Technology Needs Assessment for the Republic of Malawi

Republic of Malawi

UN TECHNOLOGY

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FOR LEAST DEVELOPED COUNTRIES

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List of Abbreviations

AGCOM	Agricultural Commercialisation Project
AI	Artificial Intelligence
AIDS	Acquired Immunodeficiency Syndrome
AIO4	4th African Innovation Outlook report
ARIPO	African Regional Intellectual Property Organisation
ASM	Artisanal and Small-Scale Mining
CGIAR	Consultative Group for International Agricultural Research
EGENCO	Electricity Generation Company (Malawi) Ltd
ESCOM	Electricity Supply Commission of Malawi
FTE	Full-Time Equivalent
GDP	Gross Domestic Product
GERD	Gross Expenditure on R&D
GII	Global Innovation Index
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GPU	Graphic Processing Unit
HIV	Human Immunodeficiency Virus
ICT	Information and Communication Technologies
IFAD	International Fund for Irrigation Development
IFPRI	International Food and Policy Research Institute
IoT	Internet of Things
IPP	Independent Power Provider
IT	Information Technology
KUHeS	Kamuzu University of Health Sciences
LDC	Least Developed Countries
LUANAR	Lilongwe University of Agriculture and Natural Resources
MACRA	Malawi Communications Regulatory Agency
MCCCI	Malawi Confederation of Chambers of Commerce and Industry
MoEST	Ministry of Education, Science and Technology
MSME	Micro, Small and Medium Enterprise
MUBAS	Malawi University of Business and Applied Sciences
MUST	Malawi University of Science and Technology
MZUNI	Mzuzu University
NAMIS	National Agricultural Management Information System
NCHE	National Commission for Higher Education
NCST	National Commission for Science and Technology
NSI	National System of Innovation
NSO	National Statistical Office
PPP	Public Private Partnership
R&D	Research and Development
SDGs	Sustainable Development Goals
SSA	Sub-Saharan Africa
STEAM	Science, Technology, Engineering, Arts, Mathematics
STEM	Science, Technology, Engineering, Mathematics
STI	Science, Technology and Innovation
SWOT	Strengths, Weaknesses, Opportunities and Threats
TNA	Technology Needs Assessment
TEVET	Technical, Entrepreneurial and Vocational Education and Training
TEVETA	Technical, Entrepreneurial and Vocational Education and Training Authority
TVET	Technical and Vocational Education and Training
UNIMA	University of Malawi
UniPod	University Innovation Pod
UNTBLDC	UN Technology Bank for Least Developed Countries
WIPO	World Intellectual Property Organisation

Foreword

Science, technology and innovation (STI) are widely recognised as essential drivers of productivity, economic diversification and long-term structural transformation. For Least Developed Countries (LDCs), and for Malawi in particular, the strategic and effective application of STI is not merely beneficial, but indispensable for addressing structural vulnerabilities, strengthening resilience, and advancing inclusive and sustainable development.

The Republic of Malawi stands at a defining juncture in its development journey. The country's long-term national development framework, Malawi 2063, articulates a clear and ambitious vision of becoming an inclusively wealthy and self-reliant, industrialised upper-middle-income country. Realising this vision will require deliberate efforts to enhance productivity, promote value addition, and modernise key sectors of the economy. In this context, STI constitutes a critical enabler, supporting industrialisation, strengthening human capital, and fostering innovation-driven growth.

At the same time, Malawi continues to face significant and interconnected challenges. It being a predominantly agriculture-based economy, high levels of poverty and vulnerability, limited access to modern energy and digital infrastructure, and constrained fiscal space underscore the urgency of prioritising technologies that are appropriate, impactful and scalable. These challenges are further compounded by global economic pressures, climate-related shocks, and increasing demands on public resources, reinforcing the need for strategic and well-targeted technological investments, which are not only necessary, but urgent.

It is within this context that the Government of the Republic of Malawi, through the Ministry of Education, Science and Technology, in partnership with the United Nations Technology Bank for the Least Developed Countries, undertook this Technology Needs Assessment (TNA). The TNA provides an evidence-based and participatory assessment of Malawi's priority technology needs, firmly grounded in national development priorities and informed by extensive stakeholder consultations across government, academia, the private sector and civil society. Its purpose is to support coherent policy formulation, guide investment decisions, and strengthen alignment between STI strategies and sectoral development objectives.

This report identifies priority sectors and cross-cutting technological areas where focused interventions can generate a transformative impact, particularly in agriculture, mining, information and communication technologies, and energy. It underscores the importance of technology domestication, skills development, data systems and innovation ecosystems as foundational elements for sustainable implementation. Crucially, the TNA recognises that technology adoption must be inclusive, context-specific, and embedded within functional value chains, responsive markets, and capable institutions, in order to deliver durable development outcomes.

Beyond its national relevance, this Technology Needs Assessment contributes to broader regional and global efforts to operationalise STI in support of the 2030 Agenda for Sustainable Development and the Doha Programme of Action for Least Developed Countries. The insights and recommendations presented in this report are intended to serve not only as a strategic roadmap for Malawi, but also as a practical learning resource for other LDCs seeking to harness STI as a catalyst for structural transformation.

It is our firm conviction that this Technology Needs Assessment will serve as a practical tool to support informed decision-making, mobilise investment, and foster coordinated action among national stakeholders and development partners. Through sustained collaboration and shared commitment, the Republic of Malawi can translate technological potential into tangible development outcomes that enhance resilience, create opportunities, and improve the quality of life for its people.

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Honourable Minister
Ministry of Education,
Science and Technology

Deodat Maharaj
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for the Least Developed Countries

Acknowledgments

We extend our sincere appreciation to the Government of the Republic of Malawi for their steadfast support and commitment to the development of this Technology Needs Assessment (TNA).

This TNA was developed by the United Nations Technology Bank for Least Developed Countries (UNTBLDC), in close partnership with the Ministry of Education, Science and Technology, as the focal ministry for STI.

The report was prepared by Dr. Robert Ridley, who served as the lead consultant for this TNA, under the overall guidance and coordination of Federica Irene Falomi and Flaminia Maldi Colombo (UNTBLDC).

The TNA was developed with the support of key informants from government, academia, research institutions, and the private sector. These stakeholders participated in interviews, consultations and validation workshops, contributing a broad range of expertise that enriched the TNA process and strengthened the analysis of sectoral challenges and opportunities.

Special recognition is due to the members of the TNA Committee, composed of representatives from national institutions and agencies across the country, whose guidance and institutional knowledge were essential to the success of this process. The full list of participating institutions is provided in Annex II.

Valuable inputs and independent technical advice were also provided by members of the Technology Expert Group (TEG), whose expertise and impartiality significantly enriched the findings of this report. The full list of TEG members is provided in Annex III.

The United Nations Technology Bank for Least Developed Countries extends its sincere appreciation to all individuals and institutions who contributed their time, knowledge and expertise to this Technology Needs Assessment. Their commitment and collaboration have been indispensable in ensuring that this report serves as a practical and evidence-based tool to support the effective integration of science, technology and innovation into Malawi's development agenda.

Executive summary

Introduction and Background

This report presents a Technology Needs Assessment (TNA) for the Republic of Malawi, conducted by the UN Technology Bank for Least Developed Countries (UN Technology Bank) in partnership with the Ministry of Education, Science and Technology of the Republic of Malawi. The TNA identifies critical areas where technological opportunities can meet national needs, and it thus serves as an important tool to guide the Science, Technology and Innovation (STI) Policy and Strategy for national development.

The TNA operates within the social, economic and national developmental policy context of Malawi. Malawi is ranked the 6th poorest country in the world based on 2025 GDP (nominal) per capita data. It thus operates in an environment of limited resources. Malawi is landlocked, and thus depends on access to ports through its neighbouring countries, Tanzania and Mozambique. Malawi remains a largely subsistence agriculture-based economy that has struggled to develop and implement mechanisation and technological changes that can reach the vast majority of its people. Primary agriculture accounts for 24% of GDP and employs 64% of the workforce. The agricultural sector accounts for approximately 80% of export earnings, and approximately 60% of agricultural exports are obtained from one product, namely tobacco. Sales of this one product accounts for approximately 50% of Malawi's export earnings.

A widely accepted national development vision, Malawi 2063 was established in 2021 under the oversight of a National Planning Commission, with the goal for Malawi to become "an inclusively wealthy and self-reliant industrialized upper-middle-income country by the year 2063". The strategy to achieve this is built upon three pillars: (i) Agricultural productivity and commercialisation, linked to value-addition manufacturing pathways. (ii) Industrialisation, with an emphasis on industrialising mining, among other services; and (iii) Urbanisation, aiming at the responsible development of linked urban centres and the creation of tourism hubs. Malawi 2063 identifies STI as a key driver of industrialisation and a core component of human capital development to help deliver on this vision. However, the implementation of the Malawi 2063 vision is challenged by the prevailing macroeconomic situation over the past several decades, exacerbated by balance of payments challenges and increasingly high levels of public debt.

Malawi's STI Environment

Malawi's National System of Innovation has expanded significantly in recent years, driven by strengthened STI governance structures, growth in tertiary education, and the increased establishment of innovation-supporting institutions. Key achievements include the operationalisation of the National Commission for Science and Technology (NCST), the creation of a full STI Directorate within the Ministry of Education, Science and Technology, and the emergence of multiple public universities and innovation hubs. Research output has risen steadily, particularly in health and agriculture, supported by strong development partner investment and the development of innovation centres such as UniPod at MUBAS, the industrial park at MUST, and agribusiness and health innovation hubs at LUANAR and KUHeS.

Malawi is still operating under a 2002 Science and Technology policy and the 2003 Act that derived from the policy. An updated national STI policy is under development. A comparative assessment of Malawian STI performance by the 4th African Innovation Outlook report of 2025 and the Global Innovation Index of 2025 demonstrate that Malawi performs above expectations based on its low GDP. It ranked 4th in Africa for scientific publications once GDP was taken into account, and 5th among the 11 low-income countries included in the Global Innovation Index. The high Global Innovation Index ranking was in large part due to a high score for the level of business sophistication

in Malawi, including its ranking for ICT service imports. It thus appears that the business environment in Malawi is well positioned to absorb innovation if the means for financing and operationalising it can be found.

However, progress has been uneven, and Malawi's NSI still faces substantial structural gaps. R&D investment remains critically low at 0.18% of GDP, with extremely limited domestic financing and a heavy dependence on foreign sources. Business expenditure on R&D and private-sector engagement in innovation are minimal, reflecting decades of deindustrialisation and weak competitiveness. Coordination across government remains fragmented, sectoral STI committees were never fully operationalised, and STI data systems, including regular R&D and innovation surveys, are still underdeveloped. Human capital also remains a major bottleneck: secondary and tertiary STEM participation is limited, teacher shortages in science subjects are severe, and the number of fulltime researchers per million inhabitants (27) is far below regional and global averages.

These weaknesses are compounded by a difficult macroeconomic environment (high inflation, limited fiscal space, restricted access to finance, and ongoing vulnerability to external shocks) obstructing consistent investment in STI. Intellectual property generation is extremely low, manufacturing capability remains weak, and Malawi risks losing skilled workers through brain drain. Although significant opportunities exist, such as a youthful population, growing MSME activity, special economic zones and regional trade frameworks, the ability to capitalise on them depends on strengthening domestic R&D funding, building STI skills, diversifying the economy, and improving governance and coordination across the NSI.

Sector and Technology Prioritisation

This Technology Needs Assessment identified Agriculture, Mining, ICT and Energy as the sectoral areas that would most benefit from an intensified application of technology and that would have an impact on national development. These areas align with Malawi 2063 priorities. These prioritisations do not diminish the need and value of applying technology across other sectors.

Technology Needs for Agriculture focused on increasing crop productivity, both for food security and for expanding market potential. This included the need for the domestication and local production of farm inputs, the digitalisation of farm management and precision agriculture, and big data management on a national scale to inform policy and practice.

Technology Needs for Mining recognised that the technologies required for large scale mining ventures would be introduced by the foreign companies investing in the sector. There was thus a focus on Artisanal and Small-Scale Mining technologies for extraction and processing, and on data management systems to support Government oversight of the sector.

Technology Needs for ICT focused on local software development for innovative service delivery in the government and commercial sectors, the management of domestic data for improved service and policy coherence, and the potential for local hardware assembly and manufacture to improve their affordability.

Technology Needs for Energy focused on expanding access to electricity and clean cooking, especially through off-grid and mini-grid solar power, noting the potential for solar power to support community agriculture and small-scale mining. It further focused on technologies required for enhanced grid stability.

None of these technologies operate in isolation. Multiple technologies need to be linked together to provide the desired outputs and outcomes, whether for increasing crop yields, increasing the production and extraction of minerals, or the provision of IT services and energy delivery. There is a need for improved strategic planning and implementation, linking across the global value chains of sectors, from research and innovation to market delivery. This includes better integration of innovative sectors

with ministerial trade and industry strategies and action plans. There is a need to improve Malawi's cross-sector capacity for fabrication, prototyping and small-scale manufacturing of essential goods and machinery in order to reduce local costs, improve maintenance capabilities, reduce imports, and create jobs. National capacity for data management, including Big Data, will also be essential across all sectors.

The Technology Needs Assessment for Malawi also identified four intersectoral technology groupings. The technology groupings are required collectively to provide the desired outcomes of: improved crop productivity and crop yield associated with areas 1 and 2; improved quality mineral yields for area 3; and quality data management for area 4. It should be noted that, although the energy sector was not individually prioritised, energy access—notably the expansion of off-grid solar power—permeates areas 1 and 3, and the consistent delivery of energy is a prerequisite for areas 2 and 4. Detailed fact sheets and implementation plans for these technology needs are provided in Chapter 4.

1. Domestication and Securing of Farm Inputs and Associated Technologies					
Fertiliser manufacture	Seed development and access / biotechnology	Irrigation	Mechanisation	Community Warehousing	Off-grid solar
2. Digitalisation of Farm Operations and Precision Agriculture and Associated Technologies					
Analysis/soil sensors	Automated Drip irrigation/ fertigation	Drones	Software development/ Mobile Apps	Logistics (IoT sensors and Block Chain)	
3. Technology Support for Artisanal and Small-Scale Mining3.					
Mechanised tools & safety equipment for extraction	Tools for Mineral Processing and Value Addition	IoT sensors for real-time local monitoring	Analytics	Digital Government support services	Off-grid solar
4. Domesticating Big Data Management Capabilities for Agriculture and Mining and Associated Technologies					
Data Centres and Cloud Computing	Unified Sectoral Data Platforms	IoT & Remote Sensing Infrastructure	Advanced Analytics & Artificial Intelligence	Cybersecurity and Risk Management	

Recommendations

Many of the recommendations listed below align with existing policy and multiple development projects. It is anticipated that the emphasis placed here on technology adoption, combined with its domestication, local adaptation and development, will add value to ongoing efforts and facilitate a coherent systems approach to national development.

1. Science, Technology and Innovation (STI) in Malawian development
STI and the development of the Malawian innovation ecosystem should remain at the centre of national economic development and planning, aligned with the full implementation of the previous Science and Technology Policy (2002) and the National STI Policy currently in development. STI should be integrated into national planning and the delivery of Malawi 2063 through a systems-based approach, recognising its capacity to support mindset change. This could be supported, for example, through the proposed institutional architecture for TNA implementation outlined in Chapter 4.

2. TNA technology prioritisation
The sub-sectoral areas and associated technologies as well as the implementation plan outlined in Chapter 4 should be supported in a holistic manner, recognising their interconnectedness. Pilot projects should be designed with scale-up in mind, rather than as isolated endeavours, recognising the importance of incentivising the private sector and community engagement for long-term sustainability.

For the area of the **domestication and securing of farming inputs**, the current focus on fertiliser manufacture, irrigation, including solar-powered irrigation, warehouse construction, and off-grid solar systems should be built upon and extended. There is need to significantly increase national capacity

for seed development, especially the application of tissue culture and genetic engineering techniques. There is a need to strongly promote agricultural mechanisation and associated local manufacture. The value of integrating community warehousing with solar-powered refrigeration for community development and reduction of post-harvest loss also deserves attention.

For the area of **digitalisation of farm operations and precision agriculture**, there is need to expand soil sensor use and automated drip irrigation beyond the large farms and estates. There is need to build on Malawi's drone expertise, to apply remote sensing technology to agriculture, and to support young IT professional and entrepreneurs to develop local software apps that address local challenges. There is need to build capacity for the application of IoT sensors and blockchain technology to support the monitoring and tracking of warehouse and transported goods. The application of this technology can greatly aid agricultural commercialisation.

For the area of **support for artisanal and small-scale mining**, the potential for the local manufacture and repair of simple mechanised hand tools and other machinery should be noted and supported. Support should be given to improved mineral processing technologies, the use of IoT sensors, mobile assay labs and off-grid solar systems, recognising their impact on both commercial productivity and on health and safety. The application of these technologies is currently at a very low level in the ASM sector and could benefit from the synergistic growth of equivalent technologies in the agriculture sector.

For the area of **domesticating big data management capabilities for agriculture and mining**, there is need to build on the current development of the National Data Centre and plans for its future expansion, along with promoting the development of private sector data centres. There is need to further unify and integrate interoperable sectoral data platforms, connecting them to IoT and remote sensors through edge gateway analytical capacity. Mining sector data management has particular potential to help formalise the ASM sector. There is need for enhanced skill development through higher education for the scale-up of data management, including in advanced data analytics, artificial intelligence and cybersecurity. A balance should be sought between providing public open access to big data and the potential to monetise access to certain data and its analysis, while continually ensuring the required levels of personal and confidential data protection are met.

3. Domestication of technologies

The sustainability of any technology scale-up requires domestication of the skill sets to operate and manage the technology, and ultimately to adapt and develop it further to meet local national requirements. Human capital development therefore lies at the heart of domestication. Sustainability is further entrenched if there is internal capacity to maintain, assemble and manufacture the technologies. Planning for these capabilities must be built into associated technology acquisition and development plans. In addition to government and private investment, such capabilities may be reinforced through negotiating and securing capacity building obligations into foreign direct investment agreements, public-private partnerships and government contracting.

4. Mechanisation and manufacture

Local maintenance, assembly and manufacturing capabilities represent a key component of national capacity to domesticate a technology. The mechanisation of the agriculture and mining sectors represents an opportunity for local manufacture, building on the investment in TEVET education underway, for example, through the EU-financed Zantchito project, and several university initiatives. There are artisans in towns and cities building equipment, such as maize shellers, on the roadside and in small workshops with expertise that could be scaled up, standardised and quality-assured in a small factory environment. Financial and development models are required to scale up such enterprises. This expertise could provide the foundation for the support industries required for scaled-up industrialisation of the agriculture, mining and other sectors.

5. Building technical capacity for research and innovation through financing R&D

There is a need to increase local research and innovation capacity across higher education,

government, philanthropic and private sectors, with special efforts to incentivise private sector R&D. This can in part be achieved by establishing more university doctoral programmes with student scholarships and associated research funding. It could be further consolidated by fully financing and operationalising the Science and Technology Fund to finance research and innovation under the oversight of the National Commission for Science and Technology as mandated by the Science and Technology Act (2003).

6. Policy alignment with commercial need

There is a need to resolve conflicts between policy, commercial and societal needs. This can be done through creating mechanisms for policy and guideline review when such conflicts are identified. It is further recommended to establish regulatory sandboxes so that the trialling of new products, services or business models can take place under regulatory observation, but with relaxed rules, so that regulators fully understand the technology and its implications before developing regulatory frameworks.

7. Partnerships

Mechanisms to promote academia-industry partnerships, in particular, are required to stimulate innovation. This might be achieved through joint conferences and fairs. Another way forward would be for the Science and Technology Fund referred to above to provide funding for joint industry academic research projects, with appropriate agreements in place to manage intellectual property. The establishment of Technology Transfer Offices in Universities also provides a potential pathway for academia-industry collaboration. High level public-private partnerships to support essential infrastructure development should also continue to be promoted through the Public Private Partnership Commission.

8. Investment

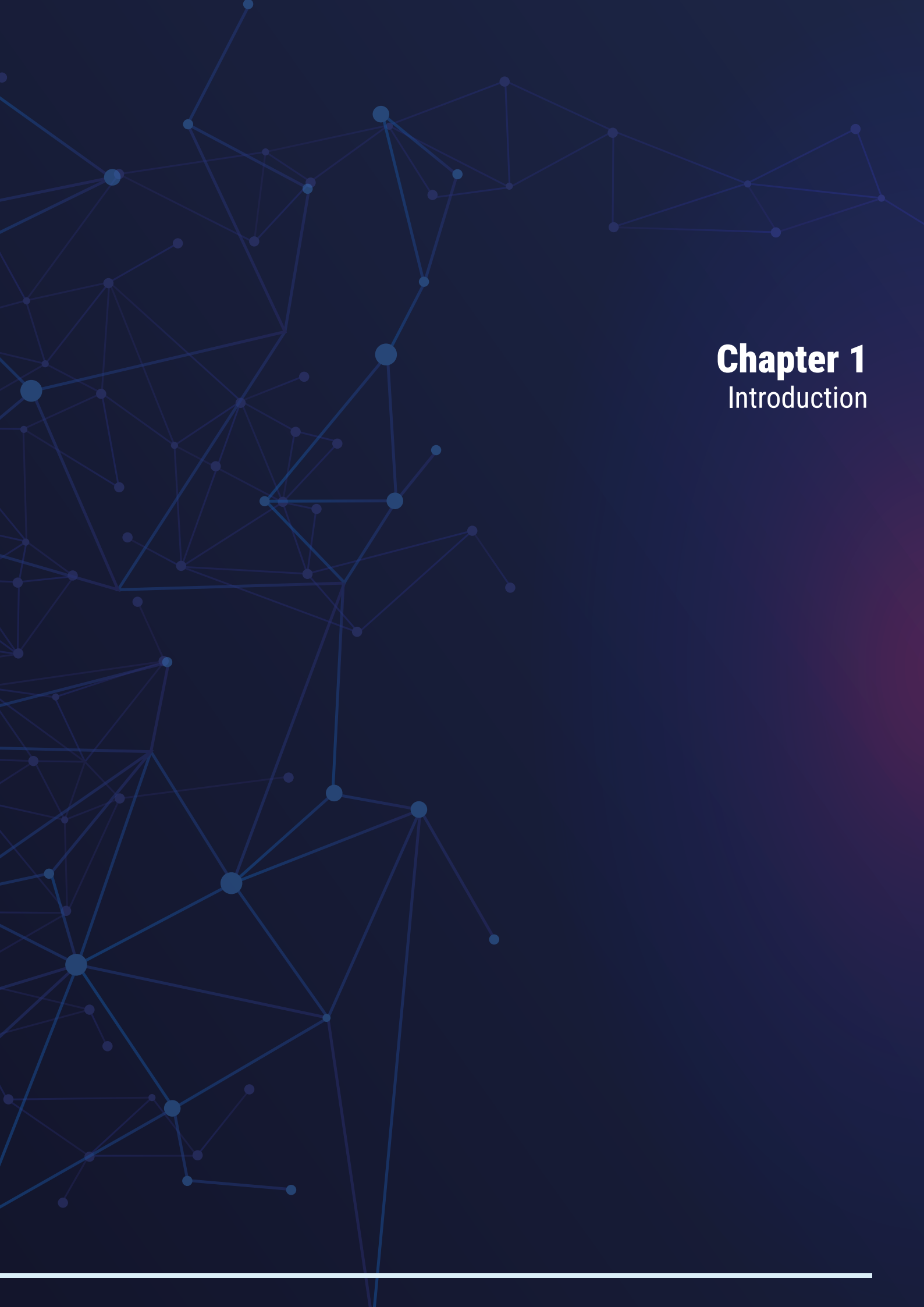
Investment requires a blend of government, private sector and development partner support for adopting, adapting, developing and scaling up innovation. In addition to the grants and public-private partnership approaches mentioned above, the government may need to incentivise private sector investment, for example, through tax concessions. The promotion of innovative business models, for example, pay-as-you-go models, may also help facilitate consumers entry into the use of technology and provide suppliers with a more sustained income. IoT technology facilitates this model, which is increasingly used in the data access and renewable energy sector. There are variations on this approach for the hiring of equipment for agriculture and mining use (for example, hello tractor, solar pumps, drones) that can facilitate access.

9. Galvanising the youth

The Malawi Government recently initiated a Youth Innovation Fund with tiered grants for different levels of business development, supported by pre-award training and incubation to help develop market-ready products. The continued development and extension of this approach, for example, linking young innovators to higher education technical expertise to help them develop their technologies, could be helpful. Youth-led innovation can also be supported through the expansion of innovation hubs to more districts across the country, beyond just the major cities.

10. Strengthening institutional capacity and coordination

Effective implementation of the identified technologies and STI recommendations will require strong coordination across government institutions, as well as clear roles and responsibilities among implementing entities. It will also depend on sustained collaboration with the private sector, financial institutions, academia and development partners. The TNA process itself has highlighted the need to further strengthen institutional capacity and coordination mechanisms in Malawi, including those for the planning, implementation and monitoring of innovation-related initiatives. Addressing these aspects will be essential to ensure that identified technologies can be effectively adopted, scaled and sustained over time.



Chapter 1
Introduction

1.1 Focus and purpose of the Technology Needs Assessment

This report presents a Technology Needs Assessment (TNA) for the Republic of Malawi conducted by the UN Technology Bank for Least Developed Countries (UNTBLDC). It is well understood that science, technology and innovation (STI) is a key driver for the socio-economic transformation and sustainable development of least developed countries (LDCs). This has been recognised by the Doha Programme of Action for LDCs 2021-2030,1 which highlights the value of STI in bringing about structural transformation to address multidimensional vulnerabilities and the achievement of the sustainable development goals (SDGs). Thus, STI has been defined as a key focus area for the ultimate sustainable and irreversible graduation of LDCs to middle-income status.

A TNA is an important tool for the development of national STI policy and strategy in support of national development. The TNA can assist LDCs to identify key areas where they can take advantage of the technological opportunities needed to contribute to their development plans, and identify strategies for priority technologies to be transferred and utilised.2 The TNA relies on a wide conceptualisation of technology and looks at technology as the systematic knowledge and skills used in the process of production or service delivery. The knowledge can be based on science, research or experience. This knowledge can be, but does not have to be, embodied in products such as devices and blueprints, or in processes. Technology includes the entrepreneurial know-how that is required to deliver products and services.

The Government of the Republic of Malawi, through the Ministry of Education, Science and Technology (MoEST), which holds responsibility for the National STI Policy, requested that the UNTBDLC conduct a TNA to complement its National STI Policy review. The TNA was thus carried out in collaboration with and under the auspices of MoEST.

1.1.1 Relevance of TNA for Malawi

The Republic of Malawi is one of the 44 least developed countries and ranked the 6th poorest country in the world by GDP (nominal) per capita in 2025. It aspires, through its visionary document Malawi 2063,3 to be an inclusively wealthy and self-reliant upper middle-income country by 2063. STI forms a key component of this aspiration, notably through the process of industrialisation, which is one of three pillars of the Malawi 2063 vision, and through human capital development, one of the seven enablers of Malawi 2063.

The Government of Malawi, through the MoEST, is reviewing its STI policy, last developed in 2002.4 Given the low financial base available to Malawi, it is important, in moving forward with technology development, that the most impactful and appropriate technologies are adopted, developed and worked upon. The TNA aligns well with Malawi's broader STI policy review process, and its recommendations will help guide STI-related and sector-specific actions for more targeted investment in technological development.

The TNA incorporates six main components that are designed to strategically support Malawi in its development:

1. An examination of the wider STI environment, including an analysis of the strengths, weaknesses, opportunities and threats of Malawi's national system of innovation.
2. Identification and prioritisation of specific sectoral and inter-sectoral needs that can be addressed utilising technologies.
3. Identification and prioritisation of technologies that can address the needs in key national sectoral and inter-sectoral areas.
4. Identification of barriers/challenges to the realisation of the prioritised technologies and factors, and conditions that can promote the technological developments.

1 https://www.un.org/ldc5/sites/www.un.org.ldc5/files/doha_booklet-web.pdf
2 https://www.un.org/technologybank/technology-needs-assessments
3 https://npc.mw/wp-content/uploads/2021/02/MW2063-VISION-FINAL.pdf
4 https://www.ncst.mw/policies-and-guidelines/

5. Technology Implementation Plan describing how the technologies can be realised.
6. Short and long-term recommendations for Malawi's future STI development.

1.2 Methodological approach

The TNA process utilised a mixed methodology approach, consisting of desk analysis, questionnaires, expert interviews and stakeholder consultation, to ensure a product that is aligned with Malawi's policies and wider developmental context. A list of individuals consulted is provided in Annex 1.

1. Desk analysis covered a variety of information sources and data, including academic literature, grey literature, databases and other sources of information:
2. A questionnaire was used to obtain the opinions of Government ministries and experts to inform the selection of priority sectors for further analysis. This choice was finalised and validated through consultation with a Technology Needs Assessment Committee comprising Government ministries (Annex 2). Based on this process, four priority sectors were identified and validated by the TNA committee, namely: (i) Agriculture; (ii) Mining; (iii) ICT; and (iv) Energy
3. A semi-structured interview format was used with identified ministerial representatives and sectoral experts within Agriculture, Mining, ICT and Energy, to define sub-sectoral priorities within these four sectors. This analysis is outlined in more detail in Chapter 4.
4. A stakeholder consultation and Technology Expert Group (TEG) was established to assist in the analysis and prioritisation of the technologies highlighted within priority subsectors. The results of this analysis and associated factsheets are outlined in Chapter 5, leading to the development of an implementation plan, which is outlined in Chapter 6.

Chapter 2
Contextual Background

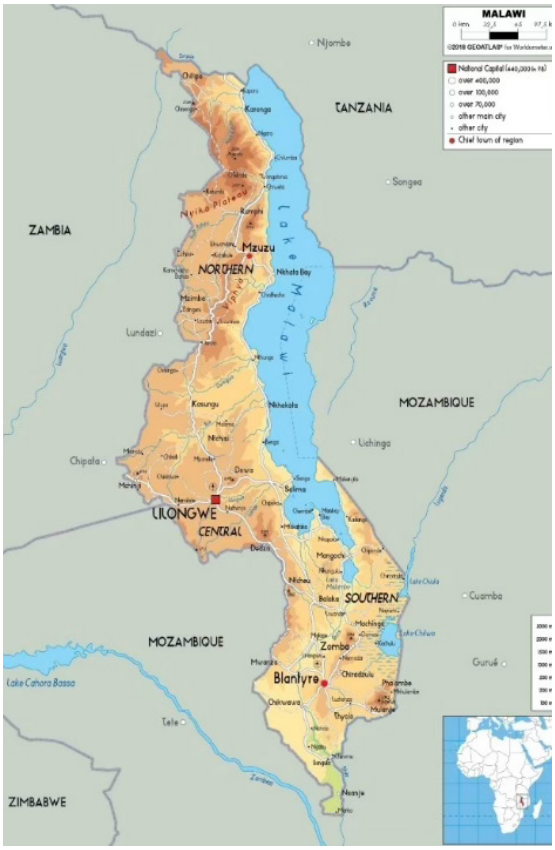
2.1 Geographic, population and socio-economic data

2.1.1 Geographic data

Malawi is a landlocked country, located in Southeastern Africa and bordered by Zambia to the northwest, Tanzania to the northeast, and Mozambique to the south, southwest, and southeast. The landlocked nature of the country and its consequential effect on access to the ocean ports, has a significant impact on Malawi's trading options. Malawi lies at the southern end of the Great Rift Valley, and has a total area of 118,484 km2. which is dominated by Lake Malawi. When combined with the country's other lakes, the water surface area occupies 24,404 km2, about 20% of the total surface area of the country. This provides opportunities for enhanced commercialised fishing, transport and tourism, if effectively managed.

The variation of altitude across the country impacts the weather patterns and resultant seasonal rainfall between November and March. This, in turn, impacts the agricultural potential of the different parts of the country, which is heavily dependent on rain-fed agriculture, both for subsistence and commerce. Malawi is therefore vulnerable to climatic changes that affect harvests, particularly the maize harvest, which is the staple carbohydrate-based diet for much of the population. Recently, with the impact of global warming, Malawi has been affected by cyclones developing in the Indian Ocean and making landfall in Mozambique or Tanzania. These have manifested as tropical storms of devastating impact, especially in the southern region of Malawi. When they occur, they tend to manifest between May and June and between October and November, heavily impacting the preparations for the planting or harvesting of crops, along with the general destruction of infrastructure.[5]

Figure 1. Physical map of Malawi[6]



2.1.2 Population and socio-economic data

A table providing key data on Malawi's population and socio-economic indicators is provided below.

Malawi is a young population of around 20 million, growing at an annual rate of 2.6%, with 41% under 15 years of age. The population growth in recent years is largely due to improved health outcomes and lower mortality rates, driven in large part by the Millenium Development Goals (MDGs) and subsequent SDGs, which emphasised improved healthcare, notably against HIV, tuberculosis and malaria. Malawi remains essentially a rural population, with 81% living in rural areas, who mainly rely on subsistence farming to survive. The poverty headcount in Malawi stands at 75%. Its GDP per capita of US$ 522.6 in 2024 ranks it as 187 out of 190 countries.

5 https://www.worlddata.info/africa/malawi/climate.php
6 Extracted from: https://images.app.goo.gl/DtCsAfjnBKczqZP98

Table 1. Social Indicators for Malawi

People	
Population[7]	20,734,262 (mid-year 2025)
Percentage population aged 0-14[8]	41% (2024)
Population Growth Rate[9]	2.6% (2024)
Rural population[10]	81% (2024)
Economy	
GDP (US$) Current Prices[11]	US$ 11.32 billion (2024)
GDP per capita (US$) Current Prices[11]	US$ 522.6 (2024); rank 187 out of 190
GDP Growth Rate[11]	1.7% (2024)
GNI per capita (USD)	$ 606 (2024)
Inflation[9]	27.9% (November 2025)
Poverty headcount ratio at $3.00 per day (2021 PPP)[11]	75.4% (2019)
Income Distribution (GINI coefficient)[11]	38.5 (2010-2023)
Labour Productivity per worker (GDP constant 2021 international $ at PPP)	$2.9 per hour (2025) vs. sub-Saharan Africa low- and middle-income average of $6.9
Working Age Population employed[12]	8.5 million (2021)
Unemployment Rate (overall) ILO estimate[11]	5.0% (2024)
Foreign Direct Investment (%GDP)[11]	2.3% (2024)
Individuals with access to internet (% population)[13]	27.7% (2024)
Access to Electricity (% population)	25.9% (2025)
Financial inclusion – including informal (% adults)[14]	88% (2023)
Economic Vulnerability Index (EVI)	43.2 (2024)
Social and Health Indicators	
Human Development Index Rank[15]	174 (2024)
Human Assets Index (HAI)	60.5 (2024)
Gender Inequality Index Rank[16]	172 (2024)
Life expectancy at birth[11]	67 (2023)
Per capita health expenditure (current international $)[11]	$105.40 (2022)
Neonatal Mortality Rate per 1,000 live births[11]	19 (2023)
Under 5 mortality rate per 1,000 live births[13]	38 (2023)
Maternal mortality rates per 100,000 live births[17]	225 (2023)
Learning Adjusted Year of School	5.5 (2020)
Literacy Rate (15 years and above)[13]	Total 68%; Male 71% Female 65% (2022)
Net enrolment rate (primary)[18]	Male 91%; Female 89% (2024)
Completion rate (primary)[19]	Male 43%; Female 46% (2024)
Net enrolment rate (secondary)[1]	Male 17%; Female 17% (2024)
Completion rate (secondary)[20]	Male 31%; Female 29% (2024)
Enrolment in Tertiary Education (% gross)[11]	Total 3%; Male 3%; Female 2% (2022)
Educational attainment to Bachelor level for 25+[11]	Total 1.3%; Male 2.2%; Female 0.6% (2020)

Primary education is free, with initial high enrolment levels in the early years of around 90%, but with low completion rates of under 50%. Enrolment in secondary education is only around 17%, with a low completion rate of around 30%. These figures hide a strong differential between private schools and public schools. At the secondary level, there is a strong differential between a small number of well-supported residential Government secondary schools distributed across the country and the predominant community day secondary schools, which have poorer infrastructure. Thus, pupils from private schools or the small number of Government secondary schools have a far better chance of attending university and engaging in higher paid employment. Tertiary sector enrolment rates have increased significantly in recent years, from 1% in 2015 to around 3 %, which is still substantially lower than the 12% sub-Saharan African average. This increase is due to an expansion of both public and private universities.

The country has abundant water resources and unique and diverse flora and fauna. Aquatic ecosystems support sectors such as fisheries, agriculture, livestock grazing, forestry, ecotourism, and water supply. These sectors all have potential for supporting STI-driven economic development. However, the lake ecosystem is threatened by eutrophication from the intensification of economic activities and development projects, climate change, and deforestation, combined with a limited implementation of appropriate environmental management strategies.

Malawi remains an agriculture-based economy, with the vast majority of its population working on the land. Historically, there have been limited mineral resources to exploit and develop. However, exploration over the last several decades has discovered sufficient mineral deposits to justify the development of a mining industry. These include rare earth minerals, precious and base metals, and industrial minerals, with several projects underway. Mining's contribution to the economy is currently less than 1% of GDP, but with ambitions for it to increase to 10% of GDP by 2030, based on the first 10-year implementation plan of Malawi 2063.[20] Recent developments indicate that this figure may be reached by 2027.[21]

General infrastructure across the country is limited. Malawi has a road network of 25,000 km, of which 21,000 km are not tarmacked roads, and many are in poor condition and vulnerable to heavy rains. As roads are the dominant mode of transport in the country, this places constraints on internal and external trade, as well as on associated economic development.22 A limited railway network exists, consisting of 933 km mainline single cape gauge, some of which is often non-operational due to railway infrastructure damage caused by flooding. Recent railway investment has improved operations along the Nacala Corridor, which links Western Mozambique to the port of Nacala via Malawi, leading to an increase in freight traffic.23 As indicated in Table 1, only 26% of the population had access to electricity in 2025 and 28% had access to the internet in 2024, with the percentage of

7 National Statistics Office, Malawi. https://www.nsomalawi.mw
8 World Development Indicators (WDI), World Bank. wdi.worldbank.org
9 The World Bank https://data.worldbank.org/country/malawi; and Malawi Nation article https://mwnation.com/world-bank-pegs-malawis-poverty-rate-at-75-4/
10 https://ilostat.ilo.org/topics//labour-productivity/
11 National Statistical Office (2021). Fifth Integrated Household Survey (IHS5) 2019-2020
12 https://africa-energy-portal.org/reports/national-energy-compact-malawi
13 https://datareportal.com/reports/digital-2024-malawi
14 https://finmark.org.za/Publications/2023_FinScope_Consumer_Survey_Malawi_2023_Report.pdf
15 Human Development Report 2024/2025. https://hdr.undp.org/content/human-development-report-2025
16 https://genderdata.worldbank.org/en/indicator/hd-hci-lays?gender=total
17 https://genderdata.worldbank.org/en/economies/malawi
18 Malawi Education Statistics Report 2023/24
19 https://mwnation.com/mining-to-contribute-12to-gdp-by-2027-chamber/
20 Malawi 2063. https://npc.mw/mw2063 and First 10-year Implementation Plan, MIP-1. https://npc.mw/mip-1-3/
21 https://mwnation.com/mining-to-contribute-12to-gdp-by-2027-chamber/
22 NTU International. https://www.ntu.eu/roads/development-of-rural-roads-in-malawi/#:~:text=Malawi%20has%20a%20road%20network,transport%20and%20internal%20freight%20transport
23 Ministry of Transport. https://www.transport.gov.mw

access being much lower in rural areas. This leads to Malawi ranking in UNCTAD's Productive Capacities Index as 191st out of 194 countries for energy and 176th out of 194 for ICT, which incorporates telecommunications and internet. Overall, Malawi ranks 193rd out of 194 in the second generation of the UNCTAD Productive Capacities Index.[24] Technological advances have led to increased engagement by the population in the wider economy. This is notably marked by financial inclusion, which has risen from 49% in 2014 to 88% in 2023, largely driven by mobile money.

2.2 Government structure and policy environment

2.2.1 Government structure and processes

As of January 2026, there are 18 ministries within the Government. The cabinet currently consists of the President, two Vice-Presidents, 18 cabinet ministers, and 7 deputy ministers.[25] There is a local government structure with 35 administrative subdivisions, each governed by their councils, consisting of both a political and a technical arm. There are 28 district councils, 4 city councils, and 2 municipal councils representing areas of urban growth, and 1 town council.[26] Alongside the local government structure is a traditional leadership structure governed by a Chief's Act that makes "*provision for the recognition, appointment and functions of Paramount Chiefs, Senior Chiefs, Chiefs, Sub-Chiefs, Councillors, Group Village Headmen and Village Headmen; and for certain aspects of District Administration and for matters incidental thereto or connected therewith.*"[27,28]

The process for Government policy development is that proposed policies are: (i) developed with wide sectoral consultation by the responsible ministry; (ii) reviewed by a meeting of Principal Secretaries; (iii) if approved, reviewed by a cabinet committee; (iv) if approved, reviewed by cabinet; and (v) if approved published in the Government Gazette.

The process for Government legislative development is that proposed legislation, which may often follow on from policy, is: (i) developed with appropriate sectoral consultation by the responsible ministry; (ii) reviewed and drafted by the Ministry of Justice; (iii) if approved, reviewed by a meeting of Principal Secretaries; (iv) if approved, reviewed by a cabinet committee; (v) if approved, reviewed by cabinet; (vi) if approved, presented to parliament for further scrutiny, where it may, if necessary, be referred to a parliamentary committee for further review; (vii) if approved by parliament, passed to the President for assent; and (viii) if assented, published in the Government Gazette to become law.

2.2.2 A broadly accepted National Development Strategy with a role for STI

In terms of overarching policy, important legislation was initiated under the DPP Government in 2017, with widespread approval, to establish a National Planning Commission to provide overall (apolitical) guidance on national planning. As part of the Act establishing the National Planning Commission, all political parties must sign up to the plans of the Commission. The subsequent Government followed up on this Act and launched the visionary strategic document of the National Planning Commission, **Malawi 2063,** in January 2021. This was followed soon after by the First 10-year implementation plan of Malawi 2063, often referred to as **MIP-1**.[29] To register for the election in 2025, new parties had to demonstrate that their policies align with the national strategy. Malawi 2063 is thus broadly accepted by all parties.

