



National Commission for Science and Technology

**NATIONAL AGRICULTURE AND
NATURAL SCIENCES RESEARCH AGENDA
(2017 – 2022)**

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National Commission for Science and Technology

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ACRONYMS AND ABBREVIATIONS

GoM	Government of Republic of Malawi
GMO	Genetically Modified Organisms
MDGs	Millennium Development Goals
MGDS II	Malawi Growth Development Strategy II
NCST	National Commission for Science and Technology
NANSRA	National Agriculture and Natural Sciences Research Agenda
NGOs	Non-Governmental Organisations
INGOs	International Non-Governmental Organisations
NCANS	National Committee on Agriculture and Natural Sciences
CDM	Clean Development Mechanism
GDP	Gross Domestic Product

PREFACE

World population is expected to grow by over a third, or 2.3 billion people, between 2009 and 2050 (FAO, 2009). Nearly all of this growth is forecast to take place in the developing countries. Sub-Saharan Africa's population is expected to grow the fastest (114 per cent) while East and Southeast Asia's population is expected to grow the slowest (13 per cent). The projections show that feeding a world population of 9.1 billion people in 2050 would require raising overall food production by some 70 per cent between 2005/07 and 2050 (*ibid.*). This suggests that production in the developing countries needs to almost double; annual cereal production, for instance, need to grow by almost one billion tonnes, meat production by over 200 million tonnes to a total of 470 million tonnes in 2050, 72 per cent of which in the developing countries, up from the 58 per cent in 2009. Feeding the world population adequately would also mean producing the kinds of foods that are lacking to ensure nutrition security.

There is general consensus in support of the observations made above that agriculture in the 21st century faces multiple challenges to produce more food and fibre to feed a growing population with a smaller rural labour force, more feedstock for a potentially huge bio-energy market, contribute to overall development in the many agriculture-dependent developing countries, adopt more efficient and sustainable production methods and adapt to climate change. When Malawi gained political independence in 1964, one of the challenges the young nation faced was to bridge the divide that existed with a dualism. The dualism that has since then continued to persist has been characterized by an agriculture that is bifurcated with strategies in the smallholder sub-sector, designed to attain food self-sufficiency through the smallholder sub-sector, and in the estate sub-sector aimed at catalysing the achievement of economic growth.

The strategies the Malawi government continued to pursue since the country gained political independence therefore took cognisance of the importance of agriculture not only as a catalyst for economic growth, but also in its role as a provider of food, clothing, and employment; as a contributor towards the development of tourism and the alleviation of poverty; and as a promoter of international competitiveness. In 1987, the Malawi government adopted the Statement of Development (1987-1996) in which enhancement of the social welfare and income of the agricultural community and the prosperity and stability of the nation as a whole achieved by means of both improving self-sufficiency in food products and expanding and diversifying export

receipts from agricultural produce were highlighted as some of the priority areas. In 1998, the Malawi government adopted Vision 2020. In Malawi Vision 2020, both agriculture and food security have been identified as key priority areas to fuel economic growth and development. In pursuit of Vision 2020, which is a long-term vision, the Malawi government has been implementing the Malawi Growth and Development Strategy (MGDS) as a medium-term policy framework for social and economic development. The MGDS I (2006-2011) and MGDS II (2012-2016) have aimed at reducing poverty through sustainable economic growth and infrastructure development, with a focus on agriculture and food security as key priority area, increasing agricultural productivity, making Malawi a hunger free nation, and increasing the contribution of agro-processing to economic growth.

In support of these policy initiatives, the Malawi government has been implementing the Economic Recovery Plan (ERP) (2012) aimed at restoring economic stability through, among others, commercial agriculture. The ERP has also been implemented concurrently with the National Export Strategy (NES) (2013–2018). The NES was aimed at both boosting domestic and external trade and improving the competitiveness of Malawian products as well as economically empowering farmers, with a focus on the poorest and most vulnerable groups. In order to achieve agricultural development goals and consistent with the Comprehensive African Agricultural Development Programme (CAADP) under New Partnership for Africa's Development (NEPAD), the Malawi government developed the Agriculture Sector-Wide Approach, ASWAp (2011-2015) designed to foster strategic investment in three socio-economic development areas: (1) food security and risk management; (2) commercial agriculture, agro-processing, and market development; and (3) sustainable agricultural land and water management. The 2016 National Agriculture Policy (NAP) envisions agriculture in Malawi by 2020 to “increasingly be oriented towards profitable commercial farming through specialization of smallholder farm production, output diversification at the national level, and value addition in downstream value chains”.

