THE UNITED REPUBLIC OF TANZANIA

TANZANIA COMMISSION FOR SCIENCE AND TECHNOLOGY
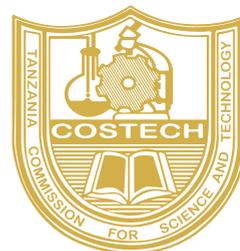
NATIONAL RESEARCH
PRIORITIES

2021/22 -2025/26

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LIST OF ABBREVIATIONS

4IR	4th Industrial Revolution
ASDP	Agricultural Sector Development Programme
CHF	Community Health Fund
COMESA	Common Market for Eastern and Southern Africa
COSTECH	Commission for Science and Technology
EAC	East African Community
FMD	Foot and Mouth Disease
FYDP	Five Year Development Plan
GDP	Gross Domestic Product
GII	Global Innovation Index
ICT	Information and Communication Technology
IIDS	Integrated Industrial Development Strategy
IPR	Intellectual Property Rights
MIC	Middle Income Country
ND	Newcastle Disease
NHIF	National Health Insurance Fund
NRP	National Research Priorities
NSGRP	National Strategy for Growth and Reduction of Poverty
OFC	Optic Fibre Cable
R&D	Research and Development

R&DIs	Research and Development Institutions
RDI	Research, Development and Innovation
SADC	Southern African Development Community
SIDA	Swedish International Development Cooperation Agency
SMEs	Small and Medium Enterprises
STI	Science, Technology and Innovation
SW	Solid Waste
TANESCO	Tanzania Electric Supply Company
TDV	Tanzania Development Vision
URT	United Republic of Tanzania
ZSGRP	Zanzibar Strategy for Growth and Reduction of Poverty

FOREWORD

Research, Development, and Innovation (RDI) is the cornerstone of socio-economic transformation of a Nation. Economic development is driven by the invention, adoption, adaptation and innovation of appropriate technologies. Country's RDI investments and interventions influence ranking on Global indices such as the Global Innovation Index (GII).

Tanzania attained lower-middle-income status in 2019 earlier than the predicted year of 2025 and moved nine (9) slots in the GII 2020 report (from 92 to 88). The transitioning of Tanzania into lower-middle-income amid a changing landscape for funding, the 4th Industrial Revolution (4IR) and uncertainties brought about by pandemics such as COVID-19 warrant strategic planning for RDI. The 2021/22-2025/26 national research priorities aim to build resilience in the sectors, producing wealth and sustainable jobs whilst developing and strengthening human capital.

The country maintains the Tanzania Development Vision 2025 (TDV) goals for industrialisation, thus prioritising demand-driven R&D programmes and activities that promote innovation for economic development and technology transfer. The R&D Priorities have been drawn up consultatively with critical stakeholders from 16 sectors and five subsectors, including health, education, food quality, safety and nutrition, water and sanitation, land management and human settlements, energy, industry and manufacturing, trade, mining, transport and logistics, agriculture, national heritage, tourism, forestry and wildlife.

R&D in the priority areas aims to increase the capacity for value addition, access to and quality of social services delivery. Programmes will take an inclusive approach and support and foster private sector participation to commercialise the outcomes of R&D.

Tanzania does not intend to blindly copy technology and industrial practices but contextualise and adapt best practices for its RDI. In this regard, strategic partnerships are an essential element of our development journey. The Swedish International Development Cooperation Agency (Sida) has been instrumental in setting the research priorities and one of the productive partners in building the

RDI ecosystem. In the period 2021/22 – 2025/26, building and strengthening strategic partnerships will continue to facilitate R&D outputs equipping Tanzania to steer socio-economic transformation that delivers economic prosperity and environmental sustainability.

The research priorities for 2021/22-2025/26 result from the efforts of dedicated researchers, scientists, innovators, inventors, policy and decision-makers, and other stakeholders who worked selflessly to prepare this document.

Lastly, and on a personal note, let me take this opportunity to acknowledge Sida for financing the development of this document as well as to extend my sincerely appreciaton to all actors in the STI community that strive to make an impactful contribution to our development.