24 https://unctad.org/system/files/official-document/aldc2023d2_en.pdf
25 Malawi Government Information and Services - Ministries
26 Ministry of Local Government, Unity and Culture website. https://www.localgov.gov.mw/
27 https://www.localgov.gov.mw/downloads/ChiefsAct.pdf
28 Kayuni et al (2019). Perceptions on the legitimacy of traditional leaders in democratic Malawi. Journal of Public Administration and Development Alternatives, 4(1), 42-54. https://journals.co.za/doi/pdf/10.10520/EJC-165fd92694
29 https://npc.mw/mip-1-3/

The development strategy outlined by Malawi 2063 centres on three main pillars.

1. **Agricultural productivity and commercialisation**, linked to value-addition manufacturing pathways.
2. **Industrialisation**, with an emphasis on industrialising mining, among other services.
3. **Urbanisation**, aimed at the responsible development of linked urban centres and the creation of tourism hubs.

These are supported by 7 enablers, namely: mindset change, effective governance systems and institutions, enhanced public sector performance, private sector dynamism, human capital development, economic infrastructure, and environmental sustainability.

Science, Technology and Innovation is a cross-cutting component of Malawi 2063, but is particularly highlighted within the industrialisation pillar and the human capital development enabler. Industrialisation policy falls under the Ministry of Industrialisation, Business, Trade and Tourism. The human capital development enabler covers: health and well-being through the Ministry of Health; primary, secondary and higher education through the Ministry of Education, Science and Technology (MoEST); and Technical, Entrepreneurial and Vocational Education and Training (TEVET) through the Ministry of Labour, Skills and Innovation. The STI policy holder is the MoEST.

The ministries with the most significant budgets within the Government are those responsible for Agriculture, Education and Health.

2.2.3 Financial policy challenges

Malawi is primarily a market-led economy, although with a number of parastatal companies in place to manage critical strategic infrastructure and critical functions, such as electricity and water.

Malawi's economy is in a deep and protracted crisis, marked by elevated inflation, declining living standards, and high rates of food insecurity[30]. Malawi's annual growth rate has slowed from an average of 4.1% (2011-2019) to 2.2% since 2020. This is lower than Malawi's 2.6% population growth rate, thus entailing a fall in GDP per capita. A major limitation on Malawi's fiscal space is its level of public debt, exacerbated by Covid-19 and recent natural disasters. Public debt was 83.6% of GDP in 2023, half of which was external debt and the other half domestic debt brought about by fiscal deficits. Interest payments on this debt were estimated to approach 50% of domestic revenue in the 2024/25 financial year. The incoming 2025 Government increased VAT from 16.5% to 17.5%, instituted a 0.05% levy on electronic transactions, and made changes to corporate, income (PAYE) and gambling taxes, as part of an effort to increase revenue and limit the growth of public debt. The macroeconomic situation is also exacerbated by a persistent balance of payments deficit, estimated at 17.3% of

Table 2. Major donors of Official Development Assistance for Malawi

Donor	Areas of Activity and issues
World Bank Group (IDA)	Primarily concessional loans for infrastructure and social programs.
United States of America	Despite the dissolution of USAID in 2025, the USA continues to provide substantial investment in health, focusing on disease surveillance and outbreak response, and also in energy and transport through the Millenium Challenge Corporation.
Global Fund	Vertical programmes on HIV/AIDS, Tuberculosis and Malaria
IMF	Focus on macroeconomic stability. Extended Credit Facility was terminated in May 2025.
European Union	Governance, Rural Development, Education, including TEVET.
Germany	Governance and social protection initiatives.
United Kingdom	Humanitarian aid, Social Protection, and Health.
African Development Bank	Economic infrastructure for Industrialisation and Agriculture
Japan	Infrastructure
Norway and Sweden	Education, human rights, and climate change

30 The Word Bank (2025). Malawi Economic Monitor. Navigating Uncertainty http://documents.worldbank.org/curated/en/099071125090031718

GDP in 2023.[31] In addition, inflation has remained high, at around 30% for several years, with correspondingly high interest rates.

The net effect of Malawi's macroeconomic challenges creates a challenging business environment for Malawi's private sector, which limits investment and expansion opportunities.

2.2.4 Development partner support

Malawi has strong development partner support. Malawi received official development assistance (ODA) and official aid totalling $ 1.73 billion (at current US$) in 2023, over double the $ 658 million it received in 1994 as it transitioned to a multi-party democracy[32] The net ODA received as a percentage of Malawi's Gross National Income was 13.2% during 2023, while the sub-Saharan African region's aggregate (without high-income countries) amounts to 3.4%.[33] Major donors and their specific areas of interest are listed below.

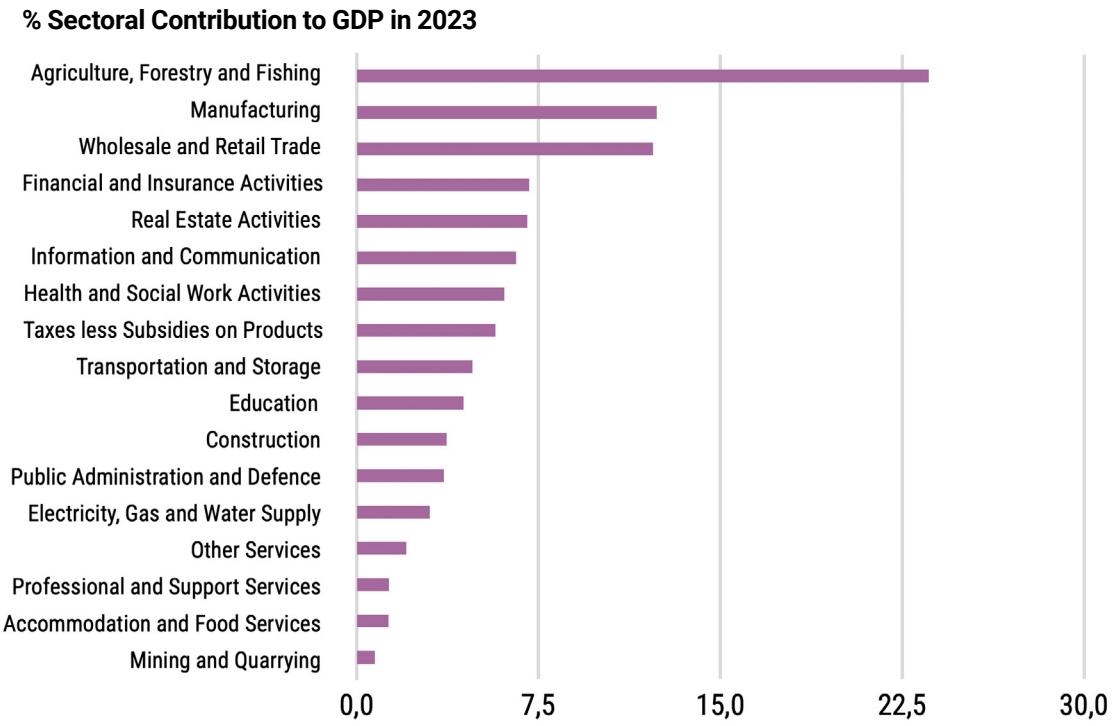
In addition, there are strong relations with a significant number of other countries, including the People's Republic of China, and India.

2.3 Economic growth and structural transformation

2.3.1 Sectoral contributions to GDP

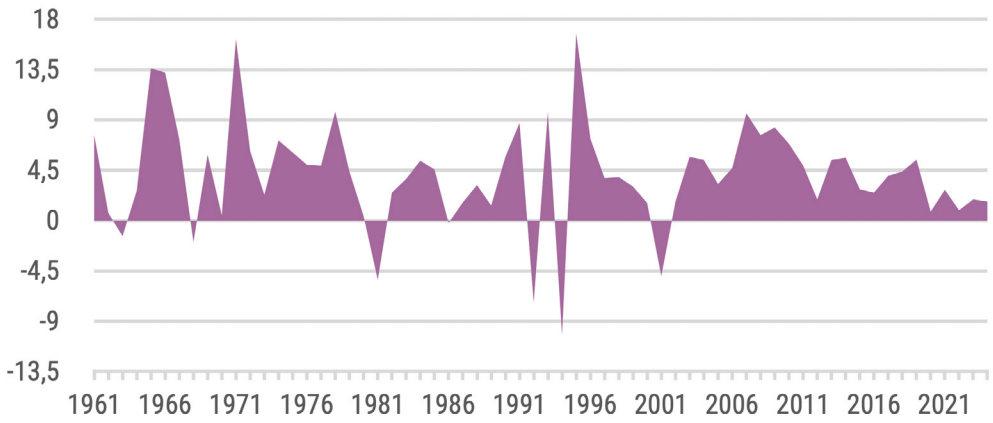
As referenced in Chapter 1, The Republic of Malawi is ranked 6th poorest country in the world by GDP per capita in 2025. As such, Malawi is in the early stages of a structural transformation from a low-income country, reliant on agriculture, with high levels of poverty and inequality, to an industrialised middle-income country based on a more diversified and inclusive economy. The current overview of different sector contributions to Malawian GDP is shown in Figure 2, taken from Malawi's 2025 Annual Economic Report.[34]

Figure 2. The percentage contribution by different sectors to GDP for 2023.



31 IMF Staff Country Reports Volume 2025 Issue 226 (2025). https://www.elibrary.imf.org/view/journals/002/2025/226/article-A001-en.xml#:~:text=6.
32 https://data.worldbank.org/indicator/DT.ODA.ODAT.CD?locations=MW
33 Net ODA received (% of GNI) | Data (worldbank.org)
34 Malawi Government, Annual Economic Report 2025. Annual Economic Report 2025.pdf

Figure 3. Growth Rate of Malawian GDP from 1961 to 2024



Growth in GDP since 1961 is shown in Figure 3 below, with data taken from the World Bank.[35] Although the growth rate is primarily positive, the data wildly fluctuates and there are limited examples of sustained growth. Given the predominance of agriculture in the economy, a major factor in GDP growth or decline is the performance of the agricultural sector. For example, the 2009 Malawi Economic Report[36], which covers a period of sustained growth from 2007 to 2010, primarily attributed the 9.7% GDP growth in 2008 to enhanced tobacco production and a relatively high pricing (in US$) of tobacco. More recently, reductions in growth rates correlate with the impact of Covid-19 in 2020-2021 and the major tropical storms of 2022 and 2023.

Table 3 illustrates the change in the contribution to the economy ascribed to each sector over time, between 2011 and 2023.[37]

There has been no significant change in the relative contributions of sectors to GDP. For example,

Table 3. Change in contribution by different sectors to GDP between 2011 and 2023

Sector	% contribution to GDP in 2011	% contribution to GDP in 2023	Change in sector's % contribution to GDP
Agriculture, forestry and fishing	32.5	23.6	**-8.9**
Manufacturing	10.4	12.4	**2**
Wholesale and retail trade	16.4	12.2	**-4.2**
Financial and insurance services	5.2	7.1	**1.9**
Real estate activities	8.6	7	**-1.6**
Information and communication	3.9	6.6	**2.7**
Health and social work activities	2.8	6.1	**3.3**
Transportation and storage	2.8	4.8	**2**
Education	2.6	4.4	**1.8**
Construction	3.1	3.7	**0.6**
Public administration and defence	2.1	3.6	**1.5**
Electricity, gas and water supply	1.4	3	**1.6**
Other Services	5	2.1	**-2.9**
Professional and support services	0.3	1.3	**1**
Accommodation and food services	2	1.3	**-0.7**
Mining and quarrying	1	0.8	**-0.2**

35 GDP growth (annual %) - Malawi | Data (worldbank.org)
36 Malawi Government 2009 Economic Report. Annual Economic Reports (finance.gov.mw)
37 https://www.epd.gov.mw/wp-content/uploads/2023/09/Annual-Economic-Report-2014.pdf

Agriculture remains the most important sector. However, it is notable that there has been a major decline in the percentage contributed by the Agricultural sector (-8.9) and the Wholesale and Retail sector (-4.2). The sectors seeing the largest growth in contribution are the Health and Social Work sector (+3.3) and the Information and Communication sector (+2.7), both service industries. Other service industries, such as Financial and Insurance services, Education, Electricity, Gas and Water, and Professional and Support services, have also increased their contribution.

The Agrifood System. An International Food and Policy Research Institute (IFPRI) publication38 argues that, despite the potential to increase GDP and employment through the service industries, growth of the agricultural sector yields the largest benefit to the poorest quintile of the population in both the rural and urban areas. Although primary agriculture accounts for only 24.4% of GDP in this data set, the agrifood system as a whole, taking into account off-farm system components, accounts for 44.1%. Likewise, its impact on employment increases from 63.5% to 77% when the off-farm components of the system are taken into account. This is outlined in Table 4 below comparing the Agrifood system with the rest of the economy.

The authors further make the point that labour productivity is significantly higher for off-farm components than on-farm components. The movement of workers from on-farm to off-farm activities, which will occur naturally as part of the process of agricultural transformation, may thus be beneficial to household incomes.

2.3.2 Balance of payments

The balance of payments for the Malawian economy is a continuing issue and is in large part responsible for the pressure on the Malawi Kwacha, inflationary pressures within the economy, and the accompanying high interest rates, which inhibit domestic investment. Malawi has a current account deficit of over US$ 2 billion (see Table 5). Much of this is due to an imbalance in the export and import of goods. The situation would be even worse if the economy were not cushioned by secondary income based largely on developmental assistance. Exported goods amount to just over US$ 1 billion, much of this due to primary agricultural products and natural resources, compared to imported goods of over US$ 3 billion. There is a need to massively increase and diversify the amount of goods exported in the short to medium term if the balance of payments issue is to be addressed.

Agriculture dominates exports. The Malawi Government reports of 2022 and 2024 both state that the Malawi's export basket continues to be dominated by agricultural products, with tobacco, tea, and sugar being the highest export commodities. However, there is increasing

Table 4. Current structure of Malawi's Agrifood system and economy (2019)[53]

	GDP		Employment	
	Value (US$ billion)	Share (%)	Workers (million)	Share (%)
Total Economy	10.4	100.0	7.6	100.0
Agrifood System	4.6	44.1	5.9	77.0
Primary Agriculture	2.5	24.4	4.8	63.5
Off Farm Agrifood System	2.0	19.6	1.0	13.5
Processing	0.8	8.2	0.2	3.1
Trade and Transport	0.8	7.7	0.6	8.2
Food services	0.1	0.8	0.1	1.7
Input and supply	0.3	3.0	0.0	0.6
Rest of Economy	5.8	55.9	1.8	23.0

38 Benson, T. (2021). Disentangling food security from subsistence agriculture in Malawi. IFPRI. See especially chapter 6. Structural transformation of Malawi's economy to end hunger. https://www.ifpri.org/sites/default/files/d9_documents/06-BK_2021_Benson_ch06_web.pdf

39 Malawi Government 2024 Economic Report. Annual Economic Reports (finance.gov.mw)

40 Malawi Government 2022 Economic Report. Annual Economic Reports (finance.gov.mw)

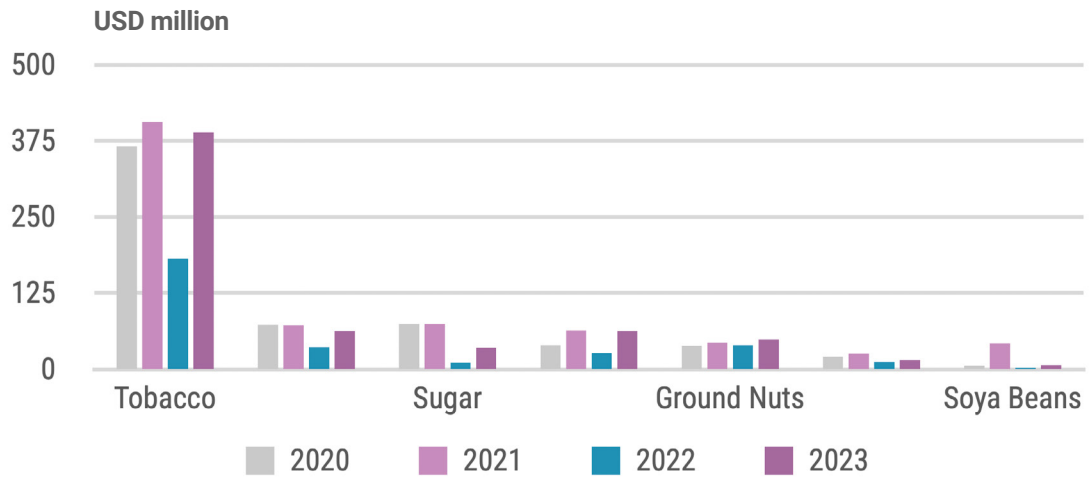
Table 5. Balance of Payments 2020-2023 (US$ millions)[26,27]

	2020	2021	2022	2023
Current account	(1,469.3)	(1,591.8)	(2,275.5)	(2,271.3)
Credit	2,152.3	2,208.9	2,198.6	2,200.0
Debit	3,621.7	3,800.7	4,474.1	4,471.4
Goods	(1,791.0)	(1,900.8)	(2,004.3)	(2,158.6)
Credit	900.9	960.9	1,022.8	1,095.1
Debit	2,692.0	2,861.6	3,027.1	3,253.7
Services	(143.9)	(120.3)	(214.8)	(226.0)
Credit	441.7	463.0	464.0	464.5
Debit	585.6	583.3	678.9	690.5
Primary income	(289.9)	(231.0)	(559.9)	(403.9)
Credit	23.2	20.4	21.3	22.9
Debit	313.1	251.4	581.2	426.8
Secondary income	755.5	660.2	503.6	517.1
Credit	786.5	764.6	690.4	617.5
Debit	31.0	104.3	186.9	100.4

diversification of agricultural output in recent years, with pulses, groundnuts, and macadamia nuts gaining in importance, as illustrated in figure 4. In summary, the agricultural sector accounts for approximately 80% of export earnings, and approximately 60% of agricultural exports are obtained from one product, namely tobacco. Sales of this one product, accounts for approximately 50% of Malawi's export earnings.

Further trade data has been obtained from the Lloyds bank trade website.[41] This indicates that the major Malawian imports are petroleum products (approximately 17% in 2022) and fertiliser (approximately 13% in 2022). The main export market for Malawi in 2022 was the European Union, notably Belgium, and a number of Southern and East African countries, with China and India becoming increasingly important markets. The major suppliers of imports were China, UAE, South Africa, and India.

Figure 4. Export earnings from Agricultural products 2020 to 2023



41 https://www.lloydsbanktrade.com/en/market-potential/malawi/trade-profile#classification_by_products

Table 6. Mining companies that have signed contracts with Malawi for production (from footnote 55)

Company	Country of Origin	Mineral to be mined	Location	Expected Start Date
Lotus Resources	Australia	Uranium	Kayelekera, Karonga	Production initiated 2025
Sovereign Metals	Australia	Rutile-Graphite	Kasiya, Lilongwe	2027
Globe Metals	Australia	Niobium	Kanyika, Mzimba	2026
Lindian Resources	Australia	Rare Earth metals	Kankankunde, Balaka	tbd
Lancaster Exploration (owned by Mkango Resources)	Canada	Rare Earth Metals	Songwe Hill, Phalombe	tbd

Mining - potential for export-led growth. Although mining and minerals currently account for around 1% of GDP, there is an urgent desire to diversify Malawi's export base through this industry in line with Malawi 2063. The country is therefore positioning itself to capitalise on a rich endowment of minerals, ranging from alluvial gold and gemstones to globally significant deposits of rutile, graphite, uranium, niobium, and rare earth elements.[42,43] There is a large amount of geological data available, with more extensive mapping underway, as a starting point for potential investors. Recent legislation has been enacted to set up a Mining Regulatory Authority and a state-owned mining company to assist with the sector's development. Five major mining agreements have been established with foreign-owned companies and there is an increased emphasis on promoting artisanal and small-scale mining. Table 6 summarises the top five mining projects underway. It is estimated that mining exports could generate US$ 3 billion per year by 2034, three times Malawi's current merchandise exports, which were at US$ 1 billion in 2023. The sector could therefore be transformational, removing Malawi's dependence on tobacco for example.

2.3.3 Population growth, distribution and unemployment

The Malawian population stood at 20.7 million in 2025 (Table 1), up from 3.6 million in 1960[44], with a working population of 8.6 million in 2024.[45] The population growth rate stands at 2.6% and is on a downward trend from a 21st century high of 2.9% in 2009.[46] Life expectancy was 67 in 2023, up from a low of 43 in 1998 at the height of the impact of the HIV/AIDS pandemic, and 36 in 1964 at the time of gaining independence.[47] The rural population is growing, but at a lower rate than the urban population, and therefore the percentage rural population is falling. It stood at 81% in 2024, down from 87% in 1994, and 95% in 1964. The population growth has led to a young population with potential for a demographic dividend. With a slightly decreasing birth rate and an extended life expectancy, there is a slight reduction in the percentage of children under 15, from 46.6% in 2012 to 41.3% in 2023, as indicated in Table 7. [48]

Malawian unemployment has oscillated between a low of 4.6% and a high of 5.8% since 1991, and stood at 5% in 2023. Importantly, the share of youth not in employment, education or training stood at 19.4% in 2020.[49] The official unemployment figures hide a significant challenge of 'underemployment' that exists within the Malawian system. Urbanisation leads to increased employment, but this is primarily through casual labour, often while maintaining a household farm. Urbanisation has not yet mediated any significant movement away from agriculture and Malawi is at the start of its urbanisation process. [50]

42 Malawi Export Development Fund Research Insights June 2025. https://www.edf.mw/index.php/research-insights
43 https://www.trade.gov/country-commercial-guides/malawi-mining-and-minerals
44 https://data.worldbank.org/indicator/SP.POP.TOTL?locations=MW
45 https://data.worldbank.org/indicator/SL.TLF.TOTL.IN?locations=MW
46 https://data.worldbank.org/indicator/SP.POP.GROW?locations=MW
47 https://data.worldbank.org/indicator/SP.DYN.LE00.IN?locations=MW
48 https://www.statista.com/statistics/520589/age-structure-in-malawi/
49 https://data.worldbank.org/indicator/SL.UEM.NEET.MA.ZS?locations=MW
50 https://ebrary.ifpri.org/utils/getfile/collection/p15738coll2/id/136900/filename/137112.pdf

Table 7. Age distribution 2012 to 2024 taken from the Statista website

Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
% 0-14 yrs	46.6	46.4	46.3	46.0	45.7	45.3	44.8	44.3	43.7	43.2	42.6	41.3
% 15-64 yrs	49.9	50.1	50.4	50.8	51.2	51.7	52.2	52.8	53.5	54.2	54.8	56.1
% 65 yrs and older	3.6	3.5	3.4	3.3	3.2	3.1	3.0	2.9	2.8	2.7	2.6	2.6

2.3.4 Summary comments on economic growth and structural transformation

Malawi's economy is primarily an agriculture-based economy. Its youthful population remains largely rural based, with approximately 63% of the working population engaged in agricultural activity, rising to 77% if one takes into account the wider agri-food industry. The agricultural sector accounts for 24% of GDP, rising to 44% if one extends to the agrifood system as a whole. Malawi is heavily dependent on primary agricultural produce for 80% of its export earnings, with tobacco alone accounting for approximately half of all export earnings. Its major import requirements are petroleum products (approximately 17% in 2022) and fertiliser (approximately 13% in 2022).

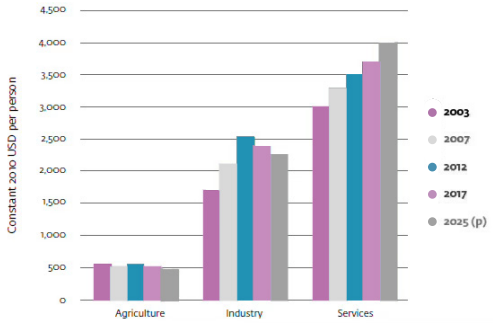
Table 3 indicates that, over the past decade, there has been a gradual reduction in the dominance of primary agriculture, wholesale and retail in the economy, with other sectors expanding, in particular the service sectors, including the social and utility services, information and communication, and the professional and financial services. This indicates a gradual diversification and development of the economy. The continued growth of these service sectors will be critical for the increased productivity and envisioned growth of agricultural commercialisation, industrialisation and urbanisation. This in turn will require an expansion of the skill sets required of the service sectors to support agricultural and industrial expansion. It will include: (i) expanded digitalisation and enhanced communication access through phone and the internet, and associated data management; (ii) expanded access to power through (renewable) energy transformation, along with access to water and improved transport systems; and (iii) an expansion of social protection and the decent work and employment that ensues from these developments. For this to occur there is a need to rapidly expand the industrial private sector and encourage the growth of small and medium-sized enterprises and their conversion into medium-sized and large enterprises.

Of the 16 companies listed on the Malawi Stock Exchange[51], ten are in the financial sector, including five Banks, two are in the telecom sector, and two are hotel chains providing consumer services. There is only one in the industrial sector, namely Press Corporation, and one, Illovo Sugar, in the consumer goods sector. Interestingly, Malawian companies feature prominently within the top 30 companies of South-Central Africa,[52] indicating a high level of regional business preparedness and competitiveness.

51 https://www.african-markets.com/en/stock-markets/mse/listed-companies
52 https://images.africanfinancials.com/fe465a7c-south-central-africa-june-top-30.pdf

An International Finance Corporation (IFC) publication diagnosing the Malawian Private Sector and Malawian markets[53] highlights that: most medium-sized and large enterprises focus on low-complexity activities; only modest skills are required in much of the current labour market; and building the knowledge base for more complex industries in the country will take time. As such, it calls for the empowerment of entrepreneurs, farmers, and youth, with opportunities for basic digital skills training providing near-term opportunities to enhance productivity and create new jobs. The report further highlights that the productivity of workers in the industrial and service sector massively outweighs the current levels of productivity among agricultural workers, in terms of value added to the economy. This is illustrated in Figure 5.

Figure 5. Value added per worker by sector taken from footnote 42



The challenges that Malawi faces to achieve growth through STI and associated industrialised activities is highlighted by its low ranking in the UNCTAD Productive Capacities Index54. Areas of particular concern are in the areas of physical infrastructure, such as transport, where it ranks 194 out of 194 countries, and energy, where it ranks 191 out of 194 countries. A major hope for Malawi is that it scores relatively highly under human capital development, where it ranks 147 out of 194 countries. These areas are discussed in more detail in the next section.

2.4 Availability of human capital and physical infrastructure

2.4.1 Human capital

Human Capital development is listed as a major enabler of the Malawi 2063. This section outlines the education and training system in Malawi and concludes with an assessment of strengths and weaknesses of Malawi's skill set and what is required for its future development. The data presented in this section on primary, secondary and tertiary levels of education, including both university education and Technical and Vocational Education and Training (TVET), are taken from 2023 data presented in the 2024 Annual Economic Report (Chapter 9) and the Malawi Education Statistics Report 2023/24,[55] except where otherwise indicated.

Primary and secondary education.

Primary school education in public schools is free in Malawi, with children supposed to start eight years of primary education at age six. However, it is not compulsory. There is a mix of both public and private provision of primary schools. Public sector primary schools operate formally under Local Government control. Those passing the primary school leaving certificate examination may qualify for four years of secondary school leading to the Malawi School Certificate of Education (MSCE). There are several types of secondary school in Malawi. These include: (i) Government secondary boarding schools of high quality situated around the country; (ii) Grant-aided secondary schools, run by religious denominations, which receive government support; (iii) Community Day Secondary Schools (CDSSs) which vary hugely in quality depending on their location and the wealth of their supporting community; and (iv) private schools. Public secondary schools operate under the central MoEST. Key statistical data to assess primary and secondary education are provided in Table 8 below.

53 IFC, 'Creating Markets in Malawi: The Road to Recovery: Turning Crisis into Economic Opportunity', 2021. https://www.ifc.org/en/insights-reports/2021/cpsd-malawi.
54 https://unctad.org/topic/least-developed-countries/productive-capacities-index
55 https://www.education.gov.mw/index.php/edu-resources/2022-education-statistics

Table 8. Critical Educational Statistics taken from the 2023/24 Education Statistics Report

Indicator	2022/23			2023/24		
	Male	Female	**Total**	Male	Female	**Total**
Primary - net enrolment	88	93	**91**	86	92	**89**
Primary - repetition rate	27	26	**26**	27	26	**26**
Primary – drop-out proportion	4.0	4.0	**4.0**	4.3	4.3	**4.3**
Primary – pupil-qualified teacher ratio			**64**			**65**
Primary – completion rate	46	50	**48**	43	46	**45**
Primary - transition rate to secondary	47	47	**47**	50	50	**50**
Secondary - net enrolment	17	17	**17**	17	17	**17**
Secondary – drop-out proportion	4.0	6.0	**5.0**	4.1	5.9	**5.0**
Secondary – completion rate	24	21	**22**	31	29	**30**

The net enrolment rate for primary schools, based on attendance from six years ago was 89% in 2024, with a gender parity index of 1.07. This compares favourably with many sub-Saharan African countries. However, 26% of students repeat a year of study and this, combined with a relatively high dropout rate, means that the completion rate of primary school in the standard time is only 45%. For those that complete primary school, the pass rate for the Primary School Leaving Certificate of Education in 2023 was 83%. The infrastructure quality of many schools is sub-standard. The Ministry of Education, Science and Technology has introduced Essential School Infrastructure Package Guidelines to address this issue. Currently, primary school teachers are trained to Certificate level, but there is a policy in place to upgrade primary school teacher qualifications to diploma and degree level. These statistics are mirrored by the high-level of learning poverty within Malawi, with only 19% of primary school learners aged seven to fourteen able to read or write at grade level.

The average number of years of schooling attained by young adults in the 20-to-24-year age group is 7.35, 6.99 for females and 7.76 for males.[56] These data, providing average values, hide huge disparities between the richest and poorest of society. For example, the number of school years attended stands at 5.4 years for the poorest quintile of the population and 10.18 for the richest quintile. The data also hide that, with only 3% of primary schools currently accessing the internet, offline ICT approaches are needed. A major commitment to improve the foundational literacy and numeracy skills of all primary school learners in standards 1 to 4 has been initiated through the Building Education Foundations through Innovation and Technology (BEFIT) programme[57] which aims to provide individual tablets, pre-loaded with curriculum-based teaching material, to each of 3,500,000 primary learners in 5,800 schools by September 2029. The programme includes the training of all teachers using the BEFIT approach and the establishment of solar installations so that all primary schools are electrified by September 2029. At secondary school level, a 'Connect-A-School' project has been launched to empower schools through cutting-edge technology that includes: distance lecturing through internet connectivity and the provision of pre-loaded tablets with learning material, including a virtual science lab app (mi-lab) developed by Mzuzu University (MZUNI).[58,59]

The application of open distance and e-learning using local radio to provide lessons and the web-based availability of teaching and learning material is also being developed and implemented.

56 UNESCO data retrieved from https://www.education-inequalities.org/indicators/eduyears/malawi#ageGroups=%5B%22eduyears_2024%22%5D&years=%5B%222020%22%5D
57 https://www.imagineworldwide.org/wp-content/uploads/Malawi-Project-Overview-General-2-27-23.pdf
58 https://www.unicef.org/malawi/press-releases/connect-school-project-launches-empower-schools-cutting-edge-technology
59 https://www.unicef.org/malawi/press-releases/connect-school-project-launches-empower-schools-cutting-edge-technology

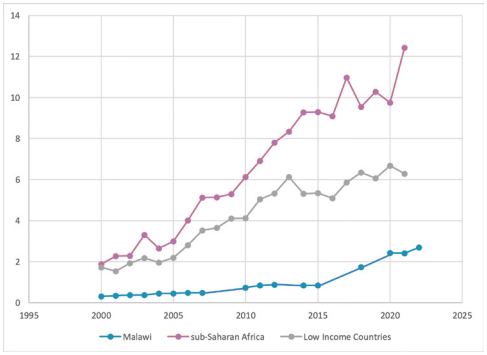
Higher education

Higher Education globally has two main objectives. The first is to undertake teaching and learning and provide students with the basic skills and knowledge that enables them to become lifelong learners. The second is to promote and undertake research to develop and advance new knowledge and technologies that can impact on society. For many years, Malawian universities focused on the first of these objectives through their bachelor and master's programmes. In recent years, they have started to also promote research through master's and doctoral programmes.

As with primary and secondary education, higher education development in Malawi is starting from a low base. The growth in gross enrolment within tertiary education between 2000 and 2022, compared to the mean values of sub-Saharan Africa and low-income countries, is shown in Figure 6.[60]

The tertiary education gross enrolment ratio was measured at 2.7% in 2022, up from 0.84% in 2015. This compares to a Sub-Saharan average of over 12% in 2021, a global average of 43%, and an Organisation for Economic Cooperation and Development (OECD) average of 79%. This expansion in recent years has resulted in approximately 1.3% of the adult population over 25 holding a bachelor's degree in 2020.61 The expansion in tertiary education enrolment has occurred through both public and private universities, and the relative enrolment between public and private universities is shown in Figure 7.

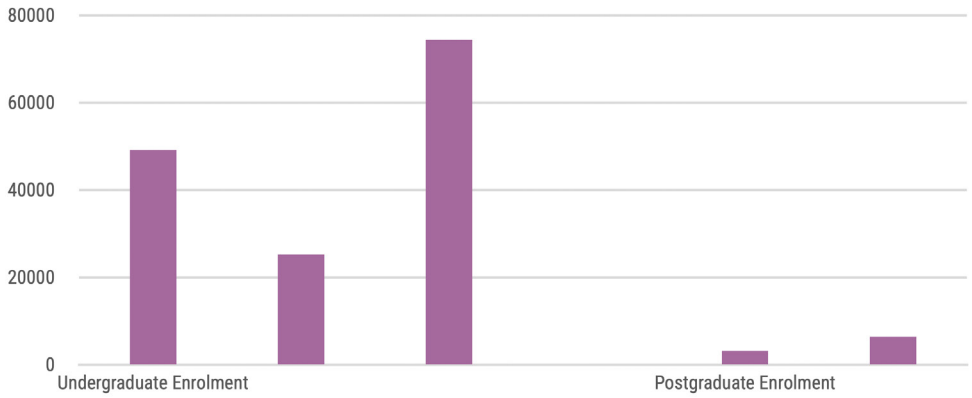
Figure 6. Comparison of Gross Enrolment in Tertiary Education in Malawi with the mean values for sub-Saharan Africa and Low-Income countries. Data taken from the World Bank database.



Total undergraduate enrolment stands at 74,414 in 2024, of which 49,195 (66%) is from public universities and 25,219 (34%) from private universities. Approximately 44% of undergraduate students are female. Total postgraduate enrolment stands at 9,656 in 2024, of which 3,217 (33%) is from public universities and 6,439 (67%) from private universities. A total of 10,918 students (13%) are enrolled as Open Distance and e-Learning (ODeL) students.

Public University education was initiated alongside independence in 1963 through the establishment of the University of Malawi in 1964. Several colleges were established within the University,

Figure 7. Comparison of public and private sector university contribution to national undergraduate and postgraduate enrolment. Data taken from the Malawi Education Statistics Report 2023/24



60 https://data360.worldbank.org/en/prosperity
61 World bank data. https://data.worldbank.org/indicator/SE.TER.CUAT.BA.ZS?locations=MW

namely Chancellor College in Zomba, Bunda College of Agriculture, and Kamuzu college of Nursing in Lilongwe, and the Polytechnic and the College of Medicine in Blantyre. Mzuzu University was established in 1997 and the Malawi University of Science and Technology (MUST) was established in 2012. The original member colleges of the University of Malawi have since de-linked and been established as universities in their own right. Bunda College of Agriculture was established as the Lilongwe University of Agriculture and Natural Resources (LUANAR) in 2011. In 2021, the remaining colleges were de-linked. Chancellor College retained the name of University of Malawi (UNIMA), the Polytechnic became the Malawi University of Business and Applied Sciences (MUBAS), and the Kamuzu College of Nursing and the College of Medicine merged to form the Kamuzu University of Health Sciences (KUHeS). These universities have all been created under Acts of Parliament and receive public subventions to help subsidise their Bachelor programmes. They are all now prominent in offering master's and doctoral research programmes.

A large number of private universities, approximately 20, have been established over the past 15 years. These range from faith-based institutions to fully private institutions and they account for about 34% of the university student population, offering both undergraduate and postgraduate degree programmes.

There is an Open Distance and e-Learning (ODeL) sub-sector developing within the university sector, which has developed further as a result of COVID-19, and this now accounts for 13% of the student population. This was started by MZUNI offering ODL programmes in 2006 and has been taken up in a major way by several other public universities, notably LUANAR and UNIMA. There is one fully online private university operating in Malawi, Unicaf University, which also offers an extensive set of Master's and doctoral programmes.

Over the past 15 years, a series of infrastructure projects have been undertaken in public universities, primarily financed by the African Development Bank and The World Bank. The latest of these, the Skills for a Vibrant Economy (SAVE)[62] project, also incorporates the TEVET sector. A notable recent STI development was the establishment of a University Innovation Pod (UniPod) with cutting edge equipment to support young innovators, based at MUBAS but serving all universities in Malawi.[63] The infrastructure investment, combined with scholarship support, has led to an increasing number of PhD qualified lecturers and the establishment of a number of STI-linked doctoral research programmes.

Technical, Entrepreneurial, Vocational Education and Training (TEVET)

Technical, Entrepreneurial, Vocational Education and Training (TEVET) in Malawi is overseen by the Technical, Entrepreneurial, Vocational Education and Training Authority (TEVETA) which accredits the TEVET programmes and the issue of awards under the TEVET Qualifications Framework. TEVETA operates under the Ministry of Labour, Skills and Innovation. It oversees several national technical colleges that provide 4-year programmes, consisting of both college course work and industrial apprenticeships leading to diplomas. The past decade has seen the introduction of community technical colleges and community skills development centres to complement the national technical colleges. However, these often have limited technical infrastructure. Several private technical and vocational colleges have also been established, often operating under faith-based organisations.

Currently, the only institution offering dedicated teacher training for TEVET programmes is MUBAS. However, there are plans to establish a specialised TEVET teacher and instructor training college. A major challenge is the low enrolment rates and the limited capacity of the national and community colleges to handle large numbers of TEVETA students. The number of relevant age youth who have attended tertiary vocational training within the past 12 months is 0.8% according to UNESCO figures.[64]

62 https://projects.worldbank.org/en/projects-operations/project-detail/P172627
63 https://unipod.ac.mw/
64 UNESCO data. https://unevoc.unesco.org/home/Dynamic+TVET+Country+Profiles/country=MWI

In addition to the technical colleges mentioned above, there are also some specialised vocational colleges operating under their respective ministries, such as the Malawi College of Health Sciences offering diplomas in nursing and other skill sets under the Ministry of Health, and the Malawi Institute of Tourism offering diplomas under the Ministry of Industrialisation, Business, Trade and Tourism.

Skill set availability and relevance

Malawi's education system described above has resulted in a literacy rate for people aged 15 and over of 68%,[65] which rises to 77% for youth aged 15 to 24,[66] based on 2022 data. The percentage of youth that have completed primary school stands at 47%,[67] and that have completed secondary school stands at 22%[68] and the percentage of Malawians who are trained to degree level stands at 1.3%[69]. The percentage of those over 25 years that hold a master's qualification is 0.9%[70] and for a doctoral qualification is 0.1%,[71] based on 2020 figures. There is therefore a literate workforce available for expanded STI activity and development, although the numbers would need to increase to ensure future sustainability.

There is a lack of data on the cumulative numbers of graduates by field of study. However, there is graduate-level expertise in agriculture from LUANAR; in general science and technology, including ICT, from multiple public universities including UNIMA, MUST and MZUNI; in engineering from MUBAS; and in health science from KUHeS. There is generic expertise in law from UNIMA and the Catholic University of Malawi, and expertise in business and finance from multiple universities, both public and private. Many areas of scientific and technical expertise, especially in ICT, are also complemented by private universities. With regards to Malawi 2063's emphasis on agriculture, the lead academic institution is LUANAR. With respect to mining, there is mining engineering expertise at MUBAS and geological expertise at UNIMA. With respect to the focus on tourism, there is expertise in tourism and hospitality at MZUNI and at the Malawi Institute of Tourism.

The lack of graduate data for specific fields of study may in future be addressed by a Higher Education Management Information System which is currently under development. There is a need to further develop Malawian specialist expertise across all STI disciplines. This requires an expansion of postgraduate programmes, especially doctoral programmes. It further requires an expansion of TEVET technician diploma-level programmes to complement the STI graduate and postgraduate level training.

2.4.2 Physical infrastructure

This section will briefly review the economic and social infrastructure of Malawi. Infrastructure related to STI, including that associated with Higher Education institutions, will be covered in the chapter on the STI environment.

Transport

Malawi's landlocked nature and lack of investment in transport infrastructure, including basic road infrastructure, has resulted in Malawi's transport system being one of the weakest in the Southern Africa Development Community (SADC)[72]. As a result of this, its freight transport costs of over US$ 10 per ton per km are about 50% higher than the regional average of US$ 7 per ton per km. A national transport master plan from 2017-2037[73] seeks to guide a multi-modal transport sector, including road, rail, water and air, but this is in its early stages and still has to be realised. Road transport accounts for 99% of passenger service, 70% of domestic freight,

65 World Bank Data. https://data.worldbank.org/indicator/SE.ADT.LITR.ZS?locations=MW
66 World Bank Data. https://data.worldbank.org/indicator/SE.ADT.1524.LT.ZS?locations=MW
67 World Bank Data. https://data.worldbank.org/indicator/SE.PRM.CUAT.ZS?locations=MW
68 World Bank Data. https://data.worldbank.org/indicator/SE.SEC.CMPT.LO.ZS?locations=MW
69 World Bank Data. https://data.worldbank.org/indicator/SE.TER.CUAT.BA.ZS?locations=MW&skipRedirection=true&view=map
70 World Bank Data. https://data.worldbank.org/indicator/SE.TER.CUAT.MS.ZS?most_recent_year_desc=false&skipRedirection=true&view=map
71 World Bank Data. https://data.worldbank.org/indicator/SE.TER.CUAT.DO.ZS?skipRedirection=true&view=map
72 JICA position paper. https://www.jica.go.jp/Resource/malawi/english/activities/c8h0vm00004bpzlh-att/transport.pdf
73 National Transport Master Plan.

and 90% of international freight,[74] including from the main seaports of Dar es Salaam in Tanzania, Nacala and Beira in Mozambique, and Durban in South Africa. Good road network connectivity to rural areas is limited, leading to higher costs for farmers to get their produce to both local and international markets. The resilience of the national transport and logistics systems were severely impacted by Tropical Cyclone Freddy in 2023.[75]

A rail network, which was operational at the time of independence, is being revived through private sector investment in the Nacala railway line which passes through Malawi to Moatize in Mozambique, operating under a company called Nacala Logistics.[76,77] There are plans to further strengthen external transport links to Mozambique and Zambia. In November 2023, Malawi, Mozambique and Zambia agreed to establish two dry ports within the Beira and Nacala corridors in order to improve Southern African Trade and Connectivity.[78] Malawi has also signed bilateral agreements with Tanzania to enhance the Dar es Salaam corridor. The 2024 Annual Economic Report states there was a doubling of rail passenger and freight transport from 2022 to 2023.

