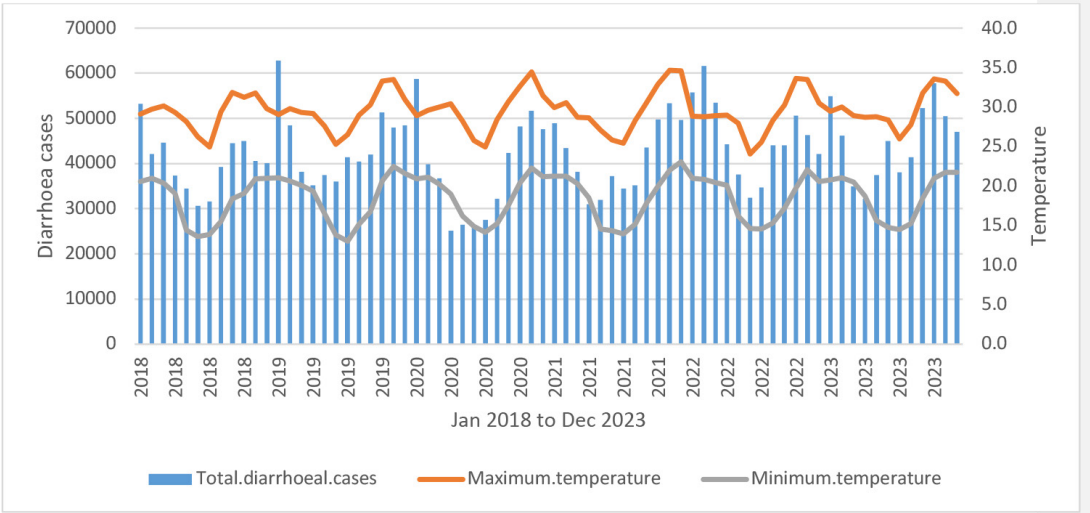


Figure 4-45:Diarrhea and temperature for aggregated data

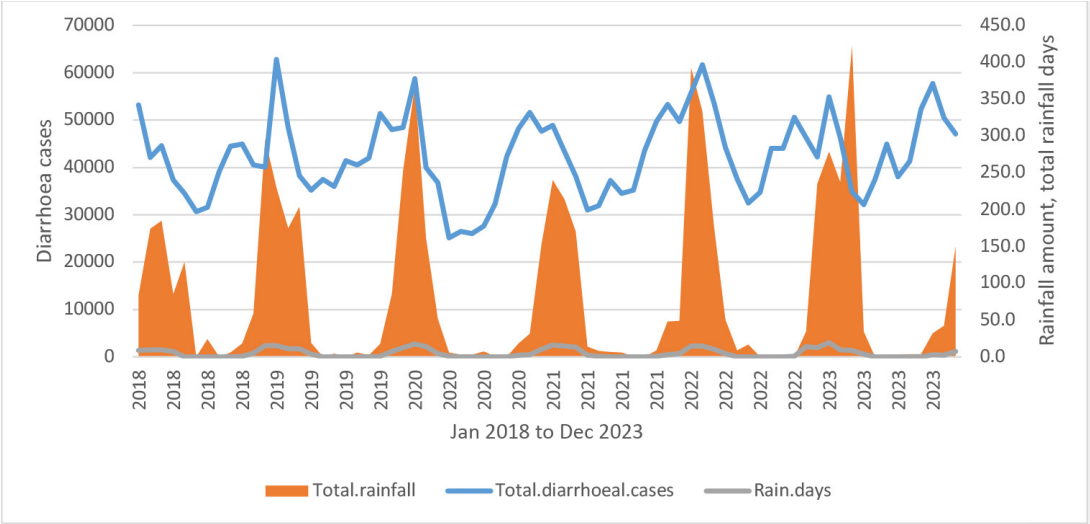


Figure 4-46: Diarrhea and rainfall

Malnutrition

Presented in Figures 4.50 and 4.51 are relationships between acute malnutrition and climatic variables for all the four districts. With regards to temperature, only maximum temperature was positively correlated with malnutrition. Some seasonality can be observed in Figure 4.50. With regards to rainfall, there was positive association with malnutrition at lag 0 and negative at lag 1 to lag 4, with decaying correlation (Figure 4.51). However, it was further observed that a negative correlation with rainfall days existed, although not significant.

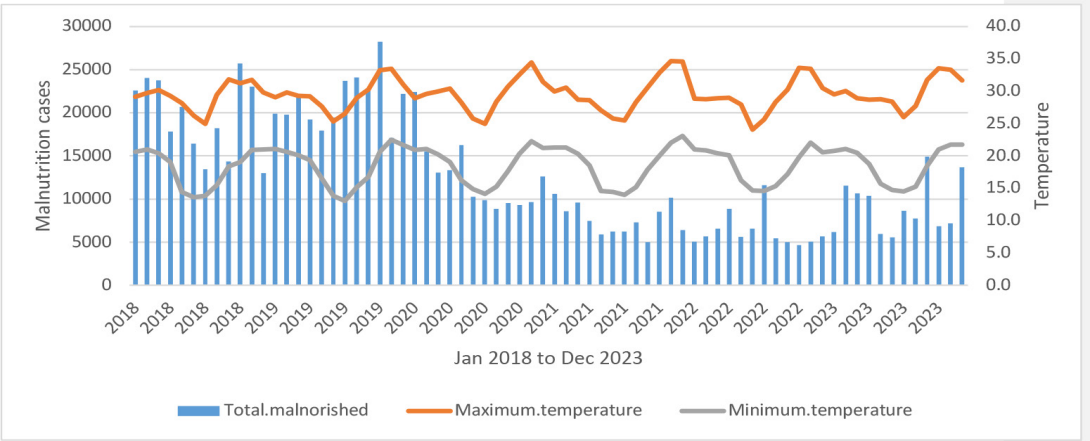


Figure 4-47:: Malnutrition and temperature with combined data

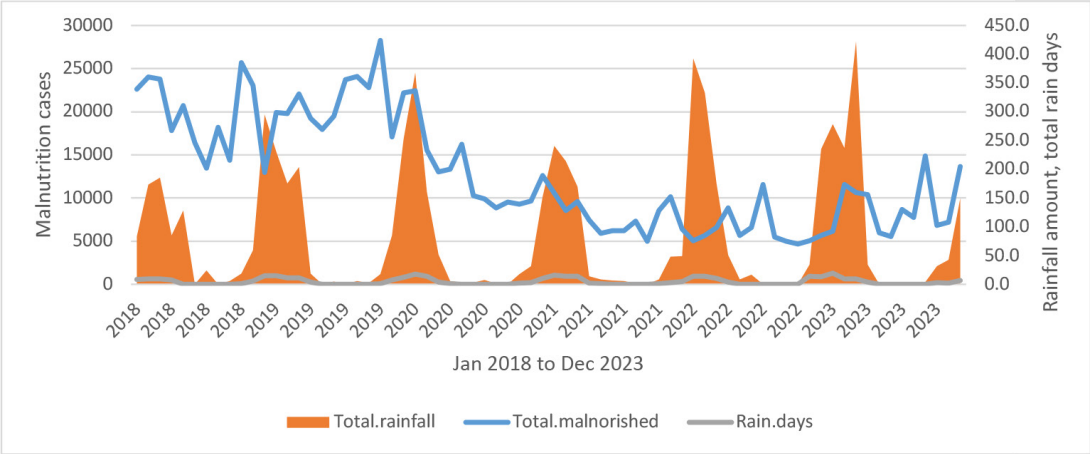


Figure 4-48 :Malnutrition and rainfall, 2018 to 2023

Hypertension

Considering hypertension, Figures 5.52 and 4.53 present graphs depicting the association with temperature and rainfall. Although the graphs show some seasonality, there was no clear evidence of correlation between hypertension and all climatic factors and at various lags.

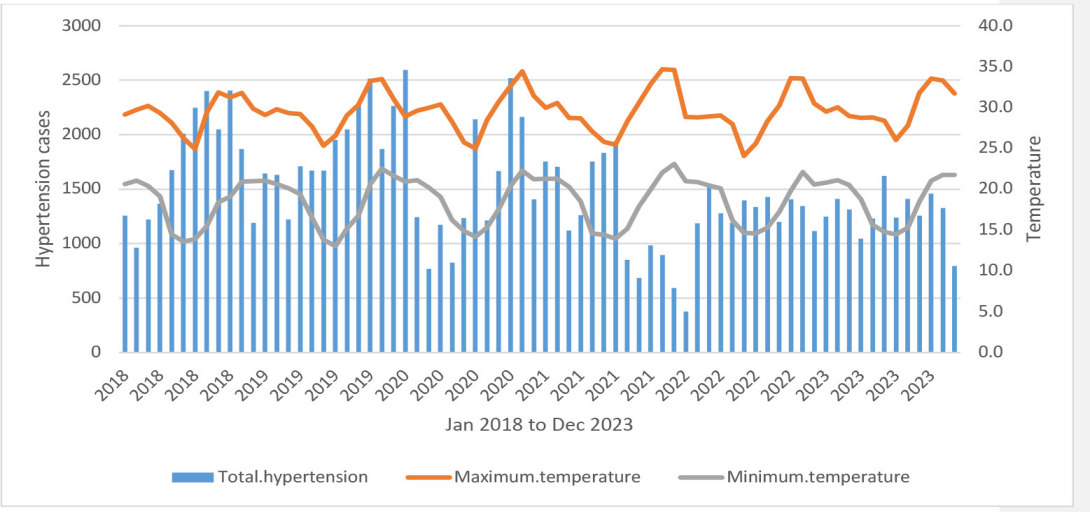


Figure 4-49:Hypertension and temperature for aggregated data

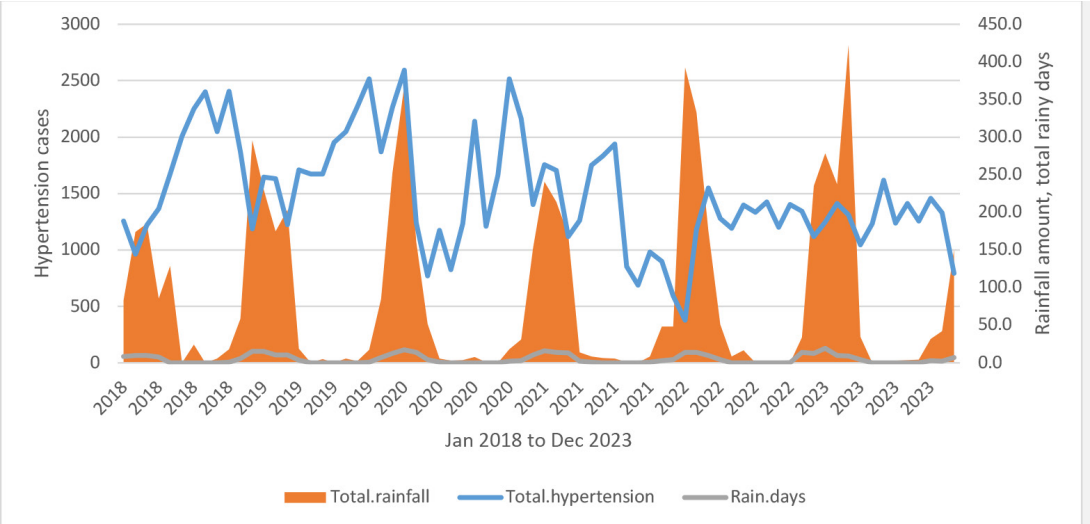


Figure 4-50:Hypertension and rainfall for aggregated data

Depression

Figure 4,54 explores the relation between depression and temperature. The association with minimum temperature were observed at lag 0 and 1; and at lags 1 and 2 for maximum temperature, with a strong correlation of maximum temperature to depression (*r=0.19* at lag 0, *r=0.15* at lag 1 and *r=0.16* at lag 2). In Figure 4.55, there was a negative association at lag 0, 1 and 2 with rainfall, and rainy days, though not significant.

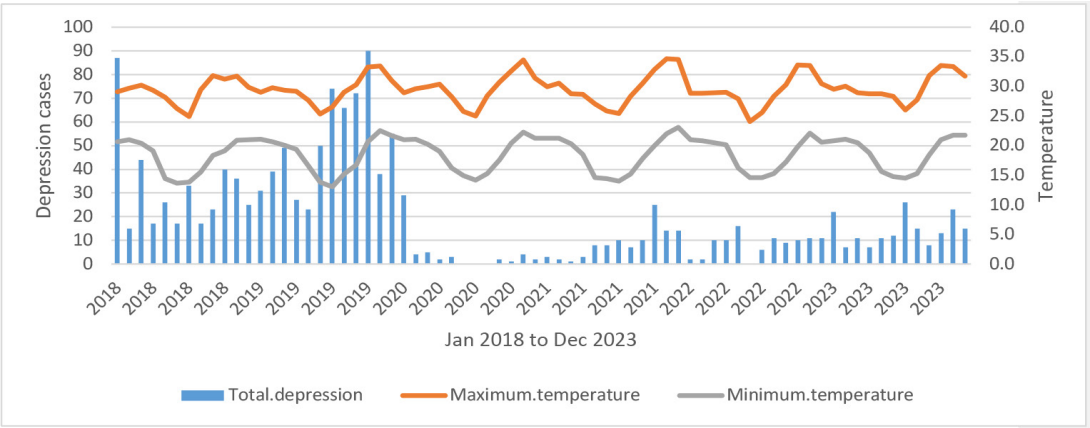


Figure 4-51:Depression and temperature

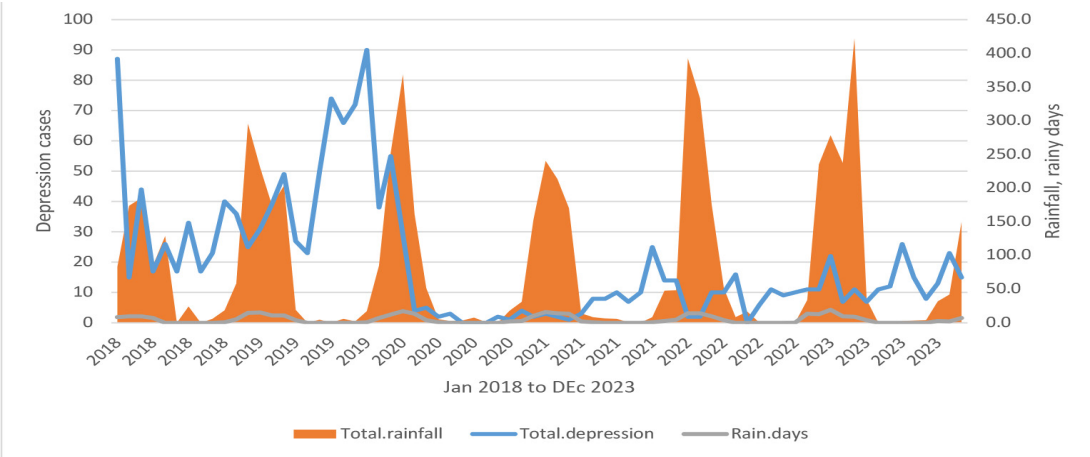


Figure 4-52:Depression and rainfall

Additional graphs showing relationships between disease data and climatic variables are presented in Appendices 1 to 4 for the districts of Chikwawa, Zomba, Lilongwe, and Salima, respectively.

Regression Modelling the association between diseases and climatic variables

A Poisson regression model was used to compare disease data to climatic variables. A separate model was used for each district. A temporal lag of 1-3 months was investigated for both temperature and rainfall. The approach used a backward model selection, in which first a full model was fitted, then terms were re-assessed and non-significant terms removed. The resultant model was then re-fitted, and the same process was applied till all terms were found to be significant. Model selection was based on step Akaike Information Criterion (stepAIC), with a small AIC indicating the best model. To control for any heterogeneity in the data, all models also included terms for the year and month. The Poisson model assumed the following form:

$$\log\ (inc_t^D) = \log\ (Population) + \sum_{i=1}^{k} \beta_{it}^D X_{it} + e_t$$

$$\log\ (inc_t^D) = \log\ (Population) + \sum_{i=1}^{k} \beta_{it}^D X_{it} + e_t$$

where inc_t is the incidence of malaria or diarrhea in district ***D*** and at time ***t***; X_{it} is a series of independent variables at time ***t***; α and β are the regression parameters corresponding to the global mean and predictor coefficients respectively; e_t represents all other district-specific unobserved effects, which are assumed to be normally distributed. For each model an adjustment for the population at risk $[\log(Population)]$ was made, which was fitted as an offset.

For diseases like malaria, the lags represent the lead time between the increase in rainfall which causes mosquito abundance, thus resulting in increased transmission of malaria a month or two later (for lag 1 and lag 2 respectively). With regards to temperature, an increase in temperature enables early maturing of eggs or larvae into adult and faster parasite development. These effects would result in more mosquitoes that would transmit malaria a month later. Similarly, for diarrhea, an increase in temperature a month earlier provides conducive environment for pathogens to grow and mature, which optimise disease transmission.

In general, the pattern of association agreed with the exploratory analysis particularly on the lag correlations. The effects of rain, maximum temperature and minimum temperature varied from district to district. Evidently, malaria is driven by all climatic variables but at different lags (Table 4.10). However, for diarrhoea, maximum temperature was a key variable for all districts and at three lag levels. Rainfall was important at lag 0 or lag 1 for diarrhea (Table 4.11).

Table 4-9: Model estimates for malaria from a multivariate model for the four selected districts in Malawi

District	Variable	Coeff	RR	95%	CI	p-value
Chikwawa	Rain	-0.001	0.999	0.995	1.00	0.049
	Rain(Lag1)	-0.00051	0.999	0.998	1.00	0.058
	Rain(Lag2)	-0.00083	0.999	0.997	1.00	0.048
	MaxTemp	-0.171	0.843	0.75	0.94	0.004
	MaxTemp(Lag1)	-0.04	0.961	0.878	0.99	0.038
	MaxTemp(Lag2)	-0.054	0.947	0.866	0.96	0.023
	MinTemp	0.126	1.134	1.01	1.31	0.008
	MinTemp(Lag1)	0.039	1.04	1.00	1.14	0.040
	MinTemp(Lag2)	-0.01	0.99	0.923	1.00	0.077
Zomba	Rain	-0.00063	1.00	0.999	1.00	0.096
	Rain(Lag1)	0.001201	0.999	0.999	1.00	0.004
	Rain(Lag2)	0.000268	1.00	0.999	1.00	0.098
	MaxTemp	0.004	1.004	1.002	1.069	0.001
	MaxTemp(Lag1)	-0.061	0.941	0.892	0.992	0.023
	MaxTemp(Lag2)	-0.007	0.993	0.958	1.029	0.703
	MinTemp	0.024	1.025	1.001	1.051	0.027
	MinTemp(Lag1)	0.07	1.073	1.02	1.129	0.006
	MinTemp(Lag2)	0.049	1.05	1.007	1.095	0.022
Lilongwe	Rain	-0.003	0.997	0.989	1.004	0.065
	Rain(Lag1)	0.000238	1	0.996	1.005	0.02
	Rain(Lag2)	0.002	1.002	0.999	1.006	0.166
	MaxTemp	0.047	1.05	1.01	1.16	0.045
	MaxTemp(Lag1)	-0.244	0.804	0.641	1.008	0.005
	MaxTemp(Lag2)	-0.127	0.926	0.753	1.139	0.037
	MinTemp	-0.172	0.909	0.759	1.088	0.296
	MinTemp(Lag1)	0.216	1.209	1.118	1.308	<0.001
	MinTemp(Lag2)	0.218	1.214	1.047	1.406	0.01
Salima	Rain	-0.004	0.996	0.993	0.999	0.006
	Rain(Lag1)	-0.003	0.997	0.996	0.998	<0.001
	Rain(Lag2)	-0.001	0.999	0.996	1.001	0.283
	MaxTemp	-0.211	0.809	0.74	0.885	<0.001
	MaxTemp(Lag1)	-0.269	0.764	0.716	0.816	<0.001
	MaxTemp(Lag2)	-0.083	0.921	0.778	1.089	0.334
	MinTemp	-0.006	0.994	0.897	1.101	0.908
	MinTemp(Lag1)	0.497	1.645	1.409	1.919	<0.001
	MinTemp(Lag2)	-0.058	0.943	0.815	1.091	0.431

Table 4-10:Model estimates for diarrhea from a multivariate model for the four selected districts in Malawi

District	Variable	Coeff	RR	95%	CI	p-value
Chikwawa	Rain	0.012	1.01	1.00	1.04	0.015
	Rain(Lag1)	-0.0004	1.00	0.999	1.00	0.367
	Rain(Lag2)	-0.0002	1.00	0.998	1.002	0.085
	MaxTemp	0.051	1.052	1.01	1.146	0.028
	MaxTemp(Lag1)	-0.006	0.994	0.935	0.997	0.039
	MaxTemp(Lag2)	-0.013	0.988	0.933	1.01	0.066
	MinTemp	-0.023	0.977	0.873	1.094	0.189
	MinTemp(Lag1)	-0.036	0.964	0.844	1.102	0.195
	MinTemp(Lag2)	0.039	1.04	1.00	1.084	0.057
Zomba	Rain	-0.00015	1.00	1.00	1.00	0.13
	Rain(Lag1)	-0.00019	1.00	0.999	1.001	0. 26
	Rain(Lag2)	-0.00052	1.00	0.999	1.001	0.19
	MaxTemp	0.056	1.057	1.027	1.089	<0.001
	MaxTemp(Lag1)	-0.02	0.98	0.936	1.026	0.39
	MaxTemp(Lag2)	0.011	1.011	0.965	1.06	0.637
	MinTemp	0.012	1.012	1.001	1.043	0.046
	MinTemp(Lag1)	0.001	1.001	1.000	1.028	0.048
	MinTemp(Lag2)	0.026	1.026	1.001	1.052	0.038
Lilongwe	Rain	0.002	1.002	1.00	1.004	0.018
	Rain(Lag1)	-0.00048	1.00	0.998	1.001	0.142
	Rain(Lag2)	-0.00073	0.999	0.998	1.000	0.185
	MaxTemp	0.003	1.003	0.96	1.048	0.879
	MaxTemp(Lag1)	0.009	1.009	0.939	1.084	0.812
	MaxTemp(Lag2)	-0.035	0.966	0.93	1.003	0.004
	MinTemp	0.013	1.013	1.001	1.049	0.046
	MinTemp(Lag1)	-0.025	0.976	0.941	1.012	0.188
	MinTemp(Lag2)	-0.009	0.991	0.968	1.014	0.417
Salima	Rain	0.001	1.001	1.000	1.002	0.012
	Rain(Lag1)	0.002	1.002	1.001	1.003	0.001
	Rain(Lag2)	0.002	1.002	1.001	1.003	0.002
	MaxTemp	0.036	1.036	1.001	1.081	0.005
	MaxTemp(Lag1)	0.078	1.081	1.027	1.138	0.003
	MaxTemp(Lag2)	-0.003	0.997	0.957	1.038	0.887
	MinTemp	-0.073	0.93	0.885	0.977	0.004
	MinTemp(Lag1)	-0.074	0.929	0.889	0.97	0.001
	MinTemp(Lag2)	-0.026	0.974	0.939	1.01	0.157

In the four selected districts, the analysis showed positive correlations between the incidence of depression and rainfall, suggesting a heightened risk of depression linked especially to rainfall above 50 mm. In most cases, the increase in cases occurs from the second month of rainfall (Table 4.12). The models also predict a decrease in most scenarios in the districts of the central region. However, there is no pattern regarding the influence of the different emission scenarios on the incidence of hypertension. The scenarios act differently when hypertension was analysed. Table 4.13 shows a positive correlation between cases of hypertension and maximum temperature, with a threshold set at 30°C for most districts.

Table 4-11: Model estimates for malnutrition from a multivariate model for the four selected districts in Malawi

District	Variable	Coeff	RR	95%	CI	p-value
Chikwawa	Rain	0.002	1.002	1.000	1.003	0.009
	Rain(Lag1)	0.000315	1.000	1.000	1.001	0.045
	Rain(Lag2)	0.001	1.001	1.000	1.002	0.004
	MaxTemp	0.001	1.001	0.976	1.027	0.093
	MaxTemp(Lag1)	-0.041	0.96	0.92	1.001	0.054
	MaxTemp(Lag2)	0.084	1.087	1.016	1.163	0.015
	MinTemp	-0.04	0.961	0.874	1.056	0.045
	MinTemp(Lag1)	0.111	1.118	1.049	1.191	0.001
	MinTemp(Lag2)	-0.043	0.958	0.9	1.02	0.178
Zomba	Rain	0.001	1.001	1.00	1.002	0.001
	Rain(Lag1)	6.34E-05	1.00	0.999	1.001	0.016
	Rain(Lag2)	0.003	1.003	1.001	1.004	<0.001
	MaxTemp	-0.004	0.996	0.967	1.026	0.8
	MaxTemp(Lag1)	-0.062	0.94	0.868	1.017	0.012
	MaxTemp(Lag2)	0.092	1.096	1.044	1.15	<0.001
	MinTemp	-0.126	0.882	0.795	0.978	0.018
	MinTemp(Lag1)	0.163	1.177	1.021	1.356	0.025
	MinTemp(Lag2)	-0.104	0.901	0.799	1.015	0.087
Lilongwe	Rain	0.001	1.001	1.000	1.002	0.022
	Rain(Lag1)	-0.00095	0.999	0.997	1.001	0.37
	Rain(Lag2)	-0.002	0.998	0.996	1.000	0.09
	MaxTemp	-0.05	0.951	0.889	1.017	0.141
	MaxTemp(Lag1)	-0.101	0.904	0.811	1.008	0.069
	MaxTemp(Lag2)	-0.066	0.936	0.881	0.995	0.034
	MinTemp	0.042	1.043	1.000	1.088	0.049
	MinTemp(Lag1)	0.097	1.102	1.008	1.204	0.033
	MinTemp(Lag2)	0.032	1.032	0.995	1.071	0.092

Salima	Rain	0.002	1.002	1.001	1.002	<0.001
	Rain(Lag1)	0.001	1.001	1.000	1.002	0.174
	Rain(Lag2)	4.15E-05	1.000	1.000	1.000	0.081
	MaxTemp	0.054	1.055	1.034	1.077	<0.001
	MaxTemp(Lag1)	-0.022	0.978	0.954	1.002	0.07
	MaxTemp(Lag2)	-0.004	0.996	0.975	1.018	0.741
	MinTemp	-0.072	0.93	0.903	0.958	<0.001
	MinTemp(Lag1)	0.026	1.026	1.006	1.047	0.012
	MinTemp(Lag2)	0.081	1.084	1.056	1.113	<0.001

Table 4-12: Model estimates for depression from a multivariate model for the four selected districts in Malawi

District	Variable	Coeff	RR	95%	CI	p-value
Chikwawa	Rain	0.000198	1.000	0.999	1.001	0.079
	Rain(Lag1)	-5.20E-05	1.000	0.999	1.001	0.084
	Rain(Lag2)	-0.00089	0.999	0.998	1.000	0.156
	MaxTemp	0.041	1.042	1.024	1.061	0.012
	MaxTemp(Lag1)	2.10E-02	1.021	0.969	1.076	0.043
	MaxTemp(Lag2)	0.051	1.052	1.029	1.076	0.008
	MinTemp	0.01	1.01	1.00	1.048	0.037
	MinTemp(Lag1)	-0.056	0.946	0.901	0.993	0.012
	MinTemp(Lag2)	0.012	1.012	1.000	1.077	0.023
Zomba	Rain	0.001	1.001	1	1.002	0.126
	Rain(Lag1)	1.00E-03	1.001	1	1.001	0.027
	Rain(Lag2)	0.001	1.001	1	1.001	<0.001
	MaxTemp	0.01	1.01	0.948	1.077	0.749
	MaxTemp(Lag1)	0.069	1.071	1.007	1.139	0.029
	MaxTemp(Lag2)	-0.021	0.98	0.965	0.995	0.009
	MinTemp	-0.085	0.919	0.897	0.941	<0.001
	MinTemp(Lag1)	0.037	1.038	0.987	1.092	0.148
	MinTemp(Lag2)	-0.052	0.949	0.911	0.989	0.012
Lilongwe	Rain	-0.00064	0.999	0.997	1.002	0.607
	Rain(Lag1)	-0.001	0.999	0.998	0.999	<0.001
	Rain(Lag2)	0.001	1.001	1	1.002	0.173
	MaxTemp	0.007	1.007	0.937	1.082	0.851
	MaxTemp(Lag1)	-0.044	0.957	0.925	0.99	0.01
	MaxTemp(Lag2)	0.036	1.037	1.022	1.052	<0.001
	MinTemp	0.018	1.018	1.000	1.097	0.064
	MinTemp(Lag1)	0.023	1.023	1.003	1.044	0.022
	MinTemp(Lag2)	-0.058	0.944	0.91	0.979	0.002

Salima	Rain	0.00028	1.000	1.000	1.002	0.002
	Rain(Lag1)	-0.00052	0.999	0.998	1.001	0.136
	Rain(Lag2)	-1.00E-03	0.999	0.997	1.000	0.162
	MaxTemp	0.034	1.034	1.000	1.091	0.019
	MaxTemp(Lag1)	-0.046	0.955	0.921	0.99	0.013
	MaxTemp(Lag2)	0.024	1.025	0.979	1.072	0.291
	MinTemp	0.014	1.014	0.962	1.069	0.016
	MinTemp(Lag1)	0.02	1.020	1.000	1.071	0.044
	MinTemp(Lag2)	-0.025	0.976	0.929	1.025	0.331

Outlook

This study set-out to quantify the relationship between climate change and health (CCH). A purposive quantitative analysis was carried out in the four districts of Chikwawa, Zomba, Lilongwe and Salima. The analysis of the trend and correlations was carried between temperature and precipitation, and the incidence of infectious diseases (malaria, diarrhea) and non-communicable disease (acute malnutrition, depression and hypertension). In the selected districts for this assessment, the analysis carried out showed negative correlations between the incidence of malaria and the maximum temperature and positive differences with the minimum temperature, although with important differences between the districts in the thresholds and lags (weeks elapsed between the climatic event and the effect on the incidence). Similarly, the analysis showed positive correlations between the incidence of diarrhea and rainfall, suggesting a heightened risk of diarrhea linked especially to rainfall above 50 mm. In most cases, the increase in cases occurs from the second week of rainfall. The models also predict a decrease in most scenarios in the districts of the central region. However, there is no pattern regarding the influence of the different emission scenarios on the incidence of diarrhea.