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Prof. Makenya Abraham Honoratus Maboko

CHAIRMAN OF THE COMMISSION

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

To achieve long-term economic growth and realise Tanzania's Development Vision (TDV) 2025 and the country's Third Five Year Development Plan (FYDP III) 2021/22-2025/26, investment in Research and Development (R&D) is imperative. Investment in R&D is a commitment that Tanzania has as a signatory to the Lagos Plan of Action (1980 – 2000) where Tanzania pledged to invest one percent (1%) of its Gross Domestic Product (GDP) and aims strategically through well-defined priorities. The National Research Priorities (NRP) is the mechanism Tanzania uses to demonstrate how R&D contributes to socio-economic development.

The Tanzania Commission for Science and Technology (COSTECH) facilitates knowledge and skills acquisition and development, fuels invention and discoveries leading to the development of commercially viable technologies that will stimulate economic growth to contribute to poverty reduction.

This NRP provides research priority areas for effectively utilising financial and human resources for socio-economic impact areas to stimulate the country's development for both mainland and Zanzibar. With limited or scarce resources, prioritisation is essential to target interventions with the most significant socio-economic impact. Nevertheless, whilst the NRP focus is on overarching research themes, it allows for incorporating changing needs as they arise.

1.2 RATIONALE

The period 2016-2020 has been pivotal for Tanzania, with the country gaining middle-income status, improving its GII ranking among other global changes such as the 4IR and the COVID-19 pandemic. It is pertinent to reassess and align research priorities to take cognisance of the changes.

The NRP updates the National Research Agenda (NRA), which set the research priorities from 2016, retaining and emphasising areas of relevance. In addition, the NRP contributes to the TDV 2025 and the Five Year Development Plan (FYDP)

III 2021/22 -2025/26 to industrialise the economy and move to higher middle-income status. The NRP also incorporates national and institutional policies and strategies that influence R&D, such as the Tanzania Long Term Perspective Plan (2011/12-2025/26), the CCM Ruling Party Manifesto 2020- 2025, and the Integrated Industrial Development Strategy (IIDS) 2025.

The NRP addresses international obligations and features its subscription to the Sustainable Development Goals (SDGs), the Science, Technology and Innovation Strategy for Africa, the Southern African Development Community (SADC) Vision 2050, East African Community Vision 2050, Paris Agreement on Climate Change and Addis Ababa Action Agenda on Financing for Development 2015.

The NRP is drafted to respond to dynamic societal needs, provide creative solutions and set the pace for socio-economic transformation. The anticipated research outputs will improve skills and build capacity, give rise to new knowledge, technology, products and processes that will improve the existing ones and enhance job creation, generate revenues and eventually achieve a sustainable industrial-based economy. The NRP will guide the formulation of institutional research priorities within specific sectors and facilitate the development of the Zanzibar Research Agenda.

Monitoring and Evaluation (M&E) is necessary to gauge the outputs and outcomes of the NRP interventions. Therefore, the NRP emphasises a structured approach to capture successes and learnings.

COSTECH championed a participatory and consultative approach to develop the NRP (2021/22 – 2025/26), drawing in stakeholders from the Government, private sector, academia and beneficiaries of R&D.

1.3 STRUCTURE OF THE DOCUMENT

The NRP consists of seven (7) chapters. The first chapter sets the background and rationale for the six broad research priorities. Chapters two to six present the details of each priority area, outlining the current status and the expected contribution from R&D. Chapter seven concludes the NRP with an implementation plan. The NRP areas provide an overarching framework for promoting and coordinating R&D in the country to fuel socio-economic transformation as set by the National development vision.

CHAPTER TWO

HUMAN CAPITAL DEVELOPMENT AND QUALITY LIVELIHOOD

Socio-economic transformation depends on human capital development built on access to quality education, health, water and sanitation, food security and nutrition, human settlement, land management and demographics. For Tanzania to attain quality livelihood and equitable access to quality services for her population, informed policies and strategies for all social groups are needed.

The 4IR has brought on the adoption of robotics and increased automation that has benefitted the industrialisation trajectory. However, the adoption of these technologies may have adverse effects on the social welfare of the population and lead to complex societal problems. Research interventions to address these emerging issues are of paramount importance.