Inland water transport remains underdeveloped. The civil aviation sector likewise requires further development. There are two international airports, one in Lilongwe and one at Chileka, just outside Blantyre, but with limited flights and infrastructure.

There is support from development partners in the transport sector. The World Bank is focusing on road transport linked to disaster risk management. The European Investment Bank is focusing on enhancing and expanding the main road network. The US Government is supporting improved road conditions to enhance farm to market access through the Millennium Challenge Corporation.[79] The Chinese Government is supporting road development within Lilongwe and railway upgrading. The African Development Bank has supported road and rail development along the Nacala corridor. The Japanese Government has supported airport development at both Lilongwe and Chileka, and road development in Lilongwe.

Energy

A good overview of Malawi's current energy situation, strategies and plans is provided in the 'National Energy Compact for Malawi'[80] published in January 2025. This was developed in alignment with the Africa Region Energy Compact and the United Nations Energy Compact, which the Government of Malawi adopted in 2021. The two main objectives of the Compact are to achieve affordable, reliable and clean energy services and to substantially increase the share of renewable energy in its energy mix. The National Energy Compact stated that, although 26% of households had access to either grid or off-grid electricity in 2024, 98% of all domestic energy came from biomass, primarily for cooking. In rural areas this largely consists of firewood and crop residue, which can largely be collected free of charge. In urban areas it largely consists of charcoal. Table 2 in the 'National Energy Compact for Malawi' document indicated that in 2024, wood use for cooking was at 87% and charcoal use at over 6%. This, along with increased land clearing for agriculture due to population increase, has contributed to a reduction in forest cover in Malawi in 2021 by 37% relative to 1990.

While access to electricity is expanding, high electricity prices and the costs of other clean fuels, such as liquefied gas, mean that many households may still utilise wood, charcoal or briquettes for their cooking needs. This is especially the case in rural areas, where off-grid

74 World Bank Assessment. https://documents1.worldbank.org/curated/en/099052423020552874/pdf/P17655808b11570c3082bd0a8cfea6e06ec.pdf
75 https://reliefweb.int/report/malawi/transport-logistics-needs-assessment-malawi-southern-africa
76 https://mwnation.com/cear-rebrands-changes-name-to-nacala-logistics/
77 https://nacalalogistics.com/our-services/
78 https://360mozambique.com/business/infrastructures/mozambique-and-malawi-to-build-two-dry-ports-in-beira-and-nacala-corridors/
79 https://www.mcc.gov/where-we-work/program/malawi-transport-land-compact/
80 https://africa-energy-portal.org/reports/national-energy-compact-malawi

power may not support cooking and where access to fuel i.e. firewood, has historically been largely free of charge. A number of financing strategies to support the planned expansion are in place, for example, through an expansion and institutionalisation of the Ngwee Ngwee Ngwee Fund to support private investment in off-grid solar and clean cooking.

Power outages are obviously extremely detrimental to industrial production and manufacture, and a secure grid-based energy supply is essential for economic growth, underlining the importance of secure and reliable grid-based energy supply. Malawi's electricity generation system remains dominated by hydropower, which increases vulnerability to climate variability. Prolonged dry periods reduce generation capacity, while extreme rainfall events can damage hydropower infrastructure, much of which is located along the Shire River. Variability in Lake Malawi water levels also poses longer-term risks to hydropower generation. Solar power can complement hydropower within the grid, although this introduces additional requirements for energy storage and grid stability management.

Water, sanitation and irrigation

Population growth, urbanisation, economic growth and industrialisation, including the expanded requirements of irrigation farming, are all creating increased demands for water resources.[81]

According to the 2024 Annual Economic Report, data from the 5th Integrated Household Survey of 2019/20 indicates that the proportion of urban households with access to improved water sources was 97.1 %, while that of rural households was 86.5 %. Sanitation remained an important developmental and public health issue, with only 35.2 % of the population accessing improved toilet facilities. The subsequent 6th version of the Integrated Household Survey is due to be published in 2026. As with transport and energy supply, the tropical storms of recent years have held back its progress. The Water Sector Investment Plan 2016-2030 is in place to improve access to water and sanitation services. The US$ 315 million Salima-Lilongwe Water Supply Project is a major PPP project piping water from Salima to the capital city Lilongwe, which will service an estimated 1.5 million people. It will also provide additional spin-off opportunities for irrigation.

Irrigation is seen as critical for enhanced agricultural productivity. Work in this area is guided by a National Irrigation Policy (2024)[82] supported by a National Irrigation Master Plan and Investment Framework[83]. It is reported that there is potentially 408,862 ha of irrigable land, of which 148,850 ha (36.5%) were under irrigation in 2023/24. Of this, 54% was under private sector irrigation and 46% under smallholder irrigation. The expansion of irrigation in the past decade has averaged 5% per year, 7% for the private sector and 4% for smallholders. A challenge for smallholder irrigation grant schemes has been the lack of follow-up support for operations and maintenance.[84] The Irrigation Policy is moving away from a 'food security only' focus to include a more commercial orientation with emphasis placed on wealth creation, export promotion and value chain addition, seeking a 20% annual increase in the volume of high-value irrigated export crops. It also seeks to operationalise an irrigation fund to pool resources for new infrastructure and rehabilitation, and aims to increase land under sustainable irrigation by 6,000 ha annually. It adopts a whole catchment approach to protect water resources.

There are a number of irrigation projects underway in Malawi. The most significant is the Shire Valley Transformation Programme to develop 43,3[70] ha for commercial farming. It consists of a main canal of 50 km, plus secondary piping and irrigation block development. The first farming block (105 ha) is scheduled to begin irrigating in late 2026. The Programme for Rural Irrigation Development (PRIDE) is a major initiative funded by the International Fund

81 JICA paper. https://www.jica.go.jp/Resource/malawi/english/activities/c8h0vm00004bpzlh-att/water.pdf
82 National Irrigation Policy (2024) https://docs.dcafs-tipdep-donors-mw.org/dt_docs/nip_mw_gvt_2024.pdf
83 National Irrigation Master Plan and Investment Framework. https://docs.dcafs-tipdep-donors-mw.org/dt_docs/master-plan-report.pdf
84 https://dcafs-tipdep-donors-mw.org/update/dcafs-irrigation-development-april-2024

for Agricultural Development (IFAD) which aims to develop 5,400 hectares of irrigated land and 12,300 hectares of rain-fed land to benefit 19,500 households working in 12 districts.[85] PRIDE has completed several new and several rehabilitation irrigation schemes and is in the final stages of completing its programme.

Information and communication technologies

Malawi has a number of polices and strategies guiding the ICT sector and digitalisation[86]. These include (i) the Digital Economy Strategy 2021 to 2026; and (ii) the National ICT Policy, which is under revision. These have been complemented by a recent Digital Readiness Assessment published in 2025.[87] International Telecommunications Union (ITU) Data is also readily available.[88]

As of January 2024, there were approximately 5.86 million internet users in Malawi, accounting for 27.7% of the total population, reflecting a 24% increase on January 2023. While this growth signals progress in digital adoption, disparities between urban (45%) and rural (20%) internet penetration remain a major challenge. The Digital Readiness Assessment ascribed this difference to high costs and insufficient digital literacy as the primary barriers to broader technology use.

A number of projects and investments are underway to further promote the digital economy, with a focus on expanding rural connectivity, streamlining government services. The World Bank-financed Digital Malawi Acceleration Project seeks to lay 2,000 km of fibre cables to connect 2,000 rural schools and 500 nationwide government offices to high-speed internet and to promote digital skills training to 10,000 men and women equally through established innovation hubs. Malawi is reducing its reliance on expensive satellite links by building direct fibre connections with neighbouring countries. Links to Zambia, Tanzania and Mozambique are already in place. Malawi is also part of an EU-funded regional backbone project to lay 10,000 km of cabling across DRC, Zambia, Zimbabwe, Mozambique and Malawi to improve cross-border resilience. ESCOM is complementing this with an 'aerial' approach, using existing electricity poles and towers as a physical carrier of fibre-optic cables and delivering them directly to homes. With respect to mobile access, there is a private initiative by Helios Towers to operate over 1,000 towers by the end of 2026 in order to improve overall mobile service quality and this is complemented by a PPP partnership implementing a Universal Service Fund Tower initiative to install 98 new communication towers.

A Tier 3 National Data Centre has been established in Lilongwe, with a back-up disaster recovery site in Blantyre, with the objective of integrating multiple national data sources onto one platform to facilitate national administration and enable big data analysis to support operational, strategy and policy decisions.

Malawi scored 2.7 out of 5 in its UNDP Digital Readiness Assessment. This characterises Malawi as "*advancing in selected areas of digital transformation but without a coordinated strategy*". Coordinated and consistent efforts will thus be required in order to ensure the optimal maintenance, utilisation, development and integration of the data infrastructure assembled to date. A skills development plan is required in order to ensure there is adequate human capital to manage and further research, develop and integrate the vast array of 4th industrial revolution IT and robotic technologies. Furthermore, a coordinated strategy requires the full engagement of the higher education and private sector for a vibrant and innovative IT business sector.

There is a strong basis for private sector growth in this field with established telecommunications companies, several mid-size Malawian IT service companies and a growing Micro Small and Medium Enterprise (MSME) sector. Statista[89] reports that the projected 2025 revenues for IT outsourcing, IT consulting and implementation in Malawi are US$ 24 million and US$ 4.2 million

85 https://pride.mw/
86 https://ict.gov.mw/index.php/blog/downloads/legislation
87 UNDP Digital Readiness Assessment. https://www.undp.org/sites/g/files/zskgke326/files/2025-05/dra_malawi_report_2025_a4_print.pdf
88 ITU Dashboard, https://datahub.itu.int/dashboards/?e=MWI&id=2
89 https://www.staista.com

respectively, with anticipated growth rates of 8.1% and 4.8% to 2030. A 2025 UNCTAD report[90] highlighted 2019 data showing that Malawi's 1.6 million MSMEs accounted for an estimated 47% of GDP and employed approximately 38% of the total working-age population. It also demonstrated how digital technologies will be leveraged in the future to integrate Malawian MSMEs into regional value and supply chains. This will lead to an increasing number of jobs requiring digital literacy.

Financial inclusion

A major impact of the technological revolution in ICT has been the expansion of financial inclusion within Malawian society. This is illustrated by the 2023 Finscope Consumer Report for Malawi (see page 54).[91] The report demonstrates that the percentage of formally financially served adults has increased from 34% in 2014 to 74% in 2023. If one includes the informally served the increase is from 49% in 2014 to 88% in 2023. The increase is due almost exclusively to the rise of mobile money use. The number of adults who are formally banked actually decreased from 27% to 13% between 2014 and 2023.

2.5 Impact of COVID-19

The data for this section is extracted from the World Bank Malawi Economic Monitor Reports 2020 to 2024,[92] unless otherwise referenced. Malawi experienced four waves of Covid from June 2020 to March 2022. Overall, these waves were well contained from a public health perspective, with relatively few deaths compared to other countries. This may be due in part to the young age range of the Malawian population and low levels of obesity and other complicating factors. Despite the relatively good public health performance, the impact of Covid-19 on Malawi's economy was highly significant. It was estimated that children lost up to 1.6 years of schooling between 2020 and 2021, though the Government worked hard to catch up on the original school timetable by shortening school holidays.

Covid restrictions led to a major reduction of economic activity within the country, compounded by the drop of international economic activity. The post-Covid economic recovery has been weak and exacerbated by the effects of several cyclones and associated flooding in 2022 and 2023, especially in the southern region of the country. Malawi had originally forecast a GDP growth rate of 4.8% in 2020, building upon a period of several years of relatively strong growth, but the final 2020 figure was reduced to 0.8% and has since only recovered to 1.5% in 2023 and 1.7% in 2024. Covid especially affected the industrial and services sector of the economy, including the tourism sector which saw the number of international passengers drop by about 50% in the immediate aftermath of Covid-19, which has still not recovered to pre-Covid levels.

In addition to the challenges presented by Covid-19, several positive impacts were brought about by the national response. Perhaps the most significant was the impetus it provided for the expansion of communication technologies and the digitalisation process, which included an expanded use of virtual meetings and online teaching. In addition, social cash transfers were initiated for the first time in urban communities and these have continued.

2.6 Emerging development agenda: graduation, SDGs, and development plans

The document driving Malawi's national development is Malawi 2063,[93] which has been described in detail in section 2.3.2. A first 10-year implementation plan (2021-2030)[94] was developed with two primary objectives: to achieve lower middle-income status by 2030; and to meet most of the SDGs whose target date is 2030. The implementation plan was budgeted and incorporated several flagship priority projects.

A 2023/24 progress report,[95] complemented

90 https://unctad.org/system/files/official-document/aldc2025d2_en.pdf
91 https://finmark.org.za/Publications/2023_FinScope_Consumer_Survey_Malawi_2023_Report.pdf
92 https://www.worldbank.org/en/country/malawi/publication/economic-monitor
93 https://npc.mw/wp-content/uploads/2021/02/MW2063-VISION-FINAL.pdf
94 https://npc.mw/mip-1-3/
95 https://npc.mw/wp-content/uploads/2024/07/MIP-1-ANNUAL-PROGRESS-REPORT-2023-2024_final_version.pdf

Table 9. Summary performance of implementation progress of the Malawi 2063 first 10-year implementation plan targets by pillar and enabler

	Complete	On Track	Slow Progress	Off track	Not started/ no data
Pillar 1: Agriculture	9%	41%	15%	21%	15%
Pillar 2: Industrialization	9%	45%	36%	5%	5%
Pillar 3: Urbanization	0%	35%	53%	6%	6%
Enabler 1: Mindset Change	8%	33%	25%	17%	17%
Enabler 2: Effective Governance	0%	47%	29%	12%	12%
Enabler 3: Enhanced Public Sector	0%	42%	42%	0%	17%
Enabler 4: Private Sector Dynamism	6%	29%	35%	6%	24%
Enabler 5; Human Capital development	2%	44%	41%	2%	11%
Enabler 6: Economic Infrastructure	0%	25%	54%	8%	13%
Enabler 7: Environmental Sustainability	5%	52%	14%	19%	10%
OVERALL SCORE	4%	40%	34%	9%	13%

by the 2022 Voluntary National Review Report for SDGs,[96] provided the following scorecard of progress against Malawi 2063 and the SDGs, shown in Tables 9 and 10 respectively. Notably, the major objective of achieving lower middle-income status by 2030 is unlikely to be achieved. Due to the exogenous shocks of Covid, tropical cyclones and the Ukraine war, the current GDP growth rate is only 1.5%. It would require an average growth rate of 10.6% from 2024 onwards to achieve the 2030 target. An average growth of 6.4%, the original target figure, would lead to lower middle-income status by 2037. The current low growth rate would extend the realisation of lower middle-income status to well beyond 2040 towards 2050. Overall, when judged against the current 10-year implementation plan, there has been some progress, but not sufficient to indicate the targets will be achieved. The reasons for this primarily relate to the continued macroeconomic challenges of low GDP growth, accompanied by a poor balance of payments, foreign exchange challenges, high inflation and high interest rates.

A similar situation can be ascribed to the SDGs, outlined in Table 10 below, with moderate progress being achieved in some areas, primarily those of a social nature. However, there is limited progress in economic growth, and consequently no progress on poverty, hunger and inequality.

Table 10. Progress on SDGs

SDG	Progress	SDG	Progress
Goal 1: No Poverty	Little	Goal 10: Reduce Inequality	Little
Goal 2: No Hunger	Little	Goal 11: Sustainable Cities and Communities	No data
Goal 3: Good Health and wellbeing	Significant	Goal 12: Responsible Consumption and Production	No Data
Goal 4: Quality Education	Significant	Goal 13: Climate Action	Moderate
Goal 5: Gender Equality	Moderate	Goal 14: Life Below Water	Significant
Goal 6: Clean Water and Sanitation	Significant	Goal 15: Life on Land	Moderate
Goal 7: Affordable and Clean Energy	Significant	Goal 16: Peace, Justice and Strong Institutions	Moderate
Goal 8: Decent Work and Economic Growth	Little	Goal 17; Partnerships for Goals	Moderate
Goal 9: Industry, Innovation and Infrastructure	Moderate	OVERALL	Moderate

96 https://npc.mw/wp-content/uploads/2022/08/Malawi-SDG-VNR-2022-final-copy.pdf

2.7 Summary comments on the contextual background to the TNA

Malawi remains one of the poorest countries in the world with historically limited natural resources available for exploitation and limited access to ports for international trade. It remains a predominantly rural economy heavily dependent on subsistence agriculture, with increasing pressure on land availability and use for subsistence farming due to population growth. Malawi's strategy for economic growth and development is based on this reality, noting Malawi's population-wide intrinsic knowledge of agriculture and a growing youthful population that can be educated to take advantage of global technological developments. The growth strategy, outlined in Malawi 2063, is thus predicated on the following elements, all of which require substantive STI input and support:

1. Increased agricultural productivity and its commercialisation, mechanisation, and industrialisation. Malawi's foreign exchange remains heavily dependent on one primary product crop, tobacco. A major effort is being made towards establishing anchor farms and mega farms, the mechanisation of agriculture, diversification of primary products, and value-addition.
2. Industrialisation. This builds upon the foundation of agricultural commercialisation, but extends into other areas, for example, mining, where there is evidence of natural mineral resources that can be exploited, leading to substantive income generation and export growth. Central to the pursuit of industrialisation is the establishment of strong backward and forward linkages between manufacturing and key sectors such as agriculture, mining, and services. There is an opportunity for expansion of the service industries required to support industrialisation and an expansion of ICT and digital-based technologies that are knowledge-based and require limited infrastructure.
3. Development of economic infrastructure equitably across the country. This includes a strong focus on energy (primarily renewable i.e. hydropower and solar) and internet access, plus the provision of water and road transport, supplemented by some rail transport.
4. The provision of social support services, especially education and health, equitably delivered at no cost or subsidised cost, to the extent possible, but complemented by private for-profit and not-for-profit investment and service.
5. Improvements in 'mindset', governance, and public sector and private sector management are recognised as a prerequisite for developmental success.

The sectoral strategies outlined in Malawi 2063 are coherent and generally recognised as valid. There is little objection to the strategies outlined. The challenge is to deliver on the strategies. STI has a significant role to play in this regard. This is particularly recognised within the industrialisation pillar and human capital development enablers of Malawi 2063, but also permeates many sectoral plans. All public universities are placing an increasing emphasis on research and innovation, notably within agriculture and associated value addition pathways, and on information technology. A national research strategy has been developed around the Malawi 2063 first 10-year implementation plan (MIP-1).

Academic achievement is valued and recognised across Malawian society, and a drive within the education system to 'equitably' improve on Science, Technology, Engineering, Arts and Mathematics (STEAM) education across genders and the five social quintiles, provides a good foundation for STI growth and development.

Innovation is increasingly seen as crucial for development through tertiary education and the small industrial sector, especially through the growth of MSMEs. The country's major financial institutions, pension funds and big banks are increasingly directing their attention to these areas to complement the Government's efforts, despite the challenge of high interest rates.

The challenge is to deliver on the Malawi 2063 strategy from a low wealth base and a relatively low level of STI expertise, with limited national resources.

Chapter 3

STI Environment, National System of Innovation (NSI) and SWOT Analysis

3.1 Development of the NSI

3.1.1 Governance and actors

History of STI policy development, ministerial oversight, and key statutory bodies

The history of Science, Technology and Innovation (STI) policy development in Malawi dates back to the early 1970s.[97] The Government established the National Research Council of Malawi (NRCM) in 1976, tasked with coordinating and promoting Science and Technology activities nationwide to achieve sustainable national development. It operated at the level of the Office of the President and Cabinet and had far-reaching responsibilities for guiding policy direction and action.

In 1988, the activities of the National Research Council of Malawi were merged with the Environmental Unit of the Ministry of Forestry and Natural Resources. This coincided with development of the country's first national science and technology policy, which was approved by the Government in 1990. This led to the creation in 1991 of a full department and then a full Ministry of Research and Environmental Affairs, which developed a five-year master plan for the policy in the same year. However, there was little cross-government coordination. This, together with the lack of adequate resources, resulted in science and technology and associated research being left largely to individual line ministries. For example, the Ministries of Agriculture and of Forestry and Natural Resources operated through a variety of research stations across the country (see section 4.2 below). The Ministry of Research and Environmental Affairs was disbanded in 1997, causing the National Research Council of Malawi to be re-established. The remaining department of Science and Technology was merged within the Ministry of Education, which was renamed the Ministry of Education Science and Technology. However, this did not solve the lack of cross-governmental coordination and financing of science and technology, and the Ministry reverted to a Ministry of Education in 2004.

The National Research Council, with UN support, led the development of a 2nd National Science and Technology Policy, approved in 2002.[98] A major objective of this policy was to promote better integration of science and technology into national planning. The policy emphasised sectoral objectives and strategies, for example, in education, agriculture, water, health, energy, trade and industry, natural resources, transport and communications, as well as cross-cutting objectives. It also addressed the need for an institutional and legal framework and financing requirements, which led to the Science and Technology Act of 2003.[99] The following institutional recommendations were made:

1. **The establishment of the National Commission for Science and Technology (NCST) as an apex body with the prime function to** *"advise the Government and other stakeholders on all science and technology matters in order to achieve a science and technology-led development."* NCST was established through the Science and Technology Act of 2003 and operationalised in 2008.
2. **The establishment of a Science and Technology Fund** to finance research and development (R&D). The Science and Technology Fund was nominally established through the Science and Technology Act of 2003, but was not launched until 2022[100] with a small capital injection of MK 291 million (US$ 167,926.90). Funding has not been substantively expanded and more resources are needed for the Fund to become fully operational.
3. **Establishing (some of) the colleges of the University of Malawi as separate universities**. In 2011, an Act of Parliament delinked Bunda College of Agriculture from the University of Malawi and established the Lilongwe University of Agriculture and Natural Resources (LUANAR), which started its operation in July 2012. In 2019, two Acts of Parliament, assented to in 2020, created the Kamuzu University of Health Sciences (KUHeS) from the College of Medicine and

97 Much of the history up to 2013 can be found in a 'GoSpin' report on 'Mapping Research and innovation in the Republic of Malawi' commissioned by UNESCO in 2014. https://unesdoc.unesco.org/ark:/48223/pf0000228807
98 https://www.ncst.mw/policies-and-guidelines/
99 https://www.ncst.mw/wp-content/uploads/2014/03/S_T_ACT.pdf
100 https://npc.mw/2022/02/npc-joins-ncst-in-the-launch-of-the-science-and-technology-fund/

the Kamuzu College of Nursing, and created the Malawi University of Business and Applied Sciences (MUBAS) from the Polytechnic. Chancellor College remained as the University of Malawi (UNIMA). These new universities, KUHeS, MUBAS and a rebranded UNIMA, were brought into operational existence in May 2021.

4. **The establishment of a University of Science and Technology**. The Malawi University of Science and Technology was established by Act of Parliament in 2012 and became formally operational in March 2014.
5. **The establishment of sectoral committees, within parent ministries**, to help establish and coordinate sectoral Research and Development (R&D) priorities. These have not been sustainably operationalised, but their more formal establishment with stakeholder membership is under discussion for the upcoming 3rd National Science Technology and Innovation Policy.

As alluded to above, historically there has been limited success in integrating science technology and innovation into national development. However, a range of institutional and organisational changes have occurred since the 2nd Science and Technology policy was approved in 2002. With the establishment of NCST in 2008, a lean Department of Science and Technology was set up within the Ministry of Education to address policy issues and international cooperation, as these could not be addressed by NCST as a statutory body. The name of the ministry was appropriately changed to recreate a Ministry of Education, Science and Technology in 2008, following its earlier dissolution in 2004.

The incoming Government of 2020 changed the name of the Ministry back to the Ministry of Education but increased the authority and capabilities of science, technology and innovation by establishing a full STI directorate within the Ministry, with a higher number and higher level of human resources. This led to substantively more policy-related action in science, technology and innovation, and a greater government engagement at regional and international levels, supported by the goals and objectives of Malawi 2063. Furthermore, a directorate of Open Distance and e-Learning was established that, along with the STI directorate and Malawi Communications Regulatory Agency (MACRA), has promoted internet access for schools and the use of offline e-based learning, through tablets at primary schools and 'virtual' laboratories in secondary schools, for example. This directorate has also promoted e-learning more widely and helped develop policy for application within the higher education sector.

The incoming Government of 2025 has retained the focus on STI by renaming the Ministry of Education back to the Ministry of Education, Science and Technology. It has also renamed the Ministry of Labour back to the Ministry of Labour, Skills and Innovation

The role of non-Government Actors in STI Policy
The establishment of the STI Directorate within the MoEST has enabled the creation of a multi-stakeholder STI Technical Working Group, which meets quarterly and can feed into Ministry and sector-related activities that are developed at the annual Joint sector review. The Technical Working Group consists of government ministries and agencies, academics, civil society, development partner representatives, some banks, and some private sector participants. This group was a critical constituency that has been consulted on the development of the 3rd National STI policy, which is under development.

Despite the recent creation of the STI Technical Working Group, the private sector has been largely absent from the STI policy space in Malawi. In fact, the private sector engages minimally in STI and associated R&D (see section 3.3.2). Malawi has suffered from de-industrialisation over the past 30 years, passing from an era of diversified enterprises through which Manufacturing Value Added contributed to 21.1% of GDP in 1992, to a reduced value of 11% in 2024[101]. This de-industrialisation has coincided with several elements that may have played a causal role: (i) structural adjustment programmes of the World Bank and International Monetary Fund that limited government support for local industries; (ii) the HIV/AIDS pandemic in the late 1990s and early 2000s that badly hit the emergent managerial and technical

101 https://data.worldbank.org/indicator/NV.IND.MANF.ZS?locations=MW

classes with the skill sets required to support industries; and (iii) trade liberalisation and globalisation. This, combined with government policies, has resulted in limited competitiveness, restricted access to finance, and lower incentive for industrial investment.

The number of companies actively engaged in R&D remains limited. In recent years, there has been a major effort by development partners to support MSMEs and social enterprises, and Malawian financial institutions are also becoming more engaged in the promotion and financing of MSME innovation and entrepreneurship. It remains, however, for this activity to be translated into a strong R&D engagement by the private sector.

3.1.2 Policy process and decision-making

Achievements have been made based on the 2002 Science and Technology Policy and the resultant 2003 Act. However, these developments, though yielding activities and some successes, have not led to an integrated policy approach. The level of cross-government coordination outlined in the 2002 Science and Technology Policy has been limited. For example, the sectoral committees devised to help integrate STI policy across the government were not operationally established. The NCST provides a basis for the generation of coherent policy advice and related action. However, to be effective, it needs to be placed firmly within a government-driven policy framework.

NCST has a board comprising a mix of ex officio members from the public sector representing key STI-associated ministries, plus academics and private sector executives as members. Despite limited resources, NCST has established some governance of research through the establishment of ethical review criteria and services. It has generated a National Research Agenda aligned with the National Planning Commission's first 10-Year Implementation Plan (MIP-1) of Malawi 2063, it has promoted science through science fairs, and has provided a platform for the promotion of individual, small-scale innovations. However, this activity needs to be backed up by resources to support R&D, for example, through an operational Science and Technology Fund. It also requires a foundational policy support infrastructure. The creation of the STI directorate within the MoEST has started to provide that support.

The STI directorate within the MoEST, with government-wide support, is coordinating the development of a 3rd National STI Policy. The draft policy attempts to be inclusive, to address coordination issues, and to have an implementation plan and M&E framework that is aligned with the national development strategy of Malawi 2063.

3.1.3 Programmes supporting STI development

Programmes supporting STI development can be divided into those that have been financed through: (i) the Malawian Government and Government finance; (ii) preferential loans and grants from the World Bank and African Development Bank; and (iii) those being financed by other development partners.

Government-driven programmes

Government has two primary roles in moving STI-related programmes forward: the first is to coordinate the creation of an environment in which both the public and private sectors are supported and encouraged to engage in STI; the second is to financially support STI.

Since the 2002 policy, the Malawi Government's focus on STI has been to establish the basic infrastructure and expertise upon which an STI ecosystem can be established. This has been done through the creation of the NCST and the expansion of tertiary education-led STI through the establishment of MUST and the unbundling of the University of Malawi to create multiple public universities engaged in STI activities. Another new university, Mombera University, is being constructed, which will focus on Animal Sciences and Mining. Much of this has taken place with development partner and private sector engagement. For example, MUST was constructed with assistance from the Government of China, while a large amount of public University and tertiary education infrastructure has been supported by African Development Bank and World Bank financing, as discussed in the next section. Efforts are underway to finalise the construction of Mombera University through a public-private

partnership.

Programmes and actions from a variety of ministries outside the MoEST are also important in creating a vibrant STI ecosystem. These include:

- The Ministry of Agriculture, Irrigation and Water Development, which hosts a significant number of research stations around the country and is undertaking numerous activities to enhance agricultural productivity and commercialisation.
- The Ministry of Energy and Mining, which is placing special emphasis on attracting investment into the mining sector in Malawi.
- The Ministry of Industrialisation, Business, Trade and Tourism, which is currently developing a revised Industry strategy that pays significant attention to promoting innovation. A major development by the Ministry over recent years has been the development and expansion of the Malawi Investment and Trade Centre. This was established by the Investment and Export Promotion Act of 2012 as a trade and inward investment promotion agency and a one-stop shop for business start-ups. The Ministry's focus broadly follows the priorities of Malawi 2063.
- The Ministry of Labour, Skills and Innovation oversees the TEVET Authority (TEVETA), which continuously reviews its curricula for industry relevance. The ministry focuses on innovation and the establishment of a labour market information system.
- The Ministry of Information and Communications Technology oversees the National Digitalisation Policy, which seeks to foster innovation and develop digital skills. It has established a MUUNI fund that finances innovation at a university and community level, as well as a Youth Innovation Fund providing grants to youth entrepreneurs.
- Intellectual Property Rights in Malawi have been strategically addressed in recent years.[102]
  - A revised Trademarks Act was introduced in 2018 and a National Intellectual Property Policy was introduced in 2019, overseen by the Registrar General's office. The overall goal of the Policy is to "leverage IP as a tool for promoting and stimulating creativity".
  - The Companies, Registrations, and Intellectual Property Centre Act of 2025 creates a semi-autonomous government agency, known as the Companies, Registrations, and Intellectual Properties Centre. It is responsible for administering and regulating the entire intellectual property rights regime, including the collection of revenue and management of registries.
  - The Copyright (Amendment) Bill of 2025 transfers administration, enforcement and oversight of copyright laws to the newly-created Companies, Registrations, and Intellectual Property Centre (CIPC).
  - The Copyright Society of Malawi (COSOMA) is now legally tasked with the collective management of rights only (such as royalty collection and distribution) rather than with general administration and enforcement of the copyright law.
- As part of the industrialisation and urbanisation pillars of Malawi 2063, special economic zones have been created for industrial expansion and development in the three major cities of Lilongwe, Blantyre and Mzuzu. Magwero Technology Park103 is under construction in Lilongwe by ARISE Integrated Industrial Platforms (ARISE IIP), which is a pan-African developer and operator of world-class industrial parks, with financing from Afreximbank, Nico Holdings and the Export Development Fund of Malawi, which is owned by the Reserve Bank of Malawi.

Within the Higher Education Sector, the MoEST and NCST, together with universities, have supported and undertaken several initiatives and developments that seek to move beyond the building of foundational infrastructure and human capacity to the delivery of innovation. [104] These include:

- The goal of setting up 17 Business and Technological Innovation Centres within Higher Education institutions by 2030. Eight

102 https://www.trade.gov/country-commercial-guides/malawi-protecting-intellectual-property
103 https://www.ariseiip.com/arise-iip-unveils-magwero-industrial-park-in-malawi/
104 Annual Economic report table 9.2, page 149

have been set up to date, the highest profile being the 'UniPod' based at MUBAS.[105]

- The launch of Grand Challenges Malawi, in conjunction with AUDA-NEPAD and the Science for Africa Foundation, through which Malawian researchers and innovators can access resources.
- Guidelines for Technology Transfer and Commercialisation and the initiation of establishing technology transfer offices at public universities.
- The establishment of Technology and Innovation Grants by NCST.
- The first ever Government-financed patent.
- Development of a National Higher Education and Industry Partnership Framework.

World Bank and African Development Bank support for STI capacity

Investment in Tertiary Education gives a substantial return on investment in low-income countries based on a World Bank decennial review of the global literature[106] and positively impacts on GDP growth, especially in low-income countries.[107] This has led to several substantive 'development bank' projects over the past 15 years that have promoted STI through tertiary education in Malawi and other means.[108] These projects are illustrated in Table 11.

Other development partners support for STI capacity

Table 12 summarises a range of activities being undertaken through funding by partners in addition to the development banks. These cover broad multi-sectoral areas of innovation through a focus on business, rural employment, higher education and TEVET, as well as specific sectoral activities in Agriculture, Health and Water and Sanitation.

Table 11. Development Bank financing of STI-related projects in Malawi since 2012. A. Tertiary Education, B. Internet Connectivity, and C. MSME support

Agency and date of approval	Date and Name of project	Objectives	Funds allocated. US$
A. Tertiary Education Projects			
African Development Bank 08.02.12	Higher Education Science and Technology	Improve the relevance of skills development in Malawi for job creation and employability of graduates	26.5 million
World Bank 24.03.24	Skills for a Vibrant Economy	To increase access, particularly for females, to labour market-relevant skills development programs, in participating Malawian institutions, targeting priority areas of the economy	100 million
21.06.21	African Centres of Excellence Project II	To strengthen selected Eastern and Southern African higher education institutions to deliver quality post-graduate education and build collaborative research capacity in the regional priority areas.	70 million across 5 countries
26.05.16	Eastern and Southern Africa Higher Education Centres of Excellence I	To strengthen selected Eastern and Southern African higher education institutions to deliver quality post-graduate education and build collaborative research capacity in the regional priority areas.	148 million across 8 countries
19.06.14	Skills Development Project	To increase access, market relevance and results orientation of supported skills development institutions in Malawi in agreed priority areas	50.9 million
B. Internet Connectivity Projects			
27.06.24	Digital Malawi Acceleration Project	Increase access to, and inclusive use of, the internet and improve the Government's capacity to deliver digitally enabled services	70 million
05.06.17	Digital Malawi Program Phase 1: Malawi Digital Foundations Project	To increase access to affordable high quality internet services for government, businesses, and citizens and to improve government's capacity to deliver digital public services	72.4 million
C. MSME Support			
25.08.20	Financial Inclusion and Entrepreneurship Scaling project	Increase financial services, promote entrepreneurship and capabilities of MSMEs in Malawi addressing Coronavirus 2019 (COVID-19) implications	86 million

105 https://unipod.ac.mw/
106 https://documents.worldbank.org/en/publication/documents-reports/documentdetail/442521523465644318/returns-to-investment-in-education-a-decennial-review-of-the-global-literature
107 https://www.acu.ac.uk/media/t23bmtt5/the-impact-of-investment-in-higher-education-on-economic-growth.pdf
108 https://projects.worldbank.org/en/projects-operations/projects-list?os=0&qterm=malawi

Table 12. Development partner support for STI capacity and impact

Development Partner	Field of Support	Description of Programmes
UNDP[109,110]	Enhancing Economic Innovation	Through a number of activities from 2019-2023, notably a Private Sector Development Programme with a budget of **US$17.5 million** a number of projects were supported through a **Malawi Innovation Challenge Fund and a Growth Accelerator Entrepreneurship Challenge**. UNDP also supported development of the UniPod that was opened at MUBAS in February 2024 and is accessible across the Higher Education system.
UNICEF[111]	Social Innovation to benefit youth and children	UNICEF operates across a number of sectors to promote the wellbeing of children and youth. The most high-profile project to be established is the **African Data and Drone Academy** housed at MUST.
Consultative Group for International Agricultural Research (CGIAR)[112,113]	Agriculture	There are 8 CGIAR centres in Malawi disseminating agricultural innovative technologies to farmers in Malawi on a holistic and integrated approach through a project called **KULIMA**. The project ran from 2019-2024 had a budget of **US$ 523,827** and was expected to reach 400,000 households.
EU	TEVET[114,115]	The **Zantchito skills for jobs** programme aims to increase employability and self-employment opportunities available to young TEVET graduates and entrepreneurs, with special attention to women's needs. It has a budget of **Euro 55 million** and runs from August 2020 to August 2027.
EU	Higher Education[116,117]	The **AU-EU Innovation Agend**a will make available Euro 300 million for 2023-2024 to support innovation across the continent in different areas aligned to the broader global EU development initiative, Global Gateway. Global Gateway is the European strategy to boost smart, clean and secure connections in digital, energy and transport sectors, and to strengthen health, education and research systems across the world by 2030, with anticipated financing of up to Euro 300 billion.
USA[118]	Higher Education	USA has in the past incorporated innovation within its programmes through USAID. However, its most recent programme, **Transforming Higher Education**, with a budget of **US$ 3,321,687**, was halted in 2025 as part of a wider review of US investment in development support.
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)[119]	Rural employment	GIZ supports a major project connected to innovation and entrepreneurship running from 2022-2025, building on similar projects funded in previous years. **Promoting income and jobs in rural areas** is working with the Malawi Ministry of Industrialisation, Business, Trade and Tourism on the development of coherent policies and strategies to enable private-sector growth in agriculture, tourism, and environmentally friendly building materials.
Wellcome Trust[120]	Health research	The Wellcome Trust is perhaps the largest single investor in science, research, and innovation in Malawi, with the largest output in terms of peer reviewed publications. It operates through the Malawi Liverpool Wellcome Trust, based at Queen Elizabeth Hospital in Blantyre in close association with the Kamuzu University of Health Sciences. It has a full range of departments and teams of researchers. Its mission is to conduct high-quality research to improve health and to train the next generation of researchers. The 2021 Annual Report indicates an annual expenditure of **GBP 12 million**, of which GBP5 million per year comes from a Wellcome Trust 5-year core grant and the remainder represents income obtained through competitive grants. It has established a 'CREATOR' clinical research support hub open to investigators from outside the Wellcome Trust Unit.
University of North Carolina Chappel Hill[121]	Health	University of North Carolina Chappel Hill has established a centre in Malawi and is contributing significantly to health research and associated innovation.
Baylor College of Medicine Children's Foundation[122]	Health	Baylor College of Medicine Children's Foundation has established a centre in Malawi and is contributing significantly to health research and associated innovation.
Michigan State University[123]	Agriculture	Michigan State University supports agricultural research programmes with LUANAR and importantly has established the MwAPATA Institute for policy research.
University of Strathclyde[124]	Water and Sanitation	Strathclyde supports a variety of activities through its 'Malawi Millennium Project' and has had particular impact in the area of Water and Sanitation for Health in collaboration with MUBAS.

109 Country Programme Evaluation 2019-2023. https://erc.undp.org/evaluation/documents/download/22480
110 https://www.undp.org/malawi
111 https://www.unicef.org/malawi/innovation-0
112 https://mel.cgiar.org/projects/815/219/an-holistic-approach-in-disseminating-cgiar-technologies-and--innovations-to-boost-the-efficiency-of-agriculture-production-systems-in-malawi
113 https://mel.cgiar.org/projects/1260
114 https://www.eeas.europa.eu/delegations/malawi/zantchito-%E2%80%93-skills-jobs-programme_en?s=107
115 https://zantchitomalawi.org/
116 https://research-and-innovation.ec.europa.eu/system/files/2023-07/ec_rtd_au-eu-innovation-agenda-final-version.pdf
117 https://www.ani.pt/media/9071/2024-01-18_horizon-europe_au-eu-innovation-platform_ncp-info-workshop_v-lorusso_final.pdf
118 https://www.foreignassistance.gov/
119 https://www.giz.de/en/worldwide/130230.html
120 https://www.mlw.mw/wp-content/uploads/2022/06/MLW_Annual-Report_2021-2-1.pdf
121 https://globalhealth.unc.edu/malawi/about-2/
122 https://baylor-malawi.org/
123 https://www.mwapata.mw/
124 https://www.strath.ac.uk/whystrathclyde/malawi/

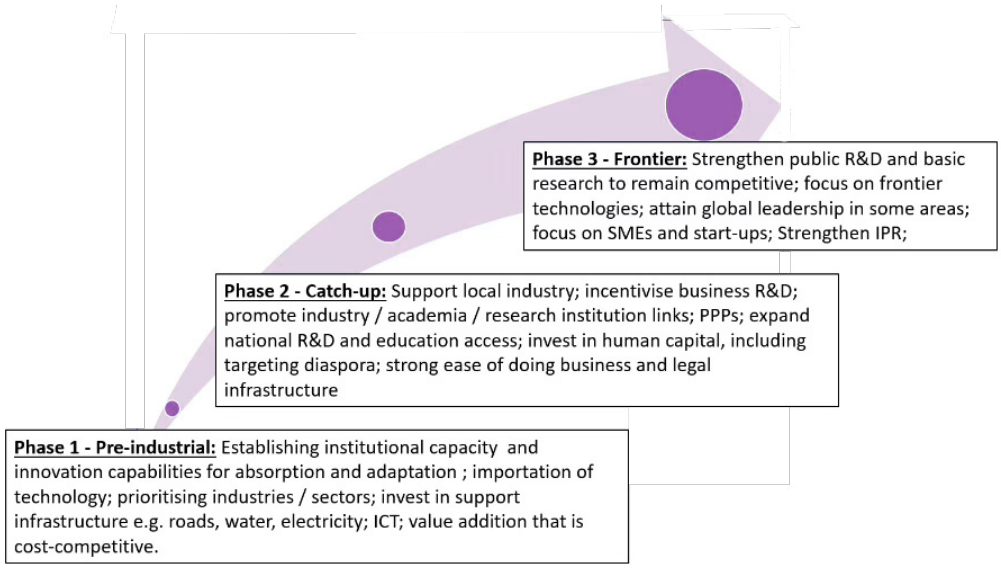
3.1.4 Summary comments on the development of a National System of Innovation

When assessing Malawi's National System of Innovation, it is important to recognise that Malawi is at the beginning of its development pathway, at the point of transitioning from phase 1 to phase 2 of a 3-stage process[125] as outlined in Figure 8.