These findings require tailored policy interventions. The good thing is that Malawi has a relatively strong policy environment for climate change adaptation and resilience. However, as in many African countries, the implementation of the policies and coordination of the relevant stakeholders remains a big challenge. The inadequate implementation is partly due to insufficient financial resources arising from low national budgetary allocation for climate resilience and adaptation measures. The financial situation of Malawi has a direct bearing on the institutional framework for climate change in the country. Indeed, the agenda for CCH is mostly driven by international NGOs rather than the national government. This negatively affects the continuity and sustainability of most CCH initiatives, and impairs the development of functional private and public partnerships at national level necessary for enhancing CCH.

4.8.2 Adaptation Strategies for the Human Health Sector

In this report, possible strategies and measures to adapt to adverse effects and impacts of climate change on human health mainly address five key diseases, namely: malaria, diarrhea (cholera and dysentery), malnutrition, hypertension, and depression which are a major problem in Malawi.

Malaria

At household and community level, there is anecdotal evidence that Malawians use fumes from burning leaves of high-scented plants, such as Eucalyptus trees or cow dung, as indigenous knowledge to act as repellents of the vectors that carry malaria parasites. The effectiveness of such LIKSPs has not been documented. Further, some rural family households have developed capacity to use presumptive diagnosis of malaria, such as the signs of fever, and have often provided own treatment using drugs from retail outlets, or herbal remedies from traditional healers. However, mushrooming of retail shops in rural communities has resulted in increasing access and use of modern repellants such as mosquito coils and Doom by many of these rural households.

At national and institutional levels, the Ministry of Health has put in place a number of strategies and measures to address the problems of malaria, which include: (i) prevention and control mechanism for malaria, and (ii) promotion of Long-lasting insecticide treated nets (LLITNs) insecticide-treated mosquito nets (ITMNs). Since 1995, the National Malaria Control Programme has been promoting the use of insect treated mosquito nets (LLITMN) as a means of vector control, especially for vulnerable groups, such as children under 5 years of age and pregnant women. Currently, Malawi is one of the countries in Africa that is participating in the malaria vaccine testing programme.

Diarrhea

At household level, both preventive and curative measures are used as a measure for combating diarrhea. Preventive measures include: (i) boiling drinking water, (ii) filtration and chlorination of drinking water, (iii) improvement in personal hygiene (maximum personal hygiene), (iv) strengthening infection, prevention and control (IPC) measures, (v) public awareness on hygiene and sanitation, (vi) provision of potable water supply, (vii) provision of subsidised chlorination tablets, (viii) improvements in garbage and waste collection and disposal in urban centers, (ix) immediate burial of cholera victims, (x) pot-to-pot chlorination of water at household level, (xi) promotion of proper and correct solid waste management practices, (xii) strengthening catchment area targeted interventions (CATI), and (xii) strengthen patient and guardian education. Curative measures include the use of: (i) oral rehydration salts, and (ii) cereal-based solutions, such as rice water. At national level, both preventive and curative measures are also used.

Malnutrition

To combat malnutrition in the face of climate change, adaptation methods include: diversifying crop production with drought-tolerant varieties, promoting nutrient-rich crops (biofortification), improving water management practices, enhancing food storage and post-harvest handling, implementing community-based nutrition education, and strengthening social safety nets to ensure access to food during climate-related disruptions, while considering gender equality and the local context to maximise effectiveness. Some of the current adaptation measures for malnutrition in Malawi include: (i) crop and diet diversification: through the cultivation of roots and tubers (cassava, sweet potatoes) and other drought tolerant crop cultivars, and (ii) winter cropping systems using small-scale irrigation systems

Hypertension

According to a publication by CEPA, climate change adaptation methods for hypertension primarily focus on alleviating the impacts of extreme heat, which can significantly worsen blood pressure control, including: increasing access to cool spaces, promoting heat awareness campaigns, modifying medication regimens based on weather conditions, and ensuring healthcare systems are prepared to manage heat-related hypertension complications; alongside broader lifestyle adaptations like staying hydrated, regular exercise, and stress management.

Depression

In order to adapt to potential impacts of depression triggered by climate change, the following strategies may be employed: engaging in pro-environmental actions, seeking social support, practicing mindfulness and cognitive restructuring, accessing professional mental health services, building resilience through community involvement, and staying informed about climate change while focusing on manageable actions; all the while acknowledging the complex emotions surrounding the issue and seeking support when needed.

Individuals can develop coping mechanisms to deal with the chronic stress of climate change by embracing psychological adaptation. This entails cultivating a proactive mindset, focusing on what can be controlled, and engaging in positive actions. Education also plays a pivotal role in building resilience. Informing individuals about climate change, its impacts, and actionable steps they can take fosters a sense of urgency. These educational efforts can also help alleviate climate change depression by addressing eco-anxiety and climate-related stress.

4.8.3 Barriers, Constraints and Gaps

Significant barriers to climate change adaptation within the health sector include: limited funding, lack of expertise in climate change within the health system, inadequate infrastructure, poor coordination between different levels of government, widespread malnutrition,

and the existing high burden of diseases like HIV/AIDS, which further weakens resilience to climate-related health shocks.

According to a World Bank report of 2023, Malawi faces significant climate-related challenges that directly and indirectly impact human health. Coupled with man-made health stressors, climate change has the potential to exacerbate the existing health burdens while creating new health risks. Changes in temperature and precipitation patterns affect the geographic range and burden of a variety of climate-sensitive health risks while impacting the functioning and capacity of Malawi's health system. Climate change-related challenges that increase Malawi's vulnerability to poor health outcomes include a wide range of climate hazards, such as extreme temperature and humidity conditions, potential changes in precipitation patterns, extreme precipitation events, seasonal aridity, droughts, and cyclones. Key barriers and constraints to climate change adaptation within the health sector include: limited expertise in climate change within the health system, inadequate funding for adaptation initiatives, weak capacity to respond to climate-related shocks, a high prevalence of HIV/AIDS impacting community resilience, poor infrastructure, and a lack of coordination between different levels of government and communities, all further exacerbated by the country's existing vulnerabilities to climate change like droughts and floods.

Reported in the same World Bank document (World Bank, 2023) are significant gaps that exist in the health sector's ability to adapt to climate change, including a lack of dedicated funding for climate-related health risks, inadequate health information systems for monitoring climate impacts, insufficient skilled healthcare workers in rural areas, and a limited understanding of climate-sensitive diseases among healthcare providers, which could exacerbate existing health inequalities and hinder effective response to climate-driven health threats like increased malaria, diarrhea, and malnutrition.

According to the Malawi Medical Journal, barriers for the health sector in addressing climate change adaptation include: limited funding for adaptation measures; inadequate infrastructure to handle climate-related disasters like floods and droughts; inadequate awareness and capacity within the health workforce regarding climate-sensitive diseases; poor access to clean water and sanitation; and existing high burdens of diseases like malaria and HIV/AIDS that exacerbate vulnerability to climate impacts. Climate change gaps within the health sector include a lack of capacity to respond to climate-related health risks; limited expertise in climate change within the health system; inadequate funding for adaptation measures; and a lack of integration of climate change considerations into existing health policies, leading to increased vulnerability to climate-sensitive diseases like malaria, cholera, and malnutrition due to extreme weather events like droughts and floods, particularly impacting vulnerable populations like women and children.

4.9 Energy

The energy sector in Malawi comprises five major sub-sectors, namely: Hydropower based electricity, Biomass energy, Petroleum, Coal, and Renewable energy (solar, wind and geothermal). As far as carbon emissions are concerned, biomass, coal and petroleum products are the major culprits. The high demand for biomass energy is fueled by the country's over-dependence on charcoal and firewood for domestic cooking and heating. In 2020, 98.8 percent of households in Malawi were using biomass energy. A higher proportion (79.1%) of the households were using firewood, followed by 18.5 percent that were using charcoal, and 1.2 percent electricity[55].

Malawi has one of the lowest electricity access rates in the world. Electrification rate currently stands at 14 percent, with severe disparities between urban and rural areas (54% in urban areas and 7% in rural areas)[56]. The inequality among the rich and poor is huge. The poorest 20 per cent report 1 per cent and the richest 20 percent report 31 percent electrification rate[57]. There is almost no coverage in the bottom 40 percent of the population; and repercussions on human development and economic transformation outcomes.

In terms of power demand**,** the 2017 IRP electricity demand forecast for the base forecast estimates that maximum demand will reach 719 MW by 2020, 1,873 MW by 2030 and 4,620 MW by 2040 (Table 4.14). The annual average growth rates are 17.5 percent through to 2020 (reflecting suppressed demand in its various forms) and 10 percent per annum from 2020 to 2030 (including the elimination of suppressed demand). This compares with annual average growth rates of maximum demand over a period from 2010 to 2015 of 4.2 percent per annum. However, between 2015 and 2016, there was heavy load shedding due to low water levels in the Shire River on which Malawi generates about 98 percent of its hydroelectricity.

Table 4-13: Electricity Demand Forecasts (maximum demand, MW sent out), Source: Integrated Resource Plan, 2017.

Year	Low Case Scenario (MW)	Base Case Scenario (MW)	High Case Scenario (MW)
2020	567	719	982
2030	1,235	1,873	2,591
2037	2,236	3,566	5,217
2040	2,841	4,620	6,945

Regarding power supply, the total installed hydropower generation capacity operated by EGENCO is 390.15 MW mainly on the Shire River, which is the outlet of Lake Malawi. A small mini hydro power plant located on Wovwe River in Northern Malawi has a generation capacity of 4.5 MW (Table 4.15).

55 Malawi Fifth Integrated Household Survey (IHS5) 2019-2020
56 Sustainable Development Goals 7 (SDG7) Report, 2020
57 Malawi Fifth Integrated Household Survey Report, 2020

Table 4-14: EGENCO Power Generation Capacity in Malawi (Source: Government of Malawi, 2021)

STATION – HYDRO	INSTALLED UNITS	AVAILABLE UNITS	INSTALLED CAPACITY (MW)	AVAILABLE CAPACITY (MW)
Nkula "A"	3	3	35.10	35.10
Nkula "B"	5	5	100.00	100.00
Tedzani I&II	4	4	40.00	40.00
Tedzani III	2	2	62.00	55.00
Tedzani IV	1	1	19.10	19.10
Kapichira I&II	4	0	129.60	0.00
Wovwe	3	2	4.35	2.90
SUB TOTAL	**22**	**17**	**390.15**	**249.10**
STATION – THERMAL				
Lilongwe "A" (Diesels)	3	03	5.40	0.00
Kanengo Phase 1 (Diesels)	5	01	10.00	0.00
Kanengo Phase 2 (Diesels)	5	1	10.00	1.60
Luwinga (Diesels)	3	0	6.00	0.00
Mapanga (Diesels)	10	6	20.00	9.60
Likoma (Diesels)	2	2	1.17	1.17
Chizumulu (Diesels)	2	2	0.66	0.66
SUB TOTAL	**30**	**11**	**53.22**	**13.02**
STATION – SOLAR				
Likoma	1	1	1.00	1.00
Chizumulu	1	1	0.30	0.30
SUB TOTAL	**2**	**2**	**1.30**	**1.30**
TOTAL	**54**	**30**	**444.67**	**263.42**

In Malawi, according to the Malawi Fifth Integrated Household Survey (IHS5) 2019-2020, 98.8 percent of the households were using solid fuels as the main source of energy for cooking. The use of charcoal multiplies by seven times the number of trees required to produce 1tonne of charcoal[58] . This process has resulted in the wanton cutting of trees, leading to deforestation and forest degradation. Deforestation has negatively influenced land degradation due to soil erosion. Annually, an estimated 0.6 to 1 percent of forest cover is lost, largely due to tree cutting to provide charcoal and firewood. This is directly undermining agricultural productivity, food and water security, and is negatively impacting hydropower generation capacity while making the country vulnerable to climate shocks and limiting social, economic and industrial development of the country. The loss of forest cover also induces prolonged droughts and enhances the processes of climate change. Over the years, it has also led to significant increases in ambient temperature. The impact of this has been uncomfortable conditions for human habitation.

58 Malawi Charcoal Study, 2013

Similarly, the overdependence on traditional biomass (wood, charcoal) as fuel to meet the country's growing energy needs are threatening Malawi's climate as forest resources, which act as carbon sinks, are being depleted (GoM, 2021). These important concerns are reflected in the choice of mitigation measures outlined in Malawi's Nationally Determined Contributions (NDCs).

The Government of Malawi in 2018 developed the National Electrification Strategy (NES) to enable efficient electricity access to scale-up. The NES presents a series of electrification-specific recommendations that focus on strengthening existing distribution networks and distribution licensees to support expansion of grid infrastructure and connectivity; promote restructuring of rural electrification/renewable energy program management; and scale-up off-grid renewable initiatives through establishing quality standards, providing fiscal incentives for solar devices and support local manufacturing of renewable, off-grid devices. The NES also provides guidance on the fiscal framework that is needed to create the enabling environment for investment in renewable energy based mini-grids for outlying communities identified under a comprehensive geospatial least cost grid electrification and off-grid complement plan, along with an off-grid market assessment for Malawi. The NES is organised into four thematic pillars namely: (i) institutional elements; (ii) policy and regulatory elements; (iii) technical and planning elements; and (iv) financial elements. Key recommendations under the NES are implemented through the Malawi Electricity Access Project (MEAP) that is being implemented by the Ministry of Energy and ESCOM with funding from the World Bank, which has provided IDA funding of US$150 million. Under this financing US$110 million is for grid access and US$40 million for off–grid access scale up. It is expected that the scale up activities will increase the off – grid rate from the current very low levels of about 6 percent to 20 percent by 2030 and on-grid access to 30 percent by the same target year[59].

4.9.1 Vulnerabilities, Impacts, and Risks

The energy sector in Malawi in vulnerable severe floods, droughts and strong winds as they disrupt hydroelectric power generation and damage infrastructure, while also affecting biomass availability due to reduced rainfall and deforestation. In January 2022 the country lost 129.60 MW of base power due to damage caused to Kapichira Hydropower Plant by Tropical Storm Ana. As such, the need to invest in a more diversified and resilient energy mix, including renewable sources like solar cannot be overemphasized.

In Malawi, climate change impacts the energy sector through its influence on hydropower generation, which is the main source of electricity, as fluctuating water levels in the Shire River due to droughts and floods directly affect power production, leading to potential energy useholds reliant on the grid. Additionally, the reliance on biomass for domestic cooking and heating in rural areas is also threatened by reduced biomass productivity due to changing weather patterns. The primary climate change risk pertinent to the energy sector is the vulnerability of its hydropower generation to extreme weather events like droughts and

59 Malawi Electricity Access Project (Project document)

floods, which are projected to become more frequent and intense due to climate change, thereby significantly impacting the country's electricity supply as a majority of its power comes from hydro sources.

4.9.2 Adaptation Strategies for the Energy Sector

Adaptation strategies for the energy sector primarily focus on diversifying energy sources away from heavy reliance on hydropower, which is vulnerable to droughts, by promoting solar, biomass, and mini-grid solutions, alongside improving energy efficiency measures, particularly in rural areas, to mitigate the impacts of climate change on energy access and supply.

For the Energy Sector, adaptation actions are aimed at minimising the damage to the energy infrastructure by the impacts of climate change. Policy and strategic interventions that have been undertaken in the energy sector for it to be better adapted to adverse impacts of climate change and to make the sector to be more resilient have therefore been anchored in the following main energy assets and infrastructure strategies which should be integrated into the national policy making process:

a. Energy Mix Diversification – Exploitation of other alternative sources of renewable energy other than hydro, which has been and continues to be heavily negatively impacted by climate change. Such diversification includes the fuel source; i) solar (already under use and under development by the private sector). ii) wind (under plan for development by the private sector). iii) biomass from agriculture waste (under plan for development by the private sector, e.g., power generation from bagasse by Illovo Sugar). iv) natural gas (under plan by both the state and the private sector). v) geothermal (under plan by Government in partnership with the private sector);

b. Location Diversification –Spread development of hydropower (moving away from focus on one river cascade to reduce negative impacts). Plans were underway to diversify hydropower away from the Shire River cascade to other sites in the center and north of Malawi (Bua, Rukuru, or Songwe);

c. Design Changes for both existing and future infrastructure – Mainly focused on hydropower and power transmission and distribution infrastructure. For hydropower - machines would be designed to withstand low water quality; for transmission and distribution lines – the strategy would be shifting lines away from known and future projected flood plains, change in foundation design and change in the design of the line structures to better withstand adverse weather conditions brought about by climate change;

d. Technology Changes –Produce or adopt and adapt to new technologies for utilising renewable sources of fuel that include the use of solar, wind, ethanol, biogas, natural gas, geothermal and other renewable types of fuel. The new technologies are likely to lender some of the old energy assets and infrastructure redundant. The cost of these new technologies must be factored in as part of the climate change adaptation measures; and

e. Power trading with other Southern African countries such as Mozambique with large hydropower generation plants will enable Malawi to not only increase variable renewable energy in the generation mix but also assist the country to decarbonise quickly.

4.9.3 Barriers, Constraints and Gaps

According to the NAPA Energy Report, key barriers and constraints to climate change adaptation in the energy sector include: heavy reliance on biomass fuel, which is vulnerable to climate change; limited access to electricity; high upfront costs of renewable energy technologies; inadequate funding; weak institutional capacity; inadequate awareness about climate change; a predominantly rural population with limited access to modern energy solutions; and poor infrastructure which hinders the development of renewable energy sources such as solar and wind power. All of above are hindrances are compounded by the country's poverty and dependence on hydropower generation which is susceptible to fluctuating water levels in Lake Malawi and hence the Shire due to changing rainfall patterns.

Also, significant gaps exist in climate change adaptation within the energy sector, primarily due to the heavy reliance on hydropower generation which is highly vulnerable to fluctuating water levels caused by changing rainfall patterns, coupled with limited access to renewable energy sources, inadequate infrastructure, and inadequate financial resources to implement adaptation measures, leaving the population, particularly rural communities, susceptible to energy disruptions and increased reliance on unsustainable biomass fuel sources like firewood.

4.10 Fisheries

In Malawi, the fisheries sector plays a critical role in poverty reduction through the provision of rural employment and, more importantly, through its contribution to household food security. About 20 percent of Malawi's area is covered by water, with Lake Malawi being the largest and most significant water body in terms of fish production. Others are Lake Chilwa, Lake Malombe, and Lake Chiuta. Per capita consumption of fish in the country is however declining as the human population in grows at a rate of 2.0 percent per annum, and the potential for increased fish production from natural waters of Malawi is limited. Fish provides a major source of protein supply, estimated at approximately 70 percent of animal protein and 40 percent of the total protein intake for the majority of the rural poor. Fish also provides essential minerals and vitamins, is available throughout the year, is accessible to the vast majority of the people, is available in times of drought and remains largely within the purchasing power of the majority of the population. The fisheries sector provides employment opportunities to over 200,000 people and supports about 14 percent of Malawi population which resides along the shores of Lake Malawi through fishing, processing, marketing, fishing gear construction, boat building and other ancillary activities. The fisheries sector is guided by the National Fisheries and Aquaculture Policy (2016).

As stated in Malawi's Third National Communication (GoM, 2021), fish production in Malawi varies annually. The catch and effort data collection system established and introduced into the country by Food and Agriculture Organization (FAO) shows that production of less than 15,000 tons was recorded between 1964 and 1974. The catches increased to around 80,000 tons in the 1980s and then declined to less than 40,000 tons in the mid-1990s. However, the dominance of *Usipa* catches (estimated to account for over 60% of the total catch) has been observed from 2000 to 2018 (Figures 4.56 to 4.57). Fish catches in 2018 was estimated at around 220,000 tons.

The large-scale fisheries in Malawi comprises midwater stern trawls, bottom water stern trawls and pair trawls. Total fish catches in the large-scale fisheries shows a steady declining trend since late 1980s (GoM, 2021). Catches declined from an average of 7,000 tons between 1976 and 1990 to an average of 3,500 tons between 2013 and 2017.

While the fish production trend in Malawi shows an increasing pattern, the large-sized and commercially important fish like Chambo *(Oreochromis spp.)* have declined. During the late 1970s, production of Chambo was about 9,000 tons annually but landings declined since 2010 and have remained at those low levels with current estimates of about 4,000 tons.

An analysis of the species groups composition in the large-scale fisheries, shows a succession of species with time. Chambo and Chisawasawa (Lethrinops spp.) were the mainstay fisheries from 1976 up until early 1990s, but they have been replaced by Ndunduma (Diplotaxodon) and Utaka *(Copadichromis spp.)*

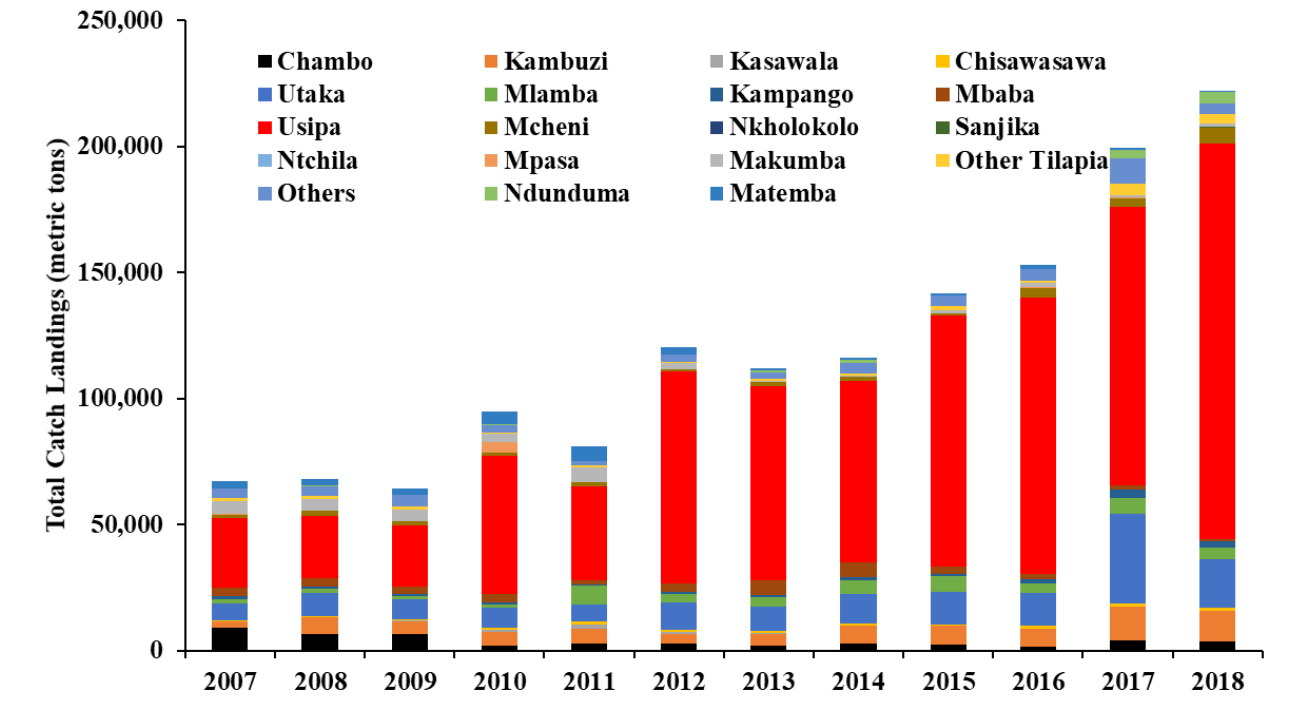


Figure 4-53:Fish production from the major water bodies of Malawi.

Source GoM (2019)

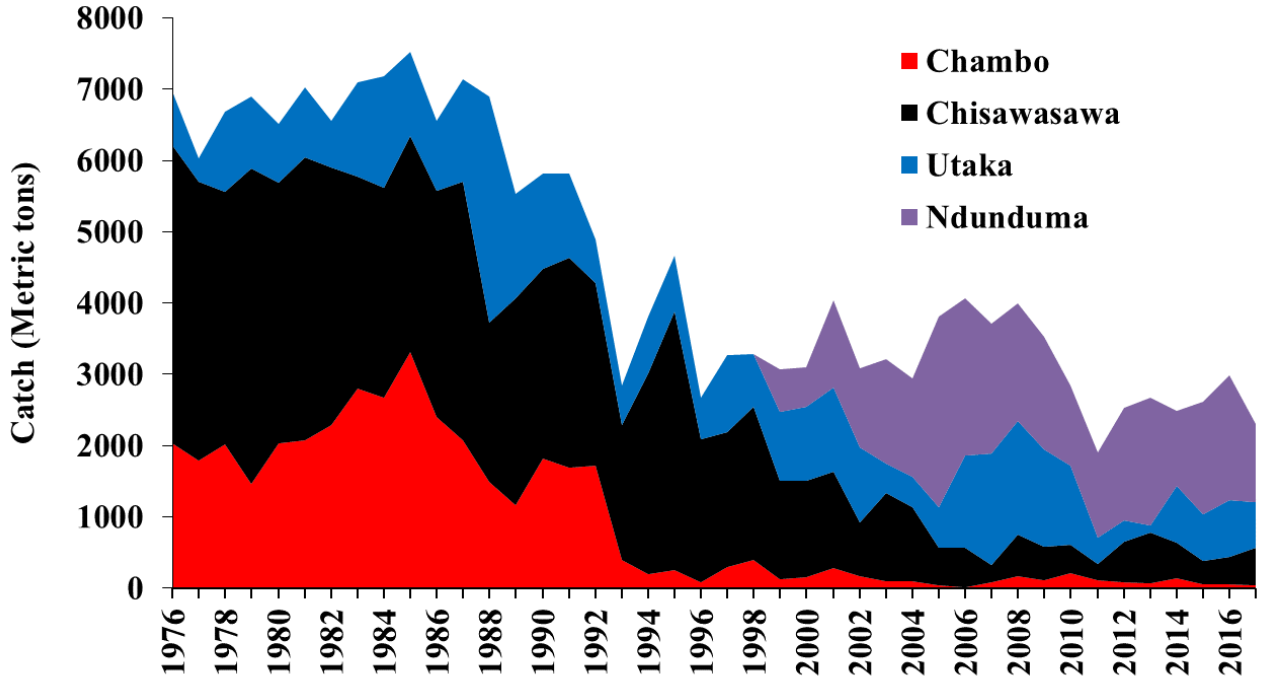


Figure 4-54: Fish production from large-scale boats showing trends in the commercially important fisheries.