Research in this area serves to complement and enhance ongoing initiatives by providing evidence to ensure cost-effectiveness, efficiency, and innovation in the sectors of education, health, settlement, water and sanitation, as well as food security and nutrition. The prime objective is to attain quality livelihood for every Tanzanian and transform the current pace of growing the population into skilled human capital for the industrial-based economy in a sustainable manner.

2.1 EDUCATION

Access to education, relevance, efficiency, management, financing, quality, and equity are highly fundamental in measuring the success of any country. Tanzania has instituted interventions in the education sector intended to increase access and improve the quality of education programs at all levels. The FYDP II shows a steady increase in enrolment at the primary level from 91.3 percent in 2015 to 110.3 percent in 2019. However, increased access to education has not been without flaws. The educational infrastructure has been overstretched, relevance of the curriculum is wanting, access to innovative finance is limited, and human resources to manage the increase below critical mass. Research should focus on improving inventiveness, innovativeness, and quality education to promote an industrial-based economy.

2.1.1 Quality and Relevant Curriculum Development and Implementation

The design and implementation of appropriate curriculum models focused on education for sustainable industrial development to ensure a competitive harmonious society is a prerequisite to achieving socio-economic development.

R&D should focus on curricula that promote industrialisation and support linkages between training, research and innovation. The curricula should emphasise the development and application of effective pedagogies, facilitate knowledge and skills for job creation and employability, promote innovative and flexible delivery modes (such as e-learning and telepresence) and, appropriate learning platforms.

2.1.2 Improving Access and Retention in Quality Education at all Levels

Tanzania has implemented several strategies to improve access to education, including eliminating fees for primary education, reducing secondary education costs, and increasing access to tertiary education through student loans. Despite the interventions, enrolment in early childhood education and dropouts in primary and secondary schools pose significant challenges.

To build a knowledge-based society with competitive human capital that can ensure the transformation to an industrialised economy, R&D needs to focus on appropriate interventions that provide equitable education and rehabilitative, educational models for school dropouts.

2.1.3 Innovative Funding Models

Public funding alone cannot sustain the demand for access to quality education. Therefore, research needs to focus on unpacking innovative funding models that can address teacher's commitment and retention and blended financing models between the private and public sectors.

2.1.4 Equity and Equality

National policies related to education recognise equal access and quality education to disadvantaged groups. Therefore, research should focus on innovative strategies to increase education access to address challenges facing disadvantaged groups and gender-based inequalities in education and career.

2.2 HEALTH

Epidemiological and demographic transitions impose a complex burden of infectious diseases alongside the increased incidence of non-communicable diseases, including emerging and re-emerging infectious diseases, maternal and child health, mental health, injuries and disabilities in Tanzania. The rapid spread of risk factors to many emerging contagious and chronic diseases not limited to lifestyle changes and urbanisation consequences requires multidisciplinary actions guided by evidence from research. Health sector reforms in Tanzania aim to ensure equitable, high-quality health care services focusing on reducing disease burden. In fostering health research for sustainable development, the adoption of priority setting has become a mandatory action to accommodate the competing national priorities.

Research priority areas in health draw on existing and emerging technologies, including nuclear sciences, social determinants of health, one health approach, and scientific discovery to maintain and improve the health of Tanzanians. These developments entangled with other national response strategies identified in different sectors to form the basis for interdisciplinary efforts and critical convergences that will decisively address challenges in health.

2.2.1 Social Determinants of Health

Over the years, global and local contextual changes in the political, social and economic arenas have substantially influenced public health directly or indirectly. These influences have been adverse for some societies determining the country's position locally, nationally, regionally and globally. Other internal and external societal factors additionally compound the transitions affecting health in human populations that may span from conception to the end of life.

Research should focus on delineating unknown adverse social determinants of health and finding solutions for the persistent unpropitious social determinants of health (defined inequalities, underserved populations, geographical areas, and vulnerable populations). Research should also facilitate the attainment of healthy lives of society members across the life span and reduce societal disease risks within the contextualised political, socio-economic and cultural environment.