Malawi remains among the six poorest countries in the world, according to GDP per capita, and has a variable, and currently low, post-Covid GDP growth rate that is below the rate of population growth. Financial limitations mean that Malawi remains heavily dependent on development partner support for the essential STI and related infrastructure required to transition from phase 1 to phase 2 above. That being stated, there are significant positive developments. There are positive movements in developing energy, transport, and the communications infrastructure, combined with support for commercial farms and special economic zones. There is significant growth and development of the tertiary education sector, which has risen from a gross enrolment rate of 0.8% in 2015 to 3% in 2022 and continues to grow. An Intellectual Property policy is in place. Higher Education institutions are engaging in innovation and business development, in part to secure their own financial future. There is evidence of enhanced MSME development and a realisation that this requires enhanced private sector investment. These MSMEs are supported by a growing number of innovation and business development hubs and associated networks. There are also some companies starting to incorporate technology-based R&D.

A major challenge within the STI space will be to enhance the prioritisation and integration of STI-related policy within national development policy through public sector and private sector investment. This will require enhanced interaction between the government, business, and academia through the so-called 'triple helix' model of innovation,[126] expanding where appropriate to incorporate civil society and environmental awareness in a quintuple helix model.[127] Achievement of an expanded triple helix and quintuple helix engagement relies on the continued growth and quality of the tertiary education sector, both university and TEVET, and

Figure 8. Innovation and developmental catch-up: moving from pre-industrial to catch-up to STI frontier status. Adapted from footnote 98.



125 Science, Technology and Innovation Policy Design and Implementation Guide. Towards a Framework (figure 1, page 3) published by UNECA can be located at https://repository.uneca.org/handle/10855/49550
126 Eskowitz (2003). Innovation in Innovation: The Triple Helix of University-Industry-Government Relations. Social Science Information 42(3):293-337. doi: 10.1177/05390184030423002.
127 Carayannis, Elias G.; Barth, Thorsten D.; Campbell, David F. J. (2012-08-08). "The Quintuple Helix innovation model: global warming as a challenge and driver for innovation". Journal of Innovation and Entrepreneurship. 1 (1): 2. doi:10.1186/2192-5372-1-2.

on access to business finance. This growth must place an emphasis on STI and on enabling the growth of MSMEs that can build on the energy of a youthful population.

A further challenge is the lack of STI-indicator data generated on a regular basis, for example, through R&D surveys, innovation surveys or bibliometric analysis. The issue of improving the prioritisation and integration of STI within national development, combined with issues associated with improved observatory capacity for the monitoring and evaluation of STI indicators, is being addressed by NCST and the National Statistics Office and is actively incorporated into the upcoming 3rd National STI Policy.

At a fundamental level, successful STI ecosystem development requires an economy with sound macroeconomic fundamentals and strong GDP growth to facilitate large-scale domestic public sector financing, and provide confidence for enhanced development partner and private sector financing.

3.2 Mapping main existing and emerging NSI actors and stakeholders

The mapping of NSI actors and stakeholders in this section is divided into two tables. Table 13 outlines the role(s) of public sector institutions. These institutions are driven primarily by legislation and policy, overseen and approved by Parliament and the Office of the President and Cabinet. The policy owners are individual ministries. These oversee departments, agencies and institutions that may play either a regulatory and support role for policy implementation, or may provide a knowledge and skill base for policy implementation.

Following on from Table 13, Table 14 illustrates how international organisations, the private sector, universities and non-governmental organisations support, finance and undertake innovation and entrepreneurship. The different types of organisations are categorised, and examples of the innovation-associated activities they support are provided.

Table 13. Ministries, Departments and Public Sector Agencies engaged in STI policy and implementation

Ministries with Policy oversight	Policy Advice, Regulation, Finance, Support (Agencies and Departments)	Knowledge and Skill Base for Implementation (Agencies, Departments and Institutions)
Finance, Economic Planning and Decentralisation	• National Planning Commission • Reserve Bank of Malawi • National Economic Empowerment Fund	National Statistical Office (NSO)
Justice and Constitutional Affairs (includes IP)	• Registrar General (Patents and Trademarks) • Copyright Society of Malawi (COSOMA)	(see UNIMA - Law)
Education Science and Technology	• National Commission for Science and Technology (NCST) • National Council for Higher Education (NCHE) • Higher Education Students Loans and Grants Board • Malawi Institute for Education (MIE)	• Public Universities (with STI expertise) • UNIMA (Natural and Social Sciences, ICT, Arts, Law, Education) • MUBAS (Applied Science, Engineering, Business) • KUHeS (Health Sciences including biomedical) • LUANAR (Agriculture, Fisheries, Natural Resources, Biotech, Veterinary, Development) • MUST (Technology incl. ICT, Climate and Earth Sciences, Medical Sciences,) • MZUNI (STI, Environmental, Social, Health, Tourism, Education) • Private universities accredited by NCHE. • Colleges accredited by NCHE
Labour, Skills and Innovation	Technical Entrepreneurial Vocational Education and Training Authority (TEVETA)	• Technical Training Colleges • Lilongwe • Mzuzu • Namitete • Salima • Soche • Community colleges • Private Colleges accredited by TEVETA. • (see also MUBAS – TEVET Education)

Ministries with Policy oversight	Policy Advice, Regulation, Finance, Support (Agencies and Departments)	Knowledge and Skill Base for Implementation (Agencies, Departments and Institutions)
Industrialisation, Business, Trade and Tourism	• Malawi Bureau of Standards • Competition and Fair-Trading Commission • Malawi Tourism Authority	• Malawi Investment and Trade Centre • Malawi Institute of Tourism • (see also MZUNI, MUBAS for Tourism)
Agriculture, Irrigation and Water Development	National Water Resources Authority	• Agricultural Research Stations • Bvumbwe • Chitedze • Lunyangwa, • Makoka • Central Veterinary Laboratory • (see also LUANAR for Agriculture) • Regional and City Water Boards • (see also MUBAS, MZUNI for water)
Energy and Mining	• Malawi Energy Regulatory Authority • National Oil Company of Malawi • Mining and Minerals Regulatory Authority	• (see MZUNI, MUBAS, MUST for Energy) • National Mining Investment Company • Department of Geological Survey • (see also MUBAS for Mining)
Information and Communications Technology	Malawi Communications Regulatory Agency (MACRA)	• National Space Agency • MUUNI Fund • (see also multiple universities – UNIMA, MZUNI, MUBAS, MUST and private universities)
Natural Resources	• Dept Forestry • Dept Fisheries • Malawi Environment Protection Agency (MEPA) • Atomic Energy Regulatory Authority	• Forestry Research Institute of Malawi • Malawi College of Fisheries • National Aquaculture Centre • Dept Climate Change and Meteorological Services • (see also MZUNI – Environment and Forestry; and LUANAR – Natural Resources and Fisheries)

Table 14. International organizations, universities and non-governmental organizations supporting innovation and entrepreneurship

Organisations / Providers of Finance	Areas of innovation covered by financing
Malawi Banks	The 8 major banks in Malawi: CDH Investment Bank, Centenary Bank, EcoBank Malawi, FDH Bank, First Capital Bank Malawi, National Bank of Malawi, NBS Bank and Standard Bank, all state a readiness to support business development across a range of sectors and technologies. Standard Bank has a flagship programme 'Phuka Hub' to support SME financing.
Pension Funds	The two main pension funds, NICO; and Old Mutual, both invest in business opportunities across multiple sectors and technologies. A partner company, NICO Technologies specializes in IT service delivery.
Venture Capital	Venture Capital is weak in Malawi. There is a small Export Development Fund (Government financed). International venture capital funds with an interest in Malawi have a current 2024 value at US$3.9million
Innovation hubs outside Higher Education	• **m-Hub**, based in Lilongwe, was the first technology and innovation hub in Malawi and is the best known. It focuses on ICT skills to support entrepreneurship and business development; and promotes digitalization, robotics and coding skills. • **Mzuzu e-hub** similarly supports business incubation with an emphasis on promoting digital literacy for potential entrepreneurs • **NxtGen Labs** is a highly technically oriented hub. It is specifically focused on innovations around emerging technologies such as Internet-of-Things, Machine Learning, Artificial Intelligence and Robotics to stimulate business development. It has an innovative education program based on learning by doing. • **Kwathu Centre** operates under the Ntha Foundation with an emphasis on digital technology application to the creative industries, involving multimedia approaches.
Innovation hubs within universities. At the moment the public universities predominate.	The public universities are all moving to develop structures that can support innovation. • **MUBAS** is hosting the UniPod hub and has established a Technology Transfer Office. It has a strong focus on engineering and applied sciences. MUBAS also hosts a business incubation and entrepreneurs Hub and a design Studio. • **MUST** is in the process of establishing an industrial park on its campus, co-locating researchers, students, entrepreneurs and business into one site. It has a strong emphasis on technological innovation. It has also established an African Drone and Data Academy. • **LUANAR** has established an agribusiness hub (Agribiz). • **KUHeS** with the Liverpool Wellcome Trust has established a CREATOR innovation hub focusing on health-related innovations and is exploring pharmaceutical manufacture • **MZUNI** has established an Entrepreneurs Training and Incubation Centre. It has an ICT incubation centre and currently has several active partnerships focusing on innovation in horticulture, tourism and renewable energy. • **UNIMA** has demonstrated the capacity for technical innovation within its university system, for example in battery development. It is also promoting innovation within the performing arts.

3.3 Performance of the NSI

3.3.1 Educational attainment: academic and TVET

Budgetary data

Much of the data presented in this section comes from the 2023-24 Education Statistics Report,[128] supplemented by the UNICEF National Budget Brief[129] and Education Budget Brief 2023-2024.[130] Table 15, based on Ministry data, shows the overall trends of education expenditure. Part A compares recurrent expenditure against overall recurrent budget allocations (excluding statutory expenditures). Part B compares Education sector expenditure (excluding development partner funds) against GDP.

Recurrent budget expenditure has remained above 20% over the years in line with the Sector-Wide Approach agreement with development partners for continued support. Education expenditure as a proportion of GDP meets the international benchmark of 4%.

The UNICEF national budget brief compares total education expenditure against total budget and shows a similar decline in expenditure to that of section A of the above table, from 22% in 2019/20 to 16% in 2022/23. According to these measurements, Malawi is meeting the 2015 Incheon declaration recommendations that governments spend 4-6% of their GDP and 15-20% of their national budget on Education.

The Ministry data on percentage sub-sectoral recurrent expenditure on higher education, secondary education and primary education, is shown in Table 16. The data shows a relatively low expenditure on secondary education of 12 to 13%, consistent with the low net enrolment rate in secondary education of 17%. It should be noted, however, that in order to expand secondary school enrolment, a major effort to construct more secondary schools is underway. Much of the recurrent budget expenditure across the sector is for personnel emoluments. Personnel emoluments account for 87% and 67% of recurrent expenditure for primary education and secondary education respectively, and a very high level of the higher education budget.

Levels of literacy and numeracy

Malawi is not a participant in the Programme for International Student Assessment (PISA).

Table 15. Education expenditure 2017/18 to 2022/23. A. comparing recurrent expenditure against overall recurrent budget; B. comparing education budget against GDP

Year	2018/19 MK billion	2019/20 MK billion	2020/21 MK billion	2021/22 MK billion	2022/23 MK billion
A – Recurrent Expenditure as proportion of budget					
Education Sector Recurrent Allocation	225	301	333	291	462
Total Recurrent Allocation (less statutory expenditures)	841	1,055	1,303	1,107	2,316
Percent Recurrent spent on Education	27%	29%	26%	26%	20%
B – Education Budget as percentage of GDP					
Education sector (less development partner contribution)	254	292	346	340	380
GDP	5,633	6,275	6,918	7,499	11,406
Percent GDP spent on Education	4.5%	4.7%	5.0%	4.5%	4.2%

Table 16. Percentage sub-sectoral recurrent expenditure in the Education budget

Education sub-sector	2021/22	2022/23
Primary education budget as a percentage of national education budget	60%	59%
Secondary education budget as a percentage of national education budget	13%	12%
Higher education budget as a percentage of national education budget	24%	24%
Management and Administration as a percentage of national education budget	3%	5%

128 Malawi Education Statistics Report 2023/24. https://www.education.gov.mw/index.php/edu-resources/education-news/175-2023-malawi-education-statistics-report
129 https://www.unicef.org/esa/media/12926/file/UNICEF-Malawi-National-Budget-Brief-2023-2004.pdf
130 https://www.unicef.org/malawi/media/10106/file/Education%20Budget%20Brief%202023-24.pdf

Data on learning poverty is also not available from the Human Capital Index Report of 2020.[131] Regionally, however, 80% of 10-year-olds cannot read and understand a simple text by the end of primary school, and the corresponding value for Malawi's income group is estimated at 89%.[132] Common Zonal Testing to assess basic educational attainment data is currently being developed and implemented through a World Bank project (Malawi Education Reform Programme) which is due to conclude and report in 2026.

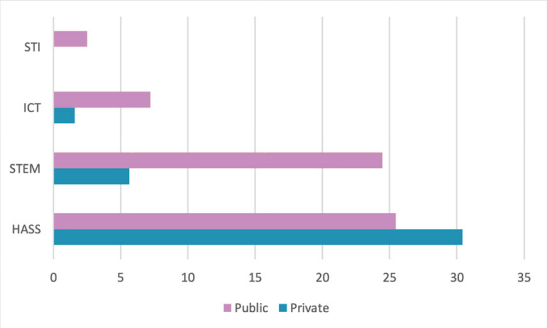
Science, Technology, Engineering and Mathematics (STEM) subject access and quality

All students at secondary level take English, Mathematics, Chichewa, Agriculture and Biology as core subjects. Based on data from the Ministry Statistics Report, approximately 59% of MSCE candidates take Chemistry and Physics. However, only 4% take computer studies. There are 1,774 secondary schools in Malawi, and across all these schools there is a total of only 756 science labs and 272 computer labs. Only 51% of schools have a library and 18% have no access to electricity.

Approximately 80% of secondary school teachers are qualified, with the vast majority having either a degree or diploma in education. The overall ratio of pupils to qualified teachers is 32, down from 47 in 2019. However, the ratio of pupils to qualified teachers in Maths is 260, in Biology is 305, in Physics is 722, and in Chemistry is 987.

There is no immediately and regularly available data on the number of students engaged in the STEM and non-STEM programmes offered in tertiary education. However, a study was undertaken on 2022 graduates across tertiary institutions[133] and this data is summarised here. The data is based on receipt of information from 24 out of 28 public universities and colleges, and 19 out of 21 private universities and colleges, representing 16,735 awards. The distribution of the awards is shown below in Table 17.

Figure 9. Percentage distribution of subject areas across public and private sector tertiary institutions. Data taken from footnote 106



The awards were divided into four categories: STEM, ICT, Humanities Arts and Social Sciences (HASS) and STI, which incorporated subjects that emphasise practical applications and technological advancements, supporting socio-economic and innovative growth objectives. The breakdown of awards by percentage across public, private and overall programmes is shown in Figure 9. It demonstrates that the public sector institutions primarily address STEM subjects. While the gender distribution between male and female was approximately equal for HAAS

Table 17. Distribution of 2022 tertiary education awards by level and gender

	Public institutions			Private Institutions			Total		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Doctorate	9	6	15	4	0	4	13	6	19
Masters	196	142	338	176	84	260	372	226	598
PG (other)	16	8	24	-	-	-	16	8	24
Bachelor	4394	3009	7403	2092	1981	4073	6486	4990	11476
Diploma	1735	887	2662	741	933	1674	2476	1820	4296
Certificate	95	28	123	76	123	199	171	151	322
TOTAL	6445	4080	10565	2909	3037	5946	9534	7201	16735

131 https://databankfiles.worldbank.org/public/ddpext_download/hci/HCI_2pager_MWI.pdf
132 https://www.iicba.unesco.org/en/node/104
133 E.B. Milanzi and T. Kumwenda. Analysis of 2022 Graduates. Personal communication

subjects, females accounted for only 35% of STEM awards, 30% of ICT awards and 26% of STI awards, indicating a gender bias that needs to be addressed across STEM and associated subjects.

3.3.2 Research and Development

A 2019/2020 R&D survey was undertaken by NCST and this data was incorporated into the 4th African Innovation Outlook report (AIO4) published by AUDA-NEPAD.[134] This section combines data from the original NCST 2019/2020 R&D survey, kindly provided by NCST, and the analysis undertaken in the AIO4. Malawi was one of only 10 of the 55 AU member states in a position to submit data for the AIO4, highlighting its potential to effectively monitor innovation performance.

Expenditure on R&D

The 2019/2020 R&D survey data reveal that Gross Expenditure on R&D (GERD) or research intensity, for 2019/20, was MK 14.6 billion, representing 0.18% of GDP. This expenditure was broken down by categories as shown in Table 18. The highest proportion of expenditure was that of Higher Education Expenditure on R&D (HERD) at 47%, followed by Government Expenditure on R&D (GOVERD) at 29%, Private non-Profit Expenditure on R&D (PnPRD) at 19%, with Business Expenditure on R&D (BERD) the lowest at 5%. It is worth noting that, in advanced economies, Business Expenditure on R&D ideally approaches 50%. Research by R&D type was fairly evenly spread among Basic research (30%), Applied Research (44%) and Experimental Development (26%).

Malawi's GERD as a percentage of GDP is low compared to other low-income countries, and significantly behind the average for lower-middle-income, middle-income, upper-middle-income and high-income countries, as shown in Table 19.

The source of R&D funding is shown in Table 20. The largest source of funds came from foreign sources at 33%. AIO4 defined Malawi's funding model for R&D as 'aid-dependent'. There is a reliance on external sources due to low Government funding.

Research Personnel

The data on research personnel is provided in detail in Annex 1 of AIO4. However, this data was reported as full numbers, rather than as researchers per million inhabitants which is the standard international format. Where conversion to the standard format has been made in this section, this was based on the 2019 population of 17.56 million, as stated by the National Statistics Office of Malawi, which in turn was based on the 2018 census.

Table 18. Percentage Composition of Malawi Gross Expenditure on R&D (GERD) 2019/2020

GERD (Total)	"% Business (BERD)	% Government (GOVERD)	% Higher Education (HERD)	%Private Non-Profit (PnPRD)
100	7	27	50	16

Table 19. Comparison of Malawi GERD with 2020 GERD for low-income countries and other income classifications (data taken from UNESCO[106])

Country classification	Malawi	Low Income	Lower Middle Income	Middle Income	Upper Middle Income	High Income
GERD (%)	0.18	0.27	0.51	1.18	1.47	2.48

Table 20. Percentage composition of Source of Funding for Malawi R&D 2019/2020

Business Sources	Government Sources	Higher Education Sources	Private non-Profit Sources	Rest of World
12	15	14	25	33

134 AUDA-NEPAD (2025) The 4th African Innovation Outlook Report (AIO-2024). Pretoria. auda-nepad.org/file-download/download/public/161674
135 https://databrowser.uis.unesco.org/browser

A top-level perspective of R&D personnel and researcher levels per million inhabitants, both by headcount and full time equivalent (FTE), is provided in Table 21. The low FTE number compared to headcount illustrates that there are very few full-time research personnel in Malawi, with most undertaking other work in addition to research.

The number of full-time equivalent researchers per million inhabitants in Malawi is very low compared even to the average for low-income countries, for which the average figure is 174, as illustrated in Table 22. There is a need to massively scale up the number of full-time researchers in Malawi. One way to do this is to massively increase the number of science and technology PhD students.

The distribution of R&D personnel (FTE) by occupation and sectors is provided in Table 23. It reinforces the GERD data, illustrating the small amount of R&D personnel in Malawian industry at about 1% of the national total. The largest contingent of R&D personnel is employed by Government. However, the vast majority of them are support staff. The largest number of researchers reside in the Higher Education sector. The overall percentage of FTE female R&D personnel was 28%.

Table 23. Distribution (FTE) by occupation across sectors (data taken from AIO4, see footnote 150)

The number of FTE research personnel across the field of science disciplines is provided in Table 24. The largest contingent of researchers was in Agriculture, aligned to the significant number of Agricultural research stations in the country, plus of course LUANAR. This was followed by Medical and Health research, which has seen a large injection of development partner support for many years, for example, through the Wellcome Trust, complemented by the strength of KUHeS health research. Unfortunately, there was not a separate classification for ICT research. Future surveys should create ICT research as a separate category of research for evaluation through publications, expenditure and

Table 21. Malawi R&D personnel and researcher headcount per million population for 2019/2020

Category of personnel	R&D personnel (Headcount)	R&D personnel (FTE)	Researchers (Headcount)	Researchers (FTE)
Total Number	2829	1656	1256	473
Number per million population	161	94	71	27

Table 22. Comparison of Malawi number of Researchers (FTE) with 2019 number of Researchers (FTE) for low-income countries and other income classifications (data taken from UNESCO)

Country classification	Malawi	Low Income	Lower Middle Income	Middle Income	Upper Middle Income	High Income
Researchers (FTE)	27	174	260	699	1,151	4,241

Table 23. Distribution (FTE) by occupation across sectors (data taken from AIO4, see footnote 107)

Occupation	Total	Business	Government	Higher Education	Private Mon-Profit
Researchers	472.5	11	161.7	284.3	15.5
Technicians	414.5	0.5	271.4	115.1	27.5
Support staff	768.9	5	657.1	96.6	10.2
Total	**1655.7**	**16.5**	**1090.20**	**495.9**	**53.1**
% Female personnel	**28%**	**30%**	**25%**	**33%**	**42%**

Table 24. Number of research personnel (FTE) for different academic disciplines.

Total	Natural Sciences	Engineering & Tech.	Medical & Health	Agriculture & Vet.	Social Sciences	Humanities and Arts	Not classified
1,655.7	127.6	102.4	198.6	475.5	155.2	27.8	568.7

136 https://databrowser.uis.unesco.org/browser

personnel, given its growing significance nationally and globally.

3.3.3 Scientific production

A good measure of the strength of an STI ecosystem is the number of peer-reviewed publications generated. AIO4 undertook a historic bibliometric analysis of the African scientific literature. The data for all types of publications (books, book chapters, articles, reviews and conference proceedings) from 2013 to 2022 is provided in Table 25. The data show a steady increase in publications from 458 in 2013 to 1,253 in 2022, giving a total of 8,432 publications for the 10-year period. The slight decrease from 2021 to 2022 can probably be attributed to the impact of Covid-19 over this period. The growth rate of publications was calculated by dividing the number of publications for the second 5-year period (2018-2022) by the number of publications for the first 5-year period (2013-2017) and was determined to be 75.10%.

A comparative analysis of national publications across Africa was undertaken in AIO4 on publication data from 2008-2022. The 55 countries of the AU were ranked based on: number of papers; number of citations; number of papers per capita of population; and number of papers per billion GDP (nominal). Malawi performed exceptionally well, ranking 16th overall out of 55 countries for the number of publications, and 4th based on the number of publications relative to its GDP. The data are presented in Table 26.

There are a number of points to be made based on this information. Firstly, a study undertaken by NCST,[137] assessing Malawi's web of science documented publications of the period 2011-2019, indicated that the vast majority of publications were in the health sciences (77%). Agricultural sciences came a distant second with 6% of publications, and environmental sciences (excluding geosciences) third with 5%. The large number of health science publications is assisted by support for the Malawi Liverpool Welcome Trust unit and the strong publication records of many KUHeS academics. A recent 2025 Research Leaders ranking by Nature[138],[139] placed KUHeS 5th across Africa for health sciences research output. Thus, although promising, the AIO4 data should not be overinterpreted as indicating an overall strength of Malawian academia, given its heavy dependence on externally-funded health sector research. The data does however indicate the strong potential for Malawian science and R&D to develop.

Secondly, the previously reported research expenditure and research personnel analysis in section 3.2 was based on 2019 data. The 2022 publication data presented in AIO4 and the KUHeS ranking for 2025 indicate that Malawian capacity for R&D may have improved significantly since 2019, and that the 2019 data may underestimate the current strength of Malawi's innovation ecosystem. An R&D survey was carried out by NCST in 2025 and it will be interesting to see how the 2025 data compare with the 2019 data reported here.

Table 25. Number of Malawian Publications 2013 to 2022 (data taken from AIO4, see footnote 150)

Total	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Growth
8,432	458	532	604	695	776	864	887	1,059	1,304	1,253	75.10%

Table 26. Malawi's rank against 55 AU member states based on scientific publication (2008-2022) (Data taken from AIO4, see footnote 150)

Country	Rank for Total Number of papers	Rank for Number of citations	Rank for Number of papers per capita	Rank for Number of papers per billion GDP (nominal
Malawi	16	13	24	4

137 Unpublished data provided by NCST.
138 https://www.nature.com/nature-index/research-leaders/2025/institution/academic/health-sciences/regions-Africa
139 Kuhes ranks 5th in African health sciences research - Nation Online https://share.google/87yXDhUjApxTlbski

3.3.4 Technological performance

Intellectual Property

Malawian Intellectual Property data consists of filings, either resident or non-resident, made directly to the Malawi office of the Registrar General,[140] or as a designated filing through the African Regional Intellectual Property Organization (ARIPO). Table 27 summarises the patent, utility model, trademark and industrial design data obtained from the World Intellectual Property Organisation (WIPO) 2024 Malawi country profile[141] and ARIPO annual reports.[142]

There are very limited residential intellectual property submissions to the Malawi office, with extremely few residential patent applications, and only a small number of residential trademark applications. Most non-residential submissions are made as designations through ARIPO. The jump to 37 non-residential patent applications to the Malawi office in 2022 were all made from India. A third of all ARIPO designated patent applications come from the USA, with 8% coming from the UK, 6% from India and 5% each coming from Germany and South Africa.

Patenting, utility models, and industrial designs have remained fairly constant over the past 6 years, but trademark registrations have seen a steady ARIPO-driven increase from 185 in 2018 to 465 in 2023. Malawi performs reasonably well among the 20 ARIPO for intellectual property designations, indicating a degree of confidence in the Malawian market.

Table 27. Summary of intellectual property filings in Malawi, including through ARIPO

Type of IP	2018 filings	2019 filings	2020 filings	2021 filings	2022 filings	2023 filings	2024 filings
Patent Malawi Office-residential	0	1	0	1	0	0	0
Patent Malawi Office-non-residential	2	1	0	1	37	1	0
Patent ARIPO designated	458	506	no data	439	451	417	385
Utility Models–Malawi Office	no data	no data	no data	no data	no data	no data	no data
Utility Models–ARIPO designated	14	9	no data	4	11	11	6
Industrial Designs–Malawi Office	no data	no data	no data	no data	no data	no data	no data
Industrial Designs–ARIPO designated	54	34	no data	24	54	51	47
Trademarks–Malawi Office	40	16	5	354	243	353	3
Trademarks-ARIPO designated	185	240	no data	274	381	465	358

140 https://www.registrargeneral.gov.mw/services/industrial-property-registry.html .
141 https://www.wipo.int/edocs/statistics-country-profile/en/mw.pdf
142 https://www.aripo.org/publications/annual-reports

Indicators of manufacturing capacity development

Refence has previously been made to Malawi having suffered de-industrialisation over the past 30 years, passing from an era of diversified enterprises through which Manufacturing Value Added contributed to 21% of GDP in 1992 to a reduced value of 11% in 2024[143].

The indicators of manufacturing capability used in this section are 'import of capital goods' and 'import of machinery and transport equipment', taken from the World Bank's 'World Integrated Trade Solutions'[144] website. Foreign direct investment and medium and high-tech export data is taken from the World Bank data base.145 Comparisons are made between Malawian data, sub-Saharan African data and World data and are averaged over the past 9 years from 2014 to 2022 in Table 28. The take home messages are that:

1. Imports of capital goods as a percentage of imports (20%) fall far below both the sub-Saharan African (27%) and global (33%) averages
2. Imports of machinery and transport equipment as a percentage of imports (23%) fall far below both the sub-Saharan African (30%) and global (37%) averages.
3. Foreign direct investment as a percentage of GDP (2.1%) is on a par with sub-Saharan African (2.1%) and global (2,3%) averages, but fluctuates considerably. Given Malawi's low GDP, foreign direct investment remains low in real terms.
4. Unsurprisingly, high tech exports as a percentage of manufactured exports (3.3%) is lower than both the sub-Saharan African average (5.8%) and the global average (21%).

These poor figures reflect the low levels of investment in manufacturing by both the public

Table 28. Comparative data between Malawi, sub-Saharan Africa (SSA) and the world for indicators of manufacturing capabilities, namely import of capital goods, import of machinery and transport equipment, as percentage of imports, foreign direct investment as a percentage of GDP and high-tech exports as percentages of exports

Indicator	2015 %	2016 %	2017 %	2018 %	2019 %	2020 %	2021 %	2022 %	2023 %	2024 %	Average value
Capital imports as % imports - Malawi	18	17	22	21	22	17	18	17	15	-	19
Capital imports as % imports - SSA	29	29	26	26	27	25	24	22	26	-	26
Capital imports as % imports - world	33	34	33	33	33	34	32	30	32	-	33
Machinery and Transport Equipment as % imports - Malawi	20	20	25	25	26	21	22	19	18	-	22
Machinery and Transport Equipment as % imports - SSA	33	32	30	30	31	27	27	25	29	-	29
Machinery and Transport Equipment as % imports - world	37	38	38	37	38	38	36	33	36	-	37
Foreign direct investment as % GDP - Malawi	3.1	1.5	1.0	0.8	0.5	2.1	1.0	1.6	1.6	2.3	1.6
Foreign direct investment as % GDP – SSA (excluding high income countries)	2.7	2.0	1.7	1.6	1.5	1.5	3.7	1.6	2.0	2.1	2.0
Foreign direct investment as % GDP - world	3.6	3.5	2.7	1.2	2.2	1.3	2.5	1.9	0.9	1.3	2.1
High tech exports as % Manufactured exports) – Malawi	1.3	2.4	2.0	2.1	6.8	2.8	6.0	2.3	5.0	2.0	3.3
High tech exports as % manufactured exports) – SSA (excluding high income countries)	6.0	5.6	5.5	6.4	6.5	5.6	5.0	6.0	5.0	6.0	5.8
High tech exports as % manufactured exports) – world	20	20	21	21	21	22	22	23	23	25	21

143 https://data.worldbank.org/indicator/NV.IND.MANF.ZS?locations=MW
144 https://wits.worldbank.org/
145 https://data.worldbank.org/indicator/BX.KLT.DINV.WD.GD.ZS?locations=MW-ZF

and private sectors, which in turn reflects the poor macroeconomic status of the country and its low level of STI capacity, whether human, institutional or infrastructural.

With regard to sectoral emphases on investment, the Malawi Investment Trade Centre146 indicates that agriculture is the sector that attracts most foreign direct investment, primarily from South Africa, the USA, UK and India. There is growing interest in renewable energy projects, particularly in the solar, wind and waste-to-energy fields, in addition to hydropower projects. Mining is similarly attracting investment. Other sectors that offer investment opportunities include agro-processing, manufacturing and tourism.

3.3.5 Entrepreneurship and innovation

Innovation and Competitiveness indices

This section will briefly review comparative data from Malawi and other countries in global indices, namely the Global Innovation Index (GII) for 2025, co-published by WIPO, and the World Competitiveness Index (2018-19) produced by the World Economic Forum. It should be recognised that both indices are reporting on data that is several years out of date, but that probably still remains valid in many respects.

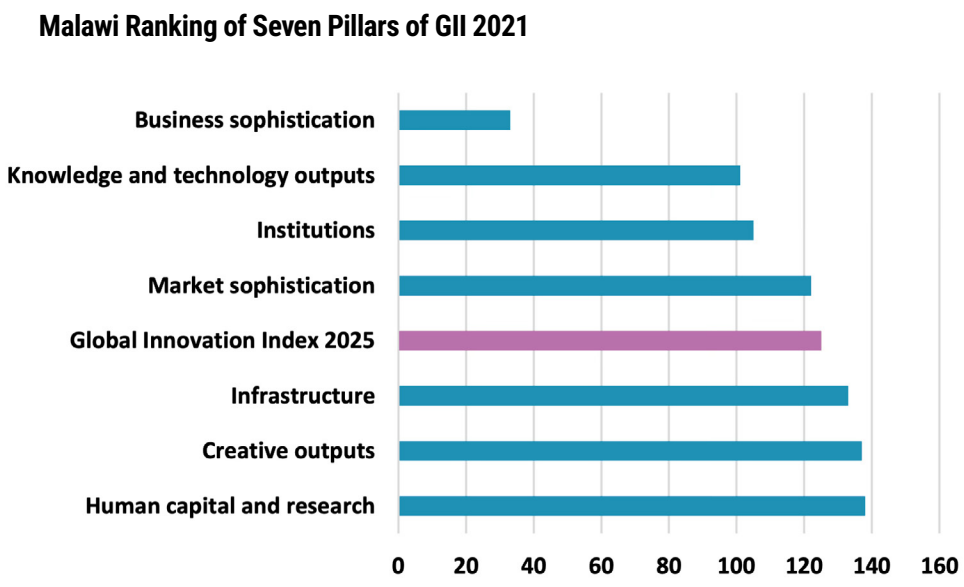
Malawi did not feature in the GII for 2022, 2023 and 2024, as key data had been missing. However, recent efforts to improve on data collection has led to Malawi's inclusion in the 2025 GII.[147]

Based on the GII criteria, Malawi regularly performs above its low-income status. Although Malawi was ranked the 6th poorest country in the world by GDP (nominal) per capita in 2025, it ranked 125th out of 139 economies featured in GII 2025. It ranked 5th out of 11 low-income countries and 20th among 32 sub-Saharan economies. This is summarised in Table 30.

The spread of rankings of the seven pillars in GII 2021, each of which is a composite of several indicators, provides insight into the strengths and weaknesses of the Malawian innovation system. This data is outlined in Figure 10.

The strengths revolve around the level of business sophistication and its technology outputs. The component of business sophistication that contributed significantly to its high business sophistication score was its top ranking (1st) for ICT service imports and other trade-related factors. Weaknesses revolve around the level of human capital and research, and the level of relevant infrastructure in the country. Human capital and research are measured by elements such as pupil-teacher ratios, enrolment rates

Figure 10. The ranking of seven pillars of GII 2025 for Malawi



146 https://mitc.mw/invest/index.php/investment-climate/fdi-in-malawi
147 https://www.wipo.int/web-publications/global-innovation-index-2025/en/index.html

in tertiary education, and gross expenditure on R&D. Infrastructure is assessed by elements such ICT access, energy output and environmental performance.

Malawi was also comparatively assessed through the World Economic Forum's Global Competitive Index, which relies on opinion-based surveys to drive its evaluation. The most recent evaluation is for 2017-18, where Malawi ranked 132 out of 137.[148] Malawi ranked extremely low in terms of its infrastructure and macroeconomic environment. It scored relatively well in terms of its health and primary education, market efficiency and financial market development, and very well in terms of its institutions and labour flexibility. It ranked 124 out of 137 for innovation. The six most problematic factors for doing business in Malawi in the 2017-18 Global Competitiveness Index were listed as: (i) Corruption, (ii) Access to financing, (iii) Tax rates, (iv) Inflation, (v) Inadequate supply of infrastructure, and (vi) Inefficient government bureaucracy.

A conclusion from this section is that the operational market and business systems to enable innovation leading to entrepreneurship and economic growth are broadly in place. The challenges lie in the levels of efficiencies with which the economy as a whole is managed, poor infrastructure, and weak human capital and research, and the challenging macroeconomic environment.

3.4 NSI SWOT Analysis

The analysis in the foregoing sections enables a determination of the strengths, weaknesses, opportunities and threats (SWOT) that impact the future direction of the Malawian STI ecosystem. A summary of the SWOT analysis is provided in Table 29.

3.4.1 Strengths

1. **Political stability**. Malawi has had a stable political environment since independence in 1964. Since 1994, multi-party presidential and parliamentary elections have been held every five years with peaceful handovers, including the re-ordering of a presidential election by a constitutional court in 2020. However, this situation cannot be taken for granted.
2. **National strategy - Malawi 2063**. The general direction for Malawian development outlined by Malawi 2063 is broadly accepted by all political parties. Indeed, political parties have to subject their manifestos to the National Planning Commission to verify that that their manifestos are aligned to Malawi 2063 for them to qualify to compete in elections. This provides a stable platform for national planning and for seeking development support.
3. **Business and market systems operational.** Malawi scores relatively highly with respect to its market and business sophistication indicators in past and present issues of the Global Innovation Index, thus facilitating the opportunity for innovation if other factors are in place.
4. **Relevant policies are in place or under development**. Policies to promote innovation and value addition are in place or under formulation across a number of areas, including STI, Industry, Trade and ICT and digitalisation.
5. **Centres of research excellence and research output**. Malawi has recognised centres of excellence in research, notably within the areas of health and agriculture, with some other emerging areas, for example, in ICT.

3.4.2 Weaknesses

1. **Poor macroeconomic environment**. Public debt is high, there is a poor balance of payments, and there are high inflation and interest rates. These factors, among others, are limiting investment and business progression. They also, along with other points listed, limit capacity for policy implementation.
2. **Limited diversification of economy**. There is an over-reliance on agricultural commodities, notably tobacco and other primary products, for export and foreign exchange earnings. At the same time, there is limited industrialisation and limited expansion into sectors beyond the agri-food industry
3. **Weak governance and coordination of STI.** There is limited centralised, government-led national coordination of STI and limited

148 https://www3.weforum.org/docs/GCR2017-2018/03CountryProfiles/Standalone2-pagerprofiles/WEF_GCI_2017_2018_Profile_Malawi.pdf

development and integration of sectoral innovation strategies into the national agenda. This results in limited engagement between government, private sector, academia and civil society stakeholders.

4. **Limited STI data and STI monitoring and evaluation capacity.** There is historically limited STI data available to enable a true monitoring and evaluation of the Malawian STI ecosystem, and there is limited observatory capacity or infrastructure for its delivery. However, it appears this is now being addressed by NCST and NSO.
5. **Low levels of human capital development and low R&D personnel count.** The entirety of the Malawian education sector requires strengthening. There is poor performance at the primary level, and low levels of access at the secondary and tertiary levels, including postgraduate doctoral research, compared to sub-Saharan African norms. This, aligned with other factors, results in low levels of R&D personnel.
6. **No substantive domestic funding of R&D.** The Science, Technology and Innovation Fund, which is embodied within policy to finance R&D, has not been established with adequate funds. There is extremely limited Business R&D.
7. **Weak intellectual property protection.** There are extremely low levels of patent, utility models and industrial design output from within Malawi.

3.4.3 Opportunities

1. **Youthful population and demographic dividend.** Malawi's youthful population could be a source of vibrancy and energy within the STI ecosystem, generating ideas for innovation and development. This may be supported by the recently established Youth Innovation Fund.
2. **Expansion and diversification of manufacturing potential.** It is widely recognised and accepted that the economy needs to diversify both to limit import substitution and to promote exports. This expansion and diversification is being promoted both within the agri-food system through the establishment of mega-farms and value addition, and in other sectors such as mining, tourism, and information technology. Special economic zones and industrial parks are also being established.
3. **MSME entrepreneurial sector.** Although relatively small, this sector is full of young entrepreneurial individuals starting up both commercial and social enterprises, supported by several technology hubs.
4. **Research and innovation infrastructure.** Although still limited, research and innovation infrastructure, including TEVET infrastructure, is undergoing expansion, for example, through university and commercial science parks.

Table 29. SWOT analysis of the Malawian STI ecosystem

Strengths	Weaknesses
1. Political stability 2. National strategy – Malawi 2063 3. Relevant policies in place or under development 4. Business and market systems operational, 5. Centres of research excellence and research output	1. Poor macroeconomic environment 2. Limited productive diversification 3. Over-reliance on tobacco and primary products for export and foreign exchange 4. Weak governance and coordination of STI 5. Limited engagement between government, private sector, academia and civil society 6. Limited STI M&E capacity and limited data collection / availability 7. Low levels of human capital development and low R&D personnel count 8. No substantive domestic financing of R&D 9. Poor intellectual property infrastructure
Opportunities	**Threats**
1. Youthful population and demographic dividend. 2. Expansion and diversification of manufacturing potential 3. SME entrepreneurial sector 4. Research and innovation infrastructure development 5. African Continental Free Trade Agreement (AfCFTA)	1. Over-reliance on external finance and its potential withdrawal / reduction 2. External socio-economic shocks 3. Brain drain 4. Regional and international competition

5. **African Continental Free Trade Agreement (AfCFTA)**. The AfCFTA provides an opportunity for Malawi to increase trade within Africa and especially with its nearest neighbours in Central, East and Southern Africa, along with the Common Market for Eastern and Southern Africa (COMESA).

3.4.4 Threats

1. **Over-reliance on external finance and its potential withdrawal/reduction.** Initiatives mentioned under 'opportunities' are often heavily reliant on external finance through development banks, development partners and private not-for-profit organisations. If these agencies lose confidence in Malawi, then a reduction in finance would be detrimental to progress.
2. **External socio-economic shocks.** Over the past two decades, there has been the international financial crisis of 2008, the Covid pandemic, climate-related disasters such as tropical cyclones and associated flooding, and impacts on the accessibility of critical goods brought about by the Russia-Ukraine war. These and related financial, health and environmental threats remain and may increase in frequency and intensity in future years.
3. **Regional and international competition.** The emergence of free trade and other international and regional developments could lead to a challenging situation for Malawi's emergent companies and its local agricultural market.
4. **Brain drain.** There is a danger of top-quality individuals at all levels of qualification and experience being enticed to take up jobs outside of Malawi.
5. **Corruption**. Corruption is an ever-present threat that can limit opportunities and prevent their realisation.