In consonance with NAP and the other national strategies and to reinforce the development pillars of Vision 2020, this National Agriculture and Natural Sciences Research Agenda (NANSRA), which is an update of the one that had been published in 2012, has identified new and emerging technologies whose use by farmers will nurture and sustain not only household food security but also bridge the dualism between the primary and secondary industries by fostering entry of smallholder farmers into the mainstream. The identification of agriculture and

natural sciences R&D strategies has been predicated upon the desire that any national programmes developed should focus on the generation of new and improved emerging technologies in the areas of land degradation, crop production, crop diversification, seed and germplasm conservation, crop value addition, livestock production, animal products and value addition, animal health, agricultural mechanization, irrigation, biotechnology, climate change, aquaculture, fisheries, forestry, water resources, environmental pollution, and basic sciences.

ACKNOWLEDGEMENT

This NANSRA update has retained the substance of the NANSRA that had been published in 2012. It is, therefore, pertinent to recognise the contributions of the stakeholders and individuals who developed the 2012 NANSRA. Professor James Bokosi (Chairperson), Lilongwe University of Agriculture and Natural Resources (LUANAR); Dr. J. Mwatseteza (Vice chairperson), University of Malawi, Chancellor College; Mrs. F. Munthali, Agriculture Research and Extension Trust (ARET); Dr. Julius Chulu, Department of Animal Health and Livestock Development (DAHLD); Mr. Michael Nkosi, Mzuzu University; Mr. M. W. Kumwenda, National Herbarium and Botanical Gardens (NHBG); Dr. A. Kamperewera, Environmental Affairs Department (EAD); Dr. Hastings Nyirenda, Tea Research Foundation of Central Africa; Dr. Mackson Banda, Department of Agriculture Research Services (DARS); Mr. Henry utila, Forestry Research Institute of Malawi (FRIM); and Mr. G. Z. Kanyerere, Fisheries Research Unit were members of the NCST's National Committee on Agriculture and Natural Sciences (NCANS) who piloted the development of the 2012 NANSRA. To all of them go the NCST's appreciations and thanks. The NCST also wishes to thank members of its Agriculture and Natural Sciences Section (ANSC), including Mr. L. J. Kampira, Chief Research Services Officer - Agriculture and Natural Sciences, Mr. B. J. Mkoko, Country Team Leader for Programme for Bio-safety Systems (PBS), Mr. Y. Chimbanga, Research Services Officer for Agricultural Sciences, and Mr. M. D. Tembo, Research Services Officer for Natural Sciences, for spearheading and coordinating all the activities which resulted in the development of the 2012 NANSRA.

1.0 BACKGROUND

The Government of Malawi (GoM) recognises the importance of agriculture and natural resources in the social economic development of Malawi. The Agriculture sector remains the main driver of economic growth in Malawi. It employs about 80% of the total workforce, contributes over 80% of the country's foreign exchange earnings, and approximately 35% of gross domestic product (GDP). The sector contributes significantly to national and household food security. It is therefore evident that investing in agriculture will foster economic growth and development and assist in attaining the aspirations of Malawians as stipulated in the country's vision 2020.

Natural resources form a principal source of social well-being and economic development in Malawi. These resources are, however, under constant stress from unprecedented human, industrial and other development activities which, if not properly managed, might generate irreversible outcomes in the long-term. It is estimated that unsustainable use of natural resources costs Malawi US\$ 191 million, or 3.5 % of GDP each year. These activities have resulted into a reduction in the proportion of land under forest cover from 41% in 1990 to 35% in 2008 (MDGs Annual Report, 2009). This is compounded by increased climate variations experienced in the form of irregular and unpredictable rainfall and prolonged dry spells, droughts, floods and temperature variability, all of which have in turn negatively affected the performance of sectors such as agriculture and natural resources.

2.0 INTRODUCTION

The conduct of research in agriculture and natural sciences in Malawi dates back to pre-independence era. Since then, the need for agriculture and natural sciences research has been growing in order to inform policy makers and all stakeholders in the sector. Agriculture is key to food security, economic growth and wealth creation. The sector however, faces a number of challenges including low absorption of improved technologies, poor support infrastructure, inadequate markets, weak private sector participation, low value-addition of agricultural and livestock products, low level of irrigation development, over-dependence on rain-fed farming, and lack of investment in mechanization. Consequently, the goal is to increase agricultural productivity and crop diversification, and thereby increasing contribution to sustainable economic growth.

Increasing population growth, coupled with relatively high poverty levels have increased pressure on natural resources and have posed a challenge to the environment. Inadequate alternative livelihoods, unaffordable energy technologies and uncoordinated policies have exacerbated environmental degradation leading to negative social and economic consequences. There is therefore urgent need for strategies aimed at increasing sustainable food production to be implemented. This calls for adequate investment to be made in R&D, in infrastructural capacity improvement, in human development, in the effective implementation of national climate-smart agricultural policy, and in the effective transfer of technologies. Central among these challenges is the improvement of the capacity and capability of national research stations and extension systems. Such investments will enable the government to improve management and sustainable utilisation of the environment and natural resources in order to achieve reduced environmental and natural resources degradation and environmental pollution. Key strategies to achieve this include:

- improving coordination of environment and natural resource management programmes;
- promoting biodiversity conservation programmes;
- promoting development and implementation of clean development mechanism (CDM) projects;
- promoting projects on waste management and air pollution control and other environmentally friendly technologies and practices.