2.2.2   Health Systems

The Tanzania health system has improved with increased health facilities from 7,014 in 2015 to 8,783 facilities in December 2020. Access to health care services has reached the village level (FYDP III), bringing health service closer to the society and improving health service delivery, including expanding health insurance coverage from 753,892 in 2016/17 to 966,792 in 2018/19 for the National Health Insurance Fund (NHIF), and 13,029,636 in 2019 for the Community Health Fund (CHF). However, health services' affordability has resulted in low NHIF and CHF beneficiaries, equivalent to 7.4 percent and 25 percent of all Tanzanians, respectively. In addition, inadequate medical personnel overburden the health system resulting in poor delivery of services. Good governance and accountability in the health system is the key for improving health care delivery.

The need for robust research on health outcomes resulting from successful efforts to offer integrated care is essential to relieve the overburdened health system. The research should provide solutions that bridge availability, access and delivery of health services within catchment areas by person and time. In addition, interventions that provide innovative training systems that generate competent human resources for health, governance, and alternative financing mechanisms can improve access through effective mobilization of funds for universal health coverage.

Delivery of health services for disadvantaged groups and reduction of the equity gap between rural and urban areas, developing and testing models for robust disease surveillance systems and maximizing the use of health information systems for clinical decision making, applying emerging technologies to improve preventive interventions and health promotion by measuring outcomes related to community interventions are all areas of great importance.

2.2.3   Medical Diagnostics and Product Safety

Advances in medical technology create an opportunity to develop new diagnostic kits, test existing biomarkers for enhancing early diagnosis to avert morbidity, promote better prognosis, hasten recovery, improve quality of life and increase survival in time. Research should focus on the efficiency and impact of existing and new medical technologies to enhance disease detection, treatment and prevention. Identification of future needs to selectively invest in specific diagnostic technologies that are contextually safe, cost-effective, and friendlier to the environment will provide better health outcomes.

2.2.4   Communicable Diseases

The incidence of common infectious diseases such as HIV/AIDS, malaria, and tuberculosis are currently declining in Tanzania due to programs and funding directed to combating these diseases. According to TACAIDS, HIV prevalence in Tanzania by 2016/17 was 4.7 percent, showing a declining trend compared to the previous status, with the number of adults and children on antiretroviral reaching 75 percent and 66 percent, respectively. Currently, linkage to care, HIV related stigma, and criminalisation of marginalised groups remain challenging. This limits the documentation of the pandemic's demographic, economic, and social impacts on individuals and families.

Tuberculosis (TB) continues to be one of the major causes of death, and the number of all TB cases diagnosed and notified increased from 128,000 to 138,000 per 100,000 population from 2015 to 2018. The increase in case notification is linked to improved diagnostic capacity with the introduction of GeneXpert. However, multidrug resistance tuberculosis (MDR TB) remains a threat as the trend shows increasing in case detection from 174 in 2015 to 449 in 2018 with an average treatment success rate of 76 percent.

Malaria transmission has declined in linkage due to insecticide-treated nets and prevention (IPTp) during pregnancy. The case incidence has increased from 122 to 124 per 100,000 population from 2015-2018, which can be linked to improved diagnostic with the introduction of malaria rapid test. Meanwhile, the number of deaths related to malaria mortality had declined by 4 percent for the same period. The malaria indicator survey 2017 reports that 7.3 percent of under-five children tested positive by rapid test.

Research priorities should enable the understanding of co-occurrence of the diseases including alarming signs, transmission mechanisms, availability of innovative diagnosis to avoid delay in treatment of infectious diseases or exposure to unneeded medication, pharmacokinetics and pharmacodynamics of the drugs for efficient treatment of the diseases and innovative vaccine for prevention. Research on exploring gender-based inequalities and age disaggregated data need to include vulnerable population.