Source : GoM 2(019)

As pointed out in the preceding discussion, the fisheries sector in Malawi is critical for food security, sustenance of livelihoods, wealth creation and as a driver for economic growth (MW2063), and significantly contributes to the country's GDP. However, climate change and climate variability pose serious challenges to the sustainable utilization of fish resources. During the past decade, the occurrence of high temperatures, extreme weather events (prolonged and frequent high wind speeds and rainfall) have increased in intensity and magnitude, resulting in varying effects on fisheries production. Blue foods, have the potential to contribute to both climate change mitigation and adaptation efforts. In Malawi, impacts of climate change and climate variability on the fisheries sector include the following;

Changes in Fish Habitats and decline in fish stocks – Capture fisheries

The increase in air temperatures has enhanced evaporation rates in some water bodies in Malawi, including deep water pools that act as refuge for fish in the capture fisheries sub-sector. The drying up of Lake Chilwa in 2021 and 2018 (Nagoli et al) and declining water levels in Lake Malawi, Lake Malombe and Lake Chiuta is a worrying development linked to rising air temperatures and other climate-related factors. Lake Chilwa is known for its shallow depth (approximately 4 m at its maximum depth) and highly sensitive to climatic fluctuations, making it very vulnerable to impacts of climate change. Rising water temperatures in lakes and rivers has altered or shrunk the available habitat suitable for breeding of most shallow fish species. The decline in high-value fish species like Chambo (Tilapia) is in addition to overfishing, linked to increased water temperatures that exceed their tolerance range, and a decline in habitat that jeopardises their recruitment potential. Changes in water levels, flow patterns and loss of habitat disrupts fish breeding and migratory patterns. In addition, the increase in water temperatures reduce the availability of dissolved oxygen (DO) in water, which is critical for fish survival. Most fish species in Malawi, except catfish, have optimal dissolved oxygen levels above 5 mg/L. The drying up of Lake Chilwa in 2018 due to prolonged dry spell resulted in the displacement of many fishing communities and loss of livelihoods.

The occurrence of Cyclone Idai in 2019 and Cyclone Freddy in 2023 resulted in severe flooding, which caused extensive damage to fishing gear, boats, docking facilities, as well as spawning grounds. Many fishers lost their livelihoods as their equipment was swept away or rendered unusable. The prevalence of strong winds and prolonged rainfall further led to additional destruction of aquaculture cage facilities installed in Lake Malawi and the flooding of landing beaches for both the small-scale and large-scale rendering them unusable. This affected the proper management of fisheries as fishers scrambled for the few available landing sites to conduct their business. Flooding may also result in the introduction of exotic fish species and invasive aquatic plants that pose risks on the aquatic biodiversity. Endemic species in Lake Malawi, one of the most biodiverse freshwater lakes in the world, may be at risk of extinction if their habitats become unsuitable. The rising water levels due to flooding also resulted in the displacement of many fishing communities along the shores of Lake Malawi and Lake Chilwa.

Changes in Water Levels - Aquaculture

Farmed fish species are vulnerable to water temperature changes, which reduce growth rates and increase mortality. Prolonged dry spells in Malawi have in the past resulted in reduced water levels and the unavailability of water for aquaculture operations in fish ponds. This has caused early harvesting of fish and loss of business. Over 500 ponds were affected in 2018 due to the dry spell that also saw the drying up of Lake Chilwa. Similarly, intense flooding due to high rainfall events has led to the destruction, and silting of fish ponds, and the escape of farmed fish into the wild. As mentioned in the preceding discussion, recent cyclones that occurred in Malawi, namely: Cyclone Idai (2019) and Cyclone Freddy (2023) caused severe damage to aquaculture facilities, resulting in extensive fish mortality and drastic reductions in the potential of most fish farmers, who are marginalised and vulnerable, to recover from the losses incurred.

Increased incidences of fish diseases

Climate change and climate variability are associated with the occurrence and spread of fish diseases, affecting both wild and farmed fish populations. Changing water temperatures create conditions that favor and accelerate the growth and proliferation of pathogens, parasites, and diseases, thereby exacerbating challenges in fisheries and aquaculture production. Warmer water temperatures stress fish, weaken their immune system and make them susceptible to diseases. Rising temperatures allow tropical pathogens to expand into previously cooler regions, introducing diseases to new fish populations. The emergence of an outbreak of epizootic ulcerative syndrome (EUS) in Malawi, particularly in Mchinji district in 2020 was a cause for concern. In Mtete River, Guwende Village and some fish farm clubs in Kawere Village, TA Kawere, Mchinji were affected as different fish species were dying and had ulcerative lesions on the skin. This raised suspicion of a case of aseptate fungi, *Aphanomyces invadans*, which causes Epizootic Ulcerative Syndrome (EUS). The disease was indeed confirmed by the Central Veterinary Laboratory housed in the Ministry of Agriculture under the Department of Animal Health and Livestock Development (DAHLD), and at the laboratory of the University of North Carolina at Kamuzu Central Hospital in Malawi. The diagnosis confirmed the EUS attack through tissue squash observed under X40 magnification and by Histopathology where scientists observed dermatitis granulomas under X40 magnification. For quality control of the results, another tissue sample was sent to the OIE EUS reference laboratory at University of Zambia (UNZA) for PCR tests, which also confirmed the presence of EUS infection. Further field studies have confirmed that this disease is prevalent when environmental conditions are favorable and conducive to its capacity to thrive and spread, particularly when water temperature is between 18°C to 25°C, with associated low pH below 7, which usually occurs during the cold season or following flood events during the rainy season.

Warmer temperatures and increased nutrients from runoff lead to the proliferation of harmful algal blooms (eutrophication) (HABs) that produce toxins harmful to fish, and oftentimes cause fish kills.

In summary, disease outbreaks result in economic losses due to fish mortality, reduced yields, and increased treatment costs; food security risks due to declining fish stocks and aquaculture productivity threaten food supplies in communities reliant on fish and; biodiversity threats as endemic fish species may be more vulnerable to emerging diseases, risking extinction.

Impacts on Livelihoods and Food Security

Reduced fish availability due to impacts of climate change may lead to lower catches, thereby threatening the livelihoods of fishing communities; and may cause a decrease in fish supply, leading to higher market prices thereby reducing accessibility for low-income households. Considering that fish is a major source of protein and micronutrients in Malawi, a decline in fish production exacerbates malnutrition, especially in vulnerable populations. Scarcity of fish resources due to climate stress may lead to conflicts between fishing communities over the natural resource. Low fish catches result in job losses in both capture fisheries and related industries, such as processing and marketing.

4.10.1 Vulnerabilities, impacts, and risks

In Malawi, climate change is significantly impacting the fisheries sector by causing declining fish stocks due to rising water temperatures, altered precipitation patterns leading to fluctuations in water levels, habitat degradation, and increased prevalence of invasive species, ultimately threatening the livelihoods of fishers and food security in the region, particularly around Lake Malawi which is an important source of fish for the country.

Reduced fish populations: Rising water temperatures in Lake Malawi can disrupt the fish's natural food chain and reduce their reproductive capacity, leading to decreased fish catches.

Habitat loss: Fluctuations in water levels caused by droughts and floods can destroy critical fish spawning grounds and aquatic vegetation, impacting fish biodiversity.

Invasive species proliferation: Changing environmental conditions can facilitate the spread of invasive plant species like water hyacinth, which can restrict fish access to feeding areas and disrupt the ecosystem balance.

Changes in fish species distribution: As water temperatures change, certain fish species may migrate to different areas, affecting local fishing communities who rely on specific fish stocks.

Impacts on small-scale fishers: The most vulnerable are small-scale fishers who depend heavily on the fisheries sector for their livelihoods, potentially pushing them further into poverty with declining catches.

Climate change poses significant risks to the fisheries sector, primarily through increased frequency and intensity of droughts and floods, leading to declining fish populations, habitat degradation, and disruption of fish breeding cycles, which can severely impact the livelihoods of communities heavily reliant on fishing for food and income.

Changes in fish species composition: Some fish species may become less abundant or disappear entirely due to changing environmental conditions, while others may thrive, impacting the overall ecosystem balance.

Habitat degradation: Increased erosion from altered rainfall patterns can lead to sedimentation in lakes, degrading fish habitats.

4.10.2 Adaptation Strategies for the Fisheries Sector

Climate change adaptation strategies for the fisheries sector primarily focus on enhancing fish stock management through practices like aquaculture development, monitoring fish populations closely, implementing fishing restrictions during vulnerable periods, diversifying fish species, promoting community-based management, and integrating climate data into fisheries management decisions, all the while considering impacts of changing water temperatures and rainfall patterns on Lake Malawi and other water bodies. These strategies are identified at departmental level and through field observations through interaction with other stakeholders. Through the Malawi Watershed Services Improvement Project (MWASIP) and similar projects implemented by the Department of Fisheries, with support from developmental partners, a number of fish ponds have been constructed in Malawi as one way of boosting fish production in the country. Listed below are some of the adaptation strategies being promoted or being planned for adoption by the Government of Malawi in the fisheries sector

Develop sustainable and climate-adaptive fisheries management

a. Promoting ecosystem-based approaches to fisheries management (EBFM) to also include catchment conservation for reducing or controlling erosion, sedimentation and improve water quality;
b. Enforcing closed season and demarcate “no fishing” zones to prevent overfishing and allow fish stocks to recover;
c. Protecting breeding and nursery habitats, such as wetlands, sanctuaries and deep pools as refuge areas for juvenile fish;
d. Reducing loos and waste, and enhancing circulatory in the blue food supply chain;
e. Supporting existing processing practices and supply chains where these enable access to nutritious and culturally appropriate foods at low cost, such as drying and improved smoking kilns in inland fisheries;

f. Promoting the conversion of aquatic food by-products into value-added products such as fish powder, dietary supplements, cosmetics, fertilizers, and other applications;

g. Growing markets for shelf-stable canned and dried fish products that can be stored without refrigeration and, depending on species, may be available to consumers at low cost;

h. Integrating aquatic foods and their nutritional and environmental benefits into school curricula to educate students from an early age; and

i. Implementing certification, labeling, rating, and other programs to guide consumers toward sustainable, low-carbon blue food options, boosting market demand.

Sustainable and climate-resilient aquaculture development

a. Investing in climate-resilient aquaculture systems, including species tolerant to high temperature and salinity changes, more resilient to changing conditions such as temperature and salinity, with a focus on locally adapted species;

b. Using technologies such as recirculating aquaculture systems (RAS) to reduce dependency on natural water bodies;

c. Investing in mega aquaculture farms to optimise the availability of nutritious foods nationally but also the export market;

d. Introducing integrated aquaculture-agriculture systems to optimise resource use and diversify livelihoods like rice-fish integration;

e. Incentivising the adoption of precision feeding techniques and efficient species to optimise nutrient intake, reduce feed waste, and improve FCR;

f. Developing and implementing training programs for farmers on advanced feeding management, precision feeding, and alternative feed ingredients to reduce GHG emissions;

g. Investing in hatchery and distribution infrastructure and establishing local and regional distribution networks to ensure small-scale farmers have reliable access to high-quality feeds and seeds;

h. Establishing comprehensive monitoring and reporting systems for key performance indicators, including feed use, to improve feeding management practices and reducing GHG emissions;

i. Establishing and enforce energy efficiency standards for aquaculture operations to optimise and reduce energy use;

j. Including aquaculture in national climate policies and energy priorities, connecting it to other sectors for comprehensive support of energy transitions; and

k. Promoting public-private partnerships (PPPs) to drive renewable energy adoption in aquaculture.

Monitoring and research

a. Conducting research on impacts of climate change on fish species and ecosystems to inform adaptive management;

b. Establishing systems to monitor water quality, fish stocks, and disease outbreaks, and providing timely information to fishers and policymakers;

c. Developing and disseminating early warning systems for extreme weather events, such as cyclones or floods;

d. Establishing and enforcing mandatory emission standards or bans on high-emission fishing gear, and promoting the adoption of low-impact, low-emission alternatives;

e. Providing incentives for retrofitting existing fishing vessels with low-emission technologies and support the development of "green" shipbuilding;

f. Investing in research and development of alternative energy sources for fishing vessels, such as green methanol, biogas, green hydrogen, and wind propulsion. This includes retrofitting vessels, adopting new engine designs, and upgrading port infrastructure;

g. Developing a global system for data collection, monitoring, and reporting of fishing fleet emissions, tailored for small-scale and artisanal fisheries, building on the experiences of the IMO and FAO;

h. Developing and investing in improved fish processing technologies that are efficient and use less fuel wood; and

i. Investing in research, development, and use of low-carbon feed ingredients, such as bacteria, yeast, earthworms, insects, algae, and single-celled proteins, ensuring they meet nutritional, environmental, and ethical standards.

Support climate-adaptive livelihoods and practices for fishers and fishing communities

a. Encouraging alternative income-generating activities, such as aquaculture, agroforestry, and eco-tourism, to reduce dependence on wild fisheries;

b. Providing training to fishing communities to embrace a culture of financial saving so that they can have alternative livelihood during lean or closed periods and reduce their overdependence on fisheries;

c. Engaging fishers and especially marginalised voices, such as women and the youth, in the fisheries value chain to identify local adaptation initiatives through participatory planning processes, and creating financial instruments to support these projects;

d. Strengthening social protection systems and safety nets for fishers and communities to manage climate-related shocks, including insurance options, disaster relief funds, and unemployment benefits;

e. Improving women's access to affordable and accessible credit, tenure rights, and labor-saving technologies to boost uptake of adaptation

measures, increasing incomes and intrahousehold decision-making, and reducing gender-related climate vulnerability; and

f. Supporting the relocation or adaptation of landing and processing facilities to align with shifting fish populations and environmental conditions.

Community Engagement and Capacity Building

a. Training fishing communities on sustainable practices and the impacts of climate change; and

b. Involving local communities in decision-making processes and co-management of fisheries.

Infrastructure Development

a. Building resilient infrastructure, such as fish landing sites, fish markets in major cities, and cold storage facilities, to withstand extreme weather events and reduce post-harvest fish losses;

b. Collaborating with MDAs responsible for irrigation to efficiently utilise dams for irrigated agriculture to support aquaculture and fisheries enhancement;

c. Investing in infrastructure to facilitate the use of fish processing by-products as substitutes for fishmeal and oils; and

d. Investing in cold-chain infrastructure, including refrigeration and transportation technologies, to minimise spoilage and loss of blue foods. This includes landing site storage, solar-powered ice makers, and coolers to improve product quality and reduce waste.

Strengthening Policy and Governance

a. Integrating climate change adaptation into national fisheries policies and development plans for proper fisheries management;

b. Providing financial support, such as grants or loans, to fishers and fish farmers for adopting climate-resilient practices;

c. Strengthening regional cooperation to address transboundary water and fishery issues; and

d. Supporting the World Trade Organization (WTO) Agreement on Fisheries Subsidies to eliminate harmful fossil fuel subsidies and promote sustainable fishing practices.

Changes in Fish Habitats and decline in fish stocks – Capture fisheries

a. Development of a digital climate information and advisory services system. With the support of UNDP under the M-CLIMES project, the Department of Fisheries in collaboration with the Department of Climate Change and Meteorological Services installed two buoys on Lake Malawi, at Monkey Bay (in waters of approximately 350m deep) and Nkhata Bay (in 90m deep waters) to provide real-time data on weather conditions over the lake (wind speed, wave height, temperature) and water quality parameters;

b. The Department of Fisheries has embraced the ecosystem-based fisheries management plan in most of the capture fishery districts of Lake Malawi. The essence of the plan is that the sustainable fisheries management in the jurisdictions of the district councils should be governed by ecosystem-based fisheries management plans. As such, the progress reporting of the district-level staff should be solely based on the three pillars of ecosystem-based fisheries management approach namely; ecological well-being, human well-being, and governance;

c. The Department with support from the AfDB funded SFAD-WM project has developed a Handbook on Climate Change Indicators for the Fisheries and Aquaculture in Malawi. These indicators will go a long way in ensuring that reporting on ecological well-being for the ecosystems in the fisheries sector is adequately covered;

d. Every month, the sector collects fisheries statistics through the Catch Assessment Survey (CAS) to determine fish harvesting levels and fishing effort. It also conducts a Frame Survey to determine the number of fishers, fishing assistants/crew by gender and their fishing gears and fishing vessels. The number of motorised fishing boats can be used to estimate the amount of annual fuel emissions into the atmosphere as we adopt sustainable management practices. Periodically, the sector also conducts lake-wide fish biomass assessment surveys as a basis for proper allocation of large-scale commercial fishers by fishing areas/zones;GTFV

e. The Department instituted a closed season for large-scale commercial fishers and the small-scale fishers that use beach seine nets to allow for proper breeding of shallow water breeding fish and enhance recruitment of the fish. It has also installed vessel monitoring system (VMS) for large-scale vessels and some selected small-scale fishers to reduce incidences of illegal, unreported, and unregulated (IUU) fishing which is a threat to sustainability of wild aquatic foods; and

f. Elsewhere in the world, the fisheries resources have benefited from restoration programs, for example, establishment of protected areas or sanctuary areas. With support from the USAID funded REFRESH project, RIPPLE Africa and the SFAD-WM, communities have identified, demarcated sanctuary areas as critical habitats for breeding of fish and refuge area for juvenile fish. In addition, the vegetation growing in these sanctuary areas, acts as sinks for carbon dioxide thereby reducing CO_2 in the atmosphere. In fact, studies have shown that Lake Malawi is a net carbon sink with an annual whole-lake CO_2 flux of about $-2.17\pm0.25\times10^{10}$ mol C yr^{-1} and a mean daily CO_2 flux of -2.05 ± 0.27 mmol C m^{-2} d^{-1} (Ngochera and Bootsma, 2020).

Changes in Water Levels – Aquaculture

Development of early warning system for fish farmers for farmed fish. Collaboration with the Department of Climate Change and Meteorological Services has seen the sector utilise daily or ten-day weather forecasts for proper planning;

Development of the National Aquaculture Strategy, which focuses on development of quality fish feed and fish seed (fingerlings), adoption of technologies and pond management for sustainability;

Promotion of genetic improved program (GIP), for rearing fish that are better adapted to local environments and climate challenges. The GIP being implemented at Domasi Aquaculture Center with technical and financial support from the WorldFish Center and SFAD-WM project, respectively aims to improve the growth rate, harvest weight and survival of the *Oreochromis shiranus* species

Promotion of deep (2 m deep ponds) and large ponds (more than 1,000 m^2) that are capable of storing water even during drought conditions. These ponds are less influenced and affected by fluctuations in air temperatures

Culturing of resilient fish species such as tilapia, catfish, and cyprinids like carp;

Long-term planning for climate-smart systems, like integrated aquaculture and agriculture (IAA), can ensure the climate resilience of aquatic foods and the benefits they deliver – rice/fish farming;

Introduction of sustainable aquaculture even in smaller water bodies.

Increased incidences of fish diseases

The Government of Malawi has put in place measures to prevent further spread of the EUS disease. As such, an emergence response strategy to outbreak of epizootic ulcerative syndrome (EUS) in Malawi was developed in 2020. To contain further spread of the EUS disease, the strategy focused on the following interventions:

a. Temporary suspension of transportation and selling of live or dead fish around the Bua River system and surrounding fish farms;
b. Suspension of fishing from the infected rivers and dams;
c. Avoiding use of fishing equipment across water bodies including fish farms to avoid cross contamination;
d. Avoiding carrying water from the infected rivers and fish ponds to other water bodies; and
e. Avoiding transferring of fingerlings from the infected areas to other areas.

The Strategy contains seven pillars and they include;

a. Rapid Surveillance;
b. Capacity Building,
c. Public Awareness,
d. Research and Policy;
e. Compensation Scheme
f. Coordination and Networking, and
g. Monitoring and Evaluation.

However, to implement the EUS Emergency Response Strategy, an amount of USD 294,800 is required. These funds are not readily available.

The Department was also in the process of finalising the Malawi National Aquatic Animal Health and Biosecurity Strategy (MNAAHBS) with support from FAO. This work was contracted to LUANAR but funding from FAO was suspended before the document could be validated and finalised. There is need to source funds to finalise this strategy

The Department has developed a Handbook on Climate Change Indicators for the Fisheries and Aquaculture in Malawi. These indicators will go a long way in ensuring that reporting on ecological well-being for the ecosystems in the fisheries sector is adequately covered

Fisheries Management

Community-Based Fisheries Management (CBFM):

- Active involvement of local fishing communities in regulating and monitoring of fish catches, monitoring illegal practices including mosquito nets from the health sector negatively impacting the fisheries sector (Chiotha et al 2017, 2018), and closed seasons for small-scale and large-scale fishers including signing of management agreements with the Director of Fisheries.
- Lake Chilwa Basin Management Program: Combines conservation with sustainable fishing, focusing on habitat restoration and floodplain management.

Catch Restrictions and Gear Regulation:

- Implementation of technical restrictions that include; size and gear restrictions to prevent overfishing and protect juvenile fish populations.
- Promotion of selective fishing gear that minimises catching of fish fry and ecosystem damage.

Climate-Resilient Aquaculture

Integrated Aquaculture-Agriculture (IAA):

- Combining fish farming with crop irrigation to optimise water use and enhance food security in some selected irrigation dams in the country. For example, under the MWASIP program, farmers in central and southern Malawi (Salima and Chikwawa District) practiced fish farming in rice paddies, boosting incomes and resilience to climate shocks.

Climate-Resilient Aquaculture Species:

- Adoption of fast-growing and stress-tolerant fish species, such as the improved strain of *Oreochromis shiranus* (Malawi tilapia) under the fish genetic improvement program (fGIP), which thrive in variable conditions.

Small-Scale Aquaculture Support:

- Government and NGOs provide training, inputs (e.g., fish seed and feed), and credit facilities to small-scale farmers for sustainable aquaculture development like the AGCOM initiative.

Disaster Preparedness and Early Warning Systems

Flood Mitigation Measures:

- Construction of raised fishponds including inserting fish-escape barriers to protect aquaculture infrastructure and fish during floods.
- Early warning systems for extreme weather events, developed in collaboration with the Department of Climate Change and Meteorological Services.

Training and Awareness Programs:

- Educating fishers on climate risks and sustainable practices, reducing vulnerability to extreme weather and water-level fluctuations.

7edge on climate-resilient fish species, weak extension services for fishers, lack of financial resources for adaptation measures, the prevalence of overfishing, inadequate infrastructure, poor governance and regulatory frameworks, socioeconomic vulnerabilities of fishing communities, and limited access to funding for adaptation initiatives. further exacerbating the impacts of climate change on already vulnerable fish stocks, particularly in the face of fluctuating water levels from droughts and floods.

Financial Constraints

- Limited access to funding for adaptation projects, particularly for small-scale fishers and aquaculture farmers.
- High costs of resilient technologies, such as advanced aquaculture systems or modern fishing equipment.

Inadequate Awareness and Knowledge

- Many stakeholders, particularly small-scale fishers, lack awareness of climate change impacts and adaptation strategies.
- Insufficient technical expertise to implement advanced management and aquaculture practices

Weak Policy and Governance Frameworks

- Inadequate enforcement of fisheries regulations and lack of integration of climate adaptation into national policies.
- Poor coordination among government agencies, NGOs, and local communities.

Infrastructure Limitations

- Poor infrastructure, such as damaged roads and inadequate cold storage facilities, limits adaptation capacity.
- Lack of access to early warning systems for extreme weather events.

Environmental Challenges

- Rapid degradation of ecosystems due to deforestation, pollution, and overfishing, reducing the effectiveness of conservation measures.
- Difficulty restoring habitats that are already severely degraded by climate impacts.

Data Gaps

- Limited data on fish stock dynamics, climate change impacts, and water quality hinders effective decision-making.
- Insufficient investment in research and monitoring systems.

Inequities in Resource Access

- Marginalised groups, such as women and small-scale fishers, often have limited access to resources, training, and decision-making processes.
- Competition for declining fish stocks can lead to conflicts, hindering collaborative adaptation efforts

4.11 Tourism

Tourism is acknowledged by most researchers as an effective tool for achieving economic growth, development and reducing poverty, especially in developing countries (Garrigos-Simon *et al*., 2015 and Hugo & Nyaupane, 2016). The case for tourism for developing countries cannot be overemphasised as it generates almost three times more than development aid (Mitchell and Ashley, 2010). Studies show that over 80 percent of the world's 46 Least Developed Countries (LDC) have prioritised tourism. Tourism accounts for 7 to 10 percent of total exports of LDCs and has also contributed to the graduation of some small island states such as Samoa, Cabo Verde, Maldives and Vanuatu (United Tourism, 2023). Tourism generates foreign exchange and creates employment (Antara *et al,* 2017; Dieke, 2010; Hrubcova *et al.*, 2016). Malawi has also prioritised tourism in the Malawi 2063 which is being implemented through the Agriculture, Tourism and Mining (ATM) Strategy. In 2022 tourism contributed 5.8 percent to Malawi's Gross Domestic Product (World Travel and Tourism Council, 2023).

Malawi's tourism is largely nature and culture based and depends largely on the natural environment; as such, the country's tourism is inseparable from the environment and climate (GoM, 2021b). Lambulira and Belo (2022) noted that Malawi's tourism products are predominantly nature and culture based and hence the need for the country to develop its tourism sector sustainably. However, Climate change continues to put pressure on the country's natural resources and in some cases destroying valuable ecological assets which are important for tourism (GoM, 2022). Three of Malawi's five tourist products lines, namely: Lake Malawi and water, Nature and Wildlife are all linked to the environment (GoM, 2017). To ensure the continued competitiveness of the country's tourism industry in a region where nature-based tourist attractions abound, the National Tourism Policy places sustainable tourism development, that is, low volume, low impact, high value tourism, at the heart of the country's tourism development (Government of Malawi, 2021a).

Promotion of sustainable tourism development revolves around the use and management of tourism resources in an environmentally, socio-culturally and economically sound way (Saarinen *et al*., 2013). According to Jamgade and Mondal (2023) the purpose of sustainable tourism is not only to generate wealth in tourism destinations but also to create wealth for future generations. The concept of sustainability is essential for the future growth and development of tourism (Pigram and Wahab, 1997). However, Climate change is a double-edged sword for tourism as the sector contributes to and also is affected by climate change (GoM, 2022). Tourism businesses and operations such as transport, accommodation, catering and non-motorised sports contribute to climate change (GoM, 2022). Therefore, tourism does not only have a financial obligation but also the moral obligation to champion the issues of climate change.

In this regard, climate change does not only affect tourism but is an existential threat to its future growth. For example, the rebounding of water levels in Lake Malawi has had serious repercussions on the flooding of hotels and lodges built on the shores of the Lake, particularly in Mangochi, Salima, and Nkhata Bay districts. This vulnerability can only be managed with proper

institutional arrangements and legal frameworks. Potential impacts of climate change on the Tourism Sector in Malawi include the following: damage to tourism facilities and tourism related infrastructure from flooding, heavy rains, and strong winds, repair costs and loss of business; loss of animal habitats, cultural and heritage sites that are essential for tourism; cancellation of holidays by tourist that affect tourism operators in the value chain; loss of jobs and livelihoods due to closure or slowing down of business; and a reduction in government tax revenue from reduced business revenue.

The tourism industry is guided by the National Tourism Policy whose main focus is development and promotion of high value low impact tourism. It is governed by the Tourism and Hotels Act of 1968. The Act has undergone piecemeal reviews over the years but still remained outdated due to its failure to include numerous emerging issues such as climate change, that continue to negatively impact on the tourism sector. The tourism sector is also subject to other primary legal instruments that address the issue of climate change such as the Environmental Management Act, National Wildlife (Amended) Act 2017, Forest Act 1997, Land Act (Amended) 2021,

Malawi has always used favorable climate as one of its major selling point. However, climate change has put this highly sought-after attribute of tourism in disarray. Considering that most tourism activities take place in the open, tourism remains highly vulnerable to the effects of climate change. Climate change effects such as the rising water level of Lake Malawi cause job losses due to slowing down of business (Jamal ***et al.,*** 2024). The rising lake levels also reduce tourism's contribution to the country's Gross Domestic Product.

Studies have also shown that the tourism industry is a larger contributor to climate changes and that it is also heavily affected by the effects of climate change (GoM, 2021b). Over the past two years, the Malawi tourism sector has suffered from several effects of climate change that included rising water level of Lake Malawi (Symon, 2024 and Jamal ***et al.,*** 2024) and Cyclone Fred that damaged tourism facilities, cultural and heritage sites and support infrastructure in southern Malawi (UNESCO, 2024).

In 2023, tourism accounted for 5.8 percent of Malawi's GDP. The unprecedented rising of lake levels in 2024 caused a lot of damage to tourism physical infrastructure and equipment and the loss of business estimated at a 1.02 percent loss to GDP (Jamal ***et al.,*** 2024).

Tourism has one of the highest economic multipliers, as it cuts across many sectors of the economy (Raina and Agrwal, 2004). In Malawi tourism has the second highest multiplier after the construction industry (World Bank, 2010). As such, its demise could collapse the economy considering that most of developing countries depend on tourism for job creation, foreign exchange earnings, economic growth and poverty reduction (Antara ***et al***, 2017; Dieke, 2010; Hrubcova ***et al.***, 2016).

As a service sector, tourism is also one of the world's largest employer, accounting for 10 percent of global employment (UNWTO, 2020). In Malawi tourism accounts for 3.2 percent of total direct employment (World Travel and Tourism Council, 2020). Therefore, the failure of tourism would mean loss of livelihoods to a larger portion of the country's workforce which is

predominantly youth and female. The increased number in the unemployed people could then to their dependence on the environment for survival, resulting in more climate change impacts.

Over the years, Malawi has witnessed an increase in tourist accommodation investment along the country's lakeshore. However, in 2024 the rising water levels of Lake Malawi caused damage to property and loss of tourism business.