3.0 GOAL AND OBJECTIVES OF THE NATIONAL AGRICULTURE AND NATURAL SCIENCES RESEARCH AGENDA

3.1 Goal

The overall goal of the National Agriculture and Natural Sciences Research Agenda (NANSRA) is to guide policy makers, development partners, researchers at R&D institutions and universities, and other stakeholders on priorities identified in agriculture and natural sciences research in Malawi.

3.2 Specific Objectives

The specific objectives of the agenda are to:

- 3.2.1 Promote the conduct of agriculture and natural science research in response to the priority needs of Malawi;

- 3.2.2 Facilitate the mobilisation of resources for the conduct of locally relevant agriculture and natural sciences research;
- 3.2.3 Promote inter- and intra-sectoral collaboration in the conduct of R&D;
- 3.2.4 Facilitate the coordination of agriculture and natural science research conducted by various stakeholders;
- 3.2.5 Promote the strengthening of capacity for conducting research in Malawi; and
- 3.2.6 Facilitate the transfer of appropriate technologies to the primary and other industries in support of:
 - 3.2.6.1 Increased agricultural production concomitant with ecologically efficient use of resources,
 - 3.2.6.2 National and local energy systems (including specifically small-scale hydroelectric generation),
 - 3.2.6.3 Food processing for domestic consumption,
 - 3.2.6.4 Value-addition of commodities for export.

4.0 GUIDING PRINCIPLES

The implementation of the NANSRA shall be guided by the following principles:

4.1 Political Will and Commitment

Undertaking meaningful research that addresses priority needs of Malawi requires adequate resources available through political will at all levels.

4.2 Value and Demand Driven Research

Stakeholders shall be required to conduct R&D responsive to the identified priority national agriculture and natural resources needs of Malawi.

4.3 Ethics, Human Rights and Law

The dignity and rights of all research participants including vulnerable populations shall be promoted and protected as enshrined in the bioethics principles, constitution of the Republic of Malawi and all relevant Malawi laws, national policies, regulations and guidelines as well as in tandem with international treaties.

4.4 Networking, Public and Private Partnerships and Collaboration

Concerted efforts and strategic partnerships with public and private research institutions and with a cross-section of other stakeholders shall be promoted.

4.5 Multidisciplinarity and Complementarity

Research studies that are multidisciplinary and/or complementary in nature shall be promoted to enhance skills transfer, optimal usage of resources, and translation of research findings into policy and programmes.

4.6 Intellectual Property Rights

Intellectual property (IP) are creations of the intellect for which legal protection may be granted. IP laws may protect, *inter alia*:

- patents,
- copyrights,
- trademarks and
- trade secrets (in some jurisdictions).

and enable innovators to reap the rewards of their innovation ideas and the associated intellectual property (IP). The patenting of innovation ideas and associated intellectual property resulting from research and development (R&D) is the protection of the investment made in R&D, which ensures that these discoveries have the opportunity to reach the stream of commerce. Investments in intellectual property are returned to the public through products that benefit the public, increased employment, and individual and corporate taxes. It is, however, recognised that there is inadequate awareness on the role of IP in most R&D institutions and the society at large. Further there is absence of the institutional technology transfer offices in the universities and R&D institutions to link researchers to industries, through technology negotiations and licensing. The NCST is, therefore, called upon to develop programmes and strategies aimed at creating awareness, building capacity and facilitating the establishment of sector specific IP guidelines, as well as initiating the establishment of technology transfer office in all relevant R&D institutions in the country.

5.0 METHODOLOGY

This section describes the approach and process that were followed in developing the National Agriculture and Natural Science Research Agenda.

5.1 Approach and Process

The setting of research priorities was guided by demand-driven principles; analytical evidence; stakeholder participation; transparency and value-demand. The general process that was followed included the undertaking of the following key activities;

- (a) Establishment of the National Task Force for the Development of the NANSRA with concrete terms of reference;
- (b) National Taskforce Workshop for the Identification of the Thematic Priority Research Areas;
- (c) Gap analysis studies in the identified thematic priority areas of research to inform the drafting of the NANSRA;
- (d) Conducting gap analysis studies by the task force team using literature review, key informant interviews, institutional consultations and focus group discussions as data collection techniques;
- (e) Subgroup meetings for each thematic priority area to review findings of gap analysis studies;
- (f) Revision of gap analysis reports by Task Force;
- (g) National Task Force Meeting to review revised gap analysis reports;
- (h) Drafting of the NANSRA using the gap analysis reports;
- (i) Review of the Draft NANSRA by a special team of advisors in agriculture and natural sciences research;
- (j) Incorporation of comments from a team of advisors;
- (k) National stakeholders' consultative meeting on the draft NANSRA; and
- (l) Finalization of the NANSRA document by incorporating comments from stakeholders workshop.