2.2.5   Neglected Infectious diseases

Neglected infectious diseases (NIDs) such as *schistosomiasis, trypanosomiasis, onchocerciasis* are endemic in Tanzania. The diseases have been more prevalent

in marginalized populations. However, most of the areas endemic to NTDs have implemented integrated NTDs control activities, with good progress made, including mass drug administration. Therefore, research should be directed toward understanding the epidemiology of these diseases and strategy towards eliminating alarming signs, vector distributions, surveillance and risk modelling, community engagement diagnosis, and management.

2.2.6   Emerging and Re-emerging Infectious Diseases

Emerging and re-emerging infectious diseases, including One Health and zoonosis diseases such as Anthrax, influenza virus, haemorrhagic fever; dengue, *Chikungunya*, Ebola, Marburg, *Zika*, Rift valley fever, Brucellosis and COVID-19, among others, are priority diseases under One Health. Monitoring these diseases from a human and animal perspective is vital as Tanzania borders countries where some have been reported. Tanzania launched a One Health Unit to allow a multidisciplinary approach to combat diseases easily transmitted across borders. Research should be directed to understand the epidemiological distribution, alarming signs, viral pathogenesis, immunology mechanism, diagnosis and vaccine interventions and disease sequalae.

2.2.7   Reproductive, Maternal, Newborn, Child and Adolescent Health

Tanzania's under-five mortality rates declined from 67 per 1,000 live births in 2015/16 to 50 per 1,000 live births in 2019/20. In 2019/20, 81 percent of all pregnant women made four (4) or more visits at antenatal clinics compared to 39 percent in 2015/16, implying that more pregnant women receive quality care and advice on safe birth control methods. This goes in parallel with an increased number of pregnant women giving birth at health facilities from 64 percent in 2015/16 to 83 percent in 2019/20.

The population census estimated maternal mortality to be 432 per 100,000 live births, which means that in every 1,000 live births, four women died due to pregnancy-related causes. In addition, a high fertility rate of 4.9 birth per reproductive woman causes a high dependency ratio, increasing the burden of care and lower workforce participation, particularly for women and girls. Maternal and child health services are provided free. However, there is a gap in accessing 'free' care and facilities both in rural and urban areas and the availability of skilled staff and accessing neonatal care units equipped with trained staff. The country has made progress in child and maternal health; however, the death rate is still high.

Research in this area should focus on assessing the quality of service delivery, equity in access to health care, referral systems, newborn care, and explore the use of m-Health in immunization and reminder on the uptake, male involvement in reproductive health, and family planning. Research should also focus on adolescent health, including mental health and reproductive needs.

2.2.8 Non-communicable diseases and genetic disorders

With increasing life expectancy from 63.1 years in 2015 to 66 years in 2019, the burden of non-communicable diseases related to longevity, such as different forms of cancer, neurodegenerative diseases and metabolic disorders, are on the rise. In addition, cases of children born with genetic malformations are increasing. These types of diseases are difficult and expensive to treat, thereby straining the limited resource capacity. Furthermore, globalization accelerates change in lifestyle, adaptation of sedentary life and transition to a western diet had increased risk of obesity and hence non-communicable diseases. Therefore, extensive research is needed in innovative approaches towards affordable and acceptable diagnostic development, disease management and regenerative sciences, prevention and treatment. In addition, studies on lifestyles associated with these issues and understanding the role of genetic factors are needed.

2.2.9 Evaluations of natural products for drugs and vaccine discovery and development

Tanzania is endowed with diverse flora and fauna, hosting a substantial resource of natural products with potential pharmacological applications. Research on isolating natural products has not sufficiently exploited this potential. Innovative research that explores natural products' phytochemical and pharmacologic (pre-clinical and clinical) properties for the prevention or treatment of high burdened diseases and guides commercialise is recommended. This includes research on the effectiveness, efficacy and dosage, short and long-term consequences of natural products / traditional medicine and vaccines for the treatment of communicable and non-communicable diseases, including emerging infectious diseases such as COVID-19.

2.3 FOOD QUALITY, SAFETY AND NUTRITION

Food and nutrition security is a precondition for the development of societies of any nation. The national nutritional strategy has continued to guide nutritional issues aimed at reducing all levels of malnutrition. The nutritional status of

children had improved since 1992 about 50 percent of children were stunted compared to 31.8 percent in 2019, although in some regions, the prevalence of stunting exceeds 40 percent. The percentage of children born underweight has declined from 13 percent in 2014/15 to 10 percent in 2019/2020. Children born underweight below 2.5 kg declined from 6.5 percent 2014/15 to 5.6 percent in 2019/20.