4.11.1 Vulnerabilities, Impacts, and Risks

Climate change is significantly impacting the tourism sector by causing more frequent and intense floods and droughts, leading to disruptions in access to tourist attractions, damage to infrastructure, and fluctuations in wildlife populations, ultimately deterring tourists from visiting the country, particularly those drawn to Lake Malawi and its surrounding ecosystems. This is a major cause of concern considering that tourism is a key source of income for many communities in Malawi.

4.11.2 Adaptation Strategies for the Tourism Sector

The Malawi tourism sector has acknowledged the reality of climate change and that it has the capacity to erode the gains made in the sector. It does not only make tourism infrastructure vulnerable to the effects of extreme alternating flood and drought conditions but can also threatens people's livelihoods through job losses and loss of life. In light of the above, the sector needs to take urgent actions to implement, review or introduce new climate change adaptation strategies. Among other things, adaptation strategies for the tourism sector in Malawi primarily focus on promoting sustainable practices, diversifying tourism offerings, investing in resilient infrastructure, and building community engagement to alleviate impacts of climate change while maximising the benefits of tourism for local communities, particularly in the face of potential challenges like fluctuating water levels in Lake Malawi and the changing weather patterns.

Currently, the National Tourism Policy provides direction for developing adaptation strategies for countering adverse impacts of climate change (GoM, 2021a). In light of the above, several tourism strategic documents provide adaptation measures for climate change in the tourism sector:

a. The National Investment Masterplan provides guidelines for the siting and development of tourism facilities along the lakeshore and other water bodies, mountains and areas of outstanding natural beauty;

b. Strategies for addressing climate change issues in the National Ecotourism Strategy include:

   i. conducting public awareness campaigns on climate change issues in communities where ecotourism facilities are located;

   ii. mainstreaming climate change issues in the ecotourism development planning process;

iii. conducting research and vulnerability assessment on the impact of climate change in selected areas i.e. Lake Malawi, wildlife reserves and national parks to determine the impact of climate change and the protection of ecotourism products and tourists;

iv. reduction in the contribution of tourism to climate change through, among other strategies, reducing greenhouse emissions from tourism and efficient and green energy use; and

v. promoting tourism business resilience and adaptation to climate change through industrywide sensitizations about climate change effects on tourism

The National Tourism Investment Masterplan (2022-2042) is a blueprint that guides tourism development and investment in Malawi for the next 20 years. The Investment Masterplan zones the country's 28 districts into 10 Tourism nodes. It also provides guidelines for development of tourism facilities along the lakeshore, mountain areas and areas of natural outstanding beauty. The guidelines stipulate that permanent tourism facilities should not be constructed within 200 m of a water body to protect infrastructure against dame caused by hazards such as floods (GoM, 2022). The Masterplan recommends accommodation prototypes for protected areas (national parks, wildlife reserves and forests), mountains, along the lakeshore and other water bodies (GoM, 2022). The prototype accommodation takes into account the design of the buildings to provide for cross and natural ventilation, type of materials to be used (ie stone, wood) and location of the facilities within a natural setting to avoid destroying the environment. Guidelines for developments along the lakeshore require that all permanent structures are constructed at least 200 metres away from the edge of the water body. The 200 metres zone is reserved for beach sports, natural landscape and existing village settlements. The 200 metre rule is subject to the Water Resources Act (2013) regulations on development along the lakeshore or near water bodies which require all lakeshore developments to start from contour 477 m above sea level. The 477 m above sea level takes precedence over the 200 m prescribed by the Tourism Investment Masterplan. For nature, culture and urban tourism sites, no permanent structures can be erected within a 250 m distance from the edge of the attraction.

The National Ecotourism Strategy (2021) implements the aspiration of the Malawi 2063 which seeks to harness the country's diverse natural and cultural assets through tourism (GoM, 2021b). The strategy recognises Government initiative to develop and improve its wildlife and natural resources for economic benefits. The Ecotourism Strategy stands in the gap where it, among other things, provides guidelines for ecotourism development in Malawi. The strategy facilitates increased and direct participation of local communities, especially women and the youth, in ecotourism development planning and beneficiation from the proceeds of tourism as a motivation for conservation. The National Ecotourism Strategy outlines plans for climate change adaptation which include countrywide climate change sensitization campaigns,

promoting adoption of climate change mitigation measures in the sector to reduce greenhouse emissions and conducting climate change impact assessment in selected areas to determine the effects of climate change and develop appropriate response measures. However, since its launch in 2021 the National Ecotourism Strategy has not been implemented. Nevertheless, the Ministry of Tourism is implementing a four-year Ecotourism Development and Marketing project with technical and financial support from the European Union, to be implemented from February 2025, to develop ecotourism products, develop ecotourism facility standards, conduct ecotourism research and promote ecotourism in key source markets. The project seeks to strengthen women and youth's entrepreneurial capacity and participation in the ecotourism value chain. It will also raise awareness on the importance of ecotourism, the preservation of natural and cultural assets and adaptation to climate change. Under Article 32 of the Draft Tourism Bill of 2023, the Director of Tourism will, among other activities, promote sustainable tourism through conducting research and public awareness on the relationship and interconnectedness between tourism, the environment and climate change.

The Ministry of Tourism will seek to achieve the following two climate change adaptation goals:

i. mainstreaming climate change in tourism planning and development at all levels; and

ii. increased adaptation of climate change mitigation practices by tourism businesses and operators

Over the past years, tourism has not been directly involved in climate change issues even though it substantially contributes to and is also impacted by the effects of climate change. In spite of this, tourism has included issues of climate change in both the National Tourism Policy (2021) and the National Tourism Investment Masterplan (2022-2024), the National Ecotourism Strategy (2021) and the draft Tourism Bill (2023) which seeks to replace the current Tourism and Hotels Act of 1968 which is not comprehensive enough to include emerging issues such as climate change.

NDCS - Implementation Progress: Since the last report (NC3), the following progress has been made in the implementation of climate change adaptation strategies in the tourism sector:

i. The National Tourism Policy (2021) provided direction for development of adaptation measures. Measures have now been developed and included in the National Ecotourism Strategy (2021), National Tourism Investment Masterplan (2022-2042) and the Draft Tourism Bill (2023).

ii. The Ministry of Tourism secured financial and technical support from the EU for implementing the Ecotourism Strategy through a project that aim to strengthen and develop new ecotourism products, mainstreaming climate issues in the planning and process and local community, and sensitise and build capacity of local ecotourism entrepreneurs

iii. The Ministry of Tourism has now a climate change focal person on the National Climate Change structures

Monitoring and evaluation of adaptation actions and processes: Currently, there is no deliberate programmes or activities in place for monitoring and evaluating adaptation actions and processes. However, the Ministry of Tourism conducts regular inspection of tourism facilities to ensure they comply with the Environment Management Act regulations on liquid and solid waste management, among others, which is part of climate change mitigation measures. In addition, all tourism investment projects appraised and approved by the Ministry of Tourism that involve construction are required to undergo an Environmental and Social Impact Assessment (ESIA) preliminary check and if the project will have negative impacts, then a full ESIA is ordered. As part of public sector reforms, the Ministry of Tourism is devolving some its tourism functions to local councils which would greatly strengthen enforcement and monitoring of set regulations and regulations. It would also assist if the Ministry of Tourism is also fully incorporated in the National Disaster Management and Coordination structures to ensure that timely information on tourist in an affected area is provided to avert harm or injury to tourists. The Department of Climate Change and Meteorological Services can also be capitated to provide timely weather updates and alerts that could be accessed by tourists and tourism business operators.

In summary, climate change adaptation strategies for the tourism sector primarily focus on managing the impacts of extreme weather events such as droughts and floods on natural ecosystems; promoting sustainable tourism practices, and building resilience within local communities that depend on tourism by implementing initiatives such as early warning systems; diversifying tourism products; and promoting eco-tourism practices to protect sensitive environments.

Ecosystem conservation and management

Protected area management: Adapting wildlife management practices to changing climate patterns, including shifting species distribution and habitat restoration projects within protected areas.

Water resource management: Implementing strategies to manage water availability during drought periods, including rainwater harvesting and efficient water use in tourism facilities.

Forestry initiatives: Reforestation and sustainable forest management to mitigate erosion and maintain biodiversity.

Community-based adaptation

Capacity building: Training local communities on climate change impacts and sustainable tourism practices to enhance their resilience and participation in tourism management.

Diversification of income sources: Promoting alternative income streams for communities beyond tourism to reduce dependence on weather-sensitive activities.

Climate-smart agriculture: Supporting sustainable farming practices to ensure food security and maintain ecosystem health.

Tourism product diversification

Shifting tourism focus: Promoting tourism activities that are less vulnerable to climate change, such as cultural tourism, birdwatching, and community-based experiences.

Developing new destinations: Exploring new tourism areas that may be less affected by climate change.

Monitoring and early warning systems

Climate data collection: Establishing robust systems to monitor weather patterns and potential climate-related risks to tourism sites.

Early warning systems: Developing communication channels to alert tourists and local communities about potential weather hazards.

4.11.3 Barriers, Constraints and Gaps

When it comes to climate change adaptation in tourism, major barriers, Constraints and Gaps include: limited knowledge about climate change impacts, lack of funding for adaptation measures, uncertainty about future climate trends, resistance to change within the tourism industry, lack of community engagement, and insufficient technical expertise to implement adaptation strategies.

Knowledge and awareness barriers: Lack of understanding about specific climate change impacts on tourism destinations; limited access to climate data and projections relevant to tourism planning; and Poor awareness among tourism operators and local communities about climate change risks.

Financial barriers: High upfront costs associated with implementing adaptation measures;

Difficulty in securing funding for climate change adaptation projects, especially for smaller businesses; and Lack of incentives for tourism operators to invest in climate-resilient practices.

Social and community barriers: Resistance from local communities to change, particularly if adaptation measures disrupt traditional practices; Lack of community engagement in decision-making processes related to climate adaptation; and Limited capacity building for local communities to participate in adaptation initiatives.

Technical barriers: Difficulty in accessing and applying appropriate technologies for climate change adaptation; Lack of expertise in developing climate-resilient tourism products and services; and Uncertainty about the effectiveness of different adaptation strategies.

4.12 Infrastructure

According to GoM (2021), the infrastructure sector broadly comprises transport and buildings subsectors, and is defined as physical structures, facilities, networks and other assets which provide services that are essential to the social and economic functioning of a community or society. As such, infrastructure covers roads, bridges, rail lines, water, airports, inland ports and buildings. The United Nations Office for Project Services (UNOPS) in 2021 reported that infrastructure is responsible for 79 percent of total greenhouse emissions and 88 percent of all adaptation costs. This is supported by the impacts felt when infrastructure is destroyed by climate and weather-related events, e.g., floods, droughts, strong winds, and wild fires. The Ministry of Transport and Public Works and departments and agencies that fall under it are major players in the infrastructure sector in Malawi.

Malawi's transport system is dominated by roads which carry more than 93 percent of internal freight and close to 90 percent of international freight, with the modal share similar in both urban and rural areas (GoM, 2017a; GoM, 2017b). The road network provides access to only about 26 percent of Malawi's population; and they are the only means of accessing and travelling within most urban and rural areas in the country. It is obvious that transport infrastructure is pivotal in accelerating growth and acts as an enabler for poverty reduction and wealth creation.

The MDGS III (GoM, 2017b) highlighted six (6) major outcomes which will result from improved transport sector in Malawi, namely: (a) reduced travel time and costs for persons and goods; (b) improved transport reliability, levels of service and service efficiency; (c) enhanced access to local and international markets; (d) improved access to inclusive social and public services; (e) reduced accidents and their effects on human life and economies in general; and (f) increased private sector investment in the operation and management of transport infrastructure.

In 2017, the Government of Malawi developed the National Transport Master Plan (GoM, 2017c) where development of transport infrastructure from 2017 to 2037 is outlined, see Table 4.16. It is imperative that the development of this infrastructure takes into account potential impacts of climate change.

Table 4-15: Infrastructure Investment for Malawi for the period 2017-2037 (Source: GoM, National Transport Master Plan).

Subsector	Main Plan Components
Roads	• Maintenance of the road network; • Rehabilitation of all failing sections of the road network; • Upgrading 1,418 km of rural roads to assist agricultural production and improve rural accessibility; • Introduction of over 500 km of segregated cycle/pedestrian facilities on high trafficked roads.
Rail	• An extension of the railway line from Beira Port in Mozambique northwards from Mutarara into Malawi, in stages (313 km); • A spur line from Mbeya to Chilumba (234 km).
Inland Water Transport	• Improved port facilities at Nkhata Bay and roll-on roll-off freight services to Mbamba Bay on the Mtwara Corridor; • Introduction of a regular freight service between Chilumba and Liwonde; • Construction of a wet port at Liwonde.
Civil Aviation	• Measures to improve safety and security to world class standards; • Runway and apron improvements at Chileka and Kamuzu International Airport to accommodate larger aircraft, and terminal capacity increases; • Developing some rural airfields for tourist use; • Handing over unused airfields to local authorities and the private sector.
Urban Transport	• Concession bus routes in high patronage corridors to large buses; • Construction of Lilongwe eastern and western bypasses; • New urban expressway in Blantyre; • Major programme of improved pedestrian and cycle facilities in Lilongwe, Blantyre, Zomba and Mzuzu; • Improved traffic management and traffic signal provision in Lilongwe and Blantyre; • Bus Rapid Transit scheme in Lilongwe.

Source: GoM 2017, National Transport Master Plan

Institutional arrangements: The Ministry of Transport and Public Works has departments of Planning, Roads, Buildings, Marine, Railways and Aviation to oversee the policy function in the development of infrastructure. The agencies include the Roads Authority, the National Construction Industry Council and the Malawi Engineering Institution.

Legal frameworks: The legal framework under which the infrastructure operates is through parliamentary registration that establishes agencies that report through appointed Board of Directors. These agencies have developed guidelines that require all operational activities to follow them by submitting environmental and social management plans. These cover roads and buildings construction projects.

4.12.1 Vulnerabilities, Impacts, and Risks

Climate change is significantly impacting the infrastructure sector primarily through increased flooding, which damages roads and bridges, hydroelectric power plants, and facilities for drinking water supply, due to erratic rainfall patterns and more extreme weather events heavy storms and droughts. This vulnerability is further exacerbated by the country's existing weak infrastructure capacity. Tables 4.17 to 4.21 were compiled from a study by the Government of Malawi in the year 2020, titled: "Climate Adaptations for Roads: Guidelines for the Road Sector to Increase its Resilience to the Effects of Climate Change".

Flood damage: Frequent and intense rainfall leads to widespread flooding, damaging roads, bridges, and other infrastructure located near rivers and floodplains, causing disruptions to transportation and access to essential services.

Water resource management: Fluctuations in water levels in Lake Malawi and the Shire River due to changing rainfall patterns affects hydropower generation and water supply, putting pressure on water treatment plants.

Erosion and landslides: Heavy rainfall triggers soil erosion and landslides, damaging roads and infrastructure in mountainous areas.

Heat stress on infrastructure: Rising temperatures may lead to increased stress on infrastructure materials like asphalt, potentially causing premature deterioration.

Climate change poses significant risks to the infrastructure sector, primarily through increased flooding events which can damage roads, bridges, power lines, and other critical infrastructure, particularly in low-lying areas near Lake Malawi, due to heavy rainfall and extreme weather events associated with changing climate patterns. additionally, droughts can impact water supply infrastructure by lowering water levels in rivers and lakes.

Table 4-16: Impacts of climate change on infrastructure

Climate Change Event	Impacts on the Road, Bridge and Building Infrastructure
Precipitation changes: Extreme rainfall events / Increase/decrease of seasonal and annual rainfall	• Flooding of roadways and wash-away • Flooding of buildings • Loss of strength of layer materials, especially in the upper support layers of the road • Damage to thin bituminous surfacing • Damage to pavement edges • Softening of surfacing material of unpaved roads • Loss of shape of unpaved roads – more maintenance • Erosion and weakening of unpaved shoulders • Erosion of side and mitre drains • Increase in pore-water pressures in roads • Roadside erosion, landslides and mudslides that close or damage roads and cause siltation of drainage structures • Overloading and blockages of drainage systems, causing erosion and flooding • Impact on soil moisture levels in subgrades and structural layers, affecting the structural integrity of roads, bridges and buildings (both negatively and positively). • Adverse impact of standing water on the road shoulders and base • Traffic hindrance and safety • Excessive moisture in materials – construction delays • Reduced working periods and increased construction delays • Water damage to partially completed works • Need for more coffer dams or flood-control measures during drainage, bridge and buildings construction • More frequent bush clearing and vegetation control • Additional repairs required to drains • Increased and improved unpaved shoulder maintenance • Increased pothole patching and crack sealing of paved roads • Changes in rate of vegetation growth and type of vegetation • Higher maintenance costs
Decreased rainfall	• Drying out and shrinkage of subgrades • More loss of fines from unsealed roads • Less water for construction and maintenance • Change of vegetation types and runoff characteristics • Shrinkage of subgrade material leading to settling of building foundation
Temperature changes: Higher maximum temperature and higher number of consecutive hot days (heat waves)	• Concerns regarding pavement integrity, e.g. bitumen softening, traffic-related deformation rutting, embrittlement (cracking due to early oxidation), migration of liquid asphalt. • Impact on landscaping • Differential thermal gradients in large bridge members, steel furniture, etc. • Excessive drying out of unsealed road surfaces – more gravel loss, corrugations and dust • Quicker loss of construction water by evaporation • More rapid aggregate deterioration and cementation reactions • Extreme use of air conditioners leading to more energy consumption

Climate Change Event	Impacts on the Road, Bridge and Building Infrastructure
Drought (Consecutive dry days)	• Susceptibility to wildfires (more frequent and intense) that threaten the transportation infrastructure directly • Greater susceptibility to mudslides/debris flows in areas deforested by wildfires when rains do come • Consolidation/shrinkage of the substructure with differential settlement as a consequence • More generation of smog • Unavailability of water for compaction work • Drought increases mortality of sensitive plants along road alignments
Increased wind speed	• Threat to stability of bridge decks • Damage to building roofs and ventilation • Damage to signs, lighting fixtures, roadside furniture and supports • Higher wind speed causes the greater dynamic force of water generated by waves on road embankments • Windblown trees blocking the roadway • More movement of sand in dry areas (onto the road and into drains)
Foggy Days	• Traffic hindrance and safety • More generation of smog

4.12.2 Adaptation Strategies for the Infrastructure Sector

In Malawi, climate change adaptation in the transport sector primarily focuses on integrating resilience measures into infrastructure development, particularly for roads and bridges, by conducting climate risk assessments before construction to identify vulnerable areas and implementing design modifications to withstand increased floods, droughts, and extreme weather events, as mandated by the National Transport Policy, with the goal of minimising long-term reconstruction costs due to climate-related damage. It is worth noting at the outset that Malawi's transport infrastructure, particularly its road network, is highly vulnerable to climate change impacts. In light of the above, the Government of Malawi has incorporated climate change adaptation into its National Transport Policy, requiring climate risk assessments to be conducted for all new transport infrastructure projects. The implementation of adaptation strategies in the transport sector is to reduce loss of life, build safe infrastructure, and 3). Building long lasting infrastructure. When implementing climate change adaptation measures for the infrastructure sector, the following costs are likely to be incurred: (1) the cost of adapting (or if needed replacing) existing infrastructure; (2) the cost of building infrastructure that is needed but not yet constructed, whether or not there is climate change; (3) the additional costs of climate-proofing new infrastructure investments made in (2); and (4) the cost of building the institutional/governance capacity to organise the tasks listed in (1-3). Adaptation strategies for the transport sector comprise the following:

Design modifications: Implementing design features like raised road sections, improved drainage systems, and stronger bridge foundations to withstand increased water flow during floods.

Material selection: Choosing construction materials that are more resistant to weather extremes.

Early warning systems: Developing systems to monitor weather patterns and issue alerts for potential climate-related disruptions.

Maintenance practices: Prioritising regular maintenance and repair of existing infrastructure to mitigate damage from climate events.

Field observations have shown that immediate adaptation requirements in the transport sector in Malawi include raising road embankments, increasing free board in bridge design, providing check dams in side drains, and replacing wooden guardrails with concrete. Some additional actions may require tinkering adaptation policies, i.e., reviewing urban planning guidelines, reviewing policies on river bank building line and cultivation, reviewing the peak flood design estimation manual, reviewing the urban transport plan, enforcing existing and new resilient construction guidelines, reviewing materials and methods used in construction, ensuring that civic education is intensified to all the citizenry about the need for climate change adaptation in the transport sector, capacity building through training of all cadres of experts in the transport sector about the need for climate change adaptation, digitization all infrastructure drawings, and banning the provision of transport services to illegal developments

The government of Malawi through MDA's has established policies or guidelines for construction and maintenance of infrastructure to adapt to climate change impacts. Some of the policies adaptation measure are summarized in Tables 4.18 and 4.19.

Table 4-17: Some of adaptation measures for the infrastructure sector

Climate Change Event	Related Possible Adaption Measures
Precipitation changes: Extreme rainfall events / Increase of seasonal and annual rainfall causing flooding	• Stabilization of the base layer • Paving of unpaved surface (double bituminous surface dressing for the low volume roads) • Raising road elevation (at least 0.5m over the maximum flood level) • Lowering the road elevations and construction of "Irish-crossing" where flood water can pass the road above it. • Increase capacity of compaction for lower moisture percentage • Building of erosion protection • Building of gabions • Building of permeable roads • Building of debris deflectors • Building of rip-rap protection • Building of underdrains in build-up areas • Building of scour checks • Building of cut-off drains • Planting of grass sodding • Improving side and mitre drains • Adjusting (flattening and shaping) embankment slopes • Building of retaining walls in sections prone to land slides • Increasing size and number of drainage structures • Raising embankment height to avoid over-flooding • Updating design for drainage systems • Slope stability studies in an attempt to minimize mass movements and mudflows as a result of increased precipitation • Measures to enhance slope stability and prevent mass movements and rock fall • Building houses in higher places
Higher maximum temperature and higher number of consecutive hot days (heat waves)	• Heat resistant paving materials (use of stiffer binders) • Improved pavement material specifications • Consideration of polymer-modified bitumen • Advanced construction technologies • Use of green construction technologies • Use of eco-friendly building designs
Drought (Consecutive dry days)	• Dust can be avoided permanently through paving of the road surface (double bituminous surface dressing for the low volume roads)
Extreme wind speed	• Increase capacity of spillways and culverts • Embankment protection through tree plantings • Decrease road traffic during storms • Use of steel trusses than the traditional timber trusses
Fog	• Installation of reflective poles on the road edge

Table 4-18: Adaptation Priorities

Priority	Description
Reinforcing infrastructure building capabilities	This includes consolidating flood prevention and management resilience, and reinforcing public construction response capabilities. Adopting climate resilient infrastructure designs
Enhancing infrastructure's climate change adaptation capabilities	This includes reinforcing transportation system adaptation capabilities, and improving transportation system warning and response capabilities
Constructing new infrastructure	This can be an adaptation strategy for water utility protection
Maintaining and restoring wetlands	This can be an adaptation strategy for ecosystem protection
Investing in flood control, early warning systems, and improved building codes	These measures can help protect infrastructure from climate change impacts
Reducing greenhouse gas emissions	This is the primary cause of climate change

The National Transport Policy as well as the Construction Policy, and other relevant policies, address climate change adaptation. The policies address climate change adaptation mainstreaming in a number of ways summarized in Table 4.20.

Table 4-19: Climate change mainstreaming for the infrastructure sector

Setting up institutional or organizational structures	Management of climate-related risks by setting up a desk officer for climate change and adaptation in the MDA's Information and awareness decision-making is encouraged to take place on the basis of the best available knowledge with regard to, for example, climate data and potential implications of climate change for different regions and sectors, as well as potential adaptation options. Continuous efforts are being made to improve the quantity, quality and policy relevance of information, keeping in mind that uncertainties will always exist. A close relationship between policy makers, climate scientists, researchers and adaptation specialists is key Efforts are being made to make optimal use of the involvement of all stakeholders and ensure the success of adaptation mainstreaming, strong government leadership and coordinated action across government departments and agencies is needed, for example through an inter-departmental coordination mechanism. Without such coordination, fragmentation of government actions hinders efforts to minimize the risks associated with climate change. A challenge is often that this process is coordinated by a ministry of environment

Designing and implementing projects that automatically take adaptation into account	All donor funded projects promoters are required to give due consideration to the risk assessments and adaptation measures adequately improving resilience to climate change and environmental disasters. Specific technical measures in the infrastructure sector are the adaptation of railways and roads to higher temperatures, better surface asphalt for airport runways to cope with heat and extreme precipitation, and retrofitting existing infrastructure drainage systems.
Integrating climate considerations into strategies and operations of financial institutions	Aligning finance with the Paris Agreement Management of climate-related risks

4.12.3 Barriers, Constraints and Gaps

Key barriers to climate change adaptation in the transport sector include: limited funding for infrastructure upgrades, inadequate maintenance practices, lack of technical expertise to design climate-resilient infrastructure, poor data on climate risks, weak institutional coordination, and the country's high vulnerability to flooding, particularly impacting road networks (Table 4.21).

Financial constraints: Insufficient funding from the government and international donors to implement necessary adaptation measures, such as building flood-resistant roads and bridges.

Poor maintenance practices: Existing roads often lack proper maintenance, making them more susceptible to damage from heavy rains and floods.

Technical capacity gaps: Lack of engineers and technical experts with the knowledge to design and build climate-resilient infrastructure.

Data limitations: Insufficient climate data to accurately assess the risks posed by extreme we2.ather events, hindering targeted adaptation planning.

Institutional challenges: Poor coordination between different government agencies responsible for transport infrastructure and climate change adaptation, leading to fragmented and sometimes conflicting efforts.

Vulnerability to flooding: Large parts of Malawi are prone to flooding, causing significant damage to roads and disrupting transportation networks.

Community awareness and engagement: Limited understanding of climate change impacts and the need for adaptation measures at the community level, hindering participation in adaptation initiatives.

Table 4-20: Some barriers and gaps in the infrastructure sector

Barrier	Description
Capacity gaps	MDA's often have limited financial, technical and human resources to plan for a complex and contested issue such as adapting to climate change. They also have many competing issues that may take more immediate priority. This leaves MDA's without sufficient resources to undertake a comprehensive program of adaptation from planning through to implementation.
Uncertainty about the risks	While there is a broad consensus that the climate is changing, there is uncertainty around the scale of these changes. Scientific knowledge will continue to grow, but, as for many other types of risks, we will never have precise forecasts of the magnitude and timing of climate risks. It will be important to adopt an approach to planning that acknowledges and can accommodate uncertainty.
Limited local information	A lack of locally relevant and practical information about potential climate impacts may be compounded by a lack of technical expertise to interpret climate change projections for the local area. At best, this may mean employing consultants to support planning efforts; at worst, planning can stall and there is minimal or no adaptation.
Limited financial resources	Small to medium-sized MDA's, including local governments, often have limited funds to spend, and these are often prioritized to more immediate issues. However, developing an adaptation plan will help to identify: • low-regrets actions that deliver existing as well as future benefits actions that can be supported and funded through existing programs • how adaptation actions can be prioritized what needs to be done now and what actions can wait.
Lack of leadership	Leadership shapes the decision-making culture of the MDA's. This applies to both formal leaders in the MDA's – and also across the locality or sector – as well as informal leadership where someone champions action. Good leadership can inspire creativity and action, while poor leadership can make action difficult or impossible.
Decision-making culture of the organization	The culture of an MDA may limit effective planning for climate change: for example, if climate change is treated as an environmental problem (rather than something that can affect all aspects of an enterprise) then it may be silenced rather than being mainstreamed across all activities of the organization.
Regulatory and institutional frameworks	Local government requires strong and clear support from state government in order to progress adaptation, and this lack of support is a barrier to action.
Legal uncertainty	The risk of legal liability – and uncertainty about what is legally defensible – has been a strong concern for councils with respect to issues of climate change. Some legal opinion indicates that councils will be protected if they can demonstrate that they have used the best available science to inform their actions.

4.13 Wildlife

Malawi is home to a diverse range of wildlife that plays a crucial ecological and socio-economic role in the country's economy. The Government of Malawi, through the Department of National Parks and Wildlife (DNPW), has established five national parks—Nyika, Kasungu, Liwonde, Lengwe, and Lake Malawi, and four wildlife reserves—Vwaza Marsh, Nkhotakota, Mwabvi, and Majete (Figure 4.58, Table 4.22). There are also three nature sanctuaries in the three main cities in the country, namely: Michiru in Blantyre, Lilongwe and Mzuzu nature sanctuaries, collectively covering about 11.6 percent of the country's total land area. Additionally, there are numerous private wildlife ranches, including Kuti Community Wildlife Ranch, Nyala Park, Game Haven, and Kaombe Wildlife Ranch, among others.