5.2. Criteria for Setting Priorities

- (a) Intellectual or scientific merit;
- (b) Relevance of the research relative to current research gaps or technical innovation;
- (c) Responsiveness to national priorities, and possible societal benefits;
- (d) Possibility of conducting the research in relation to financial, technical, and human constraints;
- (e) Scientific feasibility of completing the proposed task in the timescale and with the resources proposed;

- (f) Opportunity for spin-off and exploitation.

6.0 RESEARCH AREAS

Degradation and loss of land, water and agro-biodiversity for agricultural use are major constraints to achieving the required increase in agricultural production. Soil is a non-renewable resource on human time scales and some adverse effects of degradative processes on the quality of the topsoil as defined by the effective rooting depth are irreversible. The soil's vulnerability to degradation is a function of complex interactions between processes, factors and causes occurring at a range of spatial and temporal scales. This calls for strategies that aim to increase production of food and fibre crops concomitant with ecologically efficient use of resources. Given in this section therefore are priorities organised in thematic areas that have been identified in key research areas of land degradation, crop production, crop diversification, seed and germplasm conservation, crop value addition, livestock production, animal products and value addition, animal health, agricultural mechanization, irrigation, biotechnology, climate change, aquaculture, fisheries, forestry, water resources, environmental pollution, and basic sciences.

6.1 Land Degradation

The top two manifestations of land degradation are soil degradation and maintenance of soil productivity under population pressure.

6.1.1 Research Priorities for Soil Degradation

6.1.1.1 *Soil Degradation*

- Prevention of soil erosion,
- Maintenance of soil organic carbon pool to above the critical level (>15 g/kg) and nitrogen budgets,
- Site-specific techniques required for the restoration and maintenance of soil quality,
- Integrated soil fertility management,
- Land/soil, water and genetic resources
- Monitoring and measuring specific effects of agricultural activities and farming systems.

6.1.1.2 *Maintenance of Soil Productivity under Population Pressure.*

- Breeding for high yield and adaptability for all major crops,
- Development of area specific agronomic recommendations;

- optimisation of water use efficiency under both irrigated and rain-fed conditions,
- Improvement of nutrient use efficiencies relative to soil heterogeneity,
- Monitoring levels of soil micro-nutrient relative to soil productivity,
- Effective amelioration of effects of soil reaction on crop production,
- Effects of manipulation of the rhizosphere on soil and plant performance,
- Exploiting the genetic variation of plants and animals in support of increased crop production per unit area,
- Interactions between genotype, environment and management,
- Developing climate-smart farming systems.

6.2 Crop Production

Innovative ways of growing food crops must be found if farming communities are to increase and sustain increased crop production per unit area. Post-harvest losses also need to be mitigated through better ways of storage. These objectives can be achieved through R&D.

6.2.1 Research Priorities for Crop Production

- Enhancement of nutritional value
- Improved photosynthetic, nitrogen fixation and nutrient utilization potential
- Improved reproductive efficiency with regard to yield convertibility
- Protection of yield loss due to stress/climate change
- Mitigation of post-harvest loss
- Soil and nutrient management;
- Ways of valorising and using residues and by-products;
- Soil health and fertility improvement;
- Integrated weed, pest, disease and quality management;
- Enhancement of the function of soils as carbon (C) and nitrogen (N) sinks aimed at mitigating emissions of CO₂ (a greenhouse gas).

6.3 Crop Value Addition

Farming communities need to benefit from their efforts. For this to happen, farmers need to add value to their crops as the selling of unprocessed primary commodities brings limited returns to farmers. It is in this respect that agricultural production is increasingly practised in a systems relationship, which implies optimising the entire production chain from primary production

systems, through post-harvesting, storage and preservation, transport and marketing to value addition, both on-farm and off-farm. Value-addition entails, among other things, processing of the primary commodities. To come up with the best ways of processing raw food and preserving them before selling requires innovation as the environment in which farmers operate is continually changing. This necessitates the employment of research to generate new knowledge to enable farmers sustainably add value to their agricultural products in the areas indicated below.

6.3.1 Research Priorities for Crop Value Addition

- Agro- and animal-products processing;
- Agro-packaging and marketing;
- Preservation; specifically
- quality assurance and certification; and
- Crop multiple utilisation.