3.5 Recommendations on Malawi's STI Environment

These recommendations reflect elements that have also been incorporated into the draft of the new national Science Technology and Innovation Policy.

1. **Governance and Coordination**
    1. There needs to be improved coordination by government of sectoral and intersectoral STI strategy at both the national and local government level.
    2. Overarching mechanisms need to be established that 'continuously' support STI policy implementation and future STI policy development.
    3. Capacity to generate data is required in order to establish key metrics and indicators for assessment of STI nationally.
    4. Observatory capacity for Monitoring Evaluation and Learning of STI performance needs to be expanded to meet national needs and international reporting obligations.
2. **Application and integration of STI into key sectors for sustainable national development**
    1. There is a need to better adopt, adapt and utilise STI to meet established demand-driven development needs as outlined in Malawi 2063 and other policy documents.
    2. Design Thinking and Systems Thinking needs to be applied for STI to meet the demand-driven objectives and targets of Malawi 2063 and associated sectoral and cross-sectoral development policies.
    3. Some level of investment in frontier science, at the forefront of global knowledge generation, is required to maximise the opportunity for innovative supply-driven opportunities for socio-economic development.
    4. Certain sectors, based on their socio-economic significance, their prioritisation within Malawi 2063, and their reliance on innovation, require special attention. These cover commercially-driven sectors, and cross-cutting infrastructure and social service sectors.
3. **Enhancing STI-driven industrialisation**
    1. There is need to enhance industrialisation through technology adoption, adaptation, development and utilisation of local and international innovations and technologies.
    2. There is need for enhanced collaborations between the private sector, public sector, and academia.
    3. There is need for strengthened intellectual

property protection and enhanced capacity for the management of intellectual property and associated contractual and licensing agreements.
4. There is need for enhanced access to, and support for, appropriate technologies in peri-urban and rural areas, for example, through the engagement of local government.
5. Sustainability should be integrated into manufacturing processes through eco-friendly technologies and practices.

4. Market access for STI-driven import substitution and exports

1. There is a need for improved ease of access and support for innovative Malawian products and services to enter the Malawian market.
2. There is need for improved support for innovative Malawian products and services to access export markets.

5. Development of STI infrastructure

1. There is need for more investment in high-quality research infrastructure in universities, research institutions and industry to support R&D leading to innovation.
2. Community access to STI infrastructure, incorporating agriculture and other technologies, needs to be developed across the country, including within rural and peri-urban areas.

6. Human Capital Development

1. There is need to ensure the relevance of Science, Technology, Engineering, Arts and Mathematics (STEAM) and other STI-related education and training to socio-economic development.
2. There is need for enhanced access to STEAM and other STI-related education and training across all sub-sectors of the education system: primary, secondary, TEVET and Higher Education, and also for those outside the formal education system.
3. There is need for enhanced quality of tuition for STEAM and other STI-related education and training across all sub-sectors of the education system: primary, secondary, TEVET and Higher Education, and also for those outside the formal education system.
4. There is a need to increase the number of full-time qualified researchers, including at doctoral and post-doctoral level and technician level, within a recognised research profession.
5. There is need to promote a science culture within Malawian society through the media and through lifelong learning and continuous professional development, including for those that dropped out of the formal education system.
6. The Government and development partners should use their contractual power to negotiate employment and training obligations for companies undertaking large development projects, for example, infrastructure development, to enhance Malawian workforce capacities.

7. **Financing STI**

1. There is a need to increase public spending for R&D, notably through the functional establishment of a STI fund that has already been launched within national policy.
2. Such financing should support the full spectrum of research, namely basic research, applied research and experimental development, so that innovation can be realised.
3. There is need to incentivise private sector financing of STI and associated R&D.
4. There is need to support large-scale capital investment in R&D and manufacturing infrastructure, including through foreign direct investment.

8. Best practices for STI policy implementation

1. Partnerships should be transparent and equitable
2. STI policy and practice must be well communicated to the public
3. Gender equity must be mainstreamed throughout STI policy and practice
4. Open access to information should be maximised
5. Access to innovation should be maximised
6. An ethical approach must underpin research and the development and application of innovation

Chapter 4
Technology Needs Analysis

4.1 Determination of Priority Sectors

As outlined in Chapters 2 and 3, innovation plays a significant role in enabling development across multiple sectors. Utilising the methodological approach described in Section 1.2 of Chapter 1, the process of sector prioritisation utilised a questionnaire provided to ministries and expert informants with further input and final validation by the TNA Committee (Annex 2). It was stressed by the TNA Committee and other stakeholders that this selection process was not intended to diminish the technology needs of the sectors not prioritised in this report. Indeed, it was highlighted that many of the technologies discussed cut across multiple sectors.

Agriculture was by far the dominant sector identified for prioritisation, followed by Mining, ICT and Energy. Mining was selected based on input by the TNA Committee, given its growing importance and planned expansion within the economy. Table 30 lists the rationale provided for selection of these four sectors.

4.2 Identification of sub-sectoral areas for technological innovation

Following the selection of the priority sectors, the analysis was deepened through a sub-sectoral assessment to further refine the identification of technology needs. While sector-level analysis provides an important strategic overview, sectors such as agriculture, mining, ICT and energy encompass a wide range of activities, value chains and technological applications. As a result, sector-level prioritisation alone is insufficient to capture the specific technological challenges and opportunities that exist within different segments of each sector. The sub-sectoral analysis therefore serves to narrow the focus to areas where technological innovation can deliver the greatest impact, taking into account sectoral dynamics, capacity constraints and development priorities. This approach strengthens the analytical rigour of the TNA and ensures that the identification of priority technologies is evidence-based, targeted, and responsive to Malawi's specific development context.

In this context, semi-structured interviews were undertaken across the selected sectors of agriculture, mining, ICT and energy, utilising expertise from Government, academia and the private sector. The output from these interviews was reviewed and complemented by a stakeholder workshop consisting of government, private sector, academic and civil society stakeholders across all four sectors. These two processes resulted in the establishment of sub-sectoral strategic priority areas and a range of critical technologies associated within them (Table 31).

Detailed evaluations of the selected sectors will be presented in subsequent sections. However, some common themes emerged from interviews across all sectors that are worth noting before moving into sectoral details. These issues reflect the systemic challenges that need to be addressed if advances in science, technology and innovation are to be realised within Malawi.

Table 30. Justifications and Limitations for selection of priority sectors

Sector	Justification for the sector
Agriculture	• Economic importance • Feeds into value addition / manufacturing • Human capacity available • Tech innovations under way • Vibrant SME sector
Mining	• Potential economic benefit • Growing importance in the context of MW 2063
ICT	• Cross-cutting impact • Impacts on all areas of innovation • Growth area within economy • Human Capital available
Energy	• Necessity for industrialisation / manufacturing • Cross-cutting impact • Significant sector activity • Human capital available

Table 31. Sub-sectors identified for each of the four sectors

Sector	Sub-Sector priority areas	Associated Technology areas identified
Agriculture	1. Increased crop productivity • Food security • Expanded crops with market growth potential	1. Domestication and securing of inputs for production • Seed technology • Fertiliser manufacture • Water management and irrigation • Mechanisation (with local manufacturing) • Storage to minimise post-harvest loss • Access to off-grid solar energy 2. Digitalisation of farm management and precision agriculture • Soil sensors to analyse soil and plant health • Automated drip irrigation / fertigation • Drones • Software development / mobile apps to access management systems, data and communication • Logistics and supply chain monitoring • Cold chain • Blockchain to monitor distribution / transactions 3. National-level big data management • Climate, environmental and soil health data • Agricultural production data • Mobile network operator data (location and usage data) • Farmer / Field data • Social Data • Market and finance data (weather, land and market data)
Mining	• Artisanal and small-scale mining for mineral extraction and processing • Public sector oversight and support for the mining sector	1. Artisanal and small-scale mining technologies • Mechanised tools for extraction • Mechanised tools for processing • Internet of Things (IoT) sensors for real time health and safety and environmental monitoring • Analytics 2. Data management tools to facilitate public sector oversight • Information Technology (IT) tools for data gathering and information dissemination • Centralised government administration e.g. Registration, Contracting, Revenue collection, Security surveillance, • Market information • National-level big data e.g. geological and exploration data, operational and investment data, environmental and social data, human capital and skills data
ICT	1. Developing digital innovation and ICT services for e.g. Government, Agriculture, Mining 2. Policy coherence and digital public infrastructure 3. Affordability and local manufacture	1. Software development for ICT services • Including commerce, e-Government, cybersecurity • Including key sectors e.g. Agriculture, Mining, Energy, Finance • Full stack of ICT technologies required 2. Management of domestic data, including Big Data • Establishment of data centres • Development of unified data platforms • Connecting data bases to IoT and remote sensing infrastructure • Use of advance analytics and artificial intelligence • Managing cybersecurity and risk • Establishment of internet exchanges 3. Local hardware equipment assembly and manufacture • Emphasis on low-cost basic equipment and accessories
Energy	1. Expanding access to electricity and clean cooking 2. Grid stability	1. Enhancing off-grid and mini-grid solar • Multiple applications e.g. Solar powered applications for agriculture and mining such as Irrigation Intermediate machinery • Local assembly to lower costs 2. Enhanced Grid stability • Increased hydro power supply • Battery Energy Storage Systems • Smart / bi-directional metering • Diversification of energy sources

The need to enhance Malawian capacity for manufacturing was regularly highlighted. Malawi has suffered de-industrialisation over the past 30 years with the Manufacturing Value Added reducing from 21.1% of GDP in 1992 to 11% in 2024.[149] The demand for cutting-edge

149 https://data.worldbank.org/indicator/nv.ind.manf.zs?end=2023&locations=MW&start=2017

infrastructure for fabrication, prototyping and small-scale manufacturing has been highlighted by the demand for such services directed to the UniPod at MUBAS. However, UniPod cannot meet the demand of local industry. Some of the larger companies consulted indicated that they are considering establishing their own internal workshops so they can meet their internal demands for fabrication and equipment maintenance. Several universities are also exploring moving into small-scale manufacturing and the assembly of products such as farm machinery, fertiliser, solar panels and laptop computers.

Data management capacity, including for Big Data, and software systems development were also highlighted as areas requiring attention across multiple sectors. The capacity to integrate geophysical data with earth observation data and demographic data could greatly assist comprehensive national planning. Domestic capability to undertake large software systems development would save on foreign exchange and enhance self-reliance and control of national data systems.

Allied to the need for enhanced development of technology and manufacturing capabilities, recommendations were made to improve skills. Educational and training curricula should be reviewed to reflect the practical competencies required for technological implementation, as well as the underlying theory. In parallel, there was a call for increased investment in R&D for innovation and technology adoption, adaptation and development within Malawi.

All technology areas identified are of high importance for national development. However, it was necessary to further prioritise these to enable a detailed assessment of selected technologies. Further analysis and review by a Technology Expert Group led to the prioritisation of the following four technology areas:

1. Domestication and securing of farming inputs;
   - This has particular impact on food security, but also links to commercialisation
2. Digitalisation of farm operations and precision agriculture;
   - This has particular impact for commercial agricultural enterprises but in future could extend more extensively to small-scale farmers
3. Technology Support for Artisanal and Small-Scale Mining (ASM)
   - This would enable the transition of ASM from the informal to the formal economy through enhanced quality standards and productivity
4. Domesticating Big Data Management Capabilities for Agriculture and Mining
   - This area emerged as a composite of sub-elements from the ICT sector, in which management of domestic data was highlighted, and the Agriculture and Mining sectors, in which data gathering and dissemination were highlighted. It has implications for both service delivery and policy determination.

It should be noted that, although the Energy sector was not individually prioritised, energy access, and in particular the expansion of off-grid solar energy, permeates areas (i) and (iii), and the consistent delivery of energy is a prerequisite for areas (ii) and (iv).

The sections below provide an overview of the main technology needs for each of the four sectors, the prioritised sub-sectoral technologies and related factsheets, and the actions proposed for implementation and domestication. The factsheets cover the main features and objectives of the technology, such as: its technical operation and broader impact when put to use; the capacity status and needs of the technology, including reference to the institutional capacities available and where additional capacity building is required; the benefits and beneficiaries of the technology, including reference to the current status of the technology's deployment, its link to national policy, and the prospects for its sustainability and how its success may be measured; and finally, an evaluation of the technology, its benefits, potential disadvantages and how it may be financed.

The purpose of the factsheet is to create a succinct document that synthesises essential information for each priority technology. It communicates the key points and issues associated with the technologies for both technical and non-technical review, to help guide policies and

potential programme development.

Implementation frameworks are outlined for each of the main technology areas highlighted in the previous chapter. They are designed to facilitate the uptake and implementation of the technologies identified for: (i) the domestication and securing of farming inputs; (ii) the digitalisation of farm operations and precision agriculture; (iii) support for artisanal and small-scale mining; and (iv) domesticating big data management capabilities for agriculture and mining. The implementation frameworks seek to provide measures to address the barriers/challenges identified and identify capacity needs. Enabling factors are presented, linked to ongoing policy implementation and account taken of the potential for developing the technologies locally versus international procurement. Technology transfer needs, those responsible for implementation, and the external support required for the successful implementation of the technologies are identified, along with the risk factors and how they may be addressed and mitigated.

Within each section the technologies are linked and connected to an overarching objective and they need to be viewed holistically in that light, rather than as isolated technologies. Special attention is paid to the potential for domestication of the technologies so they become sustainable and integrated within the Malawian economy. This is assisted by the fact that, in all cases, the groupings of technologies mirror policies and initiatives that are already underway by the Government. In many cases, they are already being addressed by the private sector, civil society and academia.

Although an attempt has been made to give an indication of the scale of costs required for the introduction of these technologies, a detailed financial and business case analysis is beyond the scope of this assessment. More detailed technical and financial analysis will therefore be required before proceeding with specific projects or business ventures linked to the introduction of these technologies. However, some indication is provided of potential sources of finance for technology development and implementation. Moving forward, it is important that the quadruple helix approach to innovation is taken into account, namely through the engagement of government, the private sector, academia and civil society.

4.3 Technology Needs for Agriculture

4.3.1 Recent evolution of Agriculture in Malawi

Malawi faces cyclical food insecurity due to climate shocks,[150] reinforced by chronic poverty and low agricultural productivity. In February 2024, a long dry spell induced by El Niño affected 44 % of the maize crop and left 5.7 million people acutely food insecure. This was preceded by two tropical storms in 2022 and 2023 that devastated large areas of agricultural production in the country. UNICEF reported stunting levels in young children at 35.5% in 2020.[151]

Crop production provides the major component of the agriculture sector in Malawi. Maize is the dominant cereal crop with an average production between 2019-2023 of 3.8 million tonnes, compared to 140,000 tonnes for rice, 126,000 tonnes for sorghum and 44,000 tonnes for all other cereals. Among horticultural crops, the tuber crops of sweet potato (7.6 million tonnes) and Cassava (6.2 million tonnes) predominate.[152] Malawi is the largest producer of sweet potatoes in Africa and the second largest in the world after China.[153] Both cassava and sweet potatoes provide options for improved food security to mitigate drought-prone conditions. As outlined in section 2.4.2 (figure 4), tobacco dominates the cash crop export market, accounting for 60% of agricultural exports, followed by tea and sugar, with pulses, groundnuts, and macadamia nuts gaining in importance, along with coffee.

Livestock production has expanded in Malawi, with cattle (2 million), including dairy cattle, goats (13 million), pigs (11.5 million) and chickens (210 million) forming the major components of the

150 https://www.wfp.org/countries/malawi
151 https://www.unicef.org/malawi/reports/child-food-poverty-brief
152 Ministry of Finance and Economic Affairs (2024), Annual Economic Report 2024.
153 Longwe, K. et al (2024). Yield and Farmer preferences of biofortified orange-fleshed sweet potato varieties under drought-prone conditions In Malawi. International Potato Centre, Malawi.

livestock sector. Fisheries comprise both capture fisheries from Malawi's lakes and waterways, and aquaculture. Fish provide over 70% of dietary animal protein for Malawians, and 40% of the total protein supply. In 2023, capture fisheries were responsible for 202,000 metric tonnes, with aquaculture responsible for 9,320 metric tonnes.

Livestock production also plays an important role in rural livelihoods and household nutrition, contributing to the availability of animal-source foods and representing an important complementary component of Malawi's broader food security system.

For many years, the Malawian Agricultural policy has focused on smallholder farming and food security, reinforced by donor-driven support. Smallholder and subsistence farmers form the bedrock of agricultural production in Malawi.[154] The crop commercialisation index, i.e. the percentage value of crops sold compared to crops produced, is only 17.6%.[155] A Farm Inputs Security Programme (FISP) initiated in 2006 was later expanded in 2020 into an Affordable Inputs Programme (AIP) providing subsidised seed, fertiliser and other inputs to eligible smallholder farmers. Although smallholder farming still predominates within Malawi, there has been a significant shift over the past 5 to 10 years to commercial farming and the promotion of locally-produced value-addition products. This has coincided with efforts to mitigate against climate shocks, and to build resilience into the agriculture system.

The emphasis on commercialisation is exemplified by the efforts to promote mega-farms.[156] The mega-farm project arose from the Malawi 2063 Agenda, which specified the need to develop mega-farms for increased agricultural production and commercialisation that can contribute to urbanisation and industrialisation. The mega-farm project aims to establish large-scale production units that will anchor willing smallholder farmers from the surrounding area through an out-grower system premised on contract farming arrangements. In addition to the Government mega-farm project, there has been a natural growth of medium-scale farms, with land tenure moving from smallholder farmers to city-based farms and more graduates moving into farming. This activity has had an impact on smallholder farmers, who are now increasingly looking to move beyond subsistence and to incorporate some cash crops.

A critical issue raised through stakeholder interviews was the need for a balance to be struck between policy and logistic support for smallholder farmers Commercial large-scale farming more easily enables economies of scale, which rely heavily on subsistence farming, and support for commercialised farming. Commercial large-scale farming more easily enables economies of scale, with higher efficiency and yields resulting from an increased ability to invest in mechanisation, smart irrigation, crop rotation and improved soil quality, plus diversified crops allocated to appropriately suited soils. There is, however, a strong interface within the Malawian agricultural system between commercial enterprises and smallholder farmers. Commercial enterprises often anchor willing smallholder farmers from the surrounding area through an out-grower system based on the premises of contract farming arrangements. They may also support contracted farmers, by providing agricultural inputs and relevant training and information, to maximise yields.

4.3.2 Anticipated future evolution of agriculture in Malawi

In response to the question of how the Malawian Agriculture sector will develop in the next 5 to 10 years, one respondent stated that "the next frontier for Malawian agriculture is how to commercialise."

The future evolution of the agriculture sector is expected to be a continuation of current trends to expand commercialisation, with an increased number and size of commercial farms and an expansion of plantation agriculture, potentially supported through foreign partnership and investment. Achieving this would require an

154 Malawi IFPRI Key Facts Series: Agricultural Commercialization January 2022.
155 Carletto C, Corral P, Guelfi A. (2017) Agricultural commercialization and nutrition revisited: empirical evidence from three African countries. Food Policy 67:106–18. https://doi.org/10.1016/j.foodpol.2016.09.020
156 MwAPATA Institute working paper Np. 22/01 (2022). The Potential for Mega-Farms to Transform Malawian Agriculture.

emphasis on productivity through improved soil health, access to high-quality agricultural inputs, such as seed and fertiliser, improved irrigation, and mechanisation. This would likely lead to agriculture-associated value addition industries, for example, through simple packaging and processing technologies, and this could support import substitution and enhanced exports. Value addition and enhanced agricultural productivity and mechanisation would require the development of home-grown manufacturing capacity, improved access to energy and internet, and improved transport and logistics infrastructure. At the same time, this would need to be complemented by continued support for smallholder and subsistence farmers, so they can also benefit from an improved commercial environment for agriculture, and food security can be assured. The leading sub-sectors are tobacco, crop farming, livestock production, horticulture, fisheries and aquaculture, irrigation and agro-processing, within a market-driven environment. Livestock, fisheries, and value addition are also critical, but their success is largely dependent on productive crop cultivation.

Strengthening livestock productivity through improved genetics, animal health services and better utilisation of animal feed resources is also recognised as an important pathway for enhancing rural livelihoods and nutritional outcomes. Stakeholders noted several areas where technology needs could be considered to support the livestock sector, particularly technologies that strengthen animal health through rapid disease detection and diagnosis in the field, as well as technologies that improve the utilisation of animal feed resources.

Within the agricultural sector, the TNA process has identified and selected 'increased crop productivity' as a key area for prioritisation, with application to food security and crops with market growth potential. Although other sectors, such as livestock and fisheries, are also important for food security, nutrition and rural livelihoods, increased crop productivity lies at the heart of Malawi's social and commercial needs. A range of crops was mentioned in discussions with stakeholders, but no single crop emerged as a specific priority. Rather, the emphasis, as with the national agriculture policy, was one of broad crop diversification. The remainder of this section focuses on technology requirements for improved crop production.

4.3.3 Productivity challenges

The challenges facing improved crop productivity, in both the commercial and smallholder sectors, are many and varied. Malawi is starting from a low technology base. Desk review combined with interviews highlighted challenges and gaps affecting crop productivity as outlined in Table 32, reinforcing similar aspects identified in the National Agriculture Policy. Overall, the gaps identified reflect a combination of structural technology constraints, particularly related to soil health, inputs, irrigation, mechanisation, post-harvest management and data availability, together with non-technology barriers such as policy and regulatory limitations, access to finance, weak markets, skills gaps and behavioural factors, which together constrain crop productivity across both commercial and smallholder systems.

Technological solutions to address the technical challenges identified in Table 32 were divided into three groups: (i) Domestication and securing of inputs for production, (ii) Digitalisation of farm management and precision agriculture, and (iii) National-level big data management.

(i) Domestication and securing of inputs for production

The technologies listed here are non-digital; they are therefore potentially more readily accessible to farmers and lend themselves more easily to local manufacture. They include the following:

Fertiliser manufacture. Malawi's National Fertiliser Policy[157] promotes the upscaling of production, marketing and the use of inorganic and organic fertilisers, and encourages production using local resources and the development of new fertiliser technologies. This will require appropriate R&D and may include: the expansion of blended fertilisers enabling area-specific fertilisers aligned to soil health; the production of inorganic and organic components of blended

157 https://npc.mw/wp-content/uploads/2023/10/2021.03-National-Fertiliser-Policy-signed.pdf

Table 32. Gaps in the Agriculture Sector Limiting Crop Productivity

Technology-Related	Non-Technology Related
Poor soil health 1. 40% of Malawi's soil in bad health 2. Loss of topsoil 1. High salinity and acidification 2. Lack of organic matter 3. Limited application of digital and data management technologies for monitoring	Mindset 1. Lack of awareness of what is possible 2. Negative attitudes to change and technology 3. Require promotion and demonstration of technologies
Limited access to quality seed 1. Poor research facilities for seed development 2. Limited biotechnology application 3. Inadequate funding to develop and test seeds 4. Lack modern breeding facilities 5. Shortage of seed breeders and technicians 6. Heavily reliant on private sector	Policy and Regulation 1. Policies may be overly prescriptive rather than emphasising principles 2. Policies and regulations may be outdated and no longer apply to new technologies 3. Policies and regulations linked to tax and licensing may increase risk to investment.
Lack of irrigation 1. Only one third of Malawi's irrigation potential of 408,000 ha has been developed 2. Irrigation mitigates against climate shocks	Access to Finance 1. Limited access to credit 2. High interest rate (policy rate =26%) 3. Limited access to Foreign Exchange 4. Weak macroeconomic environment
Limited access to fertiliser 1. Malawi currently has only two substantive companies blending fertiliser and supplying only 12% of national consumption 2. No production of inorganic fertiliser, though some companies are investing in plant 3. No commercial production of organic fertiliser, though one company is investing in plant	Market Access 1. Weak value chains 2. Limited access to inputs 3. Lack of structured markets
Limited access to machinery and equipment 1. Much of Malawi's land preparation is achieved with the handheld hoe 2. Percentage distribution of agriculture mechanisation among lowest in Africa at less than 10% 3. Limited domestic manufacturing and maintenance capacity	Human Capital and Training 1. Require improved workforce planning 2. Low secondary (17%) and tertiary (3%) enrolment 3. Limited practical experience due to poor lab infrastructure 4. Require appropriate curricula
Post-harvest loss and Security 1. ≥20% maize loss post-harvest 2. This includes significant loss of harvest due to theft as reported by several respondents	
Limited access to data and information 1. Limited national data on agricultural status of land, irrigation, electricity, internet access 2. Limited market data	

fertilisers; granulation; controlled release formulations; nano-fertilisers; biofertilisers; and microbial inoculants. It is noted that some companies have indicated plans to start commercial production of inorganic and organic fertiliser in 2026.

Seed development and access. The national agriculture policy promotes the use of indigenous seeds (e.g. through community seed banks), seeds obtained through breeding, and biotechnological seeds to improve resilience to climate and weather-related risks. Improved R&D capacity is required in order to undertake and ensure the quality-assured certification of improved seeds across a variety of crops. This can be realised through traditional plant breeding to generate high-yielding resilient crops, and utilising indigenous seeds to expand the genetic diversity of crops. Where appropriate, this can be further facilitated through biotechnology approaches, such as genetic modification and tissue culture propagation. Improved seed multiplication with increased seed production and access may require an expansion of the current 25 private sector seed companies operating in Malawi.

Irrigation. A range of irrigation technologies require promotion, depending on whether their application is for smallholder farmers, small farmer collectives, medium-sized farms, or mega-farms and estate farming. Supplementary

irrigation can be made available through boreholes combined with gravity-fed schemes and the use of treadle pumps when rainfall fails. Solar-powered irrigation is an option for smallholder farmers, collectives and commercial farms. These can be combined with sprinkler systems. However, drip irrigation providing water direct to plant roots is becoming increasingly popular and is ideal for perennial plants and horticulture. Drip irrigation can be used with increasing levels of sophistication, for example, sub-surface drip irrigation, automated systems controlled by soil moisture sensors (see next section), and fertigation systems mixing fertiliser with water for irrigation. These approaches can be aligned with water harvesting and water monitoring technologies to maximise sustainability.

Mechanisation. There is need for greater use of tractors plus accessories for large farms, and walking tractors (diesel, electric, solar-powered) for small and medium-size farms for land preparation, planting and transport. This should be accompanied by increased machinery maintenance and associated capabilities, including local manufacturing and assembling capability, at least for the walking tractors. Greenhouse assembly and manufacture is also feasible, and local manufacture can also be scaled up for support machinery such as handheld and motorised sprayers, and post-harvest processing machinery such as shellers, thresher, cleaners, dehullers, solar driers, mills, and hermetic storage bags. Drone manufacture could also be incentivised for monitoring purposes, along with irrigation equipment manufacture.

Warehousing. Warehousing, along with granaries and silos, is an important element to limit post-harvest loss, complementing the use of post-harvest machinery such as the aforementioned solar driers and hermetic bags. For horticulture products, off-grid solar-powered cold storage facilities, including community storage facilities, could also be important.

(ii) Digitalisation of farm management and precision agriculture

These digital technologies require more sophisticated use, but can massively increase productivity and yields through precision agriculture. They include the following:

Soil sensor analysis. A major objective of the National Agriculture Policy is the promotion of integrated soil fertility management, strategically combining organic matter and inorganic fertiliser to provide farm-specific/field-specific solutions. The success of this approach requires soil monitoring and appropriate seed selection. Internet of Things (IoT) soil sensors can largely replace traditional lab-based analyses through the real-time monitoring of moisture content, nutrient levels (e.g. NPK), pH and broader chemical analysis, enabling AI-powered rapid decision-making and automation.

Domesticated Automated Drip Irrigation/ Fertigation. Some of the IoT soil sensor systems most readily lending themselves to automation are moisture and nutrient content. Moisture measurement enables automated drip irrigation, and this can be extended to combine with calibrated liquid fertiliser content for automated fertigation. Moisture sensing and automated drip irrigation may be among the most readily adopted and adapted technologies, and there is a young entrepreneur currently working to develop a Malawian automated drip irrigation system.

Drones. Drones can be used for remote sensing when fitted with the appropriate sensors. For example, photographic, spectral and thermal sensors can detect water stress, nutrient deficiency, and early pest infection and disease, enabling appropriate action to be taken on the ground. Drones can also be used for precision spraying of fertiliser and pesticides, and AI can facilitate autonomous drone action. There are examples of micro drones undertaking automated greenhouse pollination, replacing insects. Malawi has drone manufacturing capabilities that could be scaled up and applied to agriculture.

Software development/Mobile apps. There are multiple software and app developments for use in farming. Software is required to receive and interpret data from the sensors mentioned earlier and also to support big data management (see next section). There is also software to facilitate farm administration and management. An area of increasing importance and application in Malawi are apps that can provide information to farmers on issues ranging from weather forecasts to market pricing and other

community-based information.

Logistics (IoT sensors and Blockchain). IoT sensors can enable real-time remote monitoring of temperature and humidity as well as the remote management of warehoused stock, especially when combined with AI-supported predictive analysis. This technology also enables enhanced supply chain visibility for the location and quality of goods, and can be linked to blockchain technology to ensure the security of commercial deliveries.[158] Surveillance technologies can be used to minimise product theft from both the field and storage locations. Blockchain technology can also be used to streamline contract agreements and payments due to its effectiveness as a secure audit trail of actions.

(iii) National-level big data

As well as the IT tools mentioned in the previous sections, there is also potential to access big data to inform national-level strategic decision-making. This may include satellite and other earth observation data for the monitoring of soil health, food security, weather predictions, and water and mineral deposits. It may incorporate IoT and locally-acquired data to maximise on-the-ground decision-making. It may incorporate agricultural production data, mobile network operator data, as well as social, market and finance data. Armed with this data, advice can be made readily available to Government officers, farmers and others to assist with their decision-making. This is currently being addressed through the development of a National Agriculture Management Information System.

4.3.4 Priority technologies and implementation

Technologies for Domestication and Securing of Farm Inputs

Access to farm inputs is a crucial determinant of yield and associated productivity. Although often discussed in isolation, the traditionally considered inputs of seed and fertiliser need to be integrated holistically with other technologies to ensure sustainable yields and long-term food security. An integrated approach to agricultural productivity expands the traditional definition of farm inputs beyond seeds and fertilisers to include supporting infrastructure and technology. This framework considers irrigation, mechanisation, and post-harvest storage as critical inputs that work together, leveraging off-grid solar energy to power them and build a more resilient food system. Within this context, irrigation is seen as a key input along with appropriate levels of mechanisation. Given that up to 20% of Malawi's staple crop, maize, is subject to post-harvest loss[159], this means that warehousing and storage, along with mechanised processing, are crucial elements for delivering increased productivity. The technologies listed, with the exception of biotechnology approaches to seed development and expansion, are low-level intermediate technologies that further lend themselves to domestication. Many of these elements are energy dependent, with a notable option of increased availability through access to solar energy. Off-grid solar energy has therefore been integrated into this technology area. If effectively implemented, this priority area can lead to enhanced national self-reliance, increased productivity, and reduced dependence on imported technologies and equipment.

Domestication and securing of farming inputs

Securing and applying the essential inputs for agricultural crop production, combined with mechanisation and the reduction of post-harvest loss, dominate the food security debate in Malawi. There is a desire by smallholder farmers to increase their productivity and move to commercialisation, which may be further supported through commercial out-grower systems. The National Agriculture Policy and related frameworks like the National Agriculture Investment Plan, the National Irrigation Policy, the National Seed Policy and the Agricultural Commercialisation Project (AGCOM) support input subsidies, domestic fertiliser manufacture, seed sector development, the importation and local manufacture of machinery, private sector

158 It is worth noting that the establishment of IoT enabled storage monitoring of national facilities is included within the National Digital Economy Strategy.
159 DVV International: Article - When post-harvest losses disrupt food security efforts

investment and community action on irrigation, and the development of post-harvest facilities. There are some significant developments in inorganic and organic fertiliser manufacture, expanded irrigation, and warehouse construction. However, seed sector capacity is low, particularly with respect to the application of biotechnology, and there is limited local manufacture to support mechanisation, which is indicative of low national levels of industrialisation. There is a need to integrate off-grid solar energy with community and individual entrepreneurial farmers to support their entry into commercialised farming, including through the refrigerated storage of susceptible cash crops. This energy infrastructure will help to develop local markets at community level that can feed into a larger national market and ultimately the international market.

Digitalisation of farm operations and precision agriculture

Digital tools offer increased control of farm operations and data management, enabling improved monitoring of, and responsiveness to, the farm environment, including anticipated weather events. Digital tools enable localised responsiveness within a farm or field, or even at the level of individual plants, and responsiveness to changed soil health conditions or pests. It allows for increased control and labour-saving automation of activities and enables improved decision-making. Digital tools also facilitate farm administration and management. They can assist in enhanced logistics associated with food storage, value addition and transport of goods, and can provide up-to-date market data and facilitate information-sharing and business contracting. This fact sheet covers soil analysis through soil sensors, domesticated automated drip irrigation and fertigation, the use of drones to provide information and monitoring of large areas, software development and mobile apps to facilitate farm management and information flow, and finally blockchain technology, which can be used in conjunction with IoT sensors to facilitate the logistics associated with crop storage, processing and commercialisation. As with the technologies outlined in Factsheet 1, the value of these technologies will ultimately reside in a holistic, integrated approach. There are calls for better coordination of digital agriculture activities.

Table 33. Technologies associated with domestication and securing of farm inputs in Malawi

Issue	Fertiliser manufacture	Seed development and access / Biotechnology	Irrigation
What is undertaken	• Local manufacture and blending of inorganic fertiliser and organic fertiliser of defined quality to increase availability, variety and affordability for Malawian farmers	• Classical breeding, seed multiplication and targeted biotechnology (genetic modification, tissue culture micropropagation) to expand availability of certified, resilient seed	• Farmercentric irrigation packages: solarpump kits, lowcost drip systems to supplement rainfed agriculture and enable multiple harvests
Features	• Local manufacturing and blending plants for inorganic fertiliser; • Potential mixes combining inorganic and organic inputs; • Quality Assurance testing labs and defined formulations	• Local development and expansion of seed through classical means, • Biotechnology approaches (genetic modification and tissue culture)	• Solar-pump powered irrigation can complement large-scale gravity fed irrigation • It can also support low-cost drip systems and digital irrigation (see next fact sheet on digital irrigation)
Objectives	• Increased availability and variety of quality fertiliser • Support cropspecific and soilspecific applications • Lower costs to farmers	• Development and scaled up use of quality assured seed relevant to Malawi. • Biotechnology approaches can speed up both the development and the expansion (micropropagation) of seed.	• Supplementing rain-fed agriculture and enabling multiple harvests per year through a farmer-centric approach.
Capacity Status	• Two companies currently blend inorganic fertilisers; • Several firms and are planning 2026 manufacture of both inorganic and organic fertiliser; • Several Projects are exploring the development of inorganic and organic (compost) fertilisers LUANAR engaged in related research	• Several companies engage in limited plant breeding. • Agricultural research stations and LUANAR involved in plant breeding, but there are limited systematic approaches to scale up seed availability. • LUANAR has biotechnology expertise, but requires scaling up.	• Agricultural engineering capacity exists • Numerous companies and NGOs have capacity to design, and assemble solar powered irrigation systems • There is no capacity yet for solar panel assembly and pump manufacture.
Institutions (in addition to responsible Government ministries)	• Several Private companies engaged in blending and others planning large scale manufacture • IFAD supporting development of Mbeya fertiliser (combining inorganic and organic fertiliser); • LUANAR for training and research;	• Several companies engage in seed breeding and at least one is engaged in tissue culture. • ARET develops tobacco varieties. • LUANAR for training and research	• Companies offer turnkey solar pump solutions and others assemble and install systems. • Several universities have energy and irrigation expertise.
Capacity gaps and requirements	• Limited local commercial manufacture of inorganic and organic fertiliser • Underdeveloped Inorganic-organic integration • Limited investment in manufacturing and blending infrastructure	• Limited scaled up testing and expansion of indigenous and new seed varieties. • Limited engagement on biotechnology approaches	• No local solar panel assembly and pump manufacture • Limited capacity for maintenance • Limited financial models to facilitate solar powered irrigation
Needs addressed by technology	• Improved quantity, quality and variety of fertiliser options (inorganic, organic and blended mixes)	• Increased quantity, quality and variety of seed to meet Malawian crop-specific and situation-specific needs	• Increased yield of variety of crops, including possibility of multiple harvests; • Increased opportunity for commercialisation
Status of deployment	• Currently no local manufactured inorganic fertiliser • Two companies provide blended inorganic fertiliser • Limited commercial organic fertiliser • Current application rates (around 33 kg/hectare) fall far short of the recommended 200 kg/hectare, contributing to low productivity and soil degradation.	• Extremely limited commercial seed development • Limited government coordination • Only one case of commercial biotech • Limited academic biotech	• Only 149,000 ha of 408,000 ha irrigation potential developed. • Solar irrigation experiencing rapid expansion. • NPC study estimates that with appropriate support up to 188,000 ha smallholder land and 44,000 ha estate land could be under future solar irrigation.