Additionally, the country suffers double burden malnutrition having an overweight rate of 12.7% of adult (aged 18 years and over) women and 4.0% of adult men living with obesity in 2020. Food and nutrition security also exists when there is sufficient and nutritious food that meets dietary needs. Despite the overall improvement of food control systems, food-borne diseases persist as a cause of serious concern for the consumer because of improper food management. Food is the likely vector of multiple biological, chemical or physical hazards.

Policy oriented research on food safety, dietary intake, mitigation of risks arising from agrochemicals, preservation challenges, and aflatoxins in the food chain would contribute important information for food safety. Additionally, research in this area, should focus on food security, quantity and quality issues, safety and nutrition awareness and education as a means of improving human health and increase opportunities to pursue sustainable livelihoods and consequently improve daily living conditions.

2.3.1 Food Toxicology

The increased presence of food toxicants in the food production chain has proven to pose several health risks. Unregulated local markets and the fact that very few of the foods commonly consumed are tested for toxicity are some of the reasons for this. However, long term effects and impacts of these toxins from environmental contamination microbes such as mycotoxins or naturally occurring toxic constituents, pesticides residues, and food additives would benefit further investigation. Research should develop biomarkers to detect and measure toxicity models for computational and predictive toxicology, risk and exposure assessment studies. Furthermore, research on methods for the detection of genetically modified food products should be carried out.

2.3.2   Food Fortification and Formulation

Most households are highly vulnerable to acute and chronic malnutrition due to poor food diversification. Food fortification can be used in improving staple food nutritional composition hence overcoming deficiency problems. At the household or community level, food and nutrition security are linked to the ability of households to obtain appropriate and nutritious diets. Research on extraction and purification of micronutrients, dietary diversification using locally available food resources, improved food availability, food preservation, nutrition education, food fortification and formulation will rescue vulnerable communities from dietary deficiencies. This would improve the nutritional quality of food supply, and enhance public health benefits with minimal risk to health in Tanzania.

2.4   WATER SANITATION AND HYGIENE

Freshwater is a basic natural resource, which sustains life and provides for various social and economic needs. Although nearly 70 percent of the earth is covered by water, only 2.5 percent of this is freshwater. In Tanzania, 6.4 percent of the land is covered with fresh water bodies, including rivers, lakes, wetlands, springs, reservoirs and groundwater aquifers, and many water bodies shared with the neighbouring countries. Tanzania's annual renewable water source is estimated at 89 cubic kilometres and about 40 cubic kilometres of groundwater reserve. It is projected that by 2025, the annual average of available water per capita which is about 2,266 cubic meters, will be reduced by 33 percent to about 1,500 cubic meters per person per year. This suggests that the country may face water stress if measures are not taken.

On the other hand, the coverage of improved latrines in urban and rural areas of Tanzania is as low as 32 percent and 25 percent, respectively. Furthermore, poor management of waste water can result in the contamination of water sources leading to water-borne diseases. In addition, dilapidated infrastructure, infrastructure vandalism, rapid population growth, inefficient water uses, pollution of water sources and low investment in the water sector water supply and sanitation coverage limit progress.

2.4.1   Water Demand, Supply and Management

The availability of water in the country is highly dependent on rainfall. More than half of the country receives, on average, less than 800 mm of rain per annum. This scarcity has been a major problem, especially in rural areas. Studies show

that the main problems in rural communities include long distances of over 2 to 3 kilometres that people have to commute daily in search of water from public taps; and carrying heavy containers on their heads of about 20 to 25 litres per trip. In 2012, the demand for water in 19 capitals of regions was 463,543 m^3 per day, while the supply was 305,195 m^3 per day. Water production in the 19 Regional Urban Water Supply and Sanitation Authorities reached an average of 341.77 million litres per day in March 2013.