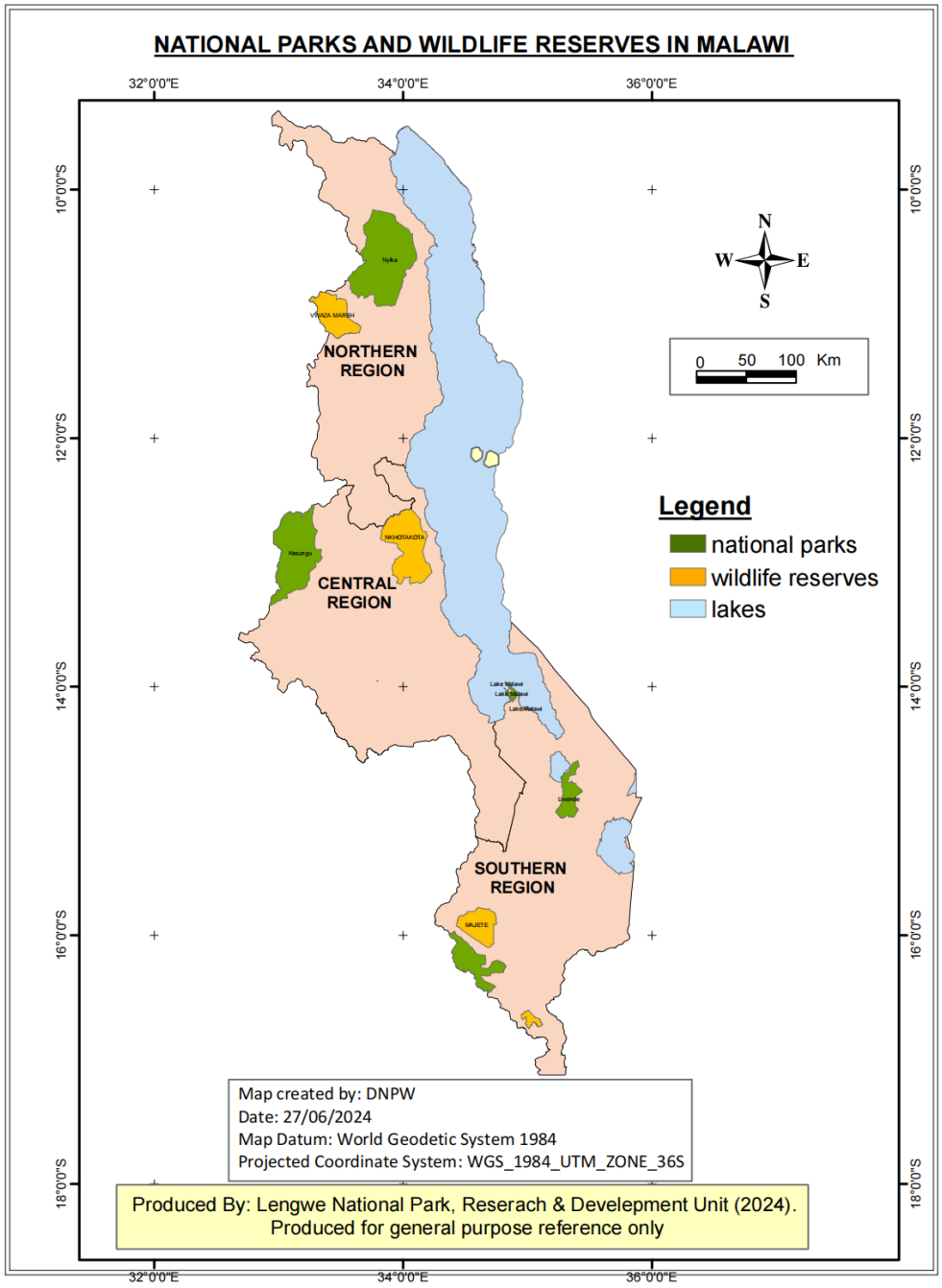


Figure 4-55: National Parks and Wildlife Reserves

Table 4-21: Area covered by National Parks and Wildlife Reserves

Category	Total Area(km^2)	National Parks and Wildlife Reserves
National Parks	3134	Nyika
	2316	Kasungu
	887	Lengwe
	548	Liwonde
	94	Lake Malawi
Wildlife Reserve	1802	Nkhotakota
	784	Majete
	340	Mwabvi
	978	Vwaza

Malawi boasts a rich diversity of animal species, including 207 mammal species, 658 bird species, 108 reptile species, 56 amphibians, and over 500 fish species found in Lake Malawi National Park (LMNP). However, the rapid decline of certain protected mammal species has diminished the value of many protected areas in Malawi, making it difficult to attract significant tourism and thereby reducing the country's competitiveness in the region. For instance, elephant populations, which were estimated at over 4,000 in the 1970s and 1980s, have now dwindled to just around 1,000. Black rhinos, Lions and African Wild dogs were locally extinct in the 1980s and 1990s, but have been successfully reintroduced in Liwonde National Park and Majete Wildlife Reserve, where their numbers are steadily increasing. Unfortunately, ivory trafficking, hunting for bushmeat, and illegal wildlife trade have been and still continue to be a menace. A key factor driving this illegal trade is the rising consumer demand in southeast Asia, particularly in China, for items made from ivory and Pangolin.

Wildlife resources provide the much-needed ecosystem services and goods for Malawi's socioeconomic development, particularly the interest they generate in tourists to view the "Big Five", namely: Elephant, Black Rhino, Buffalo, Lion and Leopard. The wildlife sector plays an important role in the conservation of biodiversity and the promotion of tourism in the country. Also, important rivers in the country arise from areas designated as National Parks and Game Reserves, hence the sector is key in water resources conservation. It is in light of the above that the Malawi Growth and Development Strategy III (MGDS III) identified wildlife as one of the sectors that could potentially contribute to the sustainable economic growth of the country. Wildlife is a tourism product, and the Department of Tourism is the mother organization.

4.13.1 Vulnerabilities, Impacts, and Risks

Climate change is significantly impacting the wildlife sector primarily through increasingly frequent and severe droughts, which affect animal reproduction, migratory patterns, and can lead to large-scale die-offs, particularly in areas like Lengwe National Park where the 1979/80 drought caused significant Nyala deaths. Other impacts include altered vegetation patterns and potential range shifts for wildlife due to changing climatic conditions.

Drought stress: This is the most significant impact, causing reduced water availability at watering holes, impacting animal reproduction rates, and forcing wildlife to migrate further in search of water sources.

Changes in vegetation: Shifting rainfall patterns can alter the composition and distribution of plant species, affecting the food availability for herbivores.

Increased fire risk: Longer dry seasons can lead to more frequent and intense wildfires, which may damage wildlife habitats and impacting animal populations.

Disrupted migration patterns: Animals that rely on seasonal migrations may be affected by changing weather patterns, causing them to migrate at different times or to different areas.

Species decline and potential extinction: Severe droughts and habitat changes can lead to population declines and even local extinction of vulnerable wildlife species.

In light of the above, impacts of climate change in Malawi are being manifested in various ways including intense rainfall, changing rainfall patterns, floods, and prolonged dry spells. An increase in temperatures and intense rain in Malawi over the past 40 years has led to both droughts and floods, resulting in shorter growing seasons, poor crop yields, food shortages, hunger, and the spread of disease in a country where 29 percent of the people already now live in extreme poverty. An increase in extreme weather events as a result of climate change will facilitate plant and animal invasions.

Invasive species can disrupt food webs and ecological balances, sometimes resulting in the local extinction of native species. Invasive Alien Species are very difficult to control and eradicate when they are fully established and pose irreversible ecological effects. Nyika National Park is one of the protected areas where this problem is prevalent. Pinus patula introduced to Nyika National Park in the 1960s has been invading the plateau and its riverine ecosystems, together with Bracken fern, replacing the native graces (GoM, 2015).

4.13.2 Adaptation Strategies for the Wildlife Sector

Adaptation strategies for climate change in the wildlife sector primarily focus on managing water availability through constructing watering points, improved fire management practices in protected areas, and considering animal translocation and breeding programs to help wildlife populations adjust to changing environmental conditions, particularly in response to increased drought events caused by climate change.

Water provision: this entails building artificial watering holes within wildlife reserves to provide access to water during dry periods.

Fire management: this involves implementing controlled burning practices to maintain healthy ecosystems and prevent uncontrolled wildfires exacerbated by dry conditions.

Animal translocation: this involves the relocating of wildlife populations to areas with more favorable conditions as their current habitats become unsuitable.

Breeding programs: these are captive breeding programs for vulnerable species to bolster populations impacted by climate change.

In the case of extreme climate change, compounded by animal populations that are at or near carrying capacity, conventional wildlife management techniques such as translocation, provision of artificial water supplies, and culling could be used. Considering the vulnerability of most protected areas in Malawi, solar-powered waterholes were drilled in the Lengwe in 2017 which is the principal ecosystem for the Nyala Antelopes. The provision of waterholes in the park has resulted in an improved animal sighting rate in the wider park as the animals are well distributed throughout the park.

Similar measures are planned for Kasungu National Park as the dry landscapes resulting from climate change are further exacerbating the human-animal conflicts in the protected area. Animals are roaming long distances in search of water and fodder, and cases of cross border incursions are very common (from Kasungu to Zambia and vice versa). (GoM,2024).

To improve ecosystem ecology in Liwonde National Park in response to the projected threat of climate change, a total of 636 animal species, which comprised 263 elephants, 80 buffaloes, 88 impalas, 109 warthogs, and 33 sable antelopes were translocated to Kasungu National Park elephants in 2022. In order to maintain healthy populations of animals and plant communities, it is recommended that elephant population density is kept at or below 0.5 animals per square kilometre throughout the park. The 2022 aerial count estimated the population at 447, of which 263 were relocated to Kasungu National Park. It was advised to decrease the elephant population, and to keep the density at or below 0.5 animals per square kilometre throughout the park.

The Government of Malawi is implementing several projects with a view to enhancing wildlife conservation and management. These include; the Shire Valley Transformation Project in Lengwe, Mwabvi, and Elephant Marsh, the landscape management project by the International Fund for Animal Welfare (IFAW) Project in Kasungu, and MWASIP in Lake Malawi National Parks, and Public Private Partnership in Wildlife Conservation and Management with a co-management agreement for Nyika and Vwaza being signed in 2023 between Peace Parks Foundation and Government for the management of the two protected areas of Nyika and Vwaza in northern Malawi.

To further the objectives of conservation and to benefit from interaction with other states, their agencies, and NGOs, Malawi's policy is to promote cooperation with regional and international institutions in the conservation and management of wildlife resources, including those that straddle international borders. A Transfrontier Conservation Area (TFCA) between Malawi and Zambia was established in 2004 with a Treaty signed by the Heads of States for Malawi and Zambia in July 2015. The TFCA has a number of protected areas, of different conservation status, covering about 28,000 km^2 which include: (a) Malawi side: Nyika National Park, Kasungu National Park and Vwaza Marsh Wildlife Reserve, and (b) Zambia side: Nyika National Park (Zambia), Lukusuzi National Park; Lundazi, Mitengi and Mikuti Forest Reserves and Musalangu Game Management Area. The Malawi -Zambia TFCA aims to promote and facilitate the development of a complementary network of protected areas within the Malawi-Zambia TFCA linked through corridors to safeguard the welfare and continued existence of migratory wildlife species including also issues of climate change.

To enhance the conservation and management of wildlife, the Department of National Parks and Wildlife entered into a Public-Private Partnership with the African Parks Network to manage Majete Wildlife Reserve in 2003, and Liwonde National Park and Nkhotakota Wildlife Reserve in 2015, respectively. The department has also entered into a comanagement agreement with Peace Parks Foundation to manage Nyika National Park and Vwaza Marsh Wildlife Reserve for 20 years, starting from 2023. These partnerships are envisaged to continue improving the management of the protected areas with animal populations and corresponding tourist numbers as has been the case with the earlier examples of Majete, Liwonde, and Nkhotakota. In 2022 Liwonde National Park managed to translocate about species to Kasungu National Park. Liwonde and Majete has also managed to reintroduce Wild Dogs which got extinct from the park a number of years ago.

4.13.3 Barriers, Constraints and Gaps

The primary barrier posed by climate change to the wildlife sector is severe drought, which disrupts animal reproduction, migration patterns, and may lead to mass die-offs, particularly impacting species like Nyala in areas like Lengwe National Park, as noted in the 1979/80 drought. Other barriers include changing rainfall patterns, altered vegetation, and increased frequency of wildfires, all impacting wildlife habitats and food sources.

Drought-induced water scarcity: Extended dry periods lead to limited access to water, forcing animals to concentrate around shrinking waterholes, impacting their ability to forage and raising competition for resources.

Habitat loss and fragmentation: Changing vegetation due to altered rainfall patterns can lead to the loss of suitable habitats for certain wildlife species, forcing them to migrate or face population declines.

Disrupted migration patterns: Animals that rely on seasonal migrations to access different food sources can be significantly impacted by changing weather patterns, leading to disruption in their natural movement.

Increased fire risk: Drought conditions can exacerbate wildfire occurrences, further damaging wildlife habitats and impacting animal populations.

Impact on prey species: Changes in plant growth due to climate variability can affect the abundance of herbivore prey, impacting predator populations reliant on them.

4.14 Forestry

Forests and woodlands provide social, economic and environmental benefits globally and nationally. They support livelihoods through the provision of shelter (house construction, and furniture), energy (fuel wood), shade, medicinal plants and food. Forest and trees also contribute to rural incomes through collection and sale of various forest products including non-timber forest products (NTFPs). Forests contribute to the economy of the country through timber exports and the provision of jobs in forestry. They also are important in the provision of ecosystem services such as nutrient cycling and soil formation. Despite their importance, forests are declining due to deforestation.

Forests in Malawi may be classified based either on land tenure or by type. When defined by type, forests are grouped into natural/indigenous or plantation forests. When classified by land tenure, Malawian forests are classified as Public, Customary or Private according to the Malawi National Land Policy (2002).

Government (protected) Forests on public land

Public forests include forest reserves, national parks and wildlife reserves. The Department of Forestry manages forest reserves and the Department of National Parks and Wildlife manages national parks and wildlife reserves. While the main objective of the DPW is to protect wild animals, all wildlife, including forests, is protected.

Customary Forests

Customary forests are those located on unallocated common access land, and Village Forest Areas (VFAs) under the jurisdiction of Traditional Authorities (TAs). They cover about 1.1 million hectares, 11.7 percent of total land area. The Forest Act (1997) allows for communities to form Village Natural Resource Management Committees (VNRMCs) for the management of these forests. Although there are no restrictions on forest product use for domestic purposes, a license is required by the VNRMC for commercial usage of forests.

Private Forests (leasehold and Freehold)

Private forests are either freehold, leasehold or privately-owned forests on customary land. Freehold forests are mostly owned by tea estates and leasehold forests are owned by tobacco estates.

4.14.1 Vulnerabilities, Impacts, and Risks

Malawi's forests are highly vulnerable to impacts of climate change, primarily due to the increasing frequency and severity of droughts, erratic rainfall patterns, and extreme weather events like floods and strong winds, which can lead to widespread tree die-off, reduced forest cover, and degradation of ecosystem services crucial for local communities.

Drought stress: Extended dry periods are a major threat, causing stress on trees and increasing susceptibility to forest fires, leading to significant loss of vegetation.

Erratic rainfall: Unpredictable rainfall patterns, including delayed onset and early cessation of rains, disrupt natural regeneration cycles in forests.

Flood impacts: While droughts are prevalent, certain areas are prone to flooding, which can damage tree roots and disrupt soil stability.

Reduced biodiversity: Climate change can lead to shifts in species distribution, potentially causing the loss of important plant and animal species within the forest ecosystem.

Charcoal production impact: Unregulated forest harvesting, especially targeting miombo woodlands to produce charcoal is affecting the natural tree regeneration (Kambewa et al., 2007). The net affect includes increased incidents of serious flooding. Past vulnerability assessments of the forest sector in Malawi to impacts of climate change used both the Holdridge and Gap Models (2021). The Holdridge Model was used to assess climate change impacts on various forest types, whereas the Gap Model was used to assess the impacts of climate change on individual tree species. Climate change projections show that some forests would significantly change while others would not (Figure 4.59).

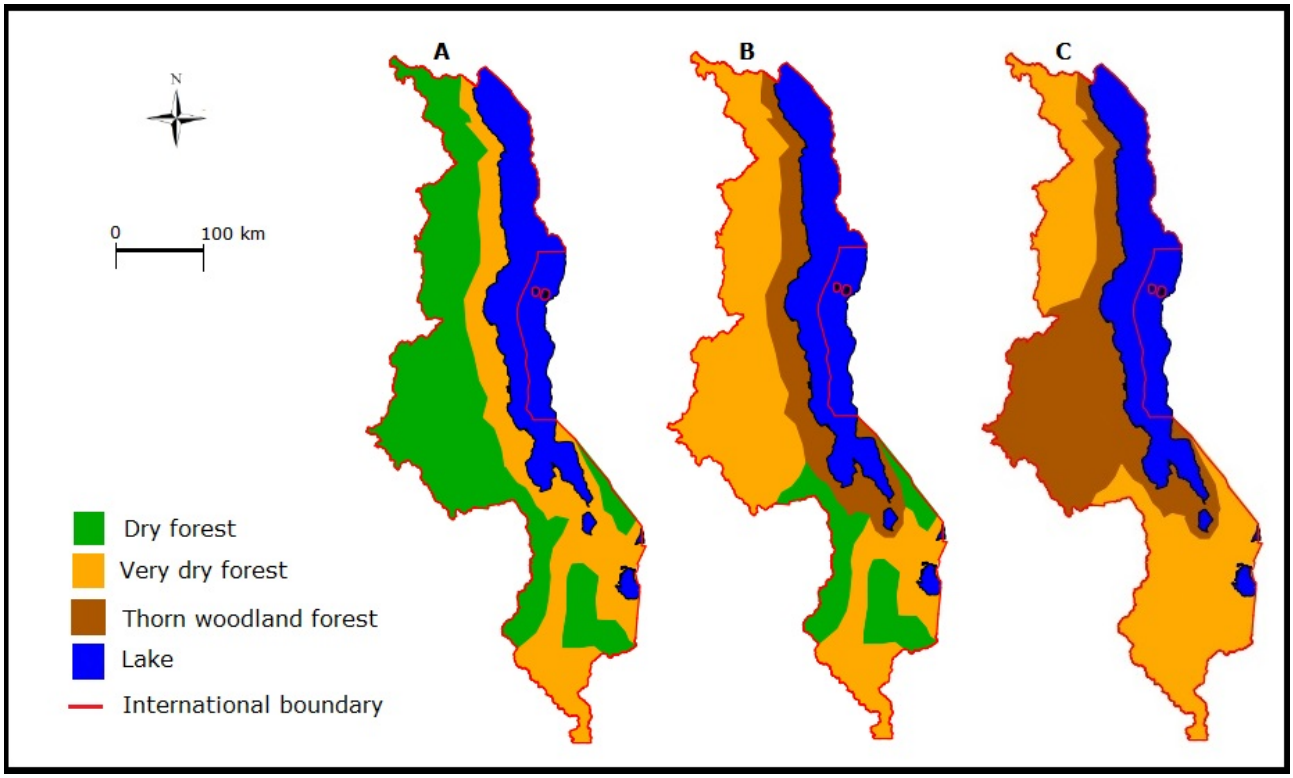


Figure 4-56: Impact of climate change on forest types using Holdridge Life Zone (HLZ) model under three scenarios, A: Near century (2011-2040); B: Mid-century (2041-2070); and C: End-century (2071-2100)

For example, the northern area and central area forests would change from dry forest in near century to very dry forest in mid-century. The central area forests would further change from very dry forest in mid-century to thorn woodland forest in end-century. The lakeshore area forests would change from very dry forest in near century to thorn woodland forest in mid-century. The shire highlands forest would change from dry forest in mid-century to very dry forest in end-century. However, the Shire Valley forests would not be affected by climate change.

4.14.2 Adaptation Strategies for the Forest Sector

Measures for forest sector adaptation to adverse impacts of climate change are primarily through initiatives like reforestation, planting drought-resistant tree species, community-based forest fire management, and improved forest management practices, aiming to lessen the severity of effects of increasing droughts, extreme weather events, and land degradation, while also preserving biodiversity and vital ecosystem services like water regulation and carbon sequestration.

Table 4.23 shows progress that has been made by the Government of Malawi in the implementation of NDCS Ambitions

Forest restoration and afforestation: Planting trees in degraded areas, particularly in the Shire River Valley, to increase forest cover and enhance carbon sequestration, while also improving water availability and soil stability.

Table 4-22: Progress made by the Government of Malawi in the implementation of NDCS Ambitions

Activity	2020/21 progress	2021/22 progress	2022/23 progress	2023/24 progress	2024/25 progress	Cummulative Achievements
Restore degraded landscapes through natural regeneration management in forest reserves and on customary estates	**9,437.92** hectares managed	**5,772.4** hectares managed	**9,214.36** hectares managed	**7,980.41** hectares managed	**4,833.06** hectares managed	**37,238.15** hectares managed
Rehabilitate government plantations	4,342.40 hectares planted	2,950.68 hectares planted	**2,704.27** hectares planted	**2,423.86 ha** planted	**3,693,340** seedlings produced to be planted to **2,797.98** hectares during 2024-25 National Forestry Season (NFS)	**12,421.21** hectares planted and a total of **20,089,337** seedlings produced

Restore customary estates through tree planting	**21,775.14** hectares **(54,422,077** tree seedlings and **15,767** bamboos planted)	**16,891.5** hectares **(42,228,748** seedlings planted)	**14,066.5** hectares (**35,166,264** tree seedlings)	**15,082.88** hectares (**37,707,190** tree Seedlings planted)	**17,818,411** tree Seedlings produced to be planted to an equivalent area of **7,127.36** hectares during the 2024-25 NFS	**67,816.02** hectares planted and a total of **187,358,461** seedlings produced
Undertake fire management through firebreak maintenance in plantations, forest reserves and forests on customary estates	**725.75** km maintained	**1,599.90** km maintained	**922.34** km maintained	**821.89** km maintained	**3,183.49** km maintained	**7,253.37** km of firebreaks maintained

Species selection: Promoting the planting of drought-tolerant and climate-resilient tree species that are better adapted to changing weather patterns, including indigenous species with high heat and drought tolerance.

Community-based forest management: Empowering local communities to actively participate in forest management through initiatives like fire management, sustainable harvesting practices, and tree planting programs to ensure long-term sustainability.

Forest fire prevention and control: Implementing strategies to prevent and combat forest fires, including early warning systems, firebreaks, and community-based fire suppression teams.

Monitoring and research: Conducting research to identify climate-sensitive forest areas, monitor tree health, and evaluate the effectiveness of adaptation measures.

Capacity building and awareness raising: Providing training and education to forest managers and local communities on climate change impacts and adaptation practices.

The Department of Forestry has developed the following strategies for addressing climate change:

National Landscape Restoration Strategy (NLRS, 2017): aimed at restoring ecological functionality to 4.5 million hectares by promoting landscape restoration in five strategic areas: agricultural technologies, community forests and woodlots, forest management, soil and water conservation and river and stream bank restoration;

National Charcoal Strategy (NCS, 2017): provides a guided framework to address problems of increased deforestation and increased demand of household cooking fuel. The strategy is aimed at setting Malawi on a path toward a diversified, sustainable and regulated household energy sector; while reducing deforestation and the associated impacts on rural livelihoods and the national economy;

National REDD+ Strategy (2020): seeks to maximise potential emission reductions by implementing targeted measures and activities that will lower net emissions by lowering rate of deforestation, lowering rates of forest degradation from unsustainable fuelwood harvesting, and enhancing carbon stocks through afforestation and reforestation; and

National Resilience Strategy 2018-2030 (2017): focus on resilience in agriculture, communities, and ecosystems, as well as cross-cutting disaster risk mitigation and response by promoting a theme of Catchment Protection and Management in integrated Watershed Management; Land and Forest Management, Restoration, and Conservation; Payment for Ecosystem Services; Forest-Based Enterprises; and Sustainable Energy as key strategic areas

As far as M&E of adaptation actions and processes is concerned,

The Department of Forestry launched the National Forest Monitoring Unit which has the specific charter to continually monitor natural and plantation forests within Malawi.

4.14.3 Barriers, Constraints and Gaps

Barriers to addressing impacts of climate change on the forest sector include widespread poverty, lack of access to funding for forest management initiatives, unsustainable agricultural practices leading to deforestation, poor forest governance, heavy reliance on firewood and charcoal for domestic cooking and heating, and limited awareness about the value of ecosystem services provided by forests.

Poverty and lack of economic incentives: Many communities rely on forests for subsistence livelihoods, leading to unsustainable harvesting practices due to limited alternative income sources.

Poor land tenure and governance: Unclear land ownership rights and weak enforcement of forestry regulations facilitate deforestation for agriculture expansion.

Subsistence agriculture: Shifting cultivation and expansion of agricultural land into forested areas are major drivers of deforestation.

Fuelwood dependence: High reliance on firewood and charcoal for cooking and heating puts pressure on forest resources.

Limited capacity for sustainable forest management: Lack of technical expertise and financial resources to implement effective forest management practices.

Climate change-induced stresses: Increasing droughts and extreme weather events exacerbate forest degradation, making it harder to regenerate forests.

Lack of awareness and community engagement: Inadequate knowledge about the importance of forests and the consequences of deforestation hinders participation in conservation efforts.

4.15 Information related loss and damage

"Loss and damage" is a general term used in UN climate negotiations to refer to consequences of climate change that go beyond what people can adapt to. For example, the loss of homes and lives during extreme floods. "Loss and damage" may result from extreme weather events such as cyclones, heavy storms, strong winds, droughts and heatwaves, as well as from slow-onset changes such as sea level rise, desertification, glacial retreat, land degradation, ocean acidification and salinization. Damages arising from the effects of climate change can be divided into two categories, namely: economic and non-economic, although oftentimes there is an overlap between the two. Economic losses and damages are those affecting resources, and goods and services that are commonly traded in markets, such as damage to critical infrastructure and property or supply chain disruptions. This can happen at an international, national, as well as a local scale, e.g., impacts on individual farmers or communities. Non-economic losses and damages maybe defined as occurrences such as the incalculable toll of losing family members, the disappearance of cultures and ways of living, or the trauma of being forced to migrate from ancestral homes.

COP 16 (2010) established a work programme on loss and damage with a view to considering approaches to address loss and damage, including impacts of extreme weather events and slow onset events in developing countries that are particularly vulnerable; and to strengthen international cooperation and expertise in order to understand and reduce loss and damage. The Subsidiary Body on Implementation (SBI) undertook technical work in the areas of: (i) assessing the risk of loss and damage; (ii) a range of approaches to address loss and damage; (iii) and the role of the Convention in addressing loss and damage.

At COP19 held in November 2013 in Warsaw, Poland, the Warsaw International Mechanism (WIM) for Loss and Damage associated with Climate Change Impacts (Loss and Damage Mechanism) was established in order to address loss and damage associated with impacts of climate change. The WIM is the main vehicle in the UNFCCC process to address loss and damage associated with climate change impacts in developing countries that are particularly vulnerable to climate change in a comprehensive, integrated and coherent manner. It is mandated, *inter alia*, to: facilitate support of action to address loss and damage; improve coordination; promote the development of, and compile, analyze, synthesize and review information; provide technical guidance and support; and make recommendations.

Under the international Paris Agreement on climate change, countries recognized the importance of "averting, minimizing and addressing" loss and damage. Loss and damage can be "averted" and "minimized" by curbing greenhouse gas emissions (mitigation) and by taking preemptive action to protect communities from consequences of climate change (adaptation). Climate change adaptation measures include protecting communities from sea level rise by helping them move to higher ground, preparing for extreme weather disasters by investing in early warning systems, protecting food supplies, switching to drought-resistant crops and much more.

Loss and damage is linked to adaptation and mitigation because it happens when efforts to reduce emissions are not ambitious enough and when adaptation efforts are unsuccessful or impossible to implement. The second instalment of the Intergovernmental Panel on Climate Change (IPCC) 6th Assessment Report, published in February 2022, acknowledges that as the magnitude of climate change increases, so does the likelihood of exceeding adaptation limits. It differentiates between "soft" limits — when adaptation options exist but communities don't have the financial resources needed to pursue them — and "hard" limits, where "there are no reasonable prospects for avoiding intolerable risks." These limits are particularly acute in vulnerable communities that lack the resources needed to implement effective adaptation options.

One reason why loss and damage has been so contentious historically is due to developed countries' concerns that compensating for losses and damages caused by adverse impacts of climate change may be construed as an admission of legal liability, triggering litigation and compensation claims on a major scale. As such, developed countries fought to include language in the Paris Agreement to prevent them from being legally responsible to provide compensation. In light of the above, a decision was reached at COP28 which states that "funding arrangements, including a fund, for responding to loss and damage are based on cooperation and facilitation and do not involve liability or compensation." This provided the assurance that developed countries were looking for to continue negotiations and set the loss and damage fund in motion.