Issue	Fertiliser manufacture	Seed development and access / Biotechnology	Irrigation
National policy anchors	• National Fertiliser Policy (2021)	• National Seed Policy (2018)	• National Irrigation Policy (2024) • Irrigation Master Plan and Investment Framework (IMPIF) 2015–2035
Sustainability and success indicators	• Local production capacity (number of manufacturing plants operational. • Share of locally produced fertiliser in national supply (%). • Adoption rates: kg/ha applied (movement toward recommended rates). • Quality compliance: proportion of products meeting national standards	• Number of certified varieties released and multiplied locally. • Seed replacement rate and availability in rural markets. • Uptake of improved varieties by smallholders. • Biosafety compliance and functioning seed certification systems	• Hectares under functional irrigation (by technology). • Number of solarpump installations with maintenance plans. • Crop intensity (harvests/year) and yield increases. • Financial viability: farmer incomes and payback periods
Beneficiaries	• Smallholder farmers • Commercial farms / estates • Population for food security	• Smallholder farmers • Commercial farms / estates • Population for food security	• Smallholder farmers • Commercial farms / estates • Population for food security
Gender dimension	• Women benefit from lower costs and targeted blends e.g. when women led coops are engaged	• Women benefit when seed distribution, credit and training are gendertargeted;	• Women gain from production, reduced seasonality and income opportunities when access is equitable
Main benefits to Malawian development	• Improved agricultural productivity • Improved food security • Improved farmer incomes and opportunities for commercialisation • improved balance of payments	• Improved agricultural productivity • Improved crop diversification • Improved farmer incomes and opportunities for commercialisation • Improved balance of payments	• Improved agricultural productivity • Improved food security • Improved farmer incomes and opportunities for commercialisation
Disadvantages	• Need regulation to ensure quality • Environmental damage if misused • Potential capital constraints • Potential market displacement of organic fertiliser if systems are not integrated	• Regulatory, biosafety and public acceptance challenges; • Risk of dependency on proprietary seed if not balanced with local varieties; • Need for coldchain or tissue culture facilities for some technologies	• High upfront costs; • Maintenance and spareparts supply chain gaps; • Risk of groundwater overabstraction without management; • Need for farmer organization for water management
Costs	Capital expenditure for plants and quality labs Plant US$0.5–2.0M; QA lab US$0.2–0.6M; Working capital for raw materials;	Private and public investment in breeding stations, tissue culture labs, seed multiplication and certification; Tissueculture lab US$0.3–1.0M;	Capital for pumps, panels, piping and drip kits; Smallholder package US$800–3,500/ha Annual operations, maintenance, battery replacement costs US$50-100/ha;
Finance Mechanisms	Concessional loans, Blended finance, PPPs, Donor grants Inputcredit schemes	Government research budgets, Donor grants, Private sector investment, Revolving seed funds.	Microcredit, Payasyougo solar models, Irrigation cooperatives Blended finance

Issue	Mechanisation	Community Warehousing	Off-grid solar
What is undertaken	• Local manufacture and provision of intermediate machinery and hireservices to improve productivity	• Community and cooperative warehouses with potential for Warehouse Receipt Systems (WRS) and solarpowered refrigeration to reduce postharvest loss and improve market access	• Offgrid solar systems powering irrigation pumps, cold storage, mechanised equipment and local processing enabling the electrification of agricultural value chains
Features	• Manufacturing of intermediate machinery required for planting and post-harvest processing e.g. hand-held tractors; tillers, shellers, thresher, cleaners, dehullers, solar driers, milling and hermetic bags; greenhouses • Potential for solar-battery powered operation	• Community warehousing enables smallholder farmers to store their produce • It can be connected to solar energy to enable refrigerated storage • Warehouse receipt systems	• Off-grid solar can support solar irrigation pumps; cold storage; and mechanised equipment for planting and processing
Objectives	• Improved productivity and enhanced commercialisation in the agricultural sector • Reduce labour intensiveness	• Reduced post-harvest loss and improved marketing of produce. • Refrigeration assists short term storage of fruit, vegetables, dairy. • Warehouse Receipt Systems enable access to collateral financing.	• Enhanced use of technologies referred to above and enhanced agricultural productivity • Spin-offs for communities include: improved health facilities; improved study time for children; improved climate resilience
Capacity Status	• Extremely limited local manufacture; with much in the informal sector. • Mechanisation at 13% of potential • Import-oriented market • Limited emphasis on innovation and scale-up of TEVET and related engineering expertise • Some capacity for solar / battery electrification of small vehicles and equipment	• Capacity for warehouse construction exists • Capacity for solar energy-based refrigeration exists • Capacity for commodity exchange and warehouse receipting exists • What is missing is implementation	• Capacities for establishing off-grid solar exists • Off-grid energy a core component of energy policy and several programmes are in place • No capacity for local assembly of solar panels or batteries • Up-front costs of investment are a limiting factor
Institutions (in addition to responsible Government ministries)	• MUBAS and MUST for engineering and prototyping • TEVETA for technical skills for small-scale manufacture • Transferrable skills exist through SGV Electric Mobility, which electrify motor bikes, and St John Paul II College that train e-bike technicians,	• ADMARC and NFRA are main providers of space. • There are emerging private sector / cooperative models. • Agricultural Commodity Exchange and AHL Commodities Exchange (AHCX) engage in Warehouse receipting	• Ngwee Ngwee Ngwee Fund and ASCENT project (both World Bank supported) plus other programmes • Private companies e.g. Yellow; Zuwa Energy; Solar Aid for installation • MUBAS, MZUNI, TEVETA for training & research
Capacity gaps and requirements	• Limited access to farm machinery • Narrow technical manufacturing base • Few, if any, dedicated factories • Few service / training centres • Narrow financial base	• Need to scale-up existing capacities • Need innovative financing models e.g. (i) PPP; (ii) incentivise large companies to make warehouse space available (e.g. Rab; CP Feeds)	• No local solar panel assembly / manufacture • Limited Quality assurance / regulation of imported products • Limited technical capacity for maintenance
Needs addressed by technology	• Improved yields • Reduced post-harvest loss • Improved productivity • Increased opportunity for commercialisation	• Reduced post-harvest loss • Increased opportunity for commercialisation	• Energy access for irrigation, cold storage, mechanised equipment; community services; • Increased productivity and value addition
Status of deployment	• Mechanisation estimated at 13% of potential • Government has incorporated local manufacturing into its 'Mechanisation 360' campaign to mechanise 500,000 hectares of smallholder land by 2027. • However, Low levels of local manufacture yet achieved • Mega Farms project also likely to stimulate local production.	• Government actively constructing community warehouses through the Transforming Agriculture through Diversification and Entrepreneurship (TRADE) Programme • Construction also under way as part of disaster preparedness	• Installed off-grid PV capacity grew from 10.4MW (2016) to over 100MW (2023). • MEAP project surpassed its target of 200,000 off-grid connections by late 2024. • The ASCENT project aims to reach 800,000 households, supporting a 70% national access goal by 2030. • Around 30 community energy systems, mostly solar PV, have been implemented

Issue	Mechanisation	Community Warehousing	Off-grid solar
National policy anchors	• Mechanisation 360 initiative and national industrialisation objectives	• Warehouse Receipts Act (2018) • TRADE Programme and national market development strategies	• National Energy Policy (2018) • Malawi Renewable Energy Strategy (2017-30) • National Electrification Strategy (2019)
Sustainability and success indicators	• Area serviced by mechanisation (% of target hectares). • Number of local manufacturing / service centres established. • Availability of hireservices and trained technicians. • Reduction in labour bottlenecks and time to land preparation / harvest.	• Number of operational community warehouses with Warehouse Receipt Systems. • Volume of produce stored and percentage sold through formal markets. • Reduction in postharvest losses and increased farmer incomes. • Use of refrigerated capacity where installed	• Number of systems installed for irrigation, cold chain and processing. • System uptime and maintenance coverage. • Household and farm income increases attributable to electrification. • Local capacity for installation and repair • Local capacity for solar panel and battery assembly
Beneficiaries	• Smallholder farmers • Commercial farms / estates • Population for food security	• Smallholder farmers • Population for food security	• Smallholder farmers • Population for food security
(Gender dimension)	• Hireservice models and targeted training can increase women's access to services and technical roles	• Women benefit when governance and access are explicitly inclusive	• Women gain time savings and income opportunities
Main benefits to Malawian development	• Improved agricultural productivity • Improved food security • Improved farmer incomes and opportunities for commercialisation • Improved levels of industrialisation	• Improved agricultural productivity • Improved food security • Improved farmer incomes and opportunities for commercialisation	• Electrified irrigation, cold chain, and value addition; • Improved food security; • improved farm incomes • Improved community services (health, education)
Disadvantages	• Risk of job displacement if not paired with new service opportunities; • High capital costs; • Maintenance and spareparts shortages; • Uneven access favouring betteroff farmers	• Requires strong governance to avoid elite capture; • Operating costs for refrigeration and security; • Need for reliable commodity exchange linkages	• Dependence on imported panels/ batteries if local assembly absent; • Quality and safety concerns for lowcost imports; • Battery disposal and lifecycle issues
Costs	• Investment in local fabrication, tooling, training centres and aftersales networks; • Small fabrication workshop US$50–200k; medium factory US$0.5–2M;	• Construction and equipment costs; refrigeration energy (solar hybrid) • Basic warehouse US$30–120k; refrigerated addon US$20–80k	• System Capital Expenditure (panels, batteries, inverters), installation and operations and maintenance; • Cost dependent on size of venture from several thousand to tens or hundreds of thousand dollars • Solar panels ($3.5k - $35k), inverters ($3k - $13k), and battery banks ($2k - $16k+) are major expenses.
Finance Mechanisms	• Concessional loans, • Equipment leasing and hireservice business models, • Publicprivate partnerships	• Capital Expenditure / Operational Expenditure financing via government programmes, • Donor grants, • PPPs, • Warehouse receiptlinked credit	• Financing via payasyougo, • Microfinance, • Grants, • Resultsbased subsidies; • Opportunities for private sector service models

Short-term measures for implementation	• Investment in the local development and manufacture of equipment to support input technologies, including appropriate R&D for seed production and prototyping of larger mechanised equipment. • This might include efforts to support factory development for basic farm equipment manufacture and solar panel and battery production • Continued training of smallholder farmers in the improved use of inputs and in the care and maintenance of equipment • Continued financial and technical support for commercial farming and primary processing
Challenges and Risks	• High costs of procuring inputs and equipment by farmers • Loss of harvest output, and loss of corresponding investment, due to adverse weather conditions e.g. flooding • Inadequate skill sets for application of inputs • High costs for private sector investment in local manufacture, • Inadequate skill sets for scaled up manufacture
Mitigation measures	• Grants, subsidies and loan systems maintained and extended for smallholder farmers • Insurance schemes to cover for harvest loss • Create more structured markets to facilitate smallholder farmer access • Promotion of sustainable commercial market systems e.g. warehouse receipt schemes, pay as you go access to services and equipment, (including solar), equipment rental • Tailored training programmes, extension services and demonstration projects • Grants, subsidies and loan schemes for major private sector investments in commercial manufacture
Opportunities for local technology development and manufacture	• Several companies are investing into the input technologies for manufacture and service provision • Universities (notably LUANAR, MUBAS and MUST) have skill sets to support R&D and prototype development • Several ongoing projects e.g. Zantchito are promoting vocational and associated entrepreneurship training • The challenge with many of the opportunities and projects is to move to scale
Responsibility	• Ministries of Agriculture; Irrigation and Water Development; Energy and Mining; Industrialisation Business Trade and Tourism; Labour and Innovation; and Education Science and Technology all have a role. • Financial Institutions supporting private sector and PPP investment • Private sector advocacy e.g. through Malawi Confederation of Chambers of Commerce and Industry (MCCCI) • Commercial and smallholder farmers • Development partners who have committed to provide support • NCST, Academia, TEVETA and civil society for training and research
M&E indicators	• Increased yields across different crops, • Increased food security • Increased market size across different crops • Increased exports
Potential sources of finance	• Public sector–led financing e.g. NEEF, MAIIC, EDF • Public sector–led investment incentives • Private Sector and Commercial Lending and equity investment • Public Private Partnerships and joint ventures with risk mitigation • Development partners • Specialised Grant and Innovation Calls

Long-term measures for implementation	• Assessment of sectoral policies and projects to ensure an integrated approach across Government • Procedures to assess intersectoral progress with the private sector, academia and civil society
Challenges and Risks	• Substantive climate and weather changes • Insufficient private sector investment to achieve sustainability • Withdrawal / non-renewal of development partner resources • Lack of sustainable public sector investment • Lack of sustained R&D for innovation • Insufficient training of farmers to realise technological benefits
Mitigation measures	• Regular coordinated assessments by Government with private sector, academia and civil society so that mitigation plans can be put in place
Opportunities for local technology development and manufacture	• Growth of farm sizes leading to economies of scale • Growth of manufacturing companies leading to economies of scale • Market size and returns on investment leading to increased R&D and the development of more sophisticated technologies
Responsibility	• Government (OPC), Private Sector (MCCCI), NCST, Academia and research institutions
M&E indicator	• Percentage and scale of combined Government and private sector investment compared to donor-based funding and financing • Percentage of private sector financing compared to public-sector financing • Manufacturing Value Added in the agriculture sector as a proportion of its contribution to GDP

Table 34. Technologies associated with digitalization of farm operations and precision agriculture

Issue	Analysis / soil sensors	Domesticated Automated Drip irrigation / fertigation	Drones	Software development / Mobile Apps	Logistics (IoT sensors and Block Chain)
What is undertaken	• Soil sensors offer a wide range of analyses that provide essential data for precision agriculture and environmental monitoring	• Local manufacturers and innovators engaged in creating or adapting automated drip irrigation / fertigation technology for the Malawian context	• Drone sensors provide precision data of soil and plant health and can perform tasks such as spraying, planting and pollination, leading to increased efficiencies, improved yields and lower environmental impact	• Software determines the outputs of all digital technologies (e.g. sensors, drones, blockchain, AI) enabling transition to data-driven "smart farming" that enhances yield and sustainability.	• IoT sensors and blockchain technology enables end to end transparency on quality and traceability of goods across the agricultural supply chain reducing post-harvest loss and facilitating product commercialisation
Features and Objectives of Technology					
Features	• Automated IoT sensors measure moisture, nutrients (N,P,K), pH, electrical conductivity / salinity, and temperature. • The data is sent in real time to farmers, often combined with software apps to support analysis and decision making, • The responses can also be automated through Artificial Intelligence	• Creating solutions for automated drip irrigation / fertigation through the original design of systems and equipment, • Custom fabrication • Local R&D • Component manufacturing.	• Cameras allow 3-D field mapping to analyse terrain and drainage • Multi- and Hyper-spectral and thermal sensors detect water stress, nutrient deficiency, early pest infection and disease • Precision spraying of fertiliser and pesticides • Precision pneumatic seed planting • Pollination, including micro-drones for greenhouse pollination • AI-enabled drone autonomous activity	• Farm management platforms to track operations, labour and finance • Apps connecting. sensors to enable precision farming and IoT integration • Supply Chain management and marketplace apps to connect with buyers and suppliers. • Software to facilitate decisions on loans and insurance decisions • AI facilitated autonomous decisions	• Sensors monitor storage and transport conditions (e.g. temperature). Trackers e.g. GPS and chain of custody stamps relay status of transport. • Blockchain provides a secure, ledger based on the data supplied by sensors, securing commercial and consumer confidence. • Blockchain also enables ease of contracting and payments and tokenisation that can be utilised as liquidity.
Objectives	• Informed decisions can be made on planting time, optimised precision irrigation, fertiliser application, and acidity of soils. It enables optimisation of greenhouse, as well as open field, environments	• Provide customised solutions for the Malawian context, engaging with smallholder farmers as well as commercial farms	• Improved efficiencies and yields in crop production • Labour savings and time savings • Reduced use of inputs and reduced environmental risk	• Improved farm and commercial management with increased yields and commercial returns. • Information for decision making from farm level to national policy level	• Operational efficiency, cold chain and supply chain integrity. • Traceability and transparency ensuring contractual compliance and fraud prevention. • Reduced loss and increased returns

Issue	Analysis / soil sensors	Domesticated Automated Drip irrigation / fertigation	Drones	Software development / Mobile Apps	Logistics (IoT sensors and Block Chain)
Capacity Status and Needs					
Capacity Status	• There is uptake by commercial farms, primarily for automated irrigation. • Several companies offer IoT sensor services • For smallholder farmers there are pilot irrigation studies, with and without wireless sensor networks. • There is university engagement and expertise.	• A small number of Malawian companies complement established commercial suppliers of global brands and installation of imported systems,	• Malawi a regional leader • MUST African Data and Drone Academy • LUANAR training in Drones for Agriculture • Prototype examples of autonomous drones • Drone corridor testing area established • Licensing of drone operators • Several companies provide drone services • Several companies manufacture drones	• Strong public university expertise • MUST Centre for AI • LUANAR Agribiz hub • Several innovation hubs • Strong policy foundation and development partner support • Multiple apps developed locally • Several Government information platforms • Large number of ICT start-ups	• Technology in its early stages in Malawi but strongly aligns with Government policy • Support through pilot projects e.g. AGCOM • Blockchain theory covered in university programmes • Some professional short courses in Blockchain are offered by external and pan-African organisations
Institutions (in addition to responsible Government ministries)	• Several companies apply the technologies • Several institutions pilot projects and research with smallholder farmers • MUST, MUBAS and LUANAR are engaged in training and research	• Companies to design, supply and install irrigation systems • A young entrepreneur is developing an automated system supported by Zantchito project (EU funded). • M-Hub and Mzuzu e-Hub support local entrepreneurship	• Malawian based drone manufacturing companies • Few Malawian companies also engage in drone educational training • Training and research expertise at MUST (African Data Drone Academy) and LUANAR (agriculture focus)	• LUANAR, UNIMA, MUBAS, MUST, MZUNI for training and research • Government, National Smallholder Farmers Association of Malawi • Private sector and hubs	• AGCOM, • Sunbird Bioenergy, • LUNAR / Mechro exploring sensors for storage • MAC Skills Development Centre (Kenya) • The Knowledge Academy (UK) • Unichrone (India) • UNIMA, • MUST, • MZUNI •
Capacity gaps and requirements	• Limited expertise developed beyond water sensors and irrigation • Training in use and data interpretation required for extension to smallholder farmers	• Limited local design and manufacture of equipment. • Limited expertise in automated systems and in business development	• Affordability and financing issues for R&D and manufacture • Infrastructure constraints e.g. connectivity gaps limit AI integration • Awareness levels are low - a need to promote agricultural applications	• Energy and connectivity constraints • Device costs of smart phones and sensors etc limit utility of apps. • Digital literacy and digital training limited • Many platforms are dependent on donor funds	• Need to enhance application of IoT sensors for storage • Need to significantly enhance training and utilisation of Blockchain technology and its application to agricultural value chains
Benefits and Beneficiaries					
Needs addressed by technology	• Ability to better manage soil health and crop production resulting in increased yields, productivity, income and savings in labour and water.	• Automated irrigation adapted to the Malawian context, including smallholder farmers, with associated benefits of increased yields, productivity, income and savings in labour	• Improved efficiencies and yields in crop production with opportunities for widespread commercialisation, industrialisation and trade impact	• Move to data driven farming decisions and advisory services • Supports move to “smart farming” that enhances yield and sustainability • Supports GDP and balance of payments	• Reduced post-harvest loss • Integrity of commercial value chain • Empowerment of farmers to commercialise • Certification of export products

Issue	Analysis / soil sensors	Domesticated Automated Drip irrigation / fertigation	Drones	Software development / Mobile Apps	Logistics (IoT sensors and Block Chain)
Status of deployment	• There is limited use beyond irrigation as outlined above. • A pilot project is collecting data from 8 sensor types across 80 nodes in Malawi and making data available to farmers.	• Several local companies installing purpose-designed systems • No Malawian manufactured systems yet on the market	• There is estate level adoption for spraying. • LUANAR engaged in drone testing • MUST engaged in automated seed planting • Government utilises drone data for crop yield estimates • Several companies are manufacturing drones, but quantity and variety is limited	• Government led deployment of information systems • Active deployment of AI and precision tools • Several homegrown companies and start-ups • International Water Management Institute Brief 36 states that 35% male farmers and 20% female farmers access digital advisory services	• Limited utilisation of IoT for storage and blockchain • Limited professional training in blockchain • Pilot projects focusing on export crops e.g. soybean, groundnut and macadamia • Ministry exploring blockchain digital ID for farmers linked to credit access
National policy anchors	• Malawi 10-Year Action Plan on Fertilisers and Soil Health (2024-2034)	• National Irrigation Policy 2024 • Irrigation Master Plan and Investment Framework 2015–2035	• Digital Economy Strategy (2021–2026) • National Agriculture Policy 2024–2029	• Digital Economy Strategy (2021–2026) • National Agriculture Management Information System	• Digital Economy Strategy (2021–2026)
Sustainability and success indicators	• High uptake and establishment of local market for soil sensor technology • Increased yields • Increased farmer profitability	• Number of Malawian companies engaged in automated systems design and manufacture • R&D spending on automated systems development	• Number of drone start-ups and growth of existing start-ups to commercial production • Percentage drone components sourced / manufactured in Malawi • Streamlined licensing • number of drone operators • Number of drone hubs	• Transition from donor funding to revenue generation models, or Malawian subsidies • Number of active farmers engaged on Government info apps • Percentage use of locally developed and managed platforms, with local data storage	• Scaled up commercial use of IoT sensors and blockchain for storage and supply chain • Financial inclusion based on credit accessed through 'digital credit histories' • University Training courses on Blockchain
Beneficiaries	• Smallholder farmers • Commercial farms / estates • Population for food security	• Smallholder farmers • Commercial farms / estates • Entrepreneurs • Population for food security	• Commercial estates • Smallholder farmers • Entrepreneurs • Youth employment • Population for food security	• Commercial estates • Smallholder farmers • Entrepreneurs • Youth employment • Population for food security	• Commercial export companies / farms in short term • Smallholder farmers in longer term • National economy
(Gender dimension)	• Women freed from farm labour when systems fully automated • Women benefit if equity-based training and promotion	• Women freed from farm labour when systems fully automated • Women benefit if equity-based training and promotion	• Higher Education parity secures women as high-tech leaders • Labour and health benefits for female smallholders	• Fewer women than men access digital advisory services • Labour and health benefits for female smallholders	• Women benefit if equity-based training and promotion

Issue	Analysis / soil sensors	Domesticated Automated Drip irrigation / fertigation	Drones	Software development / Mobile Apps	Logistics (IoT sensors and Block Chain)
Evaluation					
Main benefits (3) to Malawian development	• Increased productivity. personal and national income • Increased food security • Increased commercialisation and value-added industrialisation	• Increased food security • Increased industrialisation • Improved balance of payments	• Increased food security and yield optimisation • Economic efficiency and resource management • Youth empowerment and skill development • Climate resilience and sustainable land use	• Improved information access and productivity • Food security • Improved economic competitiveness • Youth empowerment and skill development • Early warning systems	• Market competitiveness and export growth • Empowerment of smallholders to direct market access • National macroeconomic impact e.g. GDP growth
Disadvantages	• High initial and maintenance costs • Calibration and accuracy issues when users are untrained • Data quality issues when poor maintenance / non-replacement • Solutions must meet local conditions	• Market situation may limit returns and financial sustainability of local companies • Skills gap may limit commercial growth • Poorly designed systems may have adverse environmental impact	• Potential import dependency and cost if not domesticated • Infrastructure constraints for data transmission and handling • Operational limitations if not securely regulated • Technical skills gap limiting growth	• Potential growth of income inequality between farmers • High tool dependency • Interpretation errors • Debt due to investment outlays • Cybersecurity, data privacy, risks of fraud • Erosion of tacit knowledge	• High upfront costs may not deliver expected returns • Regulatory and cybersecurity risks if not properly governed (this especially true for digitally illiterate) • Growth of digital divide
Costs	• Malawi 10-Year Action Plan allocates an estimated US $163.24 million to soil health R&D. • Sensor costs vary from low range (US$2 to5) to mid-range (US$ 50 to 100). Chameleon sensors are@ US$100 per hectare	• High up-front costs of irrigation (US$ thousands per ha) may limit take-up of technology without Government / development partner subsidy • Capital (loans, equity) required for manufacture Is high and may require supportive finance mechanisms.	• Drone as a service cost may be competitive compared to labour costs for smallholders • High quality drones and sensors cost tens of thousands of dollars • Training costs high • Custom build plants and manufacturing plants may cost up to several million dollars.	• App development costs can cost tens of thousands of US dollars • Operational costs of maintenance, cloud access, staff training and marketing are significant • These costs have to be recovered from farmers with a low-income base	• Integrated systems for large commercial silos cost up to several thousand US$ • Enterprise level blockchain systems can cost 10s and 100s of thousands of US$
Finance Mechanisms	• Implementation requires grants, loans and subsidies for individual farmers • PPP and blended finance for soil sensor manufacture.	• R&D and innovation funds required to stimulate innovation and entrepreneurship	• Financial support required for smallholder access to drone services • De-risking mechanisms need to be instituted to stimulate local manufacture	• There is need in the medium term to move from donor dependence to Malawi-driven financial solutions • Micro-transaction fees on trade and credit facilitation is a potential way forward©	• Finance may be possible from Government (e.g. AGCOM), • Donors (e.g. World Bank, EU) • Loans from Private sector and financial institutions

Implementation of digital solutions for farm operations and precision agriculture

The technologies outlined in this section build on the foundational technologies covered under the section on Domestication and securing of farming inputs, but ultimately seek to address the same issues of food security and commercialisation. Digital technologies in particular can increase farm operational and marketing efficiencies. They lend themselves to commercial large farms and estates and controlled horticulture environments, but also, through public sector management and communications apps, can provide up-to-date farm operational and market guidance to smallholder farmers. In addition to the National Agriculture Policy and related frameworks, such as the National Agriculture Investment Plan, digitalisation is supported by the Digital Economy Strategy to leverage IoT and smart farming technologies in order to modernise farming practices and support farmers with access to high-quality inputs and commercial markets. The National Agricultural Management Information System (NAMIS) digitally aggregates national data that can inform policy and support innovation and investment monitoring. This is complemented by commitments to increase digital geographic coverage and internet access. IoT soil sensor systems and remote sensing by drones are increasingly used to inform farm operations and automated irrigation and fertigation systems. There is still a reliance on imported equipment and systems, although there is now significant drone expertise in Malawi, including some drone manufacturing. There is also activity in developing domestic software and apps, especially to support information apps. Technologies that have received limited attention to date and for which there is limited capacity include the application of IoT sensors for crop storage and the corresponding application of blockchain technology to support logistics, supply chain management and audited contract management.

Short-term measures for implementation	• Continued and increased public support and promotion of private sector investment in digitalisation and the expansion of precision agriculture • Continued and increased support for local SME entrepreneurship, local software development and hardware assembly and manufacture • Continued and increased training of smallholder farmers and rural communities in digital technology • Support for university training, research and innovation in digital and drone technologies applied to agriculture, including a focus to develop and expand expertise in blockchain technology for commercial applications
Challenges and Risks	• High up-front costs of digital tools and maintenance of equipment limiting uptake • Import dependency and Forex availability limiting uptake • Inadequate capacity at farm level to implement the digital technologies • High costs for private sector investment in software development and local manufacture • Lack of adequate postgraduate level capacity for R&D • Variable power and internet limiting effectiveness of technologies
Mitigation measures	• Grants, subsidies and loan systems maintained and extended for smallholder farmers • Promotion of local manufacturing • Tailored training, extension services • Investment incentives and R&D support • Support for postgraduate research programmes • National energy and internet infrastructure investment
Opportunities for local technology development and manufacture	• Capacity exists for local software and platform development • Ther is capacity for some local hardware assembly and manufacture e.g. drones, with opportunities for expansion • Utilisation of innovation hubs and academic R&D • Skilled workforce development through Higher Education and TEVET
Responsibility	• The ministries mentioned in section 6.1 plus the Ministry of Information and Communications Technology. • Financial Institutions supporting private sector and PPP investment • Private sector advocacy e.g. through MCCCI • Commercial and smallholder farmers • Development partners who have committed to provide support • NCST, Academia, TEVETA and civil society for training and research
M&E indicators	• Percentage of agricultural land under digital surveillance or included in digital pilot projects • Number of farming households registered on NAMIS • Yield, and income level differences between digitally connected farmers and others. • Number of postgraduates qualified in GIS, GPS, and drone technology applied to agriculture
Potential sources of finance	• Public sector–led financing e.g. NEEF, MAIIC, EDF • Public sector–led investment incentives • Private Sector and Commercial Lending and equity investment • Public Private Partnerships and joint ventures with risk mitigation • Development partners • Specialised Grant and Innovation Calls
Long-term measures for implementation	• Assessment of sectoral policies and projects to ensure an integrated approach across Government • Procedures to assess intersectoral progress with the private sector, academia and civil society
Challenges and Risks	• Digital divide further marginalises rural smallholders and women • Continued infrastructure gaps • Insufficient public and private sector investment to achieve sustainability • Withdrawal / non-renewal of development partner resources • Lack of sustained R&D for innovation
Mitigation measures	• Regular coordinated assessments by Government with private sector, academia and civil society so that mitigation plans can be put in place
Opportunities for local technology development and manufacture	• Growth of farm sizes leading to economies of scale and increased demand for local equipment and innovation • Growth of companies engaged in digital agriculture innovation leading to competitive market environment for innovation • Market size and returns on investment leading to increased R&D and the development of more sophisticated technologies
Responsibility	• Government (OPC and responsible ministries), Private Sector (MCCCI), NCST, Academia and research institutions
M&E indicator	• Productivity increase and resource savings in areas using soil sensors • Traceability percentage of total volume of agricultural exports • Percentage and scale of combined Government and private sector investment compared to donor-based funding and financing • Percentage of private sector financing compared to public-sector financing

4.4 Technology needs for mining

4.4.1 Recent evolution of mining in Malawi

Malawi has several minerals with economic potential, including uranium, phosphates, bauxite, kaolinite, coal, kyanite, limestones, rare earths, graphite, sulphides, titanium minerals, and vermiculite, plus precious and semi-precious stones and gold.[160,161] Over the past decade, Malawi's mining sector has transitioned from a largely artisanal and small-scale endeavour into a more structured commercial industry. It contributes only around one percent of national GDP, but there are plans to increase this to 10% by 2030, with a possibility of the target being met by 2027. Malawi's Mining Strategic Plan[162] supported by an updated Mines and Minerals Act[163] has led to the establishment of a Malawi Mining and Minerals Regulatory Authority and the Malawi Mining Investment Company, set up to respectively regulate and promote the development of the Mining sector.

Historically, coal and limestone have been the principal minerals mined at scale. However, the presence of other commercially viable deposits has led to a move towards higher-value extraction, and several international mining development agreements with foreign companies are in place or under negotiation.

Malawi has made notable strides in strengthening its geoscientific database and regulatory environment for mining. Through the Geological Mapping and Mineral Assessment Project (GEMMAP), the country has systematically updated its geological information using modern techniques, resulting in improved data that has helped attract investor interest and supported exploration and mineral development projects across several commodities. In parallel, reforms to the legal and institutional framework have strengthened governance and oversight of the sector. The Mines and Minerals Act was revised in both 2019 and 2023, with the latter update enabling the establishment of the Mines and Minerals Regulatory Authority (MMRA), a key institution in improving transparency, licensing efficiency, and overall regulatory predictability in the sector. These combined advances in data availability and governance have created a more enabling environment for investment, formalisation, and sustainable mineral sector growth.

Artisanal and small-scale mining (ASM), which produces aggregates, gold, gemstones, clay, lime, and other mineral commodities, has become an increasingly important source of rural livelihoods and local enterprise development. Across several districts, ASM operations range from small commercial quarries to gold and gemstone extraction sites that support household incomes and local value chains. However, the majority of the sector remains informal and characterised by rudimental mining and processing practices, limited ventilation in underground workings, inadequate protective equipment, and environmental risks such as uncontrolled runoff and land degradation. In response, the Department of Mining (under the Ministry of Energy and Mining) continues to advance formalisation initiatives aimed at strengthening professionalism, safety and sustainability in the sector. These include supporting the formation and registration of mining cooperatives and associations, providing capacity-building in productivity, occupational health and safety, and environmental management, and facilitating access to licenses within the legal framework, including small-scale mining licences for extraction activities and reserved mineral licences for the buying and selling of precious stones and precious metals. These efforts seek to balance livelihood creation and economic opportunity with responsible resource management and environmental stewardship.

4.4.2 Anticipated future evolution of mining in Malawi

It is anticipated that the mining sector will grow in line with policy expectations, both through increased foreign direct investment by mining companies for large-scale projects, and by

160 https://www.trade.gov/country-commercial-guides/malawi-mining-and-minerals
161 https://www.mccci.org/business/mining-sector/
162 https://mininginmalawi.wordpress.com/wp-content/uploads/2023/05/strategic-plan-for-ministry-of-mining-2022-2027.pdf
163 https://www.a-mla.org/en/country/Malawi

scaling up formalised artisanal activities. There is a planned resumption of uranium mining and a renewed interest in cement-grade limestone. In addition, exploration and development prospects are being considered for minerals such as nickel, copper and gold, while a rare earth element operation —notably the Kangankunde Rare Earths Project in Balaka—is expected to be commissioned in the near term. Downstream, there is growing emphasis on value addition, including the local smelting of iron ore, the beneficiation of phosphate for fertiliser, and the processing of graphite for battery applications. A 2025 government directive banning the export of raw and unprocessed minerals further emphasises this approach. By cultivating linkages with the manufacturing, energy and agricultural sectors, Malawi hopes to monetise its mineral wealth more fully rather than exporting raw commodities alone.

This will require the introduction of a range of capital-intensive new technologies for the larger commercial mining sector, driven by foreign direct investment. This may include advanced modelling, surveys and real-time geotechnical monitoring to improve deposit delineation and reduce exploration risk, as well as the establishment of automated processing plants integrated with AI-driven predictive maintenance systems. There is a plan to support this by setting up a dedicated University of Mining, which could build on the mining engineering expertise of MUBAS. The government also plans to put in place improved registration, health and safety, and other regulatory processes and services.

Artisanal and small-scale mining will see greater integration and formalisation. There will be a need for enhanced access to mineral-rights registration via the online cadastral system and regularised licensing. Periodic airborne geophysical surveys will help small-scale miners to more reliably identify viable deposits. Technical assistance programmes are anticipated so as to introduce safer, more efficient extraction methods, and stronger health and safety and environmental safeguards. Channelling micro-financing and training into rural zones could assist artisanal and small-scale mining to become an engine for community-level entrepreneurship and skills development.

Table 35. Gaps limiting Artisanal and Small-Scale Mining (ASM) and Government oversight and regulation of the mining industry

Technology-Related	Non-Technology Related
Artisanal and Small-Scale Mining 1. Extraction and Processing Tools • Reliance on manual sluicing for ASM • Lack of low-emission crushing equipment • Use of mercury for gold extraction 2. Health & Safety Monitoring • No IoT sensors for dust, noise, gas monitoring • Lack of wearable alert systems • Lack of monitoring systems for ground stability, equipment for water quality monitoring and treatment etc. 3. Mineral Processing and Analytics • Delays in assays and turnaround • Limited laboratories for in-country mineral processing and analysis • Limited mobile and community labs for on-site analysis 4. Maintenance & Technical Support • Limited training on equipment upkeep • Limited remote diagnostics • No digital platforms for troubleshooting	Licensing & Tenure Security 1. Fragmented cadastre and claim registration, despite efforts to improve the situation 2. Informal tenure leading to boundary disputes Market Access & Value Chains 1. Absence of structured gold/gemstone buying centres 2. Minimal local value-addition facilities Finance & Investment 1. Scarce microcredit schemes tailored to ASM 2. High collateral requirements inhibit equipment financing Skills & Human Capital 1. Lack of full range of practical professional skill sets (engineers, business, economics, law etc.) 2. Inadequate TEVETA-level technician training 3. No dedicated artisanal curriculum 4. Lack of mining industry negotiation skills
Public Sector Oversight 1. Digital Platforms & Data Management • Lack of e-permitting • Reliance on non-automated, self-reported data for mineral production with limited capacity for independent verification • Limited use of drones for surveying • Limited surveying tools (such as GPS) and technical capacity • No real time dashboard	Policy & Regulation 1. Weak enforcement of rehabilitation and compensation 2. Require an updated Artisanal and Small-Scale Mining policy

4.4.3 Mining sector challenges and the application of technology for Malawi's development

Large-scale mining will be accessing capital intensive and up-to-date technology through foreign direct investment from international mining companies. This Technology Needs Assessment for mining has therefore focused on: (i) the artisanal and small-scale mining sub-sector, and (ii) technologies to support public sector oversight of the industry, including issues of health and safety and the environment. Technology and non-technology gaps in these two sub-sectors are provided in Table 35.

Table 36. Technology Support for Artisanal and Small-Scale Mining

Issue	Mechanised tools and safety equipment for extraction	Tools for Mineral Processing and Value Addition	IoT sensors for real-time local monitoring	Analytics	Digital Government support services	Off-grid solar
What is undertaken	• Simple mechanised tools for mineral extraction are labour saving, increase productivity and minimise safety risks	• Tools for post-extraction mineral processing, concentration and value addition provide income for miners and facilitate certification of products and formalised transactions	• IoT sensors enable monitoring of environmental quality, individual health and tracking devices promoting occupational safety and health and security, including against smuggling	• Analytical tools are critical to determine the quality of minerals to inform mining operations and enable formal certification	• Government information systems are being developed to facilitate information dissemination, licensing, and transaction processing	• Off-grid solar systems can facilitate ASM operations through machinery use, lighting and internet access
Features and Objectives of Technology						
Features	• Pneumatic tools, • Low-vibration hydraulic pumps, • Machinery providing mechanical ventilation for extraction, • Integrated Lighting • Primary Crushing • Personal Protective Equipment	• Milling • Gravity concentrators • Gemstone cutting / polishing machines.	• Air/water quality sensors • Wearable health monitors (Heart rate, temperature). • GPS tracking, geofencing devices • Use of Long-Range Wide Area Networks (LoRWANs)	• Field based portable X-Ray fluorescence • Flue gas analysers • Lab based Atomic Absorption Spectroscopy • Lab based Inductively Coupled Plasma Mass Spectrometry (ICP-MS)	• Cadastral system to administer mineral rights • Online portals / platforms • SMS technologies • Digital payments	• Solar Microgrids/Mini-grids • PV arrays, batteries • Solar Home Systems • Solar Water Pumps • Portable Solar Lighting
Objectives	• Increase productivity • Reduce manual labour • Improve Occupational Health and Safety	• Enable local value addition • End raw mineral exports • Eliminate mercury use for alluvial gold processing	• Environmental safety • Miner safety • Security of equipment • Smuggling prevention	• Mineral characterization • Environmental monitoring • Value addition • Regulatory oversight	• Improved access to services and information • Transparency and accountability • Efficiency • Improved licensing and formalisation of ASM	• Provide reliable power. • Reduce diesel fuel reliance. • Power critical safety/IT systems • Reduce manual labour • Improve health and safety

Capacity Status and Needs						
"Capacity Status"	• Very low-level mechanisation • PPE use is minimal and of poor standard	• Low, much processing still manual • Lack of access to modern equipment	• Nascent: Piloting in some formal mines. • Extremely limited in ASM	• Increasing availability of government laboratories • Limited access by ASM miners to analytic labs • Limited skill sets	• Digital infrastructure in place • Interoperability across systems under way • Platform capable of disseminating information	• Solar use expanding for basic needs. • Capacity for installation and use available • Miners require training in use
Institutions	• Ministry of Energy and Mining • MUBAS • Geological Survey Dept, • Private suppliers	• Ministry of Energy and Mining • MUBAS • TEVETA and technical colleges	• Tech companies • Academia, MUBAS • Development partners	• Geological Survey Department • Ministry of Energy and Mining • MUBAS	• Ministry of Energy and Mining •	• Malawi Energy Regulatory Authority. • MZUNI • Local solar companies,
Capacity gaps and requirements	• Lack of affordable tools • Lack of finance • Lack of maintenance skills • Need for safety training	• Limited access to machinery • Lack of skilled operators • Need for centralised processing hubs and landing centres	• Connectivity gaps in remote areas. • Lack of expertise in ASM sector	• Inadequate mineral laboratories • Lack of skilled personnel • Training needs for miners and government inspectors	• Low digital literacy • Insufficient internet access and connectivity challenges	
Benefits and Beneficiaries						
Needs addressed by technology	• Productivity • Improved occupational health and safety	• Value addition • Certification and formalisation of ASM • Limit environmental pollution	• Environmental and occupational health, • Addresses non-compliance • Smuggling	• Informed decision-making • Environmental and Health Protection • Market Access	• Formalize ASM • Mitigate environmental impact • Address corruption through transparency • Providing market information and financial services	• Access to power potentially 24/7 • Remove reliance on diesel • Productivity • Health and safety
Status of deployment	• Minimal • ASM remains a largely manual endeavour • Active support initiated	• Limited, • 12 landing centres planned	• Piloting phase in limited areas	• Lab development / rehabilitation initiated • Limited field level use	• Basic systems in place and moving towards integration • Access by miners needs improvement	• Increasing at low power e.g. lighting • Limited for higher power e.g. machinery
National policy anchors	• Mines and Minerals Act (2023). • National ASM Policy. • Occupational Safety and Health regulations • Mines and Minerals Policy (2013) • Mining Safety Regulations (1981) • Explosives Act (1996)©	• Mines and Minerals Act (2023) • 2025 Directive banning export of unprocessed minerals	• Mines and Minerals Act (2023). • (Draft) ASM Policy	• Mines and Minerals Act (2023). • (Draft) ASM Policy	• Malawi Digital Economy Strategy 2021-2026 • Data Protection Act (2024)	• Mines and Minerals Act (2023). • (Draft) ASM Policy • National Energy Policy (2018)

Sustainability and success indicators	• Increased ore output per miner • Reduced accident rates • Increased PPE compliance rates	• Volume of ASM value added exports • Formal ASM market sales	• Real-time data availability • Timely hazard alerts. • Reduced environmental incident	• Environmental compliance rate • Productivity improvement • Formalisation rate	• Licensing efficiency • Hits on cadastre portal • Formalisation rate	• System availability uptime • Increase in mineral yield • Mining community energy access • Health and Safety
Beneficiaries	• Miners, • Mining cooperatives, • Mining communities	• Miners, • Mining cooperatives, • Mining communities • Regulators	• Miners, • Mining cooperatives, • Regulators	• Miners • Regulators • Mining cooperatives • Mining communities	• Miners • Regulators • Mining cooperatives	• Miners, • Mining cooperatives, • Mining communities
(Gender dimension)	• Benefits both male and female family members • Females often in less hazardous roles	• Require equitable access to finance • Women benefit as involved in processing	• Benefits all employees on site if equitable access	• Women benefit as involved in processing	• Equitable digital access required through targeted training	• Equitable access to finance required • Potential for 'women-run solar shops'
Evaluation						
Main benefits to Malawian development	• Increased productivity. • Improved worker health. • Reduced accident costs	• Increased export value. • Job creation (artisans). • Economic diversification	• Safer working conditions. • Environmental protection. • Data-driven regulation	• Sustainable Resource Management • Enhanced Revenue Generation • Improved Public Health and Environment	• Economic Growth & Formalization • Improved Governance • Improved service delivery	• Increased miner income • Enhanced mining activity • Reduced carbon emissions
Disadvantages	• Initial cost • Maintenance costs. • Requires training •	• High capital expenditure may limit access • Need to scale up technical skills	• Infrastructure / connectivity needs • Data management challenges	• High initial costs • Requires specialized skills • Data accessibility challenges	• Digital divide • Cost of infrastructure • Cybersecurity and privacy	• High upfront costs • Intermittency of solar power if no battery storage • Vulnerability to theft
Costs	• Up to several thousand dollars per site	• Tens of thousands of dollars per processing site	• Sensors may cost hundreds of dollars.	• Significant investment for labs of hundreds of thousands of dollars	• Substantive infrastructure investment • Require investment in training programmes	• Significant capital costs of thousands and tens of thousands of dollars
Finance Mechanisms	• Development partner funding, • Revolving funds. • Microfinance, • Cooperatives savings.	• Government supported access to equipment • Development partner support • Investment loans	• Government support and Development partner support in first instance	• Government budget • Development partner support • Private sector investment • Government supported service provision	• Government budget • Development partner support • Private sector investment • Micro-transaction fees for credit facilitation	• Ngwee Ngwee Ngwee fund • Grants and soft loans for cooperatives • Pay As You Go business models

Short-term measures for implementation	• Establishment of ASM "Landing Centres" to provide access to shared modern equipment, training, and information dissemination • Training and extension services • Formation and strengthening of cooperatives • Simplified Licensing procedures • Establish pilot projects
Challenges and Risks	• Low literacy and digital literacy levels • High levels of informality and illegal mining • Inadequate enforcement capacity • Lack of mechanisation • Gender based barriers limit women accessing financial, technical and legal support
Mitigation measures	• Facilitating Access to Credit • Tailored Training Programs • Stronger Regulatory Framework • Intensified Extension Services • Build on the Geological Data Management Information System to provide online access to data that can assist miners identify promising mineral opportunities and use modern exploration tools
Opportunities for local technology development and manufacture	• Value Addition Incubation e.g. through SMEDI • Recent Government directive to limit export of unprocessed minerals • Demand for simple, robust locally manufactured, simple, and durable machinery (like improved sluice boxes, small-scale crushers, and non-toxic processing equipment) that is appropriate for the Malawian ASM context. • Collaboration with academia, government and private sector. to research, develop, and manufacture fit-for-purpose mining technologies
Responsibility	• Ministries of Energy and Mining; Industrialisation Business Trade and Tourism; Labour and Innovation; and Education Science and Technology all have a role. • Financial Institutions supporting private sector and PPP investment • Private sector advocacy e.g. through MCCCI • ASM Cooperatives • Development partners who have committed to provide support • NCST, Academia, TEVETA and civil society for training and research
M&E indicators	• Percentage of Formalized Miners • Number of Miners trained on technology and occupational health and safety standards. • Technology Adoption Rates. • Production and Value Addition Metrics • Accident Frequency Rates
Potential sources of finance	• Public sector–led financing • Malawi Mining Investment Company • Private Sector commercial lending and equity investment • Development partners
Long-term measures for implementation	• Assessment of sectoral policies and projects to ensure an integrated approach across Government • Procedures to assess intersectoral progress with the private sector, academia and civil society • Build on the Geological Data Management Information System and National Mineral Cadastre System • Invest in skills development and vocational training, with possible establishment of a National University of Mining and Technology and / or expansion of existing mining expertise at MUBAS • Creation of dedicated ASM Financial products
Challenges and Risks	• Transitioning from informal to formal sector • Continued inadequate infrastructure • Limited access to capital • Environmental degradation • Withdrawal / non-renewal of development partner resources • Lack of sustained R&D for innovation
Mitigation measures	• Regular coordinated assessments by Government with private sector, academia and civil society so that mitigation plans can be put in place • Inclusive formalisation strategies • Continuous community engagement
Opportunities for local technology development and manufacture	• Build on market development to finance local manufacture and digital innovation • Growth of companies engaged in value addition e.g. through gem cutting and polishing and gold processing equipment crate environment for private sector investment • Market size and returns on investment leading to increased R&D and the development of more sophisticated technologies
Responsibility	• Government (OPC and responsible ministries), Private Sector (MCCCI), NCST, Academia and research institutions
M&E indicator	• Uptake of digital systems • Skilled Workforce Metrics: university and TEVET graduates • Environmental compliance rates • Volume of local and foreign investment into the ASM sector • Government revenue from the formal ASM sector

The technology solutions here are divided into two categories (i) Artisanal and Small-Scale Mining; and (ii) Public Sector Oversight.