6.4 Crop Diversification

Farming communities need to diversify their crop production. This is necessitated by among other things, climate change and unpredictable weather patterns. Diversification ensures production if weather conditions favour one crop and not the other. If for example maize fails due to adverse weather conditions, one can benefit from drought resistant crops such as cassava. To identify various crops for diversification research shall be carried out.

6.4.1 Research Priorities for Crop Diversification

- Enhancement and promotion of alternative high income crops such as cotton , horticulture and floriculture;
- Domestication of indigenous crops;
- Quality analysis of non-traditional and indigenous crops; and
- Value addition of non-traditional and indigenous crops.

6.5 Germplasm Conservation

Plant genetic resources (germplasm) are the foundation for sustainable agriculture and Malawi's food security. They possess genes that offer resistance to pests and diseases and resilience to

abiotic stresses, such as drought tolerance, soil erosion, and other constraints. Genetic resources are, however, eroding at unprecedented rates as a result of the loss of habitat, outbreaks of pests and diseases, and abiotic stresses. Therefore, it has become imperative to conserve genetic resources for agricultural sustainability and the preservation of biological diversity. Conservation requires use of clean planting materials such as seeds. Clean production of seeds in a changing environment requires new knowledge that is generated through research. New knowledge is also required to store germplasm in variable environmental conditions. Research areas envisaged to promote seed and germplasm conservation are shown below.

6.5.1 Research Priorities for Germplasm Conservation

- Enhancement and promotion of locally developed crop varieties;
- Biochemical and molecular characterization of germplasm;
- Preservation of germplasm;
- Promotion of *in-situ* and *ex-situ* conservation of a wide range of plant genetic resources;
- Quality assurance and certification,
- Pre-breeding research utilizing genomics information and interfaces with wide hybridization, molecular mapping
- Transgenic crops for resistance against biotic & abiotic stresses
- Heterosis Breeding
- Introgression and pyramiding of useful genetic loci in diverse germplasm
- Studies addressing gaps between quantitative trait loci (QTL) and marker-assisted selection (MAS) for drought/abiotic stress
- drought (water relations, cellular tolerance, floral biology, stay green) and radiation use efficiency (photosynthesis efficiency, source to sink)
- Development of new crop varieties and animal breeds capable of high yields under extreme weather conditions.

6.6 Livestock Production

The purpose of the livestock production research is to develop and disseminate appropriate technologies and promoting their adoption to facilitate profitable livestock production in Malawi. Malawi is lagging in terms of quality and quantity of animals for food, hence the need to improve the status quo through generation of new knowledge through research

6.6.1 Research Priorities for Livestock Production

- Breeding and genetic improvement,
- Enhancement of non conventional livestock production,
- Feeds and feeding,
- Livestock disease and parasite management,
- Enhancement of animal welfare,
- Precision technologies aimed at improving efficiency in the management of animals as well as reducing greenhouse gas emissions, and
- Promotion of *in-situ* and *ex-situ* conservation of a wide range of animal genetic resources.

6.7 Animal Products and Value Addition

Many of the value added foods are designed to decrease chances of diseases, managing the disease conditions, extending their shelf- life, maximization of livestock products and promoting health of the consumers. In order for the processes to be done sustainably and with innovation, research has to come into play. Value addition has the advantage of increasing profit margins to farmers. As the market forces are versatile, to maintain the farmers in the market world, the farmers need the support of research in the following areas:

6.7.1 Research Priorities for Animal Products and Value Addition

- Processing of livestock and livestock products;
- Utilization of livestock and livestock products;
- Humane slaughter;
- Maximisation of livestock and livestock products; and
- Animal products and drug residues.

6.8 Domestic and Wild Animal Health

Research can help management and understanding: diagnosis, epidemiology, pathogenesis, and genomics of bacterial and viral pathogens of human and food-producing animals. Animal health research is aimed at improving the health of both domesticated and wild animals. The health of domesticated animals, with respect to food animals, has an impact on food production and farmers' returns after sales. It is also important that the health of wild animals is taken care of as some diseases can be transmitted from wild animals to farm and household animals. The

health of domesticated animals may also have a bearing on human life as some diseases can be transmitted from animals to people. Research in the following areas is therefore encouraged:

6.8.1 Research Priorities for Domestic and Wild Animal Health

- Trans-boundary animal disease control;
- Rapid diagnostic techniques for early diseases detection;
- Enhancement of veterinary public health;
- Enhancement of veterinary epidemiology;
- Animal disease vaccine production and use;
- Disposal of diseased and culled animals;
- Animal quarantine services;
- Inspectorate and regulatory services;
- Animal disease research and investigation;
- Animal welfare and health; and
- Vector-borne disease of livestock.