Action to address loss and damage could span a range of activities and should be shaped by the communities experiencing climate change impacts. Examples include weather-indexed crop insurance for farmers or proactively setting aside funds to rebuild critical infrastructure when disaster strikes. It may also entail providing immediate humanitarian assistance after an extreme weather event; offering relief and rehabilitation to victims through provision of basic amenities; enabling social protection systems to provide emergency cash transfers to the poor; and enhancing microcredit institutions to provide financing for livelihood restoration. Loss and damage funding could also help people rebuild when their homes are destroyed. The UNFCCC has created a Loss and Damage Fund to help countries and communities that are most affected by climate change. The fund provides grant-based finance to these countries. To access these funds, developing countries considered "particularly vulnerable" to climate change can apply through the established mechanisms, likely involving the submission of proposals detailing their climate-related losses and damage, with eligibility and access procedures determined by the Fund's governing board, which will consider factors such as vulnerability, impact of climate events, and existing adaptation efforts.

Details about Loss and Damage that the Government of Malawi has incurred over the past 10 years has been discussed in Section 2.0, starting with severe floods of 2015. The January 2015 rainfall was the highest on record for Malawi, with a 1 in 500-year return period. The floods caused 106 deaths, displaced 230,000 people and affected more than 1 million population in 15 districts. The Post-Disaster Needs Assessment (PDNA) estimated damage and losses

amounting to USD335 million, equivalent to approximately 5.0 percent of Gross Domestic Product, and recovery and reconstruction needs at USD494 million. This was followed by the El Nino and Southern Oscillation (ENSO) phenomena induced drought episode in 2016, resulting in estimated losses of USD500 million - approximately a 1.7 percent reduction in the country's GDP. Then came Cyclone Idai and Cyclone Kenneth in 2019, which displaced tens of thousands of families, leaving many in need of basic supplies like food and water. The two cyclones brought widespread flooding and the destruction of almost 780,000 hectares of agriculture crops. Post-disaster needs assessments following Cyclone Idai and Cyclone Kenneth and the ensuing floods estimate total recovery needs for Malawi at USD370.5 million USD. The damage caused by Tropical Storm Ana amounted to an estimated USD3.2 million. Cyclone Ana knocked off 30 percent of Malawi's electricity generating capacity by destroying the pond at Kapichira Hydropower Station, with an estimated 945,000 people required humanitarian assistance due to the storm's effects. Cyclone Gombe in 2022 caused an estimated USD17 million in damages in Malawi, primarily impacting the agricultural sector with widespread crop damage and reduced yields while Tropical Cyclone Freddy in 2023, affected over 2.5 million people, causing over 600 fatalities, economic damage estimated at USD506.7 million and substantial agricultural losses.

In 2024 the rising water levels of Lake Malawi caused damage to property and loss of tourism business. An assessment of the damage to physical infrastructure and equipment of the tourism businesses along the shores of Lake Malawi due to the rising lake levels was estimated at MWK6.36 billion and MWK 2.5 billion in lost revenue (Jamal *et al.,* 2024). The loss of business was caused by booking cancellation, cost clearing debris, repairs to damaged infrastructure (Jamal *et al.,* 2024). Apart from causing permanent damage to the tourism infrastructure, the rising lake levels also affected the flow of international tourist to Lake Malawi (Jamal *et al.,* 2024), and probably the integrity of most buildings as their foundations and structures were compromised.

From the preceding discussion, it is clear that Malawi is vulnerable to a number of natural disasters caused by such hazards as floods, droughts and strong winds whose frequency of occurrence and magnitude will increase with climate change. As such, the Government of Malawi has invested a lot in improving early warning systems as well as the construction of infrastructure such as dykes to minimise loss and damage. Several hydrometerological stations have been rehabilitated and new ones established in order to enhance the early warning system. Two buoys have been installed on Lake Malawi to collect weather and climate data as well as water quality. A number of dykes have been constructed in flood prone districts of Nsanje, Chikwawa, Salima and Karonga in order to mitigate flood disasters. Oftentimes, the Government provides basic amenities and cash (through social cash transfers) to people affected by disasters. All loss and damage issues in Malawi are handled by the Department of Disaster Management Affairs (DoDMA) in collaboration with other relevant MDAs, NGOs, development partners, CSOs and local communities.

The following is a list of projects that have been or are being implemented in Malawi since 2021 to address "Loss and Damage" in the country:

Project 1:

Malawi Catastrophe Deferred Drawdown Option (Cat DDO)

Type: Development Policy Financing with Cat DDO

Years Active: 2021–2025

Total Cost: $70 million

Description: This instrument supported policy and institutional reforms to strengthen disaster risk management (DRM) and climate resilience. It was activated in response to events such as Tropical Storm Ana (2022), Cyclone Freddy (2023), and the ongoing El Niño drought (2024). The Cat DDO also supported the implementation of the Malawi DRM Bill and the National Meteorology Policy

Project 2:

Contingency Emergency Response Project (CERP)

Type: Emergency Response Mechanism

Years Active: 2024–2025

Description: The CERP was designed to provide rapid financing for emergency expenditures following disasters. It builds on lessons from previous CERCs and is aligned with the IPF policy for urgent needs

Project 3:

Malawi Resilience and Disaster Risk Management Project (MRDRMP)

Type of Project: Disaster Risk Management & Infrastructure Rehabilitation

Years: 2021–2025

Total Cost: $80 million

Description: This project focuses on rehabilitating critical infrastructure damaged by past disasters, such as irrigation schemes and drainage systems. It includes components to enhance drought and flood risk management, particularly in the Shire River Basin, and to strengthen disaster risk management capacities at national and local levels.

Project 4:

Malawi First Growth and Resilience Development Policy Operation with Catastrophe Deferred Drawdown Option (Cat-DDO)

Type of Project: Policy Reform & Contingent Financing

Years: 2023–2025

Total Cost: $137 million ($80 million immediate support; $57 million Cat-DDO)

Description: This operation supports structural reforms aimed at strengthening fiscal sustainability, stimulating private sector growth, and increasing resilience to shocks. The Cat-DDO provides immediate liquidity in the event of a natural disaster, enabling swift response to crises such as food insecurity exacerbated by climate events.

Project 5:

Regional Climate Resilience Program for Eastern and Southern Africa 2 (RCRP-2)

Type of Project: Regional Climate Resilience & Disaster Risk Management

Years: 2023–2028

Total Cost: $250 million ($240 million for Malawi; $10 million for African Union)

Description: RCRP-2 aims to protect nearly two million people from water-related climate shocks through resilient infrastructure, improved disaster risk management, and social protection systems. In Malawi, the project prioritizes the management of the Shire River Basin and enhances coordination with neighbouring countries to improve early warning systems and information sharing.

Project 6:

Malawi Drought Recovery and Resilience Project (MDRRP)

Type of Project: Post-Disaster Recovery & Resilience Building

Years: 2021–2025

Total Cost: $104 million

Description: MDRRP supports the restoration of agricultural livelihoods and the construction of flood protection infrastructure. It aims to enhance the resilience of communities affected by droughts and floods, contributing to long-term recovery and adaptation efforts.

Project 7:

Malawi Watershed Services Improvement Project (MWASIP)

Type of Project: Watershed Management & Rural Livelihoods

Years: 2020–2025

Total Cost: $157 million

Description: MWASIP focuses on restoring degraded landscapes and improving watershed services to enhance water availability and agricultural productivity. The project includes the construction of water infrastructure and supports sustainable land management practices to build resilience against climate-induced disasters.

Project 8:

Kapichira Hydroelectric Power Station Rehabilitation

Type of Project: Energy Infrastructure Rehabilitation

Years: 2022–2025

Total Cost: $60 million

Description: Following damage from Tropical Storm Ana, this project involves the rehabilitation of the Kapichira Hydroelectric Power Station to restore 130 MW of generation capacity, which is critical for national energy security and resilience.

Project 9:

Social Cash Transfer Program (SCTP) with Climate Risk Financing

Type of Project: Social Protection & Climate Risk Financing

Years: 2023–2025

Total Cost: $142 million ($125 million IDA grant; $17 million from the Global Risk Financing Facility)

Description: The SCTP includes mechanisms to scale up support to vulnerable households in response to climate-induced shocks, such as droughts. It leverages parametric insurance products and contingency financing to provide timely assistance, enhancing the resilience of poor and vulnerable populations.

Project 10:

Mpatamanga Hydropower Project

Type of Project: Renewable Energy Development

Years: 2025–2030

Total Cost: Over $1.5 billion (including $350 million World Bank grant)

Description: This public-private partnership aims to construct a 358 MW hydropower facility along the Shire River, doubling Malawi's current hydropower capacity. The project is expected to provide electricity to over one million households and contribute to climate mitigation efforts by expanding renewable energy sources

Project 11:

Malawi Agricultural Commercialization 1

Type: Agriculture productivity development

Years Active: April 2018– December 2024

Total Cost: $95 million

Description: The objective is to increase the volume, value and diversity of agricultural exports. The Project had a CERC which was activated twice in the project life providing a total of US$ 23.7 million ($20 million and $3.7 million) to damages and losses.

Project 12:

Malawi Food Systems Resilience Project (AGCOM II)

Type: Agriculture productivity development

Years Active: November 2024– August 2029

Total Cost: $ 376 million

Description: The objective of the Project is to increase resilience of food systems and the Recipient's preparedness for food insecurity. The Project has a CERC which has been activated twice providing a total of US$ 50 million ($20 million and $30 million) to damages and losses.

Project 13:

Governance to Enable Service Delivery

Type: Local authority governance

Years Active: 2020–2026

Total Cost: $135 million

Description: To improve the institutional capacity and performance of central government and local governments to deliver basic services. The Project has a CERC which has been activated once providing a total of US$35 million to damages and losses.

4.16 Implementation progress

The discussion on a number of adaptation strategies that have been adopted by the Government of Malawi to counter negative effects of climate change on various social economic sectors has been presented in great detail in the preceding sections, covering key sectors of agriculture, water, human health, energy, fisheries, tourism, infrastructure including transport, human settlement and housing), wildlife, and forestry. Preliminary findings from the country's NDCs Stocktake, covering the period 2021-2025, show that the Government of Malawi is making good progress in the implementation of projects/activities pertaining to climate change adaptation. A few examples are given below for sectors of agriculture and water resources.

4.16.1 Agriculture Sector (Agriculture, Livestock, and Fisheries)

Conservation agriculture: crop residue and rotation

NDCS Action 1 *Identify target area or location for increase in hectares to be covered under conservation agriculture, spread across agro-ecologic*

Response: All zones in the 8 ADDs in 28 districts

NDCS Action 2 *Implement conservation area incrementally in the target area or location, in regions of quick gains, by 20,000 Ha per year.*

Response: Annually more than 20,000 hectares per year for the country has been achieved

NDCS Action 3 *Undertake conservation training and skills programmes in target areas,*

Response: Yes trainings have been done mostly in catchment areas as well as in agricultural sections by frontline staff

Conservation agriculture: conservation tillage

NDCS Action 1 *Identify target area or location for increase in hectares to be covered under conservation agriculture, spread across agro-ecological zones*

Response: All ADDs involving all Districts have earmarked to participate in the intervention

NDCS Action 2 *Implement conservation area incrementally in the target area or location, in regions of quick gains, by 40,000 Ha per year.*

Response: Annually around 20,0000 ha per year have been achieved.

NDCS Action 3 *Undertake conservation training and skills programmes in targets areas.*

Response: Trainings to both staff and farmers in catchment areas have been done in all the 8 ADDS involving all the Districts.

NDCS Action 4 *Roll-out and upscale conservation agriculture practices and training.*

Response: These are being rolled out in many sites across the country.

Promotion of efficient fertiliser use and manure management

NDCS Action 1 *Identify target area or location for increase in hectares to be covered by manure management, spread across agro-ecological zones.*

Response: All 8 ADDs covering 28 Districts are targeted.

NDCS Action 2 *Implement manure-management and compost-making measures and training in target regions, in increments of 50,000 Ha annually.*

Response: These have been implemented across the districts and the increasing cost of fertilizers have catalysed the interventions.

NDCS Action 3 *Roll-out and upscale efficient fertilizer use and manure management and training.*

Response: Most staff farmers are promoting this.

Improved rice management practices

NDCS Action 1 *Identify target area or location for increase in hectares to be covered under improved rice management, spread across agro-ecological zones.*

Response: Most irrigation schemes growing rice have been targeted.

NDCS Action 2 *Implement improved rice management across 30,000 Ha per year of farms in the targeted area (falling to 10,000 Ha per year).*

Response: Only less than 15,000 hectares per year have been achieved.

Conservation tillage within for commercial crop farming

NDCS Action 1 *Identify target area or location for increase in hectares to be covered under conservation agriculture, spread across agro-ecological zones.*

Response: All 8 ADDs, covering all the 28 Districts.

NDCS Action 2 *Implement conservation area incrementally in the target are or location, in regions of quick gains, by 40,000 Ha per annum.*

Response: This is happening across the 28 Districts.

NDCS Action 3 *Undertake conservation training and skills programmes in targets areas.*

Response: Trainings are being conducted for both staff and farmers in the target areas.

NDCS Action 4 *Roll-out and upscale conservation agriculture practices and trainings*

Response: Trainings are being conducted for both staff and farmers in the target areas.

4.16.2 Water Sector (Drought Management, Flood Management, and Integrated Catchment Management)

Water supply, storage, harvesting in drought-prone areas, including water point rehabilitation

NDCS Action 1 *Formally update and adopt Malawi's national drought plan, to include identification of priority drought-response investments*

Response: Done

NDCS Action 2 *Align the national drought plan with the national water resources management master plan, including priority new supply and storage*

Response: Done

NDCS Action 3 *Mobilize resources for the continued implementation of drought-response measures (in addition to existing measures and programmes*

Response: Done

NDCS Action 4 *Scale up pilot projects and demonstration projects to more drought-prone areas*

Response: Done

Construction of multipurpose dams for water storage

NDCS Action 1 *Review and update the plans of water supply department with a focus on drought management and climate change adaptation*

Response: Done

NDCS Action 2 *Continue resource-mobilization and implementation of ongoing plans for priority water supply projects in water-scarce or water stressed areas*

Response: Done

Integration of indigenous knowledge into early warning systems for drought

NDCS Action 1 *Compile and consolidate existing research on indigenous knowledge on climate hazards and disaster management; identify gaps*

Response: Not done

NDCS Action 2 *After gap identification, conduct targeted additional research (including collection of field data) on indigenous knowledge*

Response: Not done

NDCS Action 3 *Develop an inventory of all relevant indigenous knowledge, cross-referenced with modern scientific approaches applicable*

Response: Not done

NDCS Action 4 *Conduct pilot projects and small-scale tests of the application of indigenous knowledge in disaster response, to test validity and results*

Response: Not done

NDCS Action 5 *Integrate the lessons from the indigenous knowledge applications into revision of national and sectoral DRR / DRM plans & strategies*

Response: Not done

Planning, construction, and improvement of flood management structures such as upstream dams, storm drains, dikes, and bunds

NDCS Action 1 *Develop a focused national flood response plan (see also above), to include delineation of flood-risk areas, integrating climate change*

Response: Not done

NDCS Action 2 *Complete, approve, and adopt focused national flood response plan, as above*

Response: Not done

NDCS Action 3 *Align the national flood plan with the national water resources management master plan, as above*

Response: Not done.

NDCS Action 4 *Continue resource-mobilization and scale-up for priority flood risk prevention, response, and management projects, as above*

Response: Not done.

NDCS Action 5 *Scale up pilot projects and demonstration projects to more flood-prone areas, as above*

Response: Not done

Extension of the installation of telemetry flood forecasting and warning systems to other flood prone areas

NDCS Action 1 *Develop a focused national flood response plan (see also above), to include expansion of telemetry systems for EWS in flood-prone areas*

Response: Partially done

NDCS Action 2 *Complete, approve, and adopt focused national flood response plan, as above*

Response: Not done

NDCS Action 3 *Align the national flood plan with the national water resources management master plan, as above*

Response: Not done

NDCS Action 4 *Continue resource-mobilization and scale-up for priority flood risk prevention, response, and management projects, as above*

Response: In progress

NDCS Action 5 *Scale up pilot projects and demonstration projects to more flood-prone areas, as above*

Response: Not done.

Development and strengthening of water policies, integrated land use management policies, plans and approaches in priority watersheds and reservoirs

NDCS Action 1 *Initiate revision and strengthening of forestry and wildlife sector policies, plans, strategies to integrate watershed management and adaptation*

Response: In progress.

NDCS Action 2 *Complete revision and strengthening of forestry and wildlife policies, plans, strategies to integrate watershed management and adaptation*

Response: In progress

NDCS Action 3 *Monitor and track progress on implementation of the revised forestry and wildlife sector plans, in relation to watershed protection*

Response: In progress

NDCS Action 4 *Monitor and track progress on implementation of the revised forestry and wildlife sector plans, in relation to watershed protection*

Response: In progress

NDCS Action 5 *Evaluate the need for further reforms in the enabling environment in forestry and wildlife sectors, in relation to watershed protection*

Response: In progress.

Increase of afforestation and reforestation in catchment areas to cover areas not yet considered, and address deforestation and degradation

NDCS Action 1 *Identify target area or location for increase in hectares to be covered under protective forests and afforestation for catchment management*

Response: In progress

NDCS Action 2 *Implement tree planting and maintenance incrementally in targeted area (+ training for forest managers and communities involved*

Response: In progress

Increase of sustainable utilization and monitoring of groundwater resources

NDCS Action 1 *Update Malawi's Integrated Water Resources Management policy, strategy, and master plan, with consideration of climate change (see below)*

Response: Revised National Water Policy and Strategy done.

NDCS Action 2 *Based on the updated plans, develop an investment plan and resource mobilization strategy (including for groundwater monitoring)*

Response: Investment plan being developed

NDCS Action 3 *Mobilize additional resources for priority water resources management projects (including expanded groundwater resources monitoring)*

NDCS Action 4 *Initiate incremental roll-out and scale-up of water resources management investments (including groundwater resources monitoring)*

Response: Investment plan being developed, but groundwater monitoring being done.

NDCS Action 5 *Continue incremental roll-out and scale-up of water resources management investments (including groundwater resources monitoring)*

Monitoring of leakage and control in piped networks

NDCS Action 1 *Update Malawi's Integrated Water Resources Management policy, strategy, and master plan, with consideration of climate chang (see above)*

Response: Done.

NDCS Action 2 *Based on the updated plans, develop an investment plan and resource mobilization strategy (including for piped water leakage monitoring)*

Response: Investment plan being developed, but monitoring of Non-Revenue Water (NRW) in pipe systems being done.

NDCS Action 3 *Mobilize additional resources for priority water resources management projects (including expanded piped water leakage monitoring)*

Response: Water leakage monitoring being done=

NDCS Action 4 *Initiate incremental roll-out and scale-up of water resources management investments (including piped water leakage monitoring)*

Response: Water leakage monitoring being done.

Water use efficiency

NDCS Action 1 *Update Malawi's Integrated Water Resources Management policy, strategy, and master plan, with consideration of climate change (see above)*

Response: Done

NDCS Action 2 *Based on the updated plans, develop an investment plan and resource mobilization strategy (including for water use efficiency practices)*

Response: Investment plan being developed.

NDCS Action 3 *Mobilize additional resources for priority water resources management projects (including efficient practices by water users and water boards*

Response: Being done

NDCS Action 4 *Initiate incremental roll-out and scale-up of water resources management investments (including water efficiency practices by users and water boards)*

Response: Investment plan being developed, but water efficiency practices being promoted

NDCS Action 5 *Continue incremental roll-out and scale-up of water resources management investments (including water efficiency practices by users and boards)*

Response: Investment plan being developed, but water efficiency practices being promoted

Improvement in the coverage of rural piped water supply

NDCS Action 1 *Update Malawi's Integrated Water Resources Management policy, strategy, and master plan, with consideration of climate change (see above)*

Response: Done

NDCS Action 2 *Based on the updated plans, develop an investment plan and resource mobilization strategy (including for water quality monitoring systems)*

Response: Investment plan being developed, but water quality monitoring being done.

NDCS Action 3 *Mobilize additional resources for priority water resources management projects (including expanded water quality monitoring systems)*

Response: Investment plan being developed, but expanded water quality monitoring systems being promoted.

NDCS Action 4 *Initiate incremental roll-out and scale-up of water resources management investments (including expanded water quality monitoring systems)*

Response: Investment plan being developed, but expanded water quality monitoring systems being promoted

NDCS Action 5 *Continue incremental roll-out and scale-up of water resources management investments (including expanded water quality monitoring systems)*

Response: Investment plan being developed, but expanded water quality monitoring systems being promoted

4.17 Monitoring and evaluation

The Monitoring and Evaluation (M&E) process is crucial for ensuring project success and organizational learning as it helps to track progress made, identify challenges early on, and make data-driven decisions for improvement. Through this process, organizations collect and analyze data, and determine if a project/program has fulfilled its goals. Monitoring begins right away and extends through the duration of the project. Evaluation comes after and assesses how well the program performed. Because organizations track, analyze, and report on a project during the monitoring phase, there is more transparency. Information is freely circulated and available to stakeholders, which gives them more input on the project. A good monitoring system ensures no one is left in the dark. This transparency leads to better accountability. It is worth noting that projects never go perfectly according to plan, but a well-designed M&E helps the project stay on course and perform well. By analyzing both successes and failures, M&E facilitates learning and informs future strategies. M&E systematically tracks a project's progress against its goals and objectives. This allows for early identification of potential problems or bottlenecks, enabling timely corrective actions. By providing a clear record of activities, results, and challenges, M&E promotes accountability among project staff and stakeholders. It also allows for transparent reporting to donors and beneficiaries. M&E plans help define a project's scope, establish interventions when things go wrong, and give everyone an idea of how those interventions affect the rest of the project. This way, when problems inevitably arise, a quick and effective solution can be implemented.

Every project needs resources. How much cash is on hand determines things like how many people work on a project, the project's scope, and what solutions are available if things get off course. The information collected through monitoring reveals gaps or issues, which require resources to address. Without M&E, it would not be clear what areas need to be a priority. Resources could easily be wasted in one area that is not the source of the issue. Monitoring and evaluation helps prevent that waste. By optimizing resource allocation and improving project implementation, M&E contributes to greater efficiency and effectiveness in achieving project goals. Furthermore, M&E helps to ensure that projects are sustainable by identifying long-term challenges and opportunities for improvement. The knowledge gained from M&E provides a strong foundation for future planning, ensuring that projects are well-designed and aligned with organizational goals.

It is worth noting at the outset that the responsibility to conduct Monitoring and Evaluation (M&E) of government funded projects in Malawi rests with the Ministry of Economic Planning and Development (EP&D). At district level the onus rests with the Director of Planning while at the community level the responsibility rests with both Area Development Committees (ADCs) and Village Development Committees (VDCs). All projects related to natural resources management are managed by Village Natural Resources Management Committees (VNRMCs) at the local level, supported by Catchment Management Committees (CMCs). Considering that most of the natural disasters that take place in Malawi are caused by climate related hazards such as floods, strong winds and droughts, it is imperative that the institutional structures mentioned above should be play a key role in conducting M&E using a set of indicators to ensure that projects are implemented on time.

4.18 Cooperation, Good Practices, Experience and Lessons Learned

There are a number of things that other countries may learn from Malawi as far as climate change adaptation is concerned, mainly in the area of institutional arrangement, collaboration among various stakeholders, and community involvement in the formulation and implementation of adaptation projects. At national level, the focal point of climate change issues in Malawi is the EAD, with Focal Persons in various government ministries and departments. These focal persons meet on a regular basis to assess the performance of climate change related projects and to review consultancy reports pertinent to climate change. The Focal Persons are also key in mainstreaming climate change in respective MDAs. For NGOs and CSOs, the platform used for dealing with climate change issues in the country is the CISONECC. CISONECC is network organization for coordinating civil society initiatives for climate change management and disaster risk reduction. Established in 2008 and registered with the government of Malawi under the Trustees Incorporation Act and Council of Non-Governmental Organizations (CONGOMA) as a Non-Governmental Organization, CISONECC exists to facilitate collaboration and provide policy positions to relevant stakeholders including government and policy makers on Climate Change Adaptation and Mitigation (CCAM) and Disaster Risk Management (DRM) in the country. CISONECC's work hinges on advocacy through collective engagement with duty bearers, individual-member lobbying activities, solidarity work with other CSOs networks and special model projects. The CISONECC exists to facilitate collaboration and provide policy positions to relevant stakeholders including government and policy makers on Climate Change management and Disaster Risk Management in the country. The network was established in 2008 and it is registered with the government of Malawi under the Trustees Incorporation Act and CONGOMA as a Non-Governmental Organization.

The Government of Malawi uses Farmer Field Schools and Lead Farmers as a means of training smallholder farmers, *inter alia*, on issues pertinent to climate change adaptation in the agriculture sector. For example, the Malawi Watershed Services Improvement Project (MWASIP) uses FFS to equip local communities with the requisite skills to adopt land husbandry practices through the implementation of sustainable land management (SLM) activities. As such, a number of farmers have been trained in the districts of Mangochi (Lower Lingamasa Catchment), Machinga (Lisanjala Catchment), Zomba (Namitembo Catchment, Milale Catchment, Linthipe Catchnment, and Mgonanyani Catchment), Blantyre (Nkajidi Catchment, Namitondo Catchment, Nkaladzi Catchment, and Mulanga Catchment), Ntcheu (Lisungwi Catchment, Mvunguti Catchment, Nyuluzi Catchment, and Likuzi Catchment), Neno (Chekucheku Catchment, Golden Catchment, Mkulumadzi Catchment, and Mfundazi Catchment), and Balaka (Lower Livilidzi Catchment). Farmer Field Schools (FFS) are experiential learning programs that empower farmers with knowledge and skills to improve their agricultural practices through hands-on, participatory learning. They emphasize group-based learning, observation, analysis, and experimentation on local farms to enhance decision-making and promote sustainable agriculture. FFS are designed

as a collaborative learning environment where farmers actively participate in the learning process. Participants learn by doing, engaging in activities like observing crops, analyzing soil, and conducting experiments directly on their farms. FFS help farmers understand the complex interactions within their agro-ecosystems, enabling them to make informed decisions about resource management and crop production. By observing, analyzing, and experimenting, farmers develop critical thinking skills and the ability to make informed decisions about their farming practices. FFS promote sustainable agricultural practices such as integrated pest management, organic farming, and agroecological approaches. FFS foster a sense of community among farmers, providing a platform for sharing knowledge, experiences, and problem-solving. FFS aim to improve farmers' livelihoods, enhance food security, and promote environmental stewardship. In essence, Farmer Field Schools offer a dynamic and effective way to empower farmers with the knowledge and skills they need to adapt to changing agricultural landscapes and build more resilient and sustainable farming systems.

Lead farmers are experienced and respected farmers within a community who are selected and trained to act as a bridge between agricultural extension services and other farmers. They play a crucial role in disseminating new technologies and farming practices, often serving as trainers, mentors, and role models for their peers. Essentially, they are farmer-to-farmer extension agents. Lead farmers are usually chosen by their fellow community members or by extension agents, based on factors like their farming success, willingness to learn and share, and leadership qualities. They receive specialized training on specific agricultural technologies and practices relevant to their area, often provided by government extension services or agricultural projects. Lead farmers then use their knowledge and skills to train and mentor other farmers in their community. This might involve conducting demonstrations on their own farms, organizing group training sessions, or providing individual guidance. The lead farmer approach helps accelerate the adoption of new technologies, improve agricultural practices, and ultimately increase food security and livelihoods for smallholder farmers.

From initial findings of Malawi's NDCS Stocktake, it is apparent that there is a general consensus among stakeholders that climate change issues should be addressed in a holistic manner using ecosystems bnased approaches that include integrated catchment management. This entails both the implementation of physical measures intended to address either climate change mitigation or adaptation, as well as exploring ways of enhancing rural livelihoods, considering that adverse impacts of climate change are fuelled and aggravated by anthropogenic activities. In light of the above, in addition to constructing storm bunds and swales and planting vetiver grass to curb soil erosion, and encouraging rural communities to promote forest regeneration, communities are given financial support to run small businesses to sustain rural livelihoods, thereby preventing the target communities from cutting down trees for charcoal production as the main source of livelihood.

Also, as a good practice, it has been noted that some Local Indigenous Knowledge Systems and Practices (LIKSPs) can be supported scientifically. Such LIKSPs should be used to complement scientific findings for developing early warning systems (EWS). It is also important touse participatory scenario planning (PSP) integrating Ik and scientific knowledge systems.