Artisanal and Small-Scale Mining

Mechanised tools for extraction and processing. There is a need for improved machinery to support extraction and processing. This includes pneumatic tools, low-vibration hydraulic pumps, machinery providing mechanical ventilation for extraction, and the use of low emission crushers, mills, gem cutting/polishing machines and gravity concentrators for extraction and value addition. There is room for the domestic fabrication of simple, high-value components. Local workshops could manufacture sample splitters and riffle boxes for accurate assay preparation, as well as structural elements such as frames, sluice boxes and manual pumps for on-site extraction and preliminary processing. There could also be local manufacture of personal protective equipment.

IoT sensors for real time monitoring. IoT sensors can be used to enhance worker safety through wearable devices, assessing vital signs such as heart rate and blood pressure. They can be used to detect onsite environmental hazards, such as air quality measurements of methane, carbon monoxide and dust, water quality and ground stability. They can also be used to track the location and performance of mechanised tools to help prevent theft and provide information for preventive maintenance.

Analytics. There is need to develop laboratory support, including mobile laboratory support for high-precision analytical instruments such as atomic absorption spectrometers, UV-Visible spectrophotometers, and X-ray fluorescence. Some of these technologies are increasingly available onsite, for example, hand-held X-ray fluorimeters for the mapping and grading of minerals, and microfluidic test kits. These 'lab on a chip' kits assist with the environmental monitoring of water and soil contamination and can analyse solvent and chemical mixtures for optimising mineral leaching, froth flotation and solvent extraction.

Public Sector Oversight

Digital platforms and data management. The application of digital technologies can assist with essential oversight requirements such as digital record-keeping and the formalisation of artisanal and small mines through registration. They can facilitate the provision of advisory and market information to artisans and small companies. Furthermore, global data platform integration can be used to generate a national dashboard. This can incorporate remote sensing and Geographic Information Systems (GIS) mapping utilising drone technology, as well as blockchain and traceability systems for tracking payments and royalties.

4.4.4 Priority technologies and implementation

Technology support for artisanal and small-scale mining

Artisanal and small-scale mining requires a range of technology support measures to improve productivity and income generation, as well as the health and safety of miners in what is often a physically high-risk enterprise. In undertaking this, support is also being provided to some of the poorest rural communities in the country. Technology support also helps mining enterprises to transition from the informal to the formal sector, facilitates the regulation of mining and limits the illegal exploitation of Malawi's mineral wealth. The major minerals addressed through artisanal and small-scale mining are: precious and semi-precious gemstones, precious metals (notably gold, and particularly alluvial gold), industrial minerals such as limestone and rock aggregate, quarried minerals for construction, as well as clays for pottery and bricks, gypsum, talc, salt and glass sands. A 2025 directive banning the export of raw minerals emphasises the requirement for value addition processing technologies. This factsheet covers mechanised hand tools and safety equipment as well as tools for mineral processing and value addition, but also covers the use of digital tools such as IoT sensors. It further covers analytical technologies, digital government support services and off-grid solar systems to support energy requirements. Collectively these technologies can add value to the mining sector and

assist in the development of a skilled workforce.

Implementation

Many of the implementation issues associated with technology support for artisanal and small-scale mining mirror those associated with the sections addressing support for agriculture. In this case, technology is serving the 40,000 to 80,000 artisanal miners operating in Malawi164 who currently rely largely on hand tools in dangerous operating environments. Within this implementation process there is the element of domesticating the assembly and manufacture of machinery and tools for improved efficiency and safety of mineral extraction and processing. There is the utilisation of IoT and remote sensors for environmental monitoring and technical support. There is the value of off-grid solar systems to provide energy for mechanisation and water management. The implementation of technology support is driven by the Mines and Minerals Act (2023), which established the Mining and Minerals Regulatory Authority. A National Artisanal and Small-Scale Mining (ASM) Policy was drafted in 2025 aiming to formalise the sector, provide technical assistance, and promote safer, modernised mining operations, including digital approaches. There is broad guidance on the integration of digital technologies across production industries in the National Digitalization Policy (2023-2028). Off-grid solar energy to support the mining sector is guided by the National Energy policy, the National Energy Compact, and the Malawi Renewable Energy Strategy. Moving forward it should be recognised that much of the work to implement the application of Technology support for artisanal and small-scale mining is still in its infancy

4.5 Technology needs for information technologies

4.5.1 Recent evolution of information technologies in Malawi

As referenced in section 2.5.2 on physical infrastructure, Malawi has a number of polices and strategies guiding the ICT sector and digitalisation.[165] These include (i) the Digital Economy Strategy, and (ii) the National ICT Policy, which is under revision. These have been complemented by a recent Digital Readiness Assessment.[166]

Malawi has seen a major increase in internet access, which now stands at 27.7%. A significant fibre internet structure has been put in place to promote mobile access. This has recently been complemented by the establishment of Malawi's first local internet exchange in August 2024 and the construction of a National Data Centre through the Digital Malawi Project and Digital Malawi Acceleration Project that enables Malawi to domesticate its data management.[167] However, there remains a need for the introduction of more internet exchange points and an increase in local data centres. Malawi remains heavily reliant on foreign companies to undertake strategically important software systems development associated with the increased digitalisation of government services.

Malawi has progressed from 70,000 landline connections in the early 2000s to having 61 mobile subscriptions per 100 people in 2023.[168] There has been a significant reduction in internet costs in recent years, with Malawi transforming from one of the most expensive to one of the cheapest data jurisdictions in Africa. However, the cost for 300Mb of data still represents 5.4% of the average monthly gross national income per capita. There is a significant MSME activity, with an estimated 1,940 ICT companies formally registered through the Registrar General's office[169] and a small number of established IT-based companies. There is also increasing use and access among the youth. Malawian

164 Artisanal mining.org
165 https://ict.gov.mw/index.php/blog/downloads/legislation
166 https://www.undp.org/sites/g/files/zskgke326/files/2025-05/dra_malawi_report_2025_a4_print.pdf
167 DigiMap - Digital Malawi Project
168 https://tradingeconomics.com/malawi/mobile-cellular-subscriptions-per-100-people-wb-data.html
169 Communication from the Registrar General's office.

university students have excelled in international competitions.[170] Malawi has introduced universal digital ID registration for adults. Malawi has an e-Government Development Index ranking of 163 out of 193 countries and ranks 99th on the e-participation index. This compares to its Human Development Index ranking of 172 (see Chapter 2, Table 1)

Government and development partner plans and projects are in place to further expand ICT access, particularly through schools, and to support youth innovation and promote ICT-related businesses. A fund, the Muuni fund,[171] has been established under the Malawi Communications and Regulatory Authority to promote digital innovation and entrepreneurship. A Youth Innovation Fund[172] has recently been established with a focus on agriculture, tourism, mining and manufacture, where IT innovations may be particularly relevant. There has also been an increase in innovation hub support for IT training and entrepreneurship development over the past decade.

4.5.2 Anticipated future evolution of ICT in Malawi

Building on existing policies and their implementation to date, expanded ICT development in Malawi is expected to continue. It is anticipated that improved ICT infrastructure will lead to increased access across the country, attempting to bridge the rural urban divide. There will be continued efforts to educate and train the youth at all levels of the education system and to promote improved digital literacy across all ages. There will be an effort to improve ICT Governance and to enhance public service delivery through digital channels along with the continued expansion of digitalisation across government. There will be an increase in local hosting of all Government systems from 87% to 100%, along with improved integration through the National Data Centre. There will also be an increased participation in international ICT fora and the establishment of a National Space Agency. The delivery of public services through digital channels will be undertaken by the Department of e-Government.

Initiatives are already underway to improve connectivity, digital platforms, and access to government services to promote anti-corruption and the integrity of government services. These include, for example, centralised payment systems and an online e-Government Procurement System. At the same time, efforts will be made to ensure interoperability between government and private sector systems. This will require the training of public sector workers and the general public in basic digital skills.

The promotion of, and increasing dependence on, digital services means that there must also be an increased attention to cybersecurity resilience. Efforts will be made to protect Malawi's critical information infrastructure through sectoral computer emergency response teams, and there will be alignment to regional and international cybersecurity standards, with an emphasis on increasing public awareness of cybersecurity issues, especially as this applies to the protection of vulnerable groups.

In parallel to the Government's promotion of digitalisation and ICT, it is anticipated that there will be enhanced private sector activity, with an increased number of startup companies operating in the field, and an expansion of e-commerce and social media engagement. Many respondents anticipate an increased level of national self-reliance, with the incorporation of emerging technologies (Artificial Intelligence, Internet of Things and Robotics, Blockchain, Cybersecurity and Cryptography, Big Data, Cloud Computing and Drones) into public and private ventures.

There is a need for systemic approaches to the development of IT in Malawi, with the application of ICT technologies ideally problem-focused and automatically feeding into specialised subsectors such as AgriTech, FinTech, EdTech, e-Health, based on demand and opportunity.

A main challenge for IT expansion is access to internet, local data management and storage, access to low-cost hardware such as mobile phones, tablets and laptops, and dedicated apps

170 A team from Malawi University of Science and Technology won the sub-Saharan African regional competition and finished 4th globally at the Huawei Tech4Good Competition.
171 https://muuni.mw
172 https://nycom.mw/

to address local needs. Thus, an emphasis was placed on the following subsectors: (i) local software development so Malawi can apply its own software solutions to local issues and market opportunities; (ii) improved management of domestic data, including Big Data, to reduce reliance on international computing, lower costs and increase the speed of internal data exchanges; (iii) hardware equipment assembly and manufacture to improve access to low-cost hardware, such as mobile phones, tablets and laptops; through local assembly and manufacture.

4.5.3 Challenges to ICT development that may be addressed by technology

In addressing the challenges to ICT development, there is a recognition that there must be a strong interface between the public and private sectors to facilitate its development. Desk review combined with interviews highlighted challenges and gaps affecting the three areas for action as outlined in Table 37. Overall, the identified gaps point to a combination of technology-related constraints, particularly limited software development capacity, weak data management infrastructure, dependence on external digital services, and the absence of local hardware assembly and manufacturing, alongside non-technology barriers related to human capital and digital skills, access to finance, policy and institutional frameworks, and awareness of digital opportunities, which together constrain the development of the ICT sector across the three priority sub-sectors.

The technology solutions here are divided into three categories (i) Software development for ICT services; (ii) Management of domestic data, including Big Data; and (iii) Hardware equipment assembly and manufacture

Software development for ICT services

There is an opportunity for public sector and business-led investment in software development for a variety of sectors in Malawi, for example, AgriTech, HealthTech, FinTech and EduTech. This could build on the establishment of the National Data Centre and other data centres. Such investment would require utilisation of the full stack of software development technologies: (i) Artificial Intelligence and Machine learning: (ii) Cyber Security and cryptography; (iii) Blockchain Technologies; (iv) Internet of things and Robotics; (v) Drone Technologies; (vi) 3D computing; and (vii) Big Data and Cloud computing. The need to develop expertise to undertake large systems software development projects and to manage such systems is critical,

Table 37. Gaps Limiting ICT sectoral development across three critical subsectors

Technology-Related	Non-Technology Related
Software development for ICT services 1. Much software in use is outdated 2. Limited software development, especially for large systems 3. Limited capacity for software engineering 4. Limited capacity for emergent technologies 5. (Artificial Intelligence, Internet of Things and Robotics, Blockchain, Cybersecurity and cryptography, Big Data and Cloud Computing, Drones, 3-D printing)	Human Capital and Training 1. Need improved digital literacy allied to improved literacy and mathematics through education system 2. Need digital literacy training through continuous professional development 3. Training must involve access to hardware and practical experience 4. Specific training in cybersecurity dangers needed including for vulnerable groups
Management of domestic data, including Big Data 1. Lack of Data Management Centres 2. Lack of internet exchanges 3. Dependence on international cloud services 4. National public domain data is dispersed and not easily accessible 5. Lack of Data Management capacity 6. Lack of easy access to earth observation data 7. Lack of dependable energy supply	Mindset 1. Lack of awareness of what is possible Access to Finance 1. Limited access to Foreign Exchange inhibits ability for companies and individuals to purchase online services and online apps 2. Limited access to credit and investment for start-ups • High interest rates
Hardware equipment assembly and manufacture 1. Basic equipment (phones, tablets, laptops) is imported at high cost 2. Much computer hardware is outdated 3. Inability to access materials for repair and maintenance of hardware 4. No local hardware assembly and / or manufacturing capacity	Policy and Regulation 1. Need for a visionary overarching policy and strategy for the IT sector 2. Need to review the current institutional architecture

Table 38. Technologies associated with Big Data Management Capabilities for Agriculture and Mining in Malawi

Issue	Data Centres and Cloud Computing	Unified Sectoral Data Platforms	IoT & Remote Sensing Infrastructure	Advanced Analytics & Artificial Intelligence	Cybersecurity and Risk Management
What is undertaken	• Data centres host large data sets to enable operational analysis. This can be the basis of local cloud computing provision. It can be complemented by use of external cloud computing services in the first instance to reduce initial capital expenditure	• Sectoral data platforms are unified within interoperable systems of modular tools and technologies that enable centralisation of fragmented data for analysis	• Appropriate IoT and remote-sensing infrastructure enables a shift from standalone data collection to an integrated, high-velocity ecosystem capturing space, drone and 'on the ground' IoT data to feed into data platforms.	• Advanced Analytics and AI convert the data from sensors, satellites and registries and enable the transition from descriptive reporting into predictive and prescriptive management information	• Cybersecurity technologies restrict access to confidential data and, importantly individual citizen data. This is important to retain public trust and also to secure and protect national data sovereignty
Features and Objectives of Technology					
Features	• Minimum tier 3 classification data centre(s) with hyper-converged infrastructure capacity for large data handling, requiring appropriate power infrastructure, cooling, network fabric, processing power and security controls	• Centralised repositories of raw data (lakes) and structured data (warehouses) within interoperability frameworks and a hyper-converged infrastructure to enable future scaling	• 'Edge Gateways' to facilitate local analysis. • Low power wide-area networks of IoT sensors linked to automated validation loops • Drone ecosystem • Space data and ground data 'ground truthing' • Dedicated industrial IoT frequencies • End to end encryption	• Graphic Processing Unit (GPU) clusters enable high density computing • Automated data pipelines extract, transform and load sanitised data for analysis • Big Data frameworks enable processing of large amounts of e.g. earth observation data	• End-to-End Encryption, • Multi-Factor Authentication, • Next-Generation Firewalls, • AI-driven threat detection, • Edge-to-Cloud security protocols, • Hardware Security Modules, • automated data backups
Objectives	• Provision of capacity to manage large, integrated data sets through a local cloud, augmented, if necessary, by external cloud computing services	• Enabling of full sectoral analysis and intersectoral analysis to inform operational, strategic, policy and commercial decisions	• High quality validated and interoperable data from IoT and remote sensing sources that is transmitted with minimum power use, interference and cybersecurity risk	• Decision automation, and interoperable metadata management • Agricultural predictive yield modelling, disease protection and precision subsidy targeting • Mining 3-D geological and mineral mapping, predictive maintenance and safety and automated revenue oversight	• Protect national data sovereignty, • Ensure 99.98% availability, • Prevent breaches of sensitive farming/mining data, • Maintain public trust, • Comply with the Data Protection Act 2024

Capacity Status and Needs					
Status	• Government has a National Data Centre • Some private sector players operate dedicated centres • Major telecom providers offer localised cloud services • High performance computer at MAREN • Significant number of ICT graduates	• Tier 3 national data centre can consolidate fragmented data • National Agricultural Management Information System (NAMIS) and several mining platforms, along with other national registries, in place, with contributions from private partners. • Significant number of ICT graduates	• Malawi has capacity for integrated large-scale deployment from 'edge' to remote sensing data • There is capacity for edge gateways, drone remote sensing, earth observation integration, IoT and ground truthing, • There is graduate level expertise in ICT, data science and drone technology	• National Data Centre capacity reduces costs and dependence on external cloud computing • MUST has established a Centre for Artificial Intelligence and STEAM • Other Universities, Government and regulators and private sectors and innovation hubs support AI development and use. • Significant number of ICT graduates	• Operational at core government sites (Tier 3 National Data Centre). • Coordination efforts active through CERT-MW. • "Last mile" security for IoT remains a gap
Institutions (in addition to responsible Government ministries)	• e-Government • private telecoms • Commercial Banks • Utilities, • Open Connect Limited, • NICO Technologies, • MAREN	• AGCOM project for agriculture platform • GEMMAP project for geological data, • Digital Malawi Acceleration Project	• National Data Centre • African Data and Drone Academy (ADDA) • Malawi Space Agency • Mining companies use IoT sensors for environmental monitoring • MUST, UNIMA, MZUNI, LUANAR	• National Data Centre • MUST AI Centre, • MUBAS, LUANAR • Malawi Space Agency, • NCST, MACRA • ACADES, m-Hub and • Mzuzu e-Hub • Airtel and TNM • Digital Earth Africa	• CERT-MW, • Data Protection Authority (DPA), • MACRA, • Ministry of Information/e-Government, • National Data Centre, • Private Telecoms (Airtel, TNM).
Gaps / requirements	• Number and scale of data centres needs increasing in both the public and private sector • Capabilities and expertise for big data management.	• Technical infrastructure gaps • Data quality and standardisation gaps • Regulatory and governance gaps • Require more private sector knowledge transfer • Require more data scientists	• Power stability, rural connectivity and bandwidth bottlenecks • Shortage of advanced skills e.g. system integration with 'edge' architectures • Weak interoperability frameworks	• More GPU computing • Improved data cleaning tools • Improved validated data • Data scientists in Agriculture and Mining • Postgraduate / PhD specialists in AI • Open-source AI repository • Ethical oversight of AI	• Lack of specialized Geospatial Cybersecurity experts, • High cost of advanced security hardware, • Insufficient data security training for field staff, • Reliance on external software vendors
Benefits and Beneficiaries					
Needs addressed by technology	• Increased self-reliance and data sovereignty • Cost efficiencies and resource management • Public service delivery and transparency • Economic and sectoral development • Research and Education	• Enhanced decision making and policy coherence • Service delivery and transparency • Economic growth and private sector efficiency • Data sovereignty and security • Research and Development	• Precision data for food security • Operational Transparency in mining • Edge Computing Gateways reduce data strain • Cost and resource efficiency through remote monitoring • Evidence-based reporting and policy	• Predictive accuracy for food security e.g. maize yield forecasting • Exploration efficiency in mining • Improved resource allocation e.g. subsidy targeting • Mining safety and compliance monitoring • Evidence based governance and policy	• Protect citizen privacy (Data Protection Act 2024) • Prevent revenue loss from data manipulation • Ensure integrity of agricultural supply chains • Maintain investor confidence in the mining sector

Status of deployment	• Tier 3 Government National Data Centre with backup centre • Expansion initiatives planned to support public and private sector • Agriculture and Mining data systems in development • Private sector engagement • Academic access to high performance computer	• NAMIS established: several million farming households registered; 17 modules integrated; digitised advisory services provided. • Mining Cadastre portal; Geological Mapping Project and regulatory portal in place • Government Data Exchange platform in place • Interoperability gaps remain	• Malawi's 2025 Digital Readiness Assessment was 1.96 out of 4 indicating foundational investment, but incomplete integration into a mature digital economy. • A national architecture is being put in place • Agricultural and Mining data development may help stimulate development in other sectors	• The National Data Centre provides a centralised AI infrastructure • MUST AI Centre operational • Within Agriculture, predictive and advisory AI is integrated into NAMIS • Within mining, Malawi launched a plan to verify carbon sequestration and mineral compliance and is actively undertaking 3-D mineral mapping	• The National Data Centre provides a centralised AI infrastructure • MUST AI Centre operational • Within Agriculture, predictive and advisory AI is integrated into NAMIS • Within mining, Malawi launched a plan to verify carbon sequestration and mineral compliance and is actively undertaking 3-D mineral mapping
National policy anchors	• Digital Economy Strategy (2021–2026)	• National ICT Policy 2023-2028 • National Agricultural Policy 2024-2029 • Mines and Minerals Act 2023 • Digital Malawi Acceleration Project	• National Digitalization Policy (2023–2028) • Malawi Digital Economy Strategy (2021–2026) • National Digital and AI Strategy (2025-2030)	• National Digital and AI Strategy (2025-2030) • National Digitalization Policy (2023–2028) • Digital Malawi Acceleration Project (DMAP)	• Data Protection Act 2024, National • Digitalization Policy (2023–2028), • National Security Policy, • Mines and Minerals Act 2023, • Malawi Digital Economy Strategy (2021-2026).
Sustainability and success indicators	• Economic contribution including jobs growth • Number of ICT startups • Government interoperability • Migration of national registries to domestic tier 3 facilities • Carbon and Power Usage Effectiveness • Cyber resilience	• Number of public sector sites integrated • Reduced administrative costs • Number of startups using Application Programming Interfaces to build commercial applications • Uptime and availability • Cyber resilience • Monetisation revenue	• Digital Readiness Assessment score >3.0 • Increased accuracy in crop yield reporting • Decrease in illegal mining activities • Revenue generation using 'Data as a Service model' • Number of qualified technicians employed in domestic remote sensing	• Percentage of national AI models trained on National Data Centre • Yield Forecasting Accuracy • Increased 'hit-rate' for mineral discoveries • Data as a Service and GPU as a service revenue streams • Compliance with Data Protection Act 2024 • Successful audits of AI models	• Zero major data breaches, • 99.98% data availability (Tier 3 standard), • Successful migration of all sensitive data to domestic cloud • High compliance rates with Data Protection Act audits.
Beneficiaries	• Public sector • Private sector • Agriculture Sector • Mining Sector • Education / Research • General public	• Public sector • Private sector • Agriculture Sector • Mining Sector • Education / Research • General public	• Smallholder and commercial farmers • Mining operators • Policy makers • Digital entrepreneurs • Education / Research • Rural and underserved communities	• Public sector • Private sector • Agriculture Sector • Mining Sector • Education / Research • General public	• Government (transparency, stability), • Farmers (data privacy), • Mining firms (IP protection and investor confidence), • Citizens (data privacy, reliable services), • Financial institutions (secure eKYC)©

(Gender dimension)	• Women benefit if equity-based training and recruitment aligned to policy	• Women benefit if equity-based training and recruitment aligned to policy	• Data can be disaggregated by gender • Women benefit if equity-based training and recruitment • IoT sensors free women from agricultural labour	• Women benefit if equity-based training and recruitment • AI can support improved gender analysis	• Secure data protects female farmers from exploitation via data misuse. • Ensures women's land/subsidy data is protected from digital manipulation. • Promotes trust in digital systems
Evaluation					
Main benefits (3) to Malawian development	• Economic growth and competitiveness. • Agriculture and Mining sector transformation • Enhanced public service delivery • Data sovereignty and security • Academic, research and skill developmentc	• Agriculture: Food security and market growth • Mining: Transparency and attract Investment • Academic, research and skill development	• Economic growth • Food security • Mining Transparency • Disaster risk management • Academic, research and skill development • Evidence informed policies	• Economic growth • Food security • Mining Transparency • Disaster risk management • Academic, research and skill development • Policy analysis • Validated policies	• Investor Confidence: Secure data attracts high-value mining/agri investors. • National Security: Prevents data manipulation of critical infrastructure • Privacy: Builds public trust in e-Government services (Data Protection Act 2024).
Disadvantages	• Energy dependence and grid strain • Burden of capital costs • Obsolescence if equipment not renewed • Forex pressure • Skills gaps • Danger of market distortion / monopoly • Cybersecurity risks	• Cybersecurity risks • High financial and technical burden • Digital Divide and Exclusion • Operational inefficiencies • Ethical surveillance concerns	• Operational and maintenance costs and import dependence • Energy requirements • IoT spectrum congestion due to unlicensed use • Cybersecurity risks through IoT connections • Poor IoT operation due to low digital literacy	• High computational and energy costs • AI automated decisions may lead to lack of transparency • External software may lead to external data transfer even if data hosted locally • Human capacity challenges • High barrier for local innovation to be competitive	• High Capital Expenditure for secure hardware, • Expensive ongoing Operational Expenditure (talent, software), • Creates single point of failure (central target), • Potential for "brain drain" of skilled cyber personnel.
Costs	• Africa Regional average cost for a 1 MW data centre is @ $10 million with AI-Optimized Facilities @ $20 million.	• Software licensing and development costs, incorporating interoperability	• Agricultural sensor networks may cost tens of thousands of dollars per 10km radius • Drones may cost several thousand dollars • Edge computing units may cost several thousand dollars • Satellite data subscription may cost tens of thousands of dollars per year	• GPU cluster costs are several Million US$ • Operational energy costs are high • Software and algorithm development costs can be hundreds of thousands of dollars	• Costs are high for both Capital Expenditure and Operational Expenditure.

Finance mechanisms	• Blended finance models are needed • Public financing, • Development partners and concessionary loans • Private sector investment • PPPs	• Blended finance models are needed. • Public financing, development partners and concessionary loans • Private sector investment • PPPs • Monetising 'Data as a Service'	• Blended finance needed • Finance from public sector and development partner grants; • private sector loans and investment • "Data-as-a-Service" Revenue	• Current financing primarily through Digital Malawi Acceleration Project • Monetisation through Data as a Service • PPP innovation sandboxes may offset costs • Using open-source data can reduce costs • Edge AI processing of data at source (farm / mine can reduce costs©	• Financed by World Bank grants (DMAP), • National budget allocation • Potential Data as a Service revenue model • PPP models also used for infrastructure development

especially as many such systems apply to the management and utilisation of strategic national databases.

Management of domestic data, including big data

There is a need for continued investment and expansion of the National Data Centre and private sector and academic data centres, plus investment in internet exchanges to enhance the management of domestic data and increase the speed of local data exchange. This will assist the future development of locally-managed AI tools, cloud services, e-commerce and digital payments. The National Data Centre plans to provide improved access to pooled data that is currently dispersed across multiple systems, for example, geophysical data, demographic data and policy data. It will interface with the National Space Agency and its access to earth observation data. Such data may be readily applied to a range of sectors, including agriculture and mining. Bringing together national statistical data in this way could also serve as a public and/or monetised tool to inform a broad array of investors of developmental opportunities. Technical requirements to bring this about include the creation of unified sectoral data platforms, connection to IoT and remote sensing infrastructure, the application of data analytics and artificial intelligence, and the management of cybersecurity and risk.

Short-term measures for implementation	• Build on and fully utilise National Data Centre capacities • Strengthen and further integrate existing platforms e,g, • expand and enhance NAMIS • integrate various Mining related datasets on cadastre mapping, mineral rights management, geological data, spatial data, and ASM tracking • Seek to fully implement the provisions of the Data Protection Act to fully realise an operational National Data Policy Framework • Continue the development of pilot projects such as the AGCOM soil health pilot to demonstrate value to smallholder farmers and small-scale miners • Digital and literacy training programmes • Promote relevant graduate and postgraduate academic programmes in data science
Challenges and Risks	• Inadequate infrastructure such as access to reliable electricity and internet especially in remote areas • Limited digital literacy and skills gaps from field to policy makers • Data fragmentation and quality of data limiting interoperability • High costs of hardware and software and operational costs • Data security

Mitigation measures	• Continued promotion of infrastructure investment • Tailored Training Programs for policy makers and technical officers for data interpretation for decision making and for farmers and miners • Implement data standards and integrate fragmented data • Phased implementation and development of PPPs • Ensure robust security protocols • Broad stakeholder engagement
Opportunities for local technology development and manufacture	• Local app and platform development • IoT assembly and maintenance and drone manufacture • Data analytics services • Local content creation e.g. AI models and educational content
Responsibility	• Ministries of Information and Communications Technology. Agriculture, Energy and Mining; Industrialisation Business Trade and Tourism; Labour and Innovation; and Education Science and Technology all have a role. • Financial Institutions supporting private sector and PPP investment • Private sector delivery of digital solutions, services and technologies • Development partners who have committed to provide support • NCST, Academia, TEVETA and civil society for training and research • Farmers Union and Mining Associations
M&E indicators	• Digital readiness assessment (target ≥3.0) • National Data Centre (NDC) uptime (target ≥99.98% - Tier 3) • Data availability and quality scores for accuracy and completeness • NDC Information Security Management System audit pass rate • Percentage of farmers and miners using digital platforms • Yield / efficiency gains in pilot projects • Number of local related tech solutions / innovations recorded in Community Innovation Surveys
Potential sources of finance	• Public sector–led financing • Private Sector commercial lending and equity investment • Public Private Partnership • Development partners • Monetisation of 'data as a service' e.g. to commercial investors.
Long-term measures for implementation	• Assessment of sectoral policies and projects to ensure an integrated approach across Government • Procedures to assess intersectoral progress with the private sector, academia and civil society • Develop a National Data Infrastructure Master Plan that incorporates continued expansion of National Data Centre capacity • Integrate Data Science into national tertiary education curricula • Enforce interoperability mandates • Create an open platform where anonymized data can be ethically shared between government, researchers, and the private sector to encourage innovation
Challenges and Risks	• Continued inadequate infrastructure • Continued digital literacy challenges • Continued limited access to capital • Withdrawal / non-renewal of development partner resources • Data security and privacy concerns • Lack of sustained R&D for innovation
Mitigation measures	• Regular coordinated assessments by Government with private sector, academia and civil society so that mitigation plans can be put in place • Maintain higher education graduate and postgraduate training and research along with TEVETA training so that the required skill sets are available to operate and maximise the value from big data management and its outputs.
Opportunities for local technology development and manufacture	• Build on experience of national big data management and related commercial services and manufacture to become regional leaders in data related services and equipment assembly and manufacture • Market size and returns on investment leading to increased R&D and the development of more sophisticated technologies and services
Responsibility	• Government (OPC and responsible ministries), Private Sector (MCCCI), NCST, Academia and research institutions
M&E indicator	• Skilled Workforce Metrics: university and TEVET graduates • Percentage and scale of combined Government and private sector investment compared to donor-based funding and financing of • Percentage of private sector financing compared to public-sector financing

Hardware equipment assembly and manufacture

Stakeholders expressed a strong sentiment that there should be investment in computer and peripheral equipment assembly and manufacture. This is currently being explored by MUST, but could be expanded in partnership with the private sector. The initial product focus could be on: low-cost basic computers, laptops and tablets; networking equipment such as routers, switches and wi-fi access points; customised server solutions for clients; and peripherals such as keyboards, mice etc. If successful, this could grow into a broader consumer electronics industry.

4.5.4 Priority technologies and implementation

Big Data management capabilities for agriculture and mining

As indicated in the previous section, this area emerged as a composite of sub-elements from the Technology Needs Analysis of the ICT, Agriculture and Mining sectors. National-level big data for Malawi agriculture involves integrating diverse datasets (weather, soil, market, and mobile) into systems such as the National Agriculture Management Information System. This provides information to support early warnings, resource allocation, targeted advice, crop health monitoring, and policy planning. It ultimately boosts yields, financial inclusion, and climate resilience. Data infrastructure and digital literacy are both crucial for success. National-level big data for Malawi's mining development requires comprehensive geological surveys, integrated data on mineral potential, exploration results, environmental impacts, infrastructure, community engagement, and real-time operational data. This has to be centralised and accessible through digital platforms. Once accomplished, it can serve to attract investment, ensure transparency, and guide policy for a modern, technology-driven sector as envisioned by the government. The development of big data management capabilities for the agriculture and mining sector will have an impact on the wider capacity for big data management across multiple sectors, which is the goal of the government. The technological areas covered in this factsheet are: Data Centres and Cloud Computing; Unified Sectoral Data Platforms; IoT & Remote Sensing Infrastructure; Advanced Analytics & Artificial Intelligence; Cybersecurity and Risk Management.

Domesticating big data management capabilities for agriculture and mining

The capacity to manage large amounts of data from multiple sources is a prerequisite to maximising the value of the new digital technologies associated with the fourth industrial revolution already alluded to with respect to Agriculture in section 6.2 and Mining in section 6.3. National efforts are ongoing to integrate ground sensor data with remote sensing data, including earth observation data, and social and other data, to generate a comprehensive foundation for a one-stop shop that can provide information to inform policy and action within each of the Agriculture and Mining sectors. Ultimately, the objective is the integration of data across all governmental sectors to maximise national planning capabilities for the public sector, the private sector, and for societal use. The creation of the National Data Centre has been a prerequisite for pulling together digital technologies to realise this ambition, enable data sovereignty, and maximise the impact of the digital economy on national development. The implementation of domesticating big data management capabilities for agriculture and mining is driven by the Malawi Digital Economy Strategy, the Data Protection Act, the National Agriculture Policy, the establishment of the National Agriculture Management Information System (NAMIS), and the Mines and Minerals Act (2023). The establishment of NAMIS represents one of the first examples of a comprehensive sectoral data management system at the National Data Centre. The mining sector is developing a number of data systems that still require integration.

4.6 Technology needs for energy

4.6.1 Recent evolution of energy in Malawi

As outlined in Chapter 2 section 2.2.5, hydropower forms the basis of Malawi's electricity supply, with increasing input from solar, including off-grid solar. The 2018 National Energy Policy[173] led to the separation of responsibilities of government electricity supply and distribution to the Electricity Supply Corporation of Malawi (ESCOM), and of government-owned electricity generation to the Electricity Generation Company (EGENCO). In addition to EGENCO, the market also allows for IPPs that may contribute to on-grid and off-grid supply. For example, there have been two IPP solar farms developed in recent years, adding 101 MW capacity to the grid. Off-grid community systems utilising solar, wind and small hydropower—but predominantly solar—systems are also being developed. There has been excellent progress within the last five years in that access to electricity has increased from 12% in 2019 to 25% in 2024.[174] In 2022/23 there was removal of import duty and excise tax on some solar products to further promote clean energy access.

4.6.2 Anticipated future evolution of energy in Malawi and sub-sectoral development

Building on the expansion of energy access, a recent Energy Compact signed with the World Bank[175] aims to increase access to 70% by 2030 by means of an additional 1.15 million on-grid and 1.55 million off-grid connections. This would result in 30% grid connectivity and 40% off-grid connectivity. The Energy Compact further sets out that energy from renewable resources, including hydropower, should increase from 90% to 96% by 2030. On-grid systems will continue to rely on increased hydropower, supported by renewable—primarily solar—energy, while ensuring that grid stability is not compromised. Grid stability will be supported by the development of battery energy storage systems and further enhanced by a Malawi-Mozambique power connector that will enable Malawi to import 50 MW of power from Mozambique. The ability to connect excess off-grid solar energy from individual premises to the grid will be developed. The need for a high-powered national grid system is critical not just for individual and household access, but for business development and industrialisation, including especially mining, which has been highlighted as a high-priority area for national development.

Continued development of hydropower is exemplified by the 2025 announcement of the US$ 1.5 billion public-private partnership investment in developing the Mpatamanga hydropower project.

Off-grid solar expansion will require improved linkage of distributive off-grid renewable energy to village communities, leading to enhanced local entrepreneurship. In line with the 2018 National Energy Strategy, it is anticipated that the assembly and manufacture of solar technology will be developed.

The TNA process focused on two aspects of energy supply, namely: (i) off-grid and mini-grid solar systems, and (ii) grid stability.

4.6.3 Challenges to energy development that may be addressed by technology

Expert respondents stressed a need for an appropriate balance between the development of hydropower and solar power to ensure both electricity access and grid stability. Hydropower is much more resource-intensive and time-consuming to establish, but has the benefit that, once in place, its operational running costs diminish to relatively low levels over time, with minimal need for material replacements. Solar farms and off-grid developments are less expensive to initiate and can be established more quickly. However, they require more frequent replacement of material and their operational costs thus remain relatively high over time.

Desk review combined with interviews highlighted challenges and gaps affecting the issues

173 https://www.energy.gov.mw/docs/uploads/National-Energy-Policy-2018-Final.pdf
174 Govt signs World Bank grant to increase electricity access - ESCOM Limited
175 M300-AES-Compact-Malawi.pdf

of (i) Off-Grid and Mini-Grid Solar Energy, and (ii) Grid stability are outlined in Table 39.

Discussion around both subsectors highlighted the need to develop local fabrication, prototyping, small-scale assembly and manufacturing capabilities, including software development capabilities.

The technology solutions here are divided into two categories (i) Off-Grid and Mini-Grid Solar Energy; and (ii) Grid stability

Off-grid and mini-grid solar power

Capacity for local assembly and maintenance. Solar home systems, mini-grids and larger off-grid systems, all require high-efficiency solar panels and advanced lithium-ion battery storage systems. The high cost and the need for guaranteed quality of solar technologies, such as panels, batteries and inverters, could be addressed in part by local assembly, manufacture and maintenance.

Remote monitoring of systems. IoT platforms can be established to monitor performance, enable predictive maintenance, adjust control settings as required, and assist in theft prevention.

Smart metering enables operators to manage energy demand and facilitates a variety of pay-as-you-go systems. The data obtained by smart meters can also facilitate the future integration of off-grid systems with the main grid.

Grid stability

Smart grid controllers and programmable logic controllers are required to manage the interface of the grid with solar systems, supplemented by battery energy storage systems.

Smart bi-directional metering enables an interface between the grid and off-grid solar systems, including home systems for the import and export of energy on to the grid.

Hydropower generation remains the backbone of the grid system in Malawi. The high cost for repairs, maintenance and the time delays associated with much hydropower plant equipment could be addressed by setting up small/medium enterprises and organising targeted workshops for the manufacture and repair of hydropower machinery and equipment. In addition, there is potential to develop and oversee the development of appropriate domestic software systems to help manage grid-based hydropower generation and distribution systems.

Diversified energy sources. A number of sources in addition to hydropower and solar power are potentially available for future power generation. These include wind power, geothermal energy, bagasse from agricultural residues, and coal-powered stations.

Table 39. Gaps Limiting Energy Sectoral development

Technology-Related	Non-Technology Related
Off-Grid and Mini-Grid Solar Energy 1. Cost of materials (panels and batteries) 2. Sub-standard products on market 3. Lack of large-scale battery energy storage systems 4. Lack of local assembly and manufacture of materials 5. Limited comprehensive linkage of distributive off-grid renewable energy to village communities	Human Capital and Training 1. Lack of trained engineers with practical experience in both solar and hydro 2. Need to send employees out of country for training at a cost of MK100 million for basic training and M500 million for specific training 3. Limited consumer ability to manage solar installations 4. Need improved training of trainers and teachers in renewable energy technologies
Grid stability 1. Lack of large battery energy storage systems to manage solar energy integration on to the grid 2. Lack of smart grid management systems to optimise both on-grid and off-grid performance 3. Challenges in managing hydro power • Outdated equipment, both hardware and software • High cost and delays of importing spare parts and foreign outsourcing of maintenance 4. Lack of Diversity of energy sources	Policy and Regulation 1. Require improved alignment of regulators: Malawi Energy Regulatory Authority for licensing and systems monitoring; Malawi Revenue Authority for cross-border trade; and Malawi Bureau of Standard for certification of equipment. 2. Solar expansion appears project driven rather than 'nation-driven' 3. State-owned companies not free to operate commercially with sustainable market pricing.
	Access to Finance 1. Challenging investment environment. 2. Limited access to foreign exchange to import materials and spare parts for both hydro and solar products

4.7 Technology potential for local manufacture

In order to comparatively address the information gathered across four sectors for potential local generation, assembly and manufacture, technologies were divided into several operational sub-categories that cut across the four sectors under analysis. These were: (i) machinery and manufactured products, (ii) digital technology hardware; (iii) digital technology software, and (iv) data management tools. These were each further categorised into technologies that would have to be imported for the foreseeable future and those that had potential for local assembly and manufacture.

A major theme throughout the consultations was that local assembly, manufacture and production in support of innovative technologies was critical to the growth and sustainability of technological innovation. The sub-categorisation highlights areas where such support could be most beneficial. The sub-categories and their relation to the four sectors are provided in Table 40.

4.8 Enabling environment and institutional architecture for TNA implementation

The successful introduction, scaling and sustainability of priority technologies identified through the TNA depend not only on the availability of appropriate technological solutions, but also on the broader enabling environment and the institutional mechanisms through which these solutions are implemented. Expert consultations highlighted a number of cross-cutting non-technology challenges that affect technological innovation across sectors. Addressing these challenges in a coordinated manner, through an effective institutional architecture, is essential to ensuring that TNA priorities are translated into tangible development outcomes.