6.9 Agricultural Mechanisation and Farm Implements

Agricultural mechanisation has the potential to expand production; improve timeliness of operations; widen the application of power to crop processing, irrigation and infrastructure improvement; compensate for labour shortages; and alleviate drudgery – particularly important when the greying, feminizing workforce continues to rely on the hand-hoe for primary cultivation. Agricultural mechanisation can cause farmers' incomes to be raised and natural resources to be conserved by scaling out the practices of sustainable crop production intensification. This can create the virtuous cycle of higher incomes leading to more savings, higher demand for mechanisation services and lead to greater productivity. Smallholder agriculture in Malawi, however, has yet to be mechanised at a large scale. Research can help to develop low-cost and appropriate farm mechanisation technologies and, through demonstrations, foster their promotion for increased use by smallholder farmers thus boosting food production by the smallholder farmers in Malawi. The basic objective of the research is to design, develop, test, adapt and promote low-cost, appropriate and innovative farm mechanisation technologies.

6.9.1 Research Priorities for Agricultural Mechanisation and Farm Implements

- Development of new and alternative machines;
- Barriers to adoption of agricultural mechanization.

6.10 Irrigation

The efficiency of water application is controlled by the design of the irrigation system, and the way in which the watering program is scheduled to come up with best irrigation designs and minimize any negative impacts like increase of salts in an irrigated land. Research can provide answers for specific areas:

6.10.1 Research Priorities for Irrigation

- Maximising the synergies between water, soil and land management;
- Crop water efficiency;
- Irrigation systems/designs;
- Irrigation water management;
- Prediction models and monitoring sensors in support of precision irrigation; and
- Water quality management.

6.11 Biotechnology and Bio-safety

Biotechnology finds applications in food science, medicine, the environment and agriculture and research is rapidly expanding the possibilities of where it will be used next. Any technology brings with it risks as well as benefits, and biotechnology is no exception. These risks need to be carefully assessed before a genetically modified plant, animal or micro-organism is released. Careful assessment of any biotechnology products calls for research. This means that research in biotechnology is important for two reasons and these are: to investigate new applications in various disciplines and to safeguard human health and the environment from adverse impacts of biotech products. Possible research in Biotechnology can be in the following areas:

6.11.1 Research Priorities for Biotechnology and Bio-safety

- Development of genetically modified organisms (GMO) verification protocols;
- Confined field trials of GMO crops;
- Molecular characterization of genetic diversity;
- Molecular diagnostics;
- Genetic modification;
- Risk assessment and management;
- Marker assisted breeding and selection; and
- Tissue culture.

6.12 Climate Change

Conducting research on climate change issues is essential to understand the challenges and opportunities that global warming may have on our planet and Malawi in particular. Research will help Malawi to address what measures will be needed to adapt to these impacts and how Malawi can mitigate against the effects. Areas of research therefore include:

6.12.1 Research Priorities for Climate Change

- Climate and climate change modelling;
- Adaptation and coping mechanisms to climate change;
- Indigenous knowledge and climate change;
- Mitigation strategies against climate change;
- Climate smart agriculture; and
- Value addition to Malawi's gene pool through programmes such as vaccine production.

6.13 Aquaculture

Many challenges currently face the aquaculture sector. A large number of aquaculture stocks are being overexploited leading to aquaculture production almost not being there in Malawi. To tackle these issues, research can provide the much needed mitigating measures. Research in a variety of ways can underpin better management and promote the sustainable and competitive development of aquaculture. The research activities can provide the necessary knowledge and technological base to strengthen sustainable management as well as to promote the sustainable and competitive development of aquaculture. While doing this, environmental and socio-economic factors must be considered.

6.13.1 Research Priorities for Aquaculture

- Breeding and genetics
- Design of aquaculture systems
- Aquaculture nutrition
- Disease and parasite control
- Maximization of aquaculture products through fish processing, handling, packaging, marketing; and preservation.

6.14 Fisheries

Fish research is a branch of zoology known as ichthyology. There are three distinct groups of fish that ichthyologists study: bony fish, cartilaginous fish, and jawless fish. Fish research has

become an increasingly important study as fish populations decline throughout the world including Malawi due to population increase that has put immense pressure on fish resources. The decline of fish has an immense impact on lake and river ecosystems as well as a significant impact on one of the primary food sources for people in Malawi. Overfishing has significantly reduced fish populations across a large number of species. Research in ichthyology helps policy makers determine what course of action to take in order to maintain fish populations in Malawi waters. National and international policies are determined based on the data provided by fisheries research.

6.14.1 Research Priorities for Fisheries

- Conservation of fish species;
- Characterization of fish species;
- Fisheries environmental management system; and
- Maximisation of fish and fish products through fish processing, handling, packaging, marketing; and preservation.

6.15 Forestry

Forest & Forest Products are important economical and environmental resources in Malawi. Research may also provide solutions to new diseases and pests affecting these resources. Above all the forests should be managed with climate change in mind so that they do not go extinct.