4.19 Other Information Related to Climate Change Impacts and Adaptation

Also, as a good practice, it has been noted that some Local Indigenous Knowledge Systems and Practices (LIKSPs) can be supported scientifically. Such LIKSPs should be used to complement scientific findings for developing early warning systems (EWS). There is very little to report under this topic apart from highlighting the novel approaches adopted by the Government of Malawi in using Framer Field Schools and Lead Framers to address climate change adaptation at the community level and the incorporation of LIKSPs to complement scientific methods of EWS.

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5.0 INFORMATION ON FINANCIAL, TECHNOLOGY DEVELOPMENT AND TRANSFER AND CAPACITY-BUILDING SUPPORT NEEDED AND RECEIVED UNDER ARTICLES 9–11 OF THE PARIS AGREEMENT

5.1 National circumstances, institutional arrangements and country-driven strategies

5.1.1 Systems and processes used to identify, track and report support needed and received

Mobilization of climate finance in Malawi is guided by the National Climate Change Management Policy - NCCMP (GoM, 2016), the National Vision through the MIP-1 (GoM, 2021a) and the updated Nationally Determined Contributions – NDCs (GoM, 2021b). The NCCMP provides overall strategic direction for climate change management which includes climate finance.

In order to identify, track and report on support needed and received, Malawi has put in place different coordination and reporting mechanisms. In chapter 1, Figure 1-1, Malawi's Institutional Framework for climate change coordination was presented. It shows that the Cabinet Committee leads all climate work and enables all arms of government to coordinate their climate change actions. Below it is the Parliamentary Committee which serves to assist in lobbying for passing of environment related policies and legislations in the national assembly. This obligation includes oversight on climate finance needed and mobilized. Both committees work together with the Development Cooperation Group on Environment, Resilience and Climate Change (DCERCC).

Alongside the NDCs, Malawi has also developed a resource mobilization strategy (May, 2022) with three main areas of action namely 1) institutional framework, 2) capacity building and enhanced capacities and 3) financing mechanisms and instruments. With support from Green Climate Fund (GCF), the government in consultation with various stakeholders, is in the process of establishing a National Climate Change Fund (NCCF). When operational, the fund will be a single institutional framework that will act as basket for domestic and international resources and coordinating climate change funds. Further, a Finance Management Information System (MIS)[60] has been developed to track inflows of climate resources towards climate change related interventions by different stakeholders, including international NGOs; bilateral and multilateral institutions; development banks; United Nations programmes; academic institutions; the private sector and various non-state actors.

60 https://www.ccfinancemw.com/

5.1.2 Priorities and strategies on NDCS under Article 4 of the Paris Agreement that need support

Under the updated NDCS, Malawi revised the sectoral mitigation and adaptation targets up to 2040. The NDCS demonstrates the commitment of the Government of Malawi to meet its obligations towards addressing the challenges of climate change. The NDCS articulates areas of priority for climate change management through both mitigation and adaptation measures needed to address challenges of climate change. Malawi has presented 115 measures in its NDCS. Of these measures, 35 measures are related to mitigation while 80 measures relate to adaptation.

5.1.3 NDCS measures that need support

Identified measures in the NDCS that require support have been reported under section 1.3.2. It is worth noting that most of the financial support needs are reflected within the NDCS framework.

5.2 Underlying assumptions, definitions and methodologies

5.2.1 Assumptions and definitions

The BTR1 covers the period from 1 Jan 2021 – 31 Dec 2023. The format of tables presented in the report was informed by the Common Tabular Formats (CTF) for the electronic reporting in Decision 5/CMA.3, but due to limited space in presenting tables in the chapter, selected columns were not illustrated in the chapter. This information for the columns not included in the chapter are included in the Common Tabular Formats (CTFs) for the relevant sections that supported the compilation of the chapter. Other assumptions and definitions for this chapter have been elaborated in Table 4.2-1.

5.2.1.1 Currency conversion

In this report, estimation to the USD equivalent has been done either using official agreement exchange rate or using historical data found on oanda website (https://www.oanda.com/currency-converter). Further, estimation of the Malawi Kwacha (domestic currency) provided has been done using 1146.94 Malawi Kwacha to 1 USD as an average exchange rate at the time of reporting (see Table xxx). This is as provided by the Reserve Bank of Malawi (https://www.rbm.mw).

Table 5-1: Currency conversion for the reporting period

Currency	2021 (MWK)	2022 (MWK)	2023 (MWK)	2024 (MWK)	Average (2021-2024)
USD to MWK	800.13	930.41	1,134.53	1,722.78	1,146.96
EURO to MWK	945.98	1,001.57	1,281.29	1,921.09	1,287.48

The rest of the assumptions are outlined in Table 1.2.2 below:

Table 5-2: Assumptions and definitions

Item	Topic/issue	Assumption(s) made
1	Estimation of the amount of support needed	The amount of support needed has been estimated using national documents such as NDCs, NDCS Resource Mobilization Strategy and National Climate Change Investment Plan (NCCIP) of 2013.
2	Determination of the reporting year or time frame	This report has covered support needed and received covering the year 2021 to 2022. This aligns with the revised NDCS implementation period which commenced in 2021. Considering that most of the support provided is project based, apart from reporting on projects that started in 2021, this report has also included information on projects that started before 2021 but ended or extended beyond 2021.
3	Determination of support as committed or received	This report has determined support committed as that in which a funding institution has provided an award letter for or where an agreement is in place. Further, support is determined to be received if the amount has been moved by the donor to the recipient organization or MDA.
4	Identification and reporting of the status of the supported activity (planned, ongoing or completed	The activity is said to be planned if both the start and end date of the activity are in the future and the disbursements will not have started. For ongoing activities Implementation will have started and financial resources may or may not have been disbursed. Status is said to be completed if implementation is complete and the support disbursed fully.
5	Identification and reporting of the channel (bilateral, regional or multilateral)	The channel through which the support is provided is bilateral if the donor or development partner is a country or private company, and is multilateral if development partner is a UN Agency (e.g. UNDP) or multilateral bank (e.g. WB). The channel is regional if the support is coming from a regional body such as SADC, COMESA or Africa Union. It is worth noting that regional support also includes initiatives funded by a single donor or multilateral institution that covers different countries. In this report, such support has been classified as regional support.
6	Identification and reporting of the type of support (mitigation, adaptation or cross-cutting)	Projects or activities that will result in reduced GHG emissions have been considered as mitigation measures while those that will be taken to minimize the negative impacts of climate change have been considered as adaption measures. Those measures that will have both mitigation and adaptation attributes have been considered as cross-cutting
7	Identification and reporting of the type of support by instrument (grant, concessional loan, non-concessional loan, equity, guarantee or other)	In this report (unless otherwise stated) grant, concessional loan, non-concessional loan, equity, guarantee and other have been defined as follows: **Grant:** Funds provided with no obligation to pay back for defined activities and within an agreed timeframe. These are either provided wholesome or in tranches. **Concessional loan:** Loans provided on terms substantially more generous than loans available on the market. **Non-concessional loan:** Loans provided at near or at market rates **Equity:** Finance available on the basis of gaining a share in the receiving entity with the right to receive a portion of the profits. **Guarantee:** A legally binding agreement under which the guarantor agrees to pay any or all of the amount due on a loan instrument in the event of non-payment by the borrower. **Insurance:** Insurance policies provide for the credit agency to re-imburse the lender for losses up to a certain percentage of the credit covered and under certain conditions. **Other:** Any other funding mechanism not aligned to any of the definitions above.
8	Identification and reporting of sectors and subsectors	Identification and reporting of sectors and sub-sectors has been guided by IPCC Guidelines and classification.

9	Reporting on the use, impact and estimated results of the support needed and received	The use, impact and estimated results of the support needed and received have been obtained from individual projects description which includes project objectives and results framework/theory of change.
10	Identification and reporting of the support as contributing to technology development and transfer and capacity-building	The primary objective of the activity has been assessed to see if it relates to technology development and transfer or capacity building or both.[61]
11	Measures to avoid double counting	In order to determine financial support coming from specific sources and to avoid double counting, an analysis of each of the projects and activities was done in order to separate amounts contributed by each funding source. Particular attention was paid to identifying names of projects, amounts of funding associated with each project and period of implementation and names of implementing agencies. This has been particularly done for multi-sectoral projects with different funding sources such as the Shire Valley Transformation Project (SVTP) and the Malawi Watershed Services Improvement Project (MWASIP) and others. Further, project or activity funding has been separated based on whether funding has been committed or received.

5.2.2 Methodologies used in compiling information in this chapter

In delivering this chapter the following steps were taken:

a. Reviewed relevant documents, including national climate action plans, reports, funding proposals and project documents;

b. Engaged key stakeholders, including government ministries, department and agencies, international organizations, civil society groups, and private sector entities, to gather information on support needed and received;

c. Collected and analysed data on financial resources, technology development and transfer, and capacity-building support, including their sources, allocation, utilization, and impact;

d. Carried out Quality Control (QC) on the data using data from other sources such as OECD datasets and individual donor agencies particularly information published online. Links to this information have been provided; and

e. Identified gaps, challenges, and lessons learned in accessing and utilizing the support, and recommend strategies for improvement.

61 This is in line with both the Technology Needs Assessment report for Malawi and the 2021 Climate Change Learning Strategy

5.3 Information on financial support needed under Article 9 of the Paris Agreement

5.3.1 Priority sectors for international climate finance

Malawi's climate finance and resource mobilization drives have historically faced insurmountable challenges which ultimately lead to climate finance gaps. Some of the issues that contribute to climate finance gaps include (i) the government of Malawi's heavy reliance on aid and international partners for financing development programmes and infrastructure, (ii) growing Balance of Payment (BoP) deficits due to an over-dependence on agriculture and tobacco as foreign currency earners, (iii) the limited involvement of private sector investment in environment and climate change activities, and (iv) high levels of informal economy which limits the scope of the government to collect taxes and initiate domestic resources mobilization strategies for climate change programmes.

Based on Malawi's circumstances, multi-lateral development banks such as the World Bank, the EIB and the AfDB are preferred due their attractive debt terms and the ability to unlock inflows from other sources. Priorities for climate financing for Malawi are in both adaptation and mitigation and have been defined in the NCIP and the revised NDCs. Table 4.3-1 below outlines prioritized sectors under which Malawi wishes to attract international climate finance.

Table 5-3: Priority sectors for international climate finance

Climate Action/Sector		**Source of funding**	
Mitigation		Bilateral	Multilateral
Sector	Activity		
Energy	Electricity Generation	✔	✔
	Transport		✔
	Buildings	✔	
	Agriculture		✔
Waste	Solid Waste		✔
	Wastewater		✔
Agriculture	Crop Management		✔
	Livestock		✔
Forest and Land Use		✔	✔
	Adaptation		
Climate Services		✔	✔
Water	Drought Management	✔	✔
	Flood Management	✔	✔
	Integrated Watershed Management	✔	✔
Biodiversity & Ecosystems	Conservation of biodiversity		✔
	Resilient Ecotourism		✔
Agriculture, Livestock and Fisheries		✔	
	Flood Proofing		✔

Human Well Being	Health	✔	✔
	Nutrition	✔	✔
	Social Support	✔	✔
Cross-cutting		✔	✔

5.3.2 Estimate of funding needed

Malawi needs substantial financial resources in order to achieve its ambition on climate as outlined the updated NDCs and other national policies on climate. Overall, Malawi needs a total of around US$41.8 billion for mitigation priorities, and US$4.5 billion for adaptation priorities, representing a combined funding requirement of over US$46.3 billion from 2020 through 2040. Detailed description has been provided in CTF III.6.

5.3.2.1 Mitigation

As shown in **Table 4.5** below, in order to achieve it ambition on mitigation, Malawi needs a total of US$24.6 Billion from external sources to complement un-conditional resources that will be raised domestically.

Table 5-4: Financial support needed (mitigation)

Mitigation activity, Programme, Project or Other (2020 – 2040)	Funding needed (US$M)	Is the activity anchored within the NDCS?
Grid-connected hydropower generation	8300	Yes
Off-grid small scale solar PV systems	4	Yes
Grid connected large scale solar PV	1100	Yes
Grid connected wind power	479	Yes
Clean Coal technology - high efficiency coal-fired power plant	7500	Yes
Clean Coal technology - Carbon Capture and Storage (CCS)	4800	Yes
Modal shift: private to passenger transport	97	Yes
Modal shift: road to rail freight	6.45	Yes
Increasing ethanol blending with gasoline as a transportation fuel	253	Yes
Blending biodiesel with diesel as a transportation fuel	16	Yes
Increased use of rice husk ash (RHA) in blended cement	3	Yes
Earth stabilized blocks (ESBs) as building materials	1	Yes
Sustainable forest and landscape management	549	Yes
Alternative low carbon cement processes	1	Yes
Support industries involved in carbon capture utilization and storage	1	Yes
Landfill gas (LFG) utilization	102	Yes
Waste to Energy (WtE)	169	Yes
Waste-water treatment and reuse	67	Yes
Promotion of efficient fertilizer use and manure management	221	Yes
Improved rice management practices	100	Yes
Improved livestock husbandry	72	Yes
Improved livestock and breed management	700	Yes
Improved farm management	39	Yes
Total	**24,580**	

5.3.2.2 Adaptation

In terms of adaptation, Malawi will require approximately US $2.2 Billion through 2040 in order to achieve its ambition (see Table 4.3-3).

Table 5-5: Financial support needed (adaptation)

Adaptation Activity, Programme, Project or Other (2020 – 2040)	Funding needed (US$ M)	Is the activity anchored within the NDCS?
Community-based EWS and flood monitoring in problematic rivers	180	Yes
Designing, testing, and executing multi-hazard contingency plans	100	Yes
Integrating DRM risk assessment and monitoring in all sectors	20	Yes
Water supply, storage, harvesting in drought-prone areas	54	Yes
Construction of multipurpose dams for water storage	90	Yes
Integration of indigenous knowledge into EWS for drought	11	Yes
Planning, construction, and improvement of flood management structures such as upstream dams, storm drains, dikes, and bunds	151	Yes
Delineation of flood prone areas with flood zoning maps and the development of appropriate adaptation strategies and measures	90	Yes
Extension of the installation of telemetry flood forecasting and warning systems to other flood prone areas	54	Yes
Development and strengthening of water policies, integrated land use management plans in priority watersheds and reservoirs	25	Yes
Increase sustainable utilization & monitoring of groundwater resources	20	Yes
Improvement in the coverage of rural piped water supply	55	Yes
Development of nationwide water quality monitoring framework systems	25	Yes
Promotion of cooperation with regional and international institutions in the conservation and management of wildlife resources	15	Yes
Provision of watering points at strategic locations of national parks	30	Yes
Upscaling of measures for controlling the extinction of plant & animal species	50	Yes
Management of elephant population & implementation of diseases' control	50	Yes
Development & implementation of tourism support infrastructure plan	7	Yes
Development of a tourism crisis management strategy and plan	9	Yes
Improvement of tourist facility/buildings designs	18	Yes
Membership of the Climate Change Crisis Committee	18	Yes
Mainstreaming climate change adaptation in tourism investment plans	8	Yes
Institute and upscale drought mitigation interventions	35	Yes

Mechanize agricultural production with support to smallholder farmers	60	Yes
Establish grain export processing zones & develop resilient value chains	15	Yes
Crop and diet diversification through the cultivation of roots and tubers	12	Yes
Promotion of legumes and other multiple impact crops for soil fertility improvement and dietary improvement	30	Yes
Promotion of various drought-resilient water, soil and catchment conservation interventions on and off-farm	20	Yes
Instituting and upscaling drought mitigation interventions such as the development of new irrigation schemes	20	Yes
Introduction, expansion, & scale-up of CSA practices	20	Yes
Crop/livestock and fish farming intensification & diversification	30	Yes
Expand Greenbelt initiative	30	Yes
Strengthening of farmer organizations and market engagement	20	Yes
Restocking strategic grain reserves	20	Yes
Up-scaling feed preservation & fodder banks	12	Yes
Improving agricultural value-addition through agro-processing	15	Yes
Improving infrastructure in agricultural value chains	20	Yes
Provision of agricultural input subsidies & incentives	5	Yes
Promotion of drought tolerant or early maturing planting material	10	Yes
Constructing water reservoirs & efficient use of water	26	Yes
Soil management techniques to improve soil fertility and soil conservation	10	Yes
Minimizing hard landscaping materials which absorb heat during the day and re-radiate it at night	15	Yes
Application of ventilation and cooling strategies	8	Yes
Application of drought management in the design, construction and management of public and private infrastructure	67	Yes
Applying safety and build better and smarter principles	100	Yes
Revision of existing building standards	90	Yes
Conducting slope stability studies to reduce incidents of landslides	30	Yes
Construction of offshore breakwaters, groins to protect shorelines	30	Yes
Increase practices of boiling drinking water, filtration and chlorination of drinking water and improvement in personal hygiene	15	Yes
Enhance public awareness about water, sanitation & hygiene practices	15	Yes
Enhance health surveillance of Malaria, Diarrhea and Malnutrition	20	Yes
Promotion of insecticide-treated mosquito nets		Yes

Increase adoption of oral rehydration salts	15	Yes
Conducting of nutrition assessment, counselling, and support services	20	Yes
Promotion of dietary diversity & integration of nutrition-sensitive practices	15	Yes
Promote nutrition-specific practices	25	Yes
Preparation of long-term workforce development plans	25	Yes
Establishment of Social Support Fund for predictable, timely response (Climatic shock related Social Protection services)	80	Yes
Linkage of inclusive social support systems to risk financing options	35	Yes
Strengthen governance	90	Yes
Total	**2,185**	

5.3.2.3 Cross-cutting

An analysis of the funding needed shows that US$0.753 Billion is needed to implement cross – cutting measures (see Table 4.3-4).

Table 5-6: Financial support needed (cross-cutting)

Cross-cutting Activity, Programme, Project or Other (2020 – 40)	Funding needed (US$ M)	Is the activity anchored within NDCS?
Agroforestry	6	Yes
Conservation agriculture: crop residue incorporation and rotation	236	Yes
Conservation agriculture: conservation tillage	1	Yes
Afforestation (protective forests, woodlots and urban forests)	480	Yes
Promotion of drought-resilient water, soil and catchment conservation through farmer-managed natural regeneration	30	Yes
Total	**753**	

5.4 Information on financial support received under Article 9 of the Paris Agreement

During the reporting period, a total of US$3.045 Billion was either committed or received by Malawi for various projects and programmes in different sectors. However, only US$ 0.875 Billion was actually received. This represents 29% of the total funding earmarked for climate action (see Figure 4.5-1)

Detailed description of financial support received has been outlined in CTF III.7.

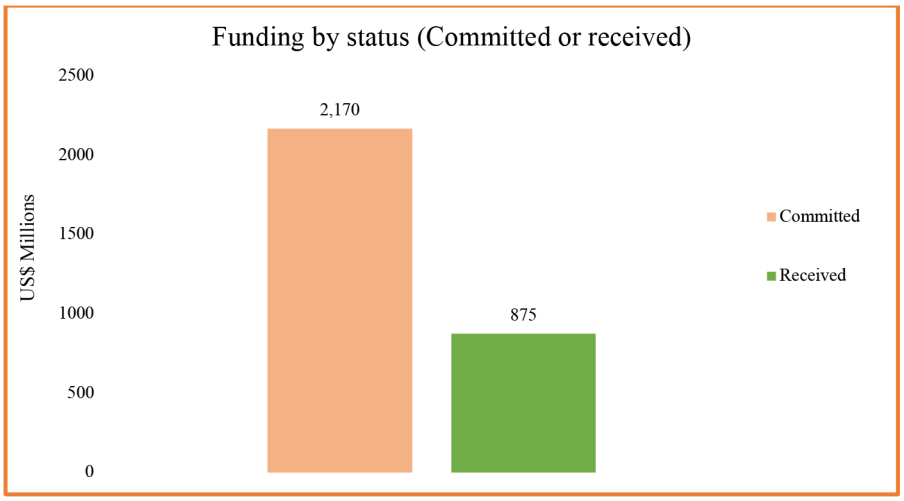


Figure 5-1: Funding committed or received

A total of US$ 1.7 Billion (either committed or received) was allocated to adaptation representing 56% of the committed or received funding. Cross-cutting and mitigation funding amounted to US$0.72 Billion and US$ 0.6 Billion respectively (see Figure 4.4-2)

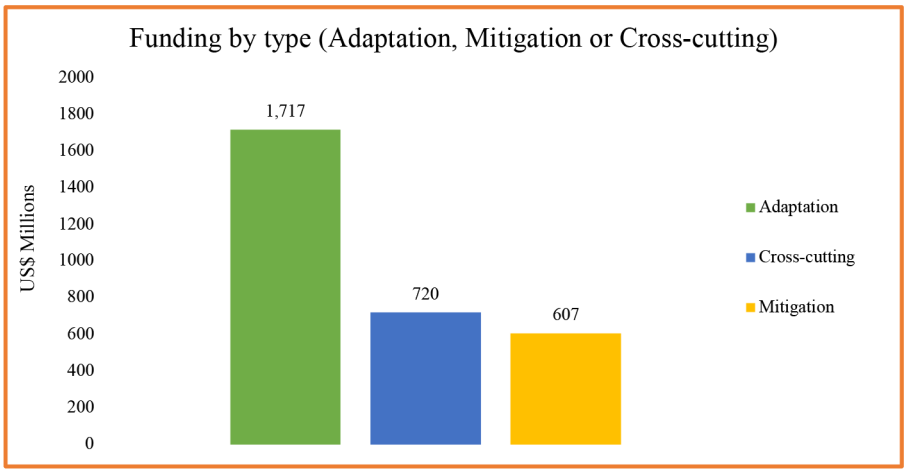


Figure 5-2: Funding by type (adaptation, cross-cutting or mitigation)

Out of the total funding committed or provided, US$ 0.5 Billion was for projects or activities that have been completed, US$1.436 Billion for on-going activities while US$1.1 Billion is for planned activities.

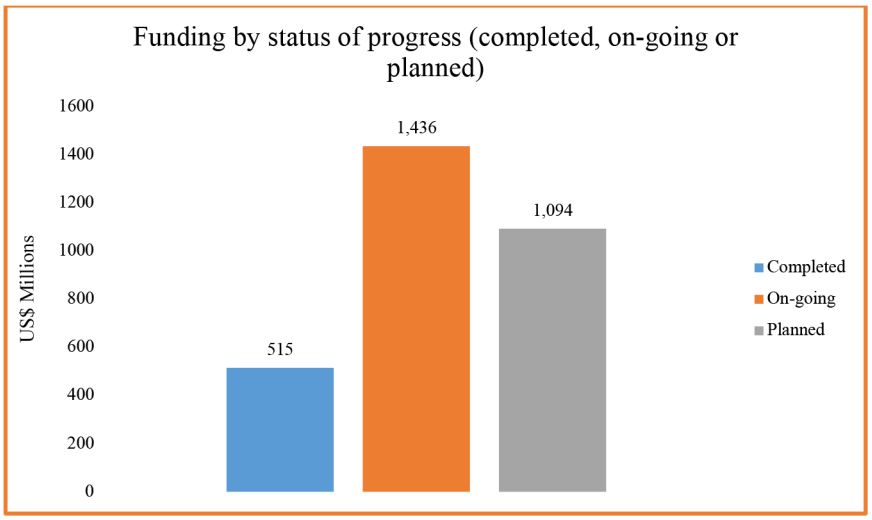


Figure 5-3: Funding by status of activities (completed, on-going or completed)

Grant funding constituted a bigger proportion of funding committed or received (i.e. 67%). Further, 33% of the funding is a combination of a grant and another financial mechanism (concessional loan or guarantee). Only 0.6% has been recorded as a concessional loan.

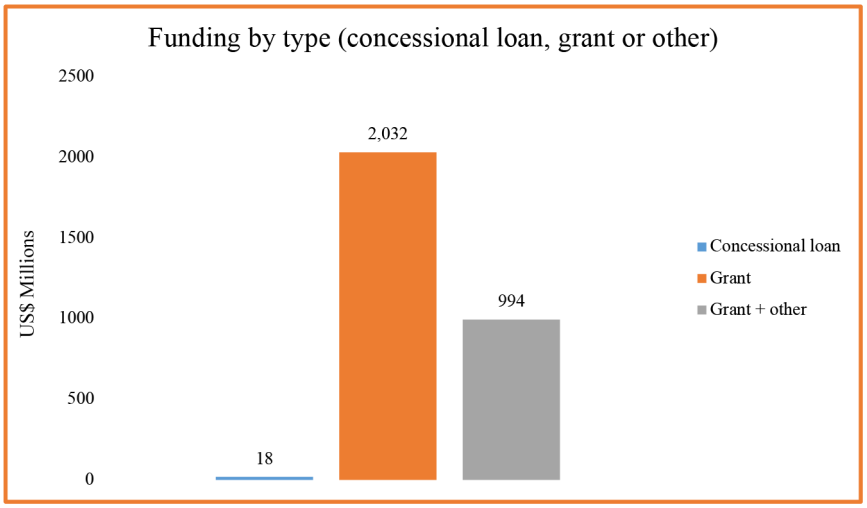


Figure 5-4: Funding received by type (concessional loan, grant or other)

5.5 Information on technology development and transfer support needed under Article 10 of the Paris Agreement

5.5.1 Plans, needs and priorities related to technology development and transfer

Malawi underwent a Technology Needs Assessment exercise targeting adaptation and mitigation in 2020[62]. Climate adaptation and mitigation technologies for key sectors were identified and taken through the prioritization process using a participatory Multi-Criteria Analysis (MCA). These sectors include agriculture, water, energy and forestry. A gender responsive approach was mainstreamed in the prioritisation process through inclusion of gender-related criteria to help prioritise climate technologies that could contribute to promotion of gender equality and economic empowerment of women and girls. In each sector, the top climate adaptation and mitigation technologies were selected. These technologies are presented in Table 4.5-1

Table 5-7: Priority technologies for climate adaptation and mitigation across sectors

Sector	Key technologies prioritized	Description of the technology	Related needs for the enhancement of endogenous capacities
Energy	Promotion of liquefied petroleum gas (LPG) for household cooking	As a cooking fuel, LPG is seen by the International Energy Agency (IEA) as one of the plausible main means for moving away from unsustainable use of biomass for cooking. The Government of Malawi also identified it as one way of reducing deforestation.	Awareness raising on LPG as a cooking fuel as well as improvement in the gas storage and distribution networks in the country.
	Promotion of biofuel as vehicle fuel	Biofuels are fuels produced directly or indirectly from organic material including plant materials and animal waste. Biofuel used in the transport sector could be fuel grade ethanol and biodiesel from energy crops such as sugar cane and Jatropha respectively. Fuel grade Ethanol is blended with petrol at blending ratios of 20:80.	Further research needs to be supported on possibility of higher blending ratios between ethanol and petrol. Further, there is need for increased production of raw materials used for production of ethanol and bio-diesel.
	Biomass gasification technology	Biomass gasifiers are energy systems that generate combustible gas (syngas) from solid biomass (any solid carbonaceous material) through series of thermo-chemical processes. The advantage of biomass gasification is that using the syngas is potentially more efficient than direct combustion of the original biomass because syngas can be combusted at higher temperatures or even in fuel cells so that the thermodynamic upper limit to the efficiency defined by Carnot's rule is higher. The syngas could be used in fuel cells and internal combustion engine.	Support for local institutions that are developing the technology such as Chitedze Agricultural Research Institution and at Jesuit Centre for Ecology and Development.

62 https://tech-action.unepccc.org/country/malawi/

Energy	Lake Malawi hydrokinetic electric power technology	Enormous electricity could be produced from hydrokinetic power extracted from Lake Malawi. From science, due to boundary layer phenomenon, the velocity of water flow increases from the lake bed with height until reaching the maximum velocity, and then it decreases unto to the water surface. It is thus, possible to place a turbine at a position of maximum water flow velocity to harness maximum hydrokinetic power.	Support for further research on the feasibility of the technology.
	Promotion of improved charcoal production kilns	Improved charcoal production kilns have the potential to increase production efficiency of charcoal reducing wastage of biomass.	Capacity building for licensed charcoal producers on the technology.
	On-grid and off-grid Solar PV Technology	Solar photovoltaic (PV) cells convert sunlight directly into electricity. Currently, crystalline silicon (c-Si) and the thin-film (TF) technologies dominate the global PV market. In a c-Si PV system slices (wafers) of solar-grade (high purity) silicon are made into cells that are assembled into modules and electrically connected. TF PV technology consists of thin layers of semiconducting material deposited onto relatively inexpensive, large-size substrates such as glass, polymer or metal.	Capacity building for local companies to assemble and install Solar PV technology
Forestry	Forest landscape restoration	Forest landscape restoration (FLR) is the process of regaining ecological functionality and enhancing human well-being across deforested or degraded forest landscapes. FLR is more than just planting trees – it is restoring a whole landscape to meet present and future needs and to offer multiple benefits and land uses over time	Preservation of indigenous species of trees and other plants utilizing local knowledge systems in combination with scientific knowledge.
	Efficient use of forest products	A forest product is any material derived from forestry for direct consumption or commercial use, such as wood, timber and poles. Wood by far the dominant product of forests in Malawi, is used for many purposes, such as source of energy (e.g. in form of firewood and charcoal), and as materials for construction (timber for construction).	Engagement of local artisans and other forest users as stakeholders in forest management.
	Urban forestry	Urban development results in the depletion and degradation of natural trees and forests in and around urban areas causing loss of vital ecosystem services and, potentially, rendering little resilience to disasters, such as those from climate change impacts. As Malawi continues to urbanize, with insufficient and or absence of strategic planning, it will result in unsustainable patterns of land use, which could exacerbate the mentioned challenges.	Capacity building on land use planning and development of urban green spaces with emphasis on urban forestry.
Agriculture	Landscape restoration for improved land productivity	A technology of regaining ecological functionality across deforested or degraded landscapes.	This technology requires sufficient local capacity building in addition to continued extension support for sustained adoption.