Table 40. Technology Needs categorised across four sectors and sub-divided into those requiring importation and those that have potential for local assembly and manufacture

Technology sub-Category	Agriculture – Crop Production	ICT	Energy – Hydro & Solar	Mining – ASM & Oversight
1(a) Machinery and Manufactured Products Requiring import	• 4WD tractors & combine harvesters • Controlled-environment greenhouse modules • Precision drip-irrigation controllers • Nano-fertiliser delivery systems • Biotech/GM seeds • Advanced controlled-release fertilisers • Automated fertigation controllers	• High speed networking equipment • Data Centre infrastructure • Enterprise servers, desktops & laptops • High-capacity switches & routers • Enterprise-grade UPS units • 3D-printers • Robotics kits • Advanced microprocessors	• Charge controllers & transformers • Hydro-turbine runners & governors • High-voltage transmission cables • Specialized slip rings & switchgear	• Heavy earth-moving equipment • Mechanized pumps & mini-excavators • Low-vibration hydraulics & multi-stage crushers • Hand-held X-Ray Fluorescence, Atomic Absorption & UV–Visible spectrometers • Microfluidic assay kits • Full PPE kits (respirators, full suits)
1(b) Machinery and Manufactured Products Potential for local assembly and manufacture	• Walking-tractor frames & implements • Shellers, dehullers & maize mills • Sluice-box frames for drip systems • Solar-drier racks • Hermetic-bag assembly • Simple post-harvest machines • Community seedbanks • Biofertiliser production • Local granule fertiliser blending • Gravity-fed irrigation kits & treadle pumps	• Data centre construction / assembly • Internet Exchange assembly • PC assembly (housings, keyboards, mice) • Network-cable & patch-panel fabrication • Basic IoT-gateway enclosures	• Solar PV panels • Lithium battery cells • Inverters • Module mounting structures & support frames • Battery-bank integration racks • Repair & fabrication of small hydro parts • Solar mini-grid installation & maintenance • Small-scale hydro refurbishment workshops	• Sample splitters & riffle boxes • Manual pumps & sluice-box frames • Basic low-emission crusher bodies • Local PPE distribution & basic manufacture • ASM training centres & cooperatives • Community-based environmental monitoring

2(a) Digital Tech Hardware requiring import	• Multispectral & thermal drones • Advanced soil-moisture/nutrient sensor nodes	• Telecom-grade routers, firewalls & cellular gateways	• Smart-grid controllers & Programme Logic Controller (PLC) systems • High-precision energy meters	• Survey drones & Light Detection and Radar (LiDAR) units • IoT sensors for dust, noise & water quality • Precision GPS survey instruments • Gas detectors, • Ground stability sensors
2(b) Digital Tech Hardware Potential for local assembly and manufacture	• Drones • IoT gateway nodes & edge-compute boxes • Sensor mounts & weather-station frames	• Enclosures for network racks & IoT hubs • Cable harnesses & patch-cord assemblies	• Edge-computer gateways for micro-grids • Control-panel housings & sensor racks	• IoT gateway & edge devices • Sensor housings & mounts
3(a) Digital Tech Software tools and services requiring import	• Proprietary precision-agricultural analytics suites • Commercial farm-management Enterprise Resource Planning	• Licensed Geographic Information System / Computer Aided Design packages • Enterprise cybersecurity toolkits	• Commercial Supervisory Control and Data Acquisition & grid-management software	• Licensed Geographic Information System mapping • Portable X-Ray Fluorimetry calibration suites • Enterprise blockchain platforms
3(b) Digital Tech Software tools and services Potential for local production	• Mobile farm-management & soil-monitoring apps • SMS advisory & market-price services • Simplified Enterprise Resource Planning apps	• Network Management Systems • Content Delivery Networks • App development for local solutions • Open-source cybersecurity & blockchain toolkits • IT training academies • Local helpdesk & managed-service providers	• Micro-grid monitoring dashboards • Solar-pump & battery-management mobile apps	• Artisanal and Small-scale Mining permitting & record-keeping platforms • Quantum Geographic Information System -based mapping toolboxes • Blockchain-based traceability & smart contracts
4(a) Data Management /Big Data Tools - requiring import	• Subscription satellite-imagery analytics • Commercial agronomic data feeds	• Cloud Business Intelligence licences (Amazon Web Services: Redshift, Azure Synapse) • Proprietary analytics engines	• Commercial energy-forecasting tools	• Commercial data-warehouse solutions • Remote-sensing analytics subscriptions
4(b) Data Management /Big Data Tools Potential for local production	• Open-source dashboards & Extract, Transform and Load pipelines • National soil / crop / environmental data bases	• On-premise Hadoop/ Spark clusters • Custom Extract, Transform and Load & Business Intelligence workflows	• Open-source energy-data portals & historians	• National Artisanal and Small-scale Mining dashboard (Extract, Transform and Load + data lake for data integration) • Open-source Laboratory Information Management & Business Intelligence dashboards

4.8.1 Creating an enabling environment

A number of cross-cutting non-technology challenges to technological innovation emerged in the expert consultations. Equal attention must be paid to these issues for the successful introduction and implementation of new technologies.

Mindset. Mindset was frequently raised by respondents as a critical issue, and one that is also highlighted within Malawi's blueprint for national development, Malawi 2063. It is recognised that there is a need for a collective move towards national self-reliance and the development of a 'can-do' attitude. This attitude is increasingly being observed among the growing number of young Malawian entrepreneurs, but needs to be encapsulated more widely within the innovation ecosystem, the education system, and government as a whole. This drive was highlighted by the repeated observation that Malawi needed to develop its own manufacturing capacity rather than rely on imports. Linked to

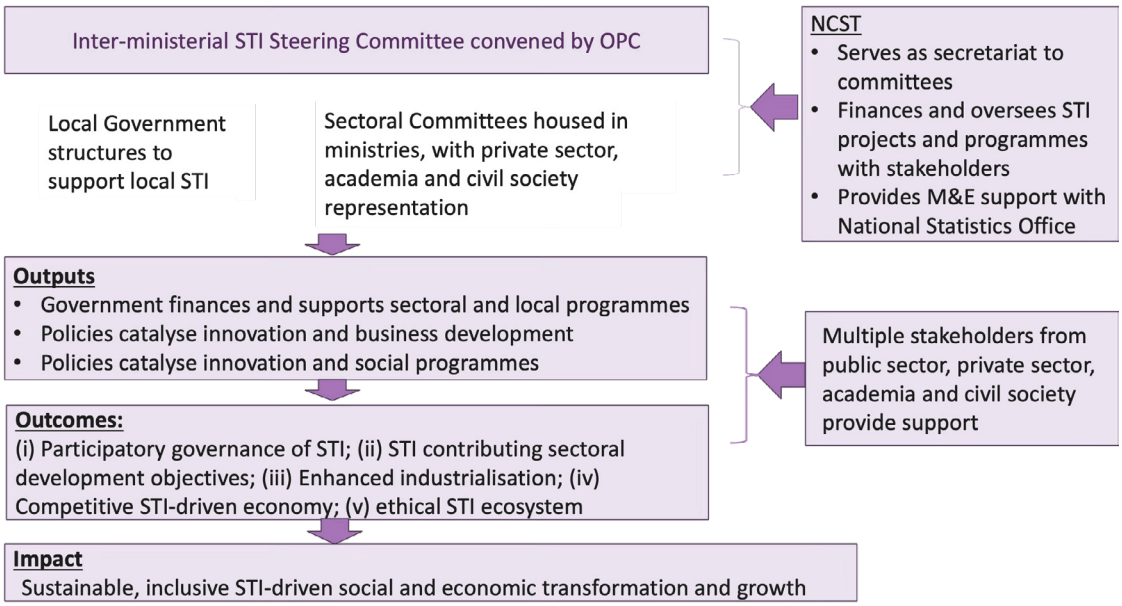
this aspect is a need for Malawian society to become less insular and to be better informed about global technological developments.

Human capital and training. Malawi's low attainment across the educational system is being addressed through a number of policies and strategies, but many, including the national education policy, require updating. The need for the practical application of learning to be embedded within education and training curricula was highlighted throughout this study. This is increasingly being addressed within Higher Education Institutions, with the public universities LUANAR, MUST, MUBAS, UNIMA and MZUNI being particularly relevant to the sectors under discussion here. The need for TEVET expansion is also critical and is recognised through the 'Zanchito Skills for Jobs Programme', a major programme supported by the European Union linking TEVET to entrepreneurship and job creation. Local innovation hubs also contribute significantly to training and need to be expanded

Finance and investment. Limited access to finance and investment through established financial institutions was frequently highlighted as a concern, with access to foreign exchange and high interest rates considered particularly critical. There is a need for more grants and low interest loans to promote innovation and start-ups. Current support is provided by: the National Economic Empowerment Fund for diversified loan products for MSMEs; the Malawi Agricultural and Industrial Investment Corporation for investment in large scale farming; the Youth Innovation Fund for small-scale start-up activity in agriculture, tourism and mining; and the Muuni Fund for digital innovation and entrepreneurship. There is, however, no substantive national fund to support research and innovation. The Science and Technology Fund under NCST needs to be properly financed.

Market access. Vibrant markets encourage and support innovation and entrepreneurship. The weak manufacturing base in Malawi has led to a situation where there are weak value chains and a lack of structured markets for agriculture and mining products in particular. For example, the only agricultural product with a structured market is tobacco. This is further exacerbated by limited access to critical inputs, especially key imported materials. Malawi is a signatory to the African Continental Free Trade Agreement (AfCFTA), the Common Market for Eastern and Southern Africa (COMESA), and Southern African Development Community agreements to limit barriers to trade. It is also seeking to enhance its transport, energy and IT infrastructure to support market access. The Malawi Investment and Trade Centre promotes effective participation in markets for all stakeholders, for example,

Figure 11. Overarching coordination infrastructure for Science Technology and Innovation from draft national STI Policy



through developing market information systems. A coordinated approach to support innovations to access markets will be essential for developing Malawian competitiveness.

Policy and Regulation. A strong, coherent and effective policy and regulatory environment can support innovation and entrepreneurship. Several policy areas require updating. Some policies have led to regulations that are overly prescriptive and lack the flexibility required to accommodate rapid technological change. Effective policies should lead to the establishment of an institutional framework that meets the needs of a changing technological landscape. Recent national policies have been developed for agriculture, mining, information and digitalisation, and energy. Business practices have been supported through the Companies, Registrations and Intellectual Property Centre Act of 2025, and the several polices are in the process of revision, including the Science, Technology and Innovation Policy and the National Industrial Policy. The use of regulatory sandboxes to allow the introduction of new technologies under appropriate oversight before determining regulatory frameworks could mitigate the adverse effects of developing poor regulation and legislation.

4.8.2 Institutional architecture for operationalising the enabling environment and implementing the TNA

Building on the enabling environment described above, there are common features for implementation across all four prioritised technology areas. All four areas focus on the systemic application of multiple technologies, involving multiple sectors and stakeholders, rather than focusing on any one isolated technology. It is therefore critical that there is coordinating oversight.

The goal of addressing priority needs is to integrate and operationalise technology interventions into the national public and private sector frameworks. Moving forward, it is important that the implementing architecture is integrated within existing national structures or planned structures and systems, and does not duplicate or establish parallel structures, which would further complicate coordination and could themselves become barriers to implementation. Effective implementation will therefore require strong coordination among relevant ministries, research institutions, private sector actors and development partners.

The draft National STI Policy proposes a national architecture for innovation, summarised in the figure below, that can be utilised for TNA implementation

Critical components of this architecture are:

1. An overarching interministerial STI steering committee convened by the Office of the President and Cabinet
2. Sectoral committees housed within ministries that have private sector, academia and civil society representation
3. Local government structures to support STI and assist local development, capacity-building and monitoring at local level
4. All of these structures are serviced by the National Commission of Science and Technology (NCST), which serves as Malawi's lead advisory body on research, science, technology and innovation. The NCST, in partnership with the National Statistics Office (NSO) also has responsibility, and is developing further capacity, for extensive monitoring and evaluation through regular R&D and Business and Community Innovation Surveys, along with other standardised NSO surveys.

Technology Needs Assessment activities and projects easily sit within this overarching architecture. Another critical component of national development architecture are the Sector Working Groups that facilitate an interface between Government ministries and development partners and which regularly undertake broad stakeholder meetings that incorporate the private sector, academia and civil society. These working groups help prioritise development financing and monitor the outputs and outcomes of development financing.

The following matrix provides further suggestions on how the implementation measures, challenges, opportunities and risks highlighted within the four prioritised technology areas may be addressed.

Table 41. TNA Implementation Matrix

Strategic Issue	Main Activity	Lead Institution(s)	Supporting Institutions
Overarching Implementation Oversight	• Oversight / guidance / prioritisation / coordination of intersectoral activities and projects	• Steering Committee of the Office of the president and Cabinet	• Lead Ministries of TNA priority area • (i) and (ii) Agriculture, Irrigation and Water Development • (iii) Energy and Mining • (iv) Information and Communications Technology • NCST
TNA related policy and strategy	• TNA related policy and strategy review, development and integration to facilitate activities	• Sectoral committees operating under lead ministries • Office of the President and Cabinet	• NCST
Scaled up 'on the ground' implementation	• Pilot projects and planning for scale-up • Incentivising private sector and other partners	• Lead Ministries of TNA priority area • Ministry of Finance, Economic Planning and Decentralisation,	• Other line ministries • Private sector • Academia • Civil society
Industrial scale-up and local production and manufacture	• Establishment of manufacture and service facilities • Establishment of new SMEs / tech companies	• Private sector • Entrepreneurs • Ministry of Industrialisation, Business, Trade and Tourism	• Other line ministries • Academia • Civil society
Research and Innovation	• Adoption, adaptation and development of technological innovation	• NCST • Private sector • Academia • Innovation hubs	• Ministry of Education Science and Technology • Ministry of Labour, Skills and Innovation • TNA lead ministries
Capacity building – planning skills needs	• Assessing short term human capital needs for TNA activities • Assessing long-term human capital needs for TNA activities	• Ministry of Labour, Skills and Innovation • TNA lead ministries	• Ministry of Education Science and Technology • Ministry of Industrialisation, Business, Trade and Tourism
Capacity Building through professional training	• Research capacity • Professional skills • Technical skills • Business / entrepreneurship skills	• Academia • NCST • TEVETA • Private sector • Innovation hubs	• Ministry of Education Science and Technology • Ministry of Labour, Skills and Innovation • TNA lead ministries
Capacity building at community level	• Community literacy, • Technical literacy, • Financial literacy • Digital literacy	• TNA lead ministry outreach and extension units	• Innovation hubs • Civil Society
Ensure environmental sustainability	• Meeting environmental standards as outlined in the Environment Management Act e.g. through Environmental and Social Impact Assessments of 'prescribed' projects	• Malawi Environment Protection Authority	• Organisations seeking to implement 'prescribed' projects e.g. Mining plus large-scale agriculture, renewable energy, and construction and mining

Generating and coordinating financing	• Identifying and overseeing finance	• Ministry of Finance, Economic Planning and Decentralisation • Private sector	• TNA lead ministries • Other line ministries • Development partners • Civil Society
Sources of Finance	• Supplying finance for TNA scale up	• Government • Private financial sector • Private equity • International and regional development finance institutions • Development partners	• Philanthropy • Civil society
Public Private Partnership	• Coordination of large scale public private partnerships for TNA implementation	• Public Private Partnership Commission	• Government • Private Sector • Other stakeholders (academia, civil society)
Gender mainstreaming	• Ensuring gender issues are incorporated into strategic planning and TNA implementation	• TNA lead ministries • Ministry of Gender, Children, Disability and Social Welfare	• Implementing stakeholders: private sector, civil society and academia
Aligning policy and action with international agreements and obligations e.g. SDGs, AU Agenda 2063	• Ratification of conventions • Aligning policies accordingly	• TNA lead ministries • Office of President and Cabinet	• Ministry of Foreign Affairs
Monitoring and Evaluation	• Ensuring key targets by projects and programmes are met both at internal project / programme level and at national level	• Lead institutions overseeing projects and programmes • NCST and NSO for national science technology and innovation monitoring	• Stakeholders for provision of data

Chapter 5
Conclusions and Recommendations

5.1 Conclusions

Science, Technology and Innovation (STI) in Malawian development

STI is increasingly recognised as critical to social and economic development in Malawi. It is highlighted as a core component of industrialisation within Malawi 2063, the nation's vision for long-term development, and is being actively promoted within the public and private sectors. There has been an expansion of public universities active in STI and research, as well as investment in the development of industrial parks, and a growth in technology-oriented start-ups. This activity is, however, starting from a low base, given Malawi's status as a low-income country. Increased public and private sector investment in STI is required in order to transform Malawi into a competitive middle-income economy, and the country is in the process of revising its National STI policy to help address this. Limited access to finance, a relatively small manufacturing base, and weak private sector R&D investment also constrain the absorptive capacity of firms to adopt and scale new technologies.

Innovation is required across multiple sectors to deliver on industrialisation and growth, whether these be commercial sectors such as Agriculture, Mining, Tourism, and industry in general, infrastructure sectors such as ICT, Energy, Transport, Construction and Water, or socially-oriented sectors such as Health, Education and the Environment. Given the inter-connected nature of today's economy, investment in any individual sector is in fact an investment in all. This interconnectedness highlights the fact that the prioritisations that have taken place to identify sectoral-oriented technologies in this TNA do not in any way reduce the significance of investment for innovation in those sectors not selected.

Sector selection and technology prioritisation for the TNA

The operational necessity of prioritising technology selection led to the identification of the commercial sectors of Agriculture and Mining and the infrastructural sectors of ICT and Energy as key sectors that would benefit from innovation and where that innovation would benefit Malawi's economy. There were several factors behind this decision. Agriculture is the foundation of Malawi's economy, and when combined within the broader agrifood industry, it accounts for 44% of Malawi's GDP and 77% of Malawi's workforce. The Mining industry is nascent in Malawi, but is regarded as a major driver of industrialisation and economic growth, with the aim of increasing its contribution to Malawi's GDP from 1% in 2023 to 10% by 2030 and indications that this target could be reached by 2027. The ICT sector lies at the centre of information management in today's increasingly knowledge-driven economy and is a major driver of innovation across all sectors. Energy is a prerequisite for innovation across all sectors, with an objective to attain 70% electricity access by 2030.

The TNA concluded by focusing on 4 main areas of technology that incorporated ICT and energy technologies with agriculture and mining technology needs. These were: (i) the domestication and securing of farming inputs including fertiliser, seed development, irrigation, mechanisation, warehousing and off-grid solar power; (ii) the digitalisation of farm operations and precision agriculture, including soil sensors, automated drip irrigation, drones, software apps, logistics and blockchain; (iii) support for artisanal and small-scale mining, including mechanised hand tools, mineral processing, IoT sensors, assay labs and off-grid solar; and (iv) domesticating big data management capabilities for agriculture and mining, including data centres and cloud computing, unified sectoral data platforms, IoT and remote sensors, advanced data analytics, and AI and cybersecurity management.

The selected areas highlight the need for a systemic, multi-disciplinary approach to innovation, and its application to developmental issues.

Domestication of technologies

A recurrent theme emerging from consultations across all technology areas was the need for Malawi to develop capacity for the assembly, manufacture and maintenance of relevant technologies where feasible. This would promote national self-reliance and industrialisation, create employment, and minimise balance of payments challenges.

Mechanisation and manufacture

Allied to the domestication of technologies is an urgent need to develop manufacturing capabilities to take advantage of both the external and internal adoption, adaptation and development of new technologies. Manufacturing Value Added contributed to 21.1% of GDP in 1992, dropping to 11% in 2024. Malawi is having to rely on imports of simple machinery and spare parts, along with costly operational delays that, with appropriate investment, could be manufactured in Malawi.

Technical capacity for research and innovation is available, but limited

There is growth in higher education and post-secondary TEVET education, and a corresponding increased research and innovation engagement, including within an increasingly vibrant MSME sector. However, Malawi ranks 125th out of 139 countries in the 2025 Global Innovation Index, and the most recent figures available (2019) indicate that Gross expenditure on R&D represents only 0.18% of GDP. Malawi's research expertise is variable. There is significant research in the agriculture sector, but limited research in the mining sector. Malawi is becoming a regional leader in areas such as drone technology and artificial intelligence, but lags behind in agricultural biotechnology and the application of blockchain technologies. There is a need to stimulate more investment in research and innovation, including within the private sector.

Policy alignment with commercial needs

Many interviewees referenced a need for improved strategic planning and implementation, linking across the global value chains of sectors from innovation to market delivery. This included better integration of innovative sectors with trade and industry strategies and action plans. Operationally, businesses cited examples where the application of antiquated and overly-prescriptive trade regulations inhibited the import and licensing of new technologies.

Partnerships

Partnership is self-evidently critical for innovation and development. There are several examples of significant public-private partnership infrastructure and service delivery projects overseen by the Public Private Partnership Commission, with partial financing coming from the World Bank Group. These include the Digital Malawi Acceleration Project that incorporates the establishment of a National Data Centre, and investment in the Mpatamanga hydropower project and several solar parks. There is, however, need for more partnership projects linking government, the private sector, academia and civil society for smaller-scale research, innovation and entrepreneurship projects. It is hoped that the institutional architecture of the draft National STI Policy (figure 12) will help address this issue.

Investment

Malawi is one of the poorest countries in the world, and so finding resources for investment will always present a challenge, especially for a government with limited fiscal room for manoeuvre. This has been exacerbated for the private sector by high exchange rates and limited access to foreign exchange, which may account for the reduction in the Manufacture Value Added contribution to GDP in recent years. Despite these challenges, resources for research and innovation must be identified if the TNA recommendations, and innovation more generally, are to be realised in Malawi.

While the identified technologies present important opportunities for long-term transformation, Malawi's current macroeconomic context, including limited fiscal space and investment capacity, may constrain large-scale deployment in the short term. Progress in these areas will therefore depend on strengthening the country's economic foundations, mobilising investment, and adopting a phased and prioritised approach to technology uptake.

The pace and scale of technology adoption will therefore depend on available financial resources, institutional capacity and partnership opportunities, and may require phased implementation over time.

Galvanising the youth - equitable realisation of the demographic dividend

Malawi is a youthful economy. Many of the youth completing their secondary schooling, technical college training and university education

recognise that, for them to succeed in life, they will have to generate their own income through innovation and entrepreneurship rather than rely on paid employment. Their energy is driving the growth of MSMEs in Malawi, notably in the agriculture and ICT sectors. There is a need to nurture and enable this ambition. Paying attention to gender issues throughout this process will help mainstream gender equality within Malawi society.

5.2 Recommendations

Many of the recommendations listed below align with existing policy and multiple development projects. It is anticipated that the emphasis placed here on technology adoption, combined with its domestication, local adaptation and development, will add value to ongoing efforts and facilitate a coherent systems approach to national development.

1. Science, Technology and Innovation (STI) in Malawian development

STI and the development of the Malawian innovation ecosystem should remain at the centre of national economic development and planning, aligned with the full implementation of the previous Science and Technology Policy (2002) and the National STI Policy currently in development. STI should be integrated into national planning and the delivery of Malawi 2063 through a systems-based approach, recognising its capacity to support mindset change. This could be supported, for example, through the proposed institutional architecture for TNA implementation outlined in Chapter 6.

2. TNA technology prioritisation

The sub-sectoral areas and associated technologies, along with the implementation plan outlined in Chapter 5, should be supported in a holistic manner, recognising their interconnectedness. Pilot projects should be designed with scale-up in mind rather than as isolated endeavours, whilst recognising the importance of incentivising the private sector and community engagement for long-term sustainability.

For the area of the **domestication and securing of farming inputs**, the current focus on fertiliser manufacture, irrigation, including solar-powered irrigation, warehouse construction and off-grid solar systems should be built upon and extended. There is need to significantly increase national capacity for seed development, especially the application of tissue culture and genetic engineering techniques. There is need to strongly promote agricultural mechanisation and associated local manufacture. The value of integrating community warehousing with solar-powered refrigeration for community development and reduction of post-harvest loss also deserves attention;

For the area of **digitalisation of farm operations and precision agriculture**, there is need to expand soil sensor use and automated drip irrigation beyond the large farms and estates. There is need to build on Malawi's drone expertise, to apply remote sensing technology to agriculture, and to support young IT professional and entrepreneurs to develop local software apps that address local challenges. There is need to build capacity for the application of IoT sensors and blockchain technology to support the monitoring and tracking of warehouse and transported goods. The application of this technology can greatly aid agricultural commercialisation.

For the area of **support for artisanal and small-scale mining**, the potential for the local manufacture and repair of simple mechanised hand tools and other machinery should be noted and supported. Support should be given to improved mineral processing technologies, the use of IoT sensors, mobile assay labs and off-grid solar systems, recognising their impact on both commercial productivity and on health and safety. The application of these technologies is currently at a very low level in the ASM sector and could benefit from the synergistic growth of equivalent technologies in the agriculture sector.

For the area of **domesticating big data management capabilities for agriculture and mining**, there is need to build on the current development of the National Data Centre and plans for its future expansion, along with promoting the development of private sector data centres. There is need to further unify and integrate interoperable sectoral data platforms, connecting them to IoT and remote sensors through edge gateway analytical capacity. Mining sector

data management has particular potential to help formalise the ASM sector. There is need for enhanced skill development through higher education for the scale-up of data management, including in advanced data analytics, artificial intelligence and cybersecurity. A balance should be sought between providing public open access to big data and the potential to monetise access to certain data and its analysis, while continually ensuring the required levels of personal and confidential data protection are met.

3. Domestication of technologies

The sustainability of any technology scale-up requires domestication of the skill sets to operate and manage the technology, and ultimately to adapt and develop it further to meet local national requirements. Human capital development therefore lies at the heart of domestication. Sustainability is further entrenched if there is internal capacity to maintain, assemble and manufacture the technologies. Planning for these capabilities must be built into associated technology acquisition and development plans. In addition to government and private investment, such capabilities may be reinforced through negotiating and securing capacity-building obligations into foreign direct investment agreements, public-private partnerships and government contracting.

4. Mechanisation and manufacture

Local maintenance, assembly and manufacturing capabilities represent a key component of national capacity to domesticate a technology. The mechanisation of the agriculture and mining sectors represents an opportunity for local manufacture, building on the investment in TEVET education underway, for example, through the EU-financed Zantchito project, and several university initiatives. There are artisans in towns and cities building equipment, such as maize shellers, on the roadside and in small workshops with expertise that could be scaled up, standardised and quality-assured in a small factory environment. Financial and development models are required to scale up such enterprises. This expertise could provide the foundation for the support industries required for scaled-up industrialisation of the agriculture, mining and other sectors.

5. Building technical capacity for research and innovation through financing R&D

There is a need to increase local research and innovation capacity across higher education, government, philanthropic and private sectors, with special efforts to incentivise private sector R&D. This can in part be achieved by establishing more university doctoral programmes, with student scholarships and associated research funding. It could be further consolidated by fully financing and operationalising the Science and Technology Fund to finance research and innovation under the oversight of the National Commission for Science and Technology as mandated by the Science and Technology Act (2003).

6. Policy alignment with commercial need

There is a need to resolve conflicts between policy, commercial, and societal needs. This can be done through creating mechanisms for policy and guideline review when such conflicts are identified. It is further recommended to establish regulatory sandboxes so that the trialling of new products, services or business models can take place under regulatory observation, but with relaxed rules, so that regulators fully understand the technology and its implications before developing regulatory frameworks.

7. Partnerships

Mechanisms to promote academia-industry partnerships, in particular, are required to stimulate innovation. This might be achieved through joint conferences and fairs. Another way forward would be for the Science and Technology Fund referred to above to provide funding for joint industry academic research projects, with appropriate agreements in place to manage intellectual property. The establishment of Technology Transfer Offices in Universities also provides a potential pathway for academia-industry collaboration. High-level public-private partnerships to support essential infrastructure development should also continue to be promoted through the Public-Private Partnership Commission.

8. Investment

Investment requires a blend of government, private sector and development partner support

for adopting, adapting, developing and scaling up innovation. In addition to the grants and public-private partnership approaches mentioned above, the government may need to incentivise private sector investment, for example, through tax concessions. The promotion of innovative business models, for example, pay-as-you -go models, may also help facilitate consumer entry into the use of technology and provide suppliers with a more sustained income. IoT technology facilitates this model, which is increasingly used in the data access and renewable energy sector. There are variations on this approach for the hiring of equipment for agriculture and mining use (for example, hello tractor, solar pumps, drones) that can facilitate access.

9. Galvanising the youth

The Malawi Government recently initiated a Youth Innovation Fund with tiered grants for different levels of business development, supported by pre-award training and incubation to help develop market-ready products. The continued development and extension of this approach, for example, linking young innovators to higher education technical expertise to help them develop their technologies, could be helpful. Youth-led innovation can also be supported through the expansion of innovation hubs to more districts across the country, beyond just the major cities.

10. Strengthening institutional capacity and coordination

Effective implementation of the identified technologies and STI recommendations will require strong coordination across government institutions, as well as clear roles and responsibilities among implementing entities. It will also depend on sustained collaboration with the private sector, financial institutions, academia and development partners. The TNA process itself has highlighted the need to further strengthen institutional capacity and coordination mechanisms in Malawi, including those for the planning, implementation and monitoring of innovation-related initiatives. Addressing these aspects will be essential to ensure that identified technologies can be effectively adopted, scaled and sustained over time.

Annex 1

List of stakeholders consulted

1. Albert Mwenifumbo – Chair of the Agriculture Technology Clearing Committee, Ministry of Agriculture
2. Ronald Ngwira – Chief Executive Officer, Pyxus (Groundnuts)
3. Kondwani Msimuko – Finance Director, Illovo Sugar Malawi
4. Ngabaghila Chatata – Managing Director, Thanthwe Enterprise
5. Dr. David Dalison Mkwambisi – Director, Institute of Industrial Research and Innovation, Malawi University of Science and Technology (MUST)
6. Prof. Emmanuel Kaunda – Vice-Chancellor, Lilongwe University of Agriculture and Natural Resources (LUANAR)
7. Dr. Sam Katengeza – Director of Research, Lilongwe University of Agriculture and Natural Resources (LUANAR)
8. Fredrick Changaya – Director General, National Planning Commission (NPC)
9. Derrick Kapolo – Representative, Farmers Union of Malawi (FUM)
10. Dr. Betty Chinyamunyamu – Chief Executive Officer, National Smallholder Farmers' Association of Malawi (NASFAM)
11. Steven Perete – Deputy Director, Malawi Communications Regulatory Authority (MACRA)
12. Paul Katema – Director, Public Procurement and Disposal Authority (PPDA)
13. Ms. Thandi Mbvundula – Chair, Task Force, Malawi Space Agency
14. Prof. Michael Zimba – Professor, Malawi University of Science and Technology (MUST)
15. Dr. Chimango Nyasulu – Lecturer and Head of ICT Department, Mzuzu University
16. Alexius Chipalamwazani – Network and Infrastructure Manager, Malawi Research and Education Network (MAREN)
17. Kondwani Mushali – Founder, Neytech Solutions
18. Wisely Phiri – Chief Executive Officer, Sparc Systems
19. Wangiwe Joanna Kambuzi – Managing Director, ED Mzuzu e-Hub
20. Matthews Kanyenda – Director and Chief Economist (ICT), Ministry of Information and Digitalisation
21. Watipasa Zikomo Kamanga – Deputy Director (IT), Department of E-Government
22. Wezi Salima – Representative, MUUNI Fund
23. Monalisa Ndau – Representative, MUUNI Fund
24. Eugene Masey – Managing Director, NextGen
25. MacMillan Chisale – Chief Technical Officer, Malawi Energy Regulatory Authority (MERA)
26. Pachalo Mwanza – Planning, Monitoring and Evaluation Specialist, Malawi Energy Regulatory Authority (MERA)
27. Maxon Chitawo – Chief Executive Officer, Electricity Generation Company (EGENCO)
28. Dr. Wayne Decker – Founder, Flame Tree Initiative
29. Saidi Banda – Deputy Director, Department of Energy
30. Emmanuel Banda – Representative, Technical, Entrepreneurial and Vocational Education and Training Authority (TEVETA)
31. Benjamin Chisamile – Representative, Ministry of Mining
32. Sandress Luhanga – Representative, Ministry of Mining
33. Mphatso Chikoti – Acting Director of Mines, Ministry of Mining
34. Ashraf Banda – Chief Economist, Ministry of Mining
35. Dr. Paulos B. Nyirenda – Chief Executive Officer, National Commission for Science and Technology (NCST); National Coordinator, Sustainable Development Networking Programme (SDNP)
36. Dr. Solomon Dindi – Chief Executive Officer, Malawi Research and Education Centre; Malawi Research and Education Network (MAREN)
37. Francis Masi – Director, UniPOD
38. George Chande – Director of Planning, Ministry of Labour
39. Gladstone Mchoma – Health Economist, Ministry of Health

40. Chisomo Kapito – Economist, Department of Land Resources Conservation
41. Charles Kumchenga – President, Malawi Congress of Trade Unions (MCTU)
42. George Khaki – Executive Director, Economics Association of Malawi (ECAM)
43. Patricia Zimpita – Director of Planning, Ministry of Industry, Trade and Tourism
44. Catherine Chilima – Representative, Ministry of Trade and Industry
45. Dr. Gelard Manthalu – Director of Planning, Ministry of Health
46. Dr. Hamilton Kamwana – Director of Planning, Ministry of Natural Resources and Climate Change
47. Department of Digitization
48. Malawi Rural Electrification Programme (MAREP)
49. Department of Agricultural Extension Services (DAES)
50. Department of Agricultural Research Services (DARS)
51. Department of Crop Development (DCD)
52. ICT Association of Malawi (ICTAM)
53. Ministry of Energy
54. Department of Energy Affairs (DEA)
55. Private sector renewable energy developers and associations

Annex 2

Malawi TNA Committee

1. Shadrick Kumtengo, Distribution Officer, Copyright Society of Malawi
2. Humphrey Mdyetseni, Chief Executive Officer, National Economic Empowerment Fund (NEEF) Limited
3. Daisy Kambalame, Chief Executive Officer, Malawi Confederated Chambers of Commerce and Industry (MCCCI)
4. Compstone Clifford Soko, Business Information and Advisory Officer, Small and Medium Enterprises Development Institute (SMEDI)
5. Benjamin Chisama, Technology Dissemination Officer, Department of Agricultural Research Services (DARS)
6. Robins Mwanga, Business Information Executive, Malawi Investment and Trade Centre (MITC)
7. Bryson Mkhomaanthu, Chief Executive Officer, PressCane Limited
8. Gibson Ngalamila, Executive Secretary, Press Trust
9. Dr Bernard Thole, Chief Executive Officer, Malawi Bureau of Standards (MBS)
10. Ronald Ngwira, Managing Director, Pyxus Agriculture Limited
11. Daniel Ekali Kwizombe, Managing Director, Dek Engineering
12. John Lungu, General Manager, Quton
13. Livison Levis Msonthe, Technology Transfer Office Manager, Malawi University of Business and Applied Sciences (MUBAS)
14. Madalitso Tsakama, Head of Research and Innovation, Malawi University of Business and Applied Sciences (MUBAS)
15. Prof. Fanuel Kapute, Director of Research, Mzuzu University
16. Samson Katengeza, Director of Research, Lilongwe University of Agriculture and Natural Resources (LUANAR)
17. Henderix Kaonga, Director of Research, Catholic University of Malawi (CUNIMA)
18. Maurice Monjerezi, Director of Research, University of Malawi (UNIMA)
19. Prof. Angela Chimwaza, Director of Research, Kamuzu University of Health Sciences (KUHeS)
20. Afred Maluwa, Director of Research, Malawi University of Science and Technology (MUST)
21. Mary Sibande Kumwanje, Director of Research, University of Livingstonia (UNILIA)
22. Dr Alice T. Mbewe, Translational Science Champion, Malawi-Liverpool Wellcome Trust
23. Supply Kawayawaya Chisi, Business Development Officer, Seed Trading Association of Malawi (STAM)
24. Modesta Tembo, Head of Member Services and Outreach, Farmers Union of Malawi (FUM)
25. Gift Numeri, National Director, Civil Society Agriculture Network (CISANET)
26. Albert Changaya, Chief Executive Officer, Agricultural Research and Extension Trust (ARET)
27. Clarence Gama, Chief Executive Officer, NICO Technologies Limited
28. Moses Munthali, Principal Agricultural Research Scientist, Chitedze Agricultural Research Station
29. Thomas Kaluvi, Technology Transfer Officer, National Commission for Science and Technology (NCST)
30. Isaac Chingota, Chief Technology Transfer Officer, National Commission for Science and Technology (NCST)
31. Humphrey Mpondaminga, Director, Department of Arts
32. Million Mafuta, Director of Electricity, Ministry of Energy
33. Captain Jails, Ministry of Transport and Public Works
34. Sabron Benjamin Kalyolyo, Ministry of Transport and Public Works
35. Assoc. Prof. Chomora Mikeka, Director of Science, Technology and Innovation, Ministry of Education
36. Dr Joseph Nagoli, Director of Knowledge and Learning, National Planning Commission (NPC)
37. Gift Kadzamira, Director General, National Commission for Science and Technology (NCST)
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39. Baldwin Chiyamwaka, Secretary for Information, Ministry of Information and Digitalisation
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41. Elwin Sichiola, Executive Director, Technical, Entrepreneurial and Vocational Education and Training Authority (TEVETA)
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43. Dr Rachel Chimbwete Phiri, Principal Secretary for Basic Education, Ministry of Education
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45. Dr Florida Banda, Director of Secondary Education, Ministry of Education
46. Dr Levis Eneya, Director of Higher Education, Ministry of Education
47. Grace Milner, Director of Basic Education, Ministry of Education
48. Dr Golden Msilimba, Director of Quality Assurance Services, Ministry of Education
49. Stonie Chazunda, Director of Finance, Ministry of Education
50. Francisco Zimba, Director of Human Resources Management and Development, Ministry of Education
51. Wilson Nyasulu, Principal Economist, Ministry of Finance, Economic Planning and Development
52. Assoc. Prof. Joshua Valeta, Director of Open, Distance and e-Learning, Ministry of Education
53. Dr Zizwa Msukuma, Director of Teacher Education and Development, Ministry of Education
54. Victoria Geresomo, Director of Education Planning, Ministry of Education
55. Dr George Vakusi, Deputy Director of Science, Technology and Innovation, Ministry of Education
56. Blessings Kaudzu, Director of Internal Audit, Ministry of Education
57. Maureen Maguza Tembo, Deputy Director of School Health and Nutrition, Ministry of Education
58. Arthur Chiphiko, Deputy Director of Education Infrastructure Management Unit, Ministry of Education
59. Chrissie Mtonga, Deputy Director of Information, Communication and Technology, Ministry of Education
60. Mary Mmangisa, Supplies Officer, Ministry of Education
61. Kondwani Jawati, Chief Legal Officer, Ministry of Education
62. Mphatso Nkuonera, Public Relations Officer, Ministry of Education
63. Chigomezgo Gondwe, Strategic Communications Advisor, Ministry of Education
64. Daud Suleman, Director General, Malawi Communications Regulatory Authority (MACRA)
65. Dr Paulos Nyirenda, Chairperson, Malawi Internet Service Providers' Association (MISPA)
66. Charles Kamoto, Managing Director, Airtel Malawi Limited
67. Ted Sauti Phiri, Board Chairperson, Telekom Networks Malawi (TNM) Limited
68. Tom Greenwood, Chief Executive Officer, Helios Towers
69. Country Director, VillageReach
70. Kitty Chingota, Public Relations Manager, Electricity Supply Corporation of Malawi (ESCOM)
71. William Liabunya, Chief Executive Officer, Electricity Generation Company (EGENCO)
72. Emmanuel Nyasulu, Chief Executive Officer, Open Connect Limited (OCL)
73. Benedicto Kondowe, Executive Director, Civil Society Education Coalition (CSEC)
74. Martha Gondwe, National Youth Council of Malawi (NYCOM)
75. Mrs Fanny Kutedze, Acting Registrar, Blantyre International University
76. Hadi Hallouche, Chief Executive Officer, Puma Energy Malawi
77. Alfred Chinombo, Registrar, Malawi University of Science and Technology (MUST)
78. Prof. Michael Zimba, Executive Dean, Malawi Institute of Technology and Founding Lead, Centre for Artificial Intelligence and STEAM (CAIST), Malawi University of Science and Technology (MUST)
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82. Prof. MacPherson Mallewa, Vice Chancellor, Kamuzu University of Health Sciences (KUHeS)
83. Yonamu Ngwira, Registrar, Mzuzu University
84. Solomon Dindi, Chief Executive Officer, Malawi Research and Education Network (MAREN)
85. Ronald Tembo, Head of Universal Service Fund, Malawi Communications Regulatory Authority (MACRA)
86. Dr John Phuka, Innovation Coordination Team
87. Takula Michael Kapalamula, Head of Personal Banking, Standard Bank Malawi
88. Macfussy Kawawa, Chief Executive Officer, National Bank of Malawi
89. Prof. Martin Mkandawire, Scientist in the Diaspora
90. Hazel Shawa, Head of Solutions Mapping, United Nations Development Programme (UNDP) Malawi
91. Her Excellency Fiona Ritchie, UK High Commissioner to Malawi, Foreign, Commonwealth and Development Office (FCDO)
92. Paul Dielemans, Programme Manager, GIZ
93. Hugh Riddell, Country Manager for Malawi, World Bank
94. Dr Natalia Kanem, Executive Director, United Nations Population Fund (UNFPA)
95. Alfred Tsitsi, Project Manager, Food and Agriculture Organization of the United Nations (FAO)
96. His Excellency Liu Hongyang, Ambassador of the People's Republic of China to Malawi
97. Michael Malewezi, Programme Officer, Japan International Cooperation Agency (JICA)
98. Mayamiko Nkoloma, Chief Executive Officer, iMoSys
99. Sanga Kanthema, Founder and Chief Executive Officer, Dolphin Health Innovations and QubiX Robotics
100. Vincent Kumwenda, Chief Executive Officer, mHub
101. Janet Kapito, Operations Manager, Robotics Foundation Ltd
102. Litness Chaima, Communications and Engagement Manager, Mzuzu e-Hub
103. Wangiwe Joanna Kambuzi, Managing Director, Mzuzu e-Hub
104. Eugene Maseya, Managing Director, NxtGen Labs
105. Bright Chidzumeni, Head of Technology and Innovation Strategy, Save the Children
106. Dumisani Kaunda, Co-Founder and Senior Software Engineer, Multicsystems
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108. Richard Chirwa, Director for Technical and Vocational Training, Ministry of Labour
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110. Mtendere Caroline Wemba, Principal Economist, Department of Economic Planning and Development, Ministry of Finance and Economic Affairs
111. Ernest Thipa, Librarian and ICT Officer, Agricultural Research and Extension Trust (ARET)
112. Mrs Chikondano Mussa, Secretary for Labour, Ministry of Labour
113. Paul Katema, Director of e-Government, Ministry of Information and Digitalisation
114. Michel Hebert, Chief Executive Officer, Telekom Networks Malawi (TNM) Limited
115. Dr Mangani Chilala Katundu, Secretary for Education, Ministry of Education
116. Sunduzwayo Jere, Chief Executive Officer, Blue One Ltd
117. Hon. Thabo Chakaka-Nyirenda, Attorney General, Ministry of Justice
118. Hon. Brainax M. A. Kaise, Chairperson, Parliamentary Committee on Science, Education and Technology
119. Dr Thandekile Ndhlovu, Chairperson, Malawi Space Agency Task Force
120. Phillip Madinga, Managing Director, Standard Bank Malawi
121. Zandile Shaba, Managing Director, Centenary Bank Malawi
122. William Mpinganjira, Group Chief Executive Officer, FDH Bank
123. Dickxie Kampani, Secretary for Agriculture
124. Chauncy Simwaka, Secretary for Tourism
125. Dr Joseph Chizotera Mkandawire, Secretary for Mining

126. Dr Samson Mndolo, Secretary for Health
127. Eng. Gerald Khonje, Chief Executive Officer, National Construction Industry Council (NCIC)
128. Dr Anthony Ziba, Director of ICT, Malawi University of Business and Applied Sciences (MUBAS)
129. Dr Amelia Taylor, AI Lecturer, Malawi University of Business and Applied Sciences (MUBAS)


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