6.15.1 Research Priorities for Forestry

- Genetics and tree improvement;
- Forestry ecology and ecosystem;
- Forest conservation and protection;
- Characterization of forest biodiversity;
- Ethno-botanical / economic botany research;
- Utilization of timber and non-timber products;
- Forest management systems;
- Ecological inventories and modelling;
- Enhancement of the function of forests as C and N sinks aimed at mitigating greenhouse gas emissions and combating desertification and land degradation.

6.16 Water Resources

There are two types of water sources in Malawi and these are surface water and groundwater. Water is not in a uniform way available to all Malawians due to quantity and quality problems. Water may be available in large quantities, like along the lakes and rivers, but it may not be safe for human consumption due to microbial and physicochemical contamination. Both ground and surface water may be contaminated due to both anthropogenic activities and natural processes. To make the water suitable for human use there is need to understand how good the available water is so that it can be treated according to what is in the water. This can be done through research. In addition to having water of poor quality, quantities may be a problem and therefore innovative ways may need to be found to control its usage and conserve it.

6.16.1 Research Priorities for Water Resources

- Water conservation;
- Water quality assessment and monitoring;
- Estimation of water availability;
- Water resources and indigenous knowledge system;
- Water treatment and cleanup technologies;
- Water catchment management; and
- Water conveyance systems.

6.17 Bio-energy and Bio-fuels

The agricultural production of bio-fuels is becoming increasingly viable and desirable. The following research priorities have been identified:

6.17.1.1 Research Priorities for Bio-energy and Bio-fuels

- Identification of suitable crops for bio-fuel production;
- Development of engineering plants of different capacities: adaptation of farm implements;
- Environmental impact of using bio-fuel and the economics thereof;
- Value-addition to the protein-rich residue for the feed and food markets.

6.18 Environmental Pollution

Pollution has an impact on public health as it has a bearing on the burden of diseases in Malawi. Prolonged exposure to environmental pollution can have adverse impacts on one's

health although sometimes it takes long for diseases to be manifested partly due to long incubation period. It is important to understand the sources of air, water and soil pollution so that mitigation strategies can be mapped out. For this to take place research has to come into play to provide the much needed life saving answers.

6.17.1 Research Priorities for Environmental Pollution

- Air, water and soil pollution monitoring;
- Development of air, water and soil clean-up strategies;
- Environmental degradation;
- Environmental pollution modelling, dynamics and transformations;
- Water and sanitation; and
- Waste management.

6.18 Basic Sciences

Basic science research is important to generate new knowledge, as a foundation of latter innovations and applications. This knowledge may not be used to solve problems immediately but can be used later in life. The identification of new and emerging technologies aimed at increasing sustainable agricultural production that not only ensures food security at household level but also assists smallholder farmers in entering the mainstream is widely recognized to be very important. This NANSRA has therefore identified R&D all of which focus on the development of new and improved emerging technologies in the areas of biotechnology, information and communication technology, geographic information systems and earth observation technology, product differentiation, macro- and microeconomics of agriculture and value-adding processes, bio-energy

6.18.1 Biotechnology

Biotechnology, which may be defined as a set of technologies that include tissue culture and recombinant deoxyribonucleic acid (DNA) techniques, bioinformatics and genomics, proteomics and structural biology, is used to exploit and modify living organisms to create or produce new intellectual property, tools, goods, products and services.

6.18.1.1 Research Priorities for Environmental Pollution

- Food security and environmental sustainability
- Maintenance of plant and animal biodiversity and health.

- Handling of bio-safety relative to societal concerns about biodiversity use.

6.18.2 Information and Communications Technology

The Agricultural Geo-referenced Information System (AGIS) is useful for obtaining information on crop areas and yield estimates for agricultural statistics, disease type organisms and pests.

6.18.2.1 Research Priority for Information and Communications Technology

- Effective use of global positioning technologies for data collection on natural resources.

6.18.3 Geographic Information Systems, Spatial Modelling and Scenario Planning

The spatialisation of data, combined with remote-sense imagery ideally using AGIS technology, provides a powerful tool for effective decision making.

6.18.3.1 Research Priority for Geographic Information Systems, Spatial Modelling and Scenario Planning

- Generation of spatial technologies for use/applications in environmental modelling, agricultural statistics, climate change, and natural resource inventories and monitoring.

7.0 IMPLEMENTATION OF THE RESEARCH AGENDA

The NANSRA is the overarching guiding instrument for generating evidence that will be used in the agriculture and natural sciences sector in order to inform the development of policies and agricultural interventions. To ensure full implementation of the Research Agenda, there is a need for involvement of various stakeholders at both national and international levels in the design and execution of research, with the support of the legal tutelage of the National Commission for Science and Technology (NCST)

While Government of Malawi appreciates the diversity of needs and interests of different stakeholders in agriculture and natural sciences research, stakeholders are, however, called upon to ensure that research in Malawi is geared towards addressing the research priorities that have been outlined in this document during the period of the Agenda. It is, therefore, expected that stakeholders will make deliberate efforts in conducting and supporting research in the identified priorities.