Agriculture	Integrated crop-livestock-aquaculture-forest production systems	a technology which integrates four different production systems within the same area or farmland in order to maximize its production capacity. The interaction between the production systems generates mutual benefits. In addition, a diversified portfolio of production systems ensures increased resilience of the farming households from climate variability and changes.	This technology requires sufficient local capacity building in addition to continued extension support for sustained adoption.
	Community based agricultural extension	A technology based on the idea of providing specialized and intensive technical training to 1 or 2 people in a community who then promote a variety of appropriate technologies and provide technical services with occasional support and review from a supporting organization	Initial local capacity building is required supplemented by backstopping support from frontline agricultural extension agents
Water	Rainwater harvesting	A technology through which rainwater is captured from manmade surface catchments such as rooftops, and road drainage and culverts, and stored in reservoirs or storage tanks for use during dry periods	Capacity building for local artisans to manufacture and install water harvesting equipment.
	Integrated river basin management (IRBM)	IRBM is an approach of looking at the whole river basin at a time, understanding different components of the basin, and manipulating how these can work together in order to sustainably supply water for different types of uses in the face of climate change.	Capacity building for local communities to understand the technology and related benefits.
	Integrated flood management	An integrated technology to flood management. It integrates land and water resource development in flood-prone areas and aims to minimize damages and losses associated with floods, and maximize the net benefits from the use of alluvial-rich soils of the floodplains for farming.	Capacity building for local institutions and communities on flood hazard mapping, flood proofing of critical infrastructure and provision of early warning information systems.

5.6 Information on technology development and transfer support received under Article 10 of the Paris Agreement

Malawi has received technology development and transfer support from a number of bilateral, regional and multilateral mechanisms as outlined in CTF III.9. Table xxx below outlines common technologies that have been supported including how the technology is contributing to enhancement of endogenous capacities and know how as well as the stage of technology development and transfer.

Table 5-8: Supported technologies and how they enhance endogenous capacities

Technology development and transfer support received	Type of technology	How support contributes to technology development and transfer, endogenous capacities and know-how	Stage of the technology cycle supported
Malawi Watershed Services Improvement Project (MWASIP) – CTF TableIII.7 TITUKULANE Food Security and Resilience Project - CTF TableIII.7 Building community and ecosystem resilience through livelihood improvement and rehabilitation of badly degraded areas - CTF TableIII.7 Sustainable Management of Landscapes (SAMALA) - Flanders and Ireland - CTF TableIII.7 Climate Resilience Initiative in Malawi (CRIM) Project I - CTF TableIII.7 Malawi Resilience and Disaster Risk Management Project (MRDRMP) - CTF TableIII.7	Landscape restoration for improved land productivity	The project provides training on proven and locally developed SLM technologies to restore degraded landscapes and increase land productivity. These include physical and biological soil and water conservation techniques (contour ridging, box ridging, infiltration ditches, gully reclamation, vetiver hedgerows, vegetative river/ stream-bank protection etc.)	Deployment – climate friendly SLM technologies are being promoted within communities using a catchment management approach

Increased Access to Clean and Affordable Decentralized Energy Services in Selected Vulnerable Areas of Malawi - CTF TableIII.7 Africa Mini grids Program - Malawi - CTF TableIII.7 Malawi Energy Programme - Wala Malawi - TableIII.7	Solar PV Technology	Scaling up and strengthening Malawi's first mini-grid, independent and vertically integrated energy company operated as a social enterprise; provide micro-capital grants and pilot innovative service arrangements for clean energy mini grids. By setting up a social enterprise to operate 168kWP generated from Mini grids at Lujeri Estate local capacity is enhanced. Further, this project is training at least 300 people on how to operate a minigrid with 28 districts covered by clean energy Mini grids training programmes.	Research, development and dissemination
Modern Cooking for Healthy Forests in Malawi - CTF TableIII.7 Accelerating Alternative Energy and Fuel Efficient Techologies through the Green Economic Transition Facility - CTF TableIII.7	Improved cook stoves and clean cooking	This intervention supports accelerated adoption of clean cooking technologies through inclusive and sustainable business and entrepreneurship opportunities. Locally developed cooking technologies and fuels are being promoted under this programme in order to address deforestation.	Diffusion
Transformational Adaptation for Climate Resilience in Lake Chilwa Basin of Malawi (TRANSFORM) - TableIII.7	Early Warning Systems and Hazard Monitoring	This intervention is reducing vulnerability and increasing resilience through innovation and technology transfer in EWS and Hazard Monitoring around Lake Chilwa Basin. Building on indigenous climate knowledge, communities within the basin are developing early warning information and adapatation strategies that incorporate both science and local knowledge	Diffusion

Box 5-1: Case Study 1: Scaling up the use of Modernized Climate Information and Early Warning Systems in Malawi (M-CLIMES) Project

Scaling Up the Use of Modernized Climate Information and Early Warning Systems in Malawi (M-CLIMES) Project funded by the Green Climate Fund supports Government of Malawi (GoM) to take steps to save lives and enhance livelihoods at risk from climate-related disasters. It addresses technical, financial, capacity, and access barriers related to weather and climate information (CI) by investing in enhancing hydro-meteorological capacity for early warnings (EWs) and forecasting, development and dissemination of tailored products including for smallholder farmers and fishers, and strengthening capacities of communities to respond to climate-related disasters. The objective of the project is to reduce vulnerability to climate change impacts on lives and livelihoods, particularly of women, from extreme weather events and climate change. The expected key Fund level impact is increased resilience and enhanced livelihoods of the most vulnerable people communities and regions. The primary measurable benefits include approximately 1.4M direct and 0.7M indirect beneficiaries (total 12% of the population) who will gain access to critical weather information.

The M-CLIMES project has registered significant progress since its conception and achieved the project goal of reaching an estimated 2 million people with lifesaving early warnings and severe weather advisories through improved monitoring, packaging and dissemination of tailored climate information that can save lives and protect livelihoods. The installation of additional hydro-met equipment and systems, including automated weather stations, automated hydro stations, lake based weather buoys, lightning detection and warning systems and weather data integration systems, has improved the hydromet observation network in Malawi. Similarly, the training of hydromet staff in operation and maintenance, data modelling and improved forecasting has improved the accuracy of weather forecasts and related climate services. Seasonal and short-term agro-weather information and advisories for small-holder farmers have been produced and disseminated to more than 500,000 (53% women) smallholder farmers across 14 districts via PICSA (Participatory Integrated Climate Services for Agriculture) approach using the national agriculture extension network and the Agro weather SMS dissemination Platform. More than 300,000 people (over 30% female) in fishing communities in 4 lakeshore districts have been reached with regular weather and safety advisories through various media including community radio programs and awareness campaigns. The Telemetry Community Based Flood Early Warning System continue to provide live saving advance flood warnings to over 175,000 people (over 50% women) across eight flood prone districts. A comprehensive community-based flood preparedness program in the flood prone communities has helped the communities to implement a set of preparedness and preventive actions to save lives and livelihoods.

Box 5-2: GETF has increased national LPG storage capacity



The Green Economic Transition Facility (GETF) is a competitive and transparent business support facility partnering with companies willing to invest and, or diversify into green business solutions. The first window of the facility, 'Accelerating Alternative Energy and Fuel-Efficient Cooking Technologies' with support from Irish Aid, supports companies to assist households in urban and peri-urban centers of Malawi transition to alternative energy and fuel-efficient technologies which includes LPG for cooking reducing their reliance on illegal charcoal for cooking and resulting in decreased deforestation. Through the facility, four companies namely 265 Energy, Gasman, Blue Waves and Mount Meru are increasing the supply of LPG in urban and peri-urban areas to ensure sustained access of the product for cooking in place of illegal charcoal. Through their combined efforts, national LPG storage capacity has more than doubled from 50 tonnes original capacity to 128 tonnes as new capacity. This is expected to ensure sustained supply of LPG and increased adoption of the technology.

5.7 Information on capacity-building support needed under Article 11 of the Paris Agreement

5.7.1 Malawi's capacity-building needs, constraints and gaps related to CC

Malawi has prioritized three areas for capacity building support in order to achieve its vision of a knowledge-driven climate change resilient country by 2030, pursuing a low carbon development pathway in line with the National Climate Change Management Policy of 2016 as outlined in its 2021 climate change learning strategy (GoM, 2021c). The prioritized areas have been outlined in CTF III.10 and relate to the following components:

5.7.1.1 Individual capacity building

Malawi has made tremendous progress in improving human resources capacity in terms of raising awareness and building knowledge and skills to design, develop and implement climate change adaptation and mitigation programmes, projects and activities. Despite this progress, a lot more work needs to be done in creating awareness of climate change issues by the general public, in both urban and rural areas; and increasing numbers and improving the range of skills to address current and emerging climate change challenges. In terms of CC learning content, the individual learning needs vary from basic, intermediate to advanced knowledge and skills. The following priority actions were selected in order to address the identified needs and gaps under Individual learning and skills development:

- Developing innovative national climate change awareness raising programmes to meet the needs of diverse stakeholders;
- Training lead trainers from key stakeholder groups (CISONECC, Faith Based Organizations, Association of Environmental Journalists, Youth Groups, Women Groups) about climate science, adaptation, mitigation, policy and negotiation;
- Developing training of trainers' programme for Agricultural Extension Officers and Lead Farmers to impart knowledge of climate smart agriculture (CSA) to farming households; and
- Training government professional officers at national and district levels, policy makers and parliamentarians in basic knowledge of climate change science, impacts of climate change on sustainable development, CC financing, governance and negotiation.

5.7.1.2 Institutional capacity building

Environmental Affairs Department in the Ministry of Natural Resources and Climate Change (MoNRCC) is the National Focal Point on climate change issues. The establishment of a dedicated department is one of the greatest boosts in the institutionalization of climate change programmes, projects and activities in Malawi. The Department plays a leading role in climate change learning, through the Steering Committee on Climate Change and the Technical Committee on

Climate Change, urging ministries/departments to continue support positions of Climate Change Desk Officers. Furthermore, the Strategy on Climate Change Learning targets primary and secondary schools, higher education institutions, community colleges, technical institutions, NGOs, CBOs CISONECC, Association of Environmental Journalists, and business associations to spearhead climate change training and awareness initiatives. Although Malawi has a number of institutions involved in climate change issues, none of them is wholly dedicated to climate change training, research and awareness. The following priority actions were selected for institutional capacity building in Malawi:

- Reviewing and updating curricular on climate change at primary and secondary schools
- Mainstreaming climate change learning in existing curricular at tertiary education institutions (e.g. University of Malawi, Malawi University of Science and Technology (MUST), Mzuzu University (MZUNI), Lilongwe University of Agriculture and Natural Resources (LUANAR), Kamuzu University of Health Sciences (KuHES) and Catholic University); and
- Developing and/or strengthening infrastructure for climate change learning (classroom space, E-learning facilities, National Library Services and Academic libraries, Climate Centers, etc.).

5.7.1.3 Resource mobilization

The main thematic areas for climate change learning strategy in Malawi relate to individual learning needs and institutional capacity building. It has however been noted that in order to effectively implement various activities associated with these two main pillars, it will be absolutely necessary to source adequate financial resources. It is in light of the above that stakeholders and participants at the two National Workshops (Please mention them) strongly supported the idea of coming up with a third pillar, financing, so that appropriate strategies could be developed to ensure sustainable funding for climate change in general, and CC learning activities in particular. In 2013, the Government developed and launched the National Climate Investment Plan to provide potential investors and funders a basket of prioritised investment projects in which the Government was looking for potential partners to support and invest. Priority actions have been developed to address financing gap. The following priority actions were selected under this priority area:

- Developing human resource capacity with knowledge and skills to develop fundable project proposals for local and international sources;
- Mobilizing local resources for Climate Change learning; and
- Mobilizing international resources for Climate Change learning.

5.7.2 Processes for enhancing public awareness, public participation and access to information in relation to capacity-building

Malawi has implemented a number of processes for enhancing public awareness, public participation and access to information in relation to capacity building as outlined below:

5.7.2.1 Strengthening the National Youth Network on Climate Change (NYNCC)

The National Youth Network on Climate Change (NYNCC), founded in 2011, has been working with the Government of Malawi in advancing the voice of the youth on the climate change management agenda in the Country. However, in the absence of enabling strategic frameworks, their efforts were not coordinated amongst their membership and with stakeholders. As a youth network which has a great passion for climate change issues in the country, the Network needs to have an established ground for continuous improvement in its performance. In order to strengthen the network, support has been provided under the UN:CC Learn Programme to develop a strategic plan and to establish an online platform that will allow information sharing on climate.

5.7.2.2 Establishing Malawi Higher Education Institutions Network on Climate Change Learning (MHEINCCL)

Having identified gaps in coordination mechanisms among Higher Education Institutions in climate change learning in the country, the project facilitated establishment of the Malawi Higher Education Institutions Network on Climate Change Learning (MHEINCCL). The main objective the MHEINCCL is to champion climate change learning in Higher Education Institutions (HEIs) in Malawi and beyond. Specifically, the Network intends to:

i. Expand interest for CC learning among HEIs in Malawi and beyond;
ii. Influence decision-making towards investments in CC learning in Malawi and in the region;
iii. Represent HEIs in high level national committees on CC;
iv. Promote CC learning activism among HEIs in Malawi;
v. Advance CC learning and related research among HEIs in Malawi and beyond;
vi. Provide technical and academic support and advice on CC learning related issues among various stakeholders; and
vii. Attend to any other issues related to CC learning of interest to HEIs that arise from time to time.

5.8 Information on capacity-building support received under Article 11 of the Paris Agreement

Malawi has received varying support on capacity building. This has been outlined in CTF III.11. Key highlights of support provided include the following:

- Building capacities of civil society organizations to improve the quality of GCF proposals submitted and enabling participatory monitoring of GCF projects
- Building the capacity of national and district level authorities to improve DRM, with the objective of reducing future hazard impacts and ensuring effective humanitarian response.
- Facilitating participation of youth in climate change impact mitigation through establishment of community youth led enterprises in waste management.

Box 4-3: Support for Climate Change Learning in Malawi by UN CC:Learn

Malawi faces high climate variability and an increasing number of extreme weather events. Since 2012, UN CC:Learn has been working with the government of Malawi and other stakeholders in the country to design and implement a strategic and results-oriented approach to climate change learning. Together with the Government of Malawi and key stakeholders, UN CC:Learn facilitated the development the country's first national climate learning strategy, which was launched in 2013 and in 2021, the strategy was updated using a multi-stakeholder and cross-sectoral approach. The updated strategy sets out a number of objectives including the following:

- Developing a critical mass of human resources with the requisite understanding, knowledge and skills to respond to the impacts of climate change,
- Strengthening the national institutions and systems that will spearhead climate change training initiatives, and
- Developing a sustainable financing mechanism for climate change learning programmes.

5.9 Information on support needed and received for the implementation of Article 13 of the Paris Agreement and transparency-related activities, including for transparency-related capacity-building

Malawi needed and has received varying support for the implementation of Article 13 of the Paris Agreement and transparency-related activities, including for transparency-related capacity building. All the support has been provided through multi-lateral institutions and is on-going.

Table 5-9: Support received in the implementation of Article 13 of the Paris Agreement and transparency-related activities

Title of activity/ programme/project	Objectives and description	Use, impact and estimated results	Amount ($)
Preparation of BTR1 and NC4 to the UNFCCC	This project objective is to support Government of Malawi prepare and submit the First Biennial Update Report (BTR1) and the Fourth National Communication to the United Nations Framework Convention on Climate Change (UNFCCC).	BTR1 and NC4 reports submitted to UNFCCC. In addition, different stakeholders (including private sector) participate in the transparency initiative through provision of data	566,115
Malawi Climate Transparency Framework under the Capacity Building Initiative for Transparency (CBIT)	The objective of the project is to establish or strengthen national capacity to track progress on national commitments made under the Paris Agreement and also to prepare comprehensive and accurate reports capturing their implementation in the medium to long-term.	Among others the project will ensure that: 1) Malawi's institutions effectively collaborate to track and report Greenhouse Gas (GHG) emissions, climate actions and support needed and received; 2) Stakeholders use the data management platform to support the MRV system; 3) The climate transparency unit, relevant sector institutions and stakeholders perform their roles in the MRV system on a continuous basis	1,156,320
Initiative for Climate Action Transparency - ICAT	The project objective is to enable Malawi to manage and track the implementation of its NDCS mitigation actions by putting in place a framework for regular collection and management of the necessary data		166,306

5.10 Conclusion

Malawi is committed to report transparently its climate action and support (needed and received) in line with transparency related goals of the Paris Agreement. In reporting financial, technology development and transfer and capacity building support needed and received, Malawi is guided by national institutional and policy frameworks such as the Malawi 2063, the NCCMP, revised NDCS and the NDCS resource mobilization strategy with the National Adaptation Plan currently under development.

Malawi has determined that it needs a total of US$41.8 billion for mitigation priorities, and US$4.5 billion for adaptation priorities, representing a combined funding requirement of over US$46.3 billion from 2020 through 2040. Of these amounts, US$24.6 Billion is required from external sources for mitigation actions, US $2.2 Billion for adaptation and US$0.753 Billion for cross-cutting climate action. During the reporting period, Malawi received an estimated US$ 0.875 Billion in climate financial support while a further US$2.17 Billion has been committed by different funding institutions.

6.0 INFORMATION TO BE REPORTED WHEN NATIONAL COMMUNICATIONS AND BIENNIAL TRANSPARENCY REPORTS ARE SUBMITTED JOINTLY EVERY FOUR YEARS

6.1 Status of climate change research and systematic observation

Malawi through the Department of Climate Change and Meteorological Services participates in two Regional Climate Outlook Forums (RCOFs); Southern African Region COF (SARCOF) annually and South-west Indian Ocean COF (SWIOCOF) on invitation. These are mainly active during the approach of rainfall season: SARCOF is for the Southern African Development Community (SADC) countries; SWIOCOF is for Indian Ocean (IO) islands (Comoros, Madagascar, Mauritius, Reunion, Seychelles) and IO west coast countries (Mozambique and Tanzania).

Regionally, meteorological services in the SADC are linked through the SADC Climate Services Centre (located in Botswana). Its coordination capability is not very strong and has so far dealt with weather/ seasonal forecasting issues and network expansion and management. Additionally, the forums do not include formal arrangements for data sharing and human capacity building.

6.1.1 Gaps in meteorological, atmospheric and oceanographic research and observation in Malawi

Observation and monitoring imply the examination of the state of the earth's atmosphere and its underlying surface in a particular area at a particular time of the day by using instruments and eyes within a given short period of time. Hydro meteorological observation and monitoring in Malawi comprise systems such as automatic weather stations, conventional meteorological stations, automatic and manual hydrological monitoring stations and lake-based buoys on Lake Malawi; while upper air observations include use of accessible satellite imagery and upper air balloons. The use of the latter is limited by resources.

In Malawi, the observation stations are not adequate and well distributed over the national territory. There are 21 principle meteorological conventional stations which observe full range of weather elements including temperature, wind speed and direction, rainfall, sunshine hours, cloud cover, visibility, humidity and atmospheric pressure. These are also working as climatological stations supported by 21 subsidiary agro-meteorological stations, over 400 rainfall stations and over 81 Automatic Weather Stations. Some of the subsidiary Agro meteorological stations are no longer operational due to other factors. Currently, there is no upper air observation station and weather radar, and there is only one satellite observation station.

An ideal situation would be to have a station covering a radius of about 20km in flat areas and smaller radius in hilly areas. Although this is the ideal situation, a minimum of one station per district would be very useful to improve the spatial resolution. The 21 full meteorological stations available are representing wider areas, thereby affecting precision and reliability of the data. Furthermore, data transmission to the responsible departments is not automated and the availability of data capturing staff is not adequate. There is also no backup for the data management system available. As such, this increases data backlog and risk of losing data. Meanwhile, the use of various types of rain gauges in the rainfall stations affects the quality and comparability of data, because installation of rain gauges is not fully regulated. There is need therefore to procure and install additional conventional and Automatic Weather stations and to adequately service them. It is also recommended that on installation of rain gauges and other observation equipment by stakeholders, regulations and standards be implemented and DCCMS approves the rain gauges to be used and that distribution is regulated. There is need to improve the collaboration in procurement and installation of weather/ climate monitoring equipment in the country.

6.1.2 Identified needs and priorities for climate change research and systematic observation

Malawi has developed a National Framework for Water and Climate Services (NFWCS) to run from 2024 to 2029 with a total budget of USD 63,413,706.01 (GoM, 2024). The NFWCS will serve as a multi-stakeholder platform facilitating the development and delivery of hydro meteorological services at the country level including climate change research and systematic observation. This critical mechanism, aligned with the Global Framework for Climate Services (GFCS), focuses on enhancing the co-production, customization, delivery, and utilization of science-based climate predictions and services in key areas such as agriculture and food security, disaster risk reduction, energy, health, and water.

Establishing the NFWCS is crucial for enhancing climate risk management through the development and utilization of country-specific climate information and services. This framework informs coordinated and integrated action, decision-making, and policy formulation based on national contexts. Decision-makers at all levels and across sectors require hydro meteorological information and services for short-, medium-, and long-term planning. Effective development and delivery of hydro meteorological services at the national level necessitate close collaboration among service providers, researchers, and users, including governments, civil society, communities, the private sector, technical partners, and donors.

While it is expected that some elements of the NFWCS will be funded by Government of Malawi through funding allocations to specific ministries, the NFWCS has also proposed additional support from international funding institutions such as Green Climate Fund (GCF) Readiness funds, Global Environment Facility (GEF), Adaptation Fund (AF), Special Climate Change Fund (SCCF) and Least Developed Countries Fund (LDCF), Bilateral Country Funds and other development cooperation missions such as NORAD and the Norwegian Embassy, FCDO, GIZ, Flanders, Qatar fund, Kuwait fund, EU, ECHO, REDD+, Indian government, Irish Aid, USAID, Bill Gates Foundation, AfDB, Arab, Development Bank, JICA, China Aid, Australian government, and other multilateral financial institutions such as the World Bank and United Nation (UN) agencies; UNDP, UNEP, FAO, WFP, UNICEF and WMO. Funds will also be mobilized through private sector through Public-Private-Partnerships with mobile telecommunications companies, construction companies, energy and water boards, aviation among others. The country will also continue participating in various initiatives of regional blocks such as SADC and the AU in support of the NFWCS.

6.2 Gender and climate action

6.2.1 Gender and climate context in Malawi

Malawi ranks towards the bottom of the UNDP's 2022 Gender Equality Index (148 out of 172 countries and territories) with an overall Human Development Index (HDI) value of 0.508 (172 out of 193 countries and territories) (UNDP, 2024). Related to climate change, Malawi's Planetary pressures-adjusted HDI dropped to 0.501 in 2022, a testament of the impact of climate change on human development.

The unequal status of women in relation to men in Malawi is shaped by the intersection of poverty, discriminatory customary laws, and inequitable treatment in private and public spheres. Malawi has matrilineal and patrilineal systems that both perpetuate discrimination against women in terms of resource control. Women generally fare worse than men on most social and economic indicators including wage equality, political participation, secondary and tertiary education enrolment, and literacy.

Despite making up 70% of the agricultural workforce, and producing as much as 80% of the agricultural produce for consumption and sale (Lodhi, 2018), women score poorly across all development indicators. They are less likely to be food secure, more likely to be classified as poor or ultra-poor than men (FAO, 2011), are less likely to own land or have control over household resources, have limited opportunities to access credit (Malindi & Kasambala, 2018), and are frequently excluded from participation in community (Molloy, 2016) or national level decision making. Women's limited economic empowerment also contributes to their vulnerability to climate change impacts. Inadequate access to land, labour, inputs and credit makes women more likely to engage in low-productivity subsistence agriculture and business activities that generate low returns.

As a result of climate change impacts, women may be forced to sell off assets such as small livestock or seek other means of generating income to support a family. Men's larger involvement in cash crop production and waged labor may mean they are susceptible to wage loss when crops fail, or they may temporarily migrate to other areas in search of other employment opportunities.

Climate-extreme events such as drought often lead to household food insecurity and malnutrition, with different impacts for men, women, and children. These impacts are linked to gendered vulnerabilities contextualized by social and cultural norms. Because women are the main providers of food for their families, they face greater constraints due to climate events. Resulting increasing vulnerability also expose women to other risks such as HIV as they resort to engaging in commercial sex work to fend off hunger.

6.2.2 Policies, Strategies and Frameworks for mainstreaming gender and other cross-cutting issues in climate action

Climate change and gender inequality are complex challenges that are interconnected. They require an integrated approach that builds resilience while also promoting human rights and justice, particularly for already marginalized people. Malawi's National Gender Policy (GoM, 2015) stipulates that Malawi is committed to gender parity, women's empowerment and upholding of women's rights as a prerequisite to poverty reduction and sustainable development. This commitment is premised on the provisions of the Republican Constitution of Malawi and also on the basis that gender equality is a basic human right as affirmed in a number of international and regional human rights instruments to which Malawi is a signatory, such as the Convention on Elimination of All Forms of Discrimination against Women.

Mainstreaming gender in Natural Resources, Environment and Climate Change Management is one of the prioritized actions through the gender policy. The policy has recognized that gender inequalities in natural resource and environmental management which include under representation of vulnerable groups in decision making forums on the utilization of forests, land and water has led to deterioration of natural resources and has displaced communities, especially those living in poverty. Other gender challenges include inadequate information and education on sustainable environment management, inadequate gender responsive environmental policies and programmes and inadequate mitigating measures of the impact of environmental degradation and climate change.

At international level, Malawi signed up to the Lima Work Programme on Gender at COP20[63]. This established a two-year work programme to promote gender balance and achieve gender-responsive climate policy by encouraging parties and relevant organizations to support training and awareness-raising for all delegates on issues related to gender and climate change, and building the skills and capacity of female delegates to enhance their participation in negotiations. Progress for Malawi on the implementation of the Lima work programme has been slow owing to a number of challenges as follows:

- Lack of relevant expertise and capacity within line ministries and institutions to conduct in-depth gender analysis, limited knowledge on the development of advocacy and gender mainstreaming approaches and inconsistent implementation of gender-responsive laws, policies, guidelines, plans and programs;
- Limited coordination among relevant stakeholders, coupled with insufficient domestic budget allocated for the implementation of gender-related plans and activities;

63 https://unfccc.int/topics/gender/workstreams/the-enhanced-lima-work-programme-on-gender

- Lack of financial and technical support from UNFCCC that target female negotiators from LDC group to participate actively in the climate change meetings;
- Limited financial Support from UN agencies, NGOs, private sectors, other funding agencies and UNFCCC to the least developing countries including financing of capacity building activities in the field of gender and climate change; and
- Limited support for Gender and Climate Change Focal Points to carry out the mandate as accorded in the Lima work Programme.
- Under-representation of women at the decision making and policy level in relation to climate change and disaster risk reduction. This includes limited representation at regional and global platform on climate change and disaster risk reduction.

6.3 Conclusion

Malawi through the participates in two Regional Climate Outlook Forums (RCOFs); Southern African Region COF (SARCOF) annually and South-west Indian Ocean COF (SWIOCOF) on invitation. At national level, observation stations are not adequate and well distributed limiting the functionality of climate observation. The country has developed a National Framework for Water and Climate Services (NFWCS) to run from 2024 to 2029 with a total budget of USD 63,413,706 and will require external support.

Regarding gender and climate action, climate change affects different gender categories differently. However, it has been observed that in Malawi, women tend to sell their assets in order to cope with climate impacts. Gender transformative approaches are thus essential to enhance climate action (Chiotha et al., 2018 as a result Malawi Government has prioritized the mainstreaming of gender in Natural Resources, Environment and Climate Change Management through the National Climate Change Policy (NCCMP) in particular the Gender policy in general. In addition, at international level, Malawi signed up to the Lima Work Programme on Gender to promote gender balance and achieve gender-responsive climate policy.

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