7.1 Stakeholders

Key stakeholders that are being called upon for the implementation of the Agenda include government ministries with line functions that have bearing on determinants of agriculture and natural sciences and their research centres of excellences and affiliate; research institutions; public and private academia circles; the civil society organisations; private sector organisations; NGOs; INGOs; and international co-operating partners.

7.2 Coordinating Structures

Key coordinating and regulatory structures and mechanisms for agriculture and natural sciences research review and clearance in Malawi in the identified priorities shall remain the NCST through its National Committee on Agriculture and Natural Sciences.

7.3 Capacity Building, Transparency and Accountability

To ensure ownership in the design and execution of the NANSRA, stakeholders' efforts aimed at fostering capacity building in the conduct and dissemination of research results by local researchers and research institutions will be promoted. To mitigate implementation risks, any strategies or efforts by stakeholders geared towards achieving successful operationalisation of the Agenda will be fostered. Such efforts and strategies will revolve around the following:

- (a) **Capacity risks:** promoting covering issues of human and financial resources, processes and systems in research; and
- (b) **Governance risks:** targeting ownership, decision-making, accountability, transparency and oversight in research.

8.0 FINANCING OF THE NATIONAL AGRICULTURE AND NATURAL SCIENCES RESEARCH AGENDA

Financing of research in the identified priority areas is critical for the realisation of the goal and objectives of this Agenda. Stakeholders are, therefore, implored to support the financing of research geared towards addressing priorities outlined in this Agenda. The following mechanisms of financing this Agenda shall be pursued:

8.1 Government Funding

Government shall commit direct resources at various levels to support the undertaking of research in the identified priorities. This will be done through the established Science and Technology Fund.

8.2 Research Grant Scheme

Researchers and all other stakeholders intending to undertake research in the identified priorities shall be encouraged to take advantage of the existing national and international research grant schemes which exist.

8.3 Public and Private Partnerships

Public and private partnerships shall be an important vehicle for nurturing resource mobilisation for research in the priority areas. Researchers in public and private sectors shall be encouraged to pursue a spirit of collaboration in undertaking research. Deliberate efforts in cultivating corporate social responsibility to support the financing of the Agenda shall be encouraged and sought after by researchers at various levels.

9.0 DISSEMINATION OF RESEARCH FINDINGS

Research dissemination entails popularization of research results. Researchers shall ensure that scientific knowledge is communicated to a wider audience beyond the research community. Reporting of research and its results shall be the responsibility of every researcher and the research institution. The responsibility may be delegated to either the sponsor or any individual upon mutual agreement. Research communication shall entail expressed commitment to publish or disseminate the results within a specified period.

It is incumbent upon research institutions to promote multifaceted and comprehensive research communication to achieve high quality research dissemination. Institutions conducting research in agriculture and natural sciences shall have a responsibility for dissemination of research results to ensure that the results reach end-users. The researchers have a responsibility of publishing and organizing events for dissemination of research results. All approved research studies shall have a component on dissemination of results. Institutions shall be required to establish budget lines for dissemination of research results. Institutions shall establish research data banks and repositories and compile annual directories of research in order to facilitate access and availability of research data and information for use by end-users.

The National Commission for Science and Technology shall ensure that usable research findings are disseminated for utilisation at the national level by policy makers, communities, target populations, researchers and all other relevant stakeholders. It is, therefore, hoped that the NANSRA will stimulate interest that will generate research evidence in the identified priority areas.

10.0 MONITORING AND EVALUATION OF THE AGENDA

The tracking of the stakeholders' adherence to the Agenda shall be part and parcel of monitoring the Agenda implementation. The tracking will be informed by some tools/indicators as described below. This tracking shall benchmark the review of the Agenda.

10.1 Tools for Tracking Adherence to the Agenda

10.1.1 Monitoring and Evaluation (M&E) Reports

NCANS shall be supported to be undertaking M&E visits to sites where the approved studies are being conducted.

10.1.2 Progress and Final Reports

Progress and final reports shall be submitted to the NCANS that approved the study as per its stipulated guidelines and standard operating procedures. At the end of the research study, final report shall be deposited with NCST.

10.1.3 Database and Directory of Research Studies

Final reports of studies deposited with NCST shall be used to compile database and directories of approved research studies.

10.2 Review of the Agenda

This Agenda has a lifespan of five years. Informed by emerging issues in agriculture and natural sciences and the above stated indicators for tracking the stakeholders' adherence to the implementation of the Agenda, there shall be a midterm evaluation followed by a final review of the Agenda after five years.