In March 2018, about 78 percent of the residents in regional towns had access to water, compared to 60 percent in district townships and 75 percent for Dar es Salaam. Currently, there are 123,880 water points, which can serve 30,972,000 people, which is about 85.2 percent of the rural population. However, only 85,286 water points are functioning, which serve 21,321,500 people, that is, 58.7 percent of the rural population. This situation is attributed to inadequate institutional setup for planning, designing and managing rural water supply schemes, leading to high operational and maintenance costs. The trend reveals that there is still a substantial size of the population lacking water supply services.

The GoT has instituted measures to address water conservation that reduce wastage arising from leakages, but little has been put in place to address domestic, public and industrial wastage of water from inefficient uses. In March 2018, country statistics show that on average, non-revenue water in Urban Water Supply and Sanitation Authorities was about 32 percent compared to 20 percent of international standards. Knowledge of water use management is needed to reduce unnecessary water consumption. The National Water Policy of 2002 calls for mass education on frugal water use, conservation, and efficient water uses. However, information on efficient services of water in the nation is limited.

Hence, there is a need to research water harvesting techniques; appropriate and affordable sustainable technologies for water pumping and supply, and involvement of communities and extension of water supply networks infrastructure and equipment, which will then increase access to water in both urban and rural areas. Furthermore, research is needed to develop solutions, indigenous knowledge and modern technologies, practices to address inefficient use of water, identify frugal water use technologies, and put water use management in place.

2.4.2 Water Quality and Safety

Water quality is a matter of great concern in many parts of the country. This is true for both point and non-point sources of water. Increased human activities, including poor land use practices and uncontrolled abstractions and pollution of water bodies, impact the quantity and quality of the available water sources. Some parts of the country obtain and use only salt water for all their household purposes. Most villages share common water sources, i.e. wells, which is a risk factor when contamination occurs.

Therefore, research on better approaches to improve water quality, quantity, harvesting, monitoring, purification, assessment, and practical and cost-effective water quality and pollution control mechanisms is needed.

2.4.3 Waste water Management

Water use in urban areas results in waste estimated at 80 percent of the water supplied. Public waste water is disposed of using septic tanks and pit latrines that contaminate ground water sources and the environment. The National Water Policy of 2002 advocates waste management strategies such as rehabilitating and/ or constructing new sewerage systems and sludge disposal facilities; establishing cesspit emptying services; discharging the untreated wastewater to the sea through long and deep-sea outfalls, and others. These interventions need to be backed up with research by developing cost-effective technologies for wastewater treatment, recycling, reuse, and reducing domestic, municipals, and industries wastes.

2.4.4 Integrated Water Resources Management

The Water Resources Management Act No. 11 of 2009 and its regulations govern water sources management systems. Despite sound water sources management and development framework, there are challenges in water resources management. There is limited data collection and dissemination, poor assessment of water resources, minimal basin integrated planning, water use conflict, unequitable water distribution and unsustainable utilisation. The engagement of communities and stakeholders, the financing mechanisms, conservation and protection of water sources and pollution control are areas that need attention. Furthermore, Tanzania shares eleven lakes and rivers with other countries, yet there are inadequate cooperative frameworks for the shared water bodies. Therefore, research should develop innovative models for establishing comprehensive community and cross- borders integrated water sources management.

2.4.5   Solid Waste Management

In Tanzania, the quantity of Municipal Solid Waste (SW) generated countrywide amounts to about 10,000 tonnes/day, and the waste generation rate varies from 0.4-1.0 kg/person/day. As much as 80–90percent of SW generated in urban areas is not collected. Most of the domestic waste, which accounts for about 60 percent of the total SW generated daily, is disposed-off by burning or burying. A lot of the SW ends up in drains or dumpsites, open spaces, across streets, maintenance holes, water bodies or on beaches and riverbanks, causing air, soil, land and water pollution. The generation of waste from mining and quarrying sectors is small compared to the other sectors like manufacturing, agriculture, and other economic activities. Solid waste recycling and reuse are practised, albeit in a small scale and unorganised manner. For example, in 2017, 92,606 tonnes of waste were recycled in Dar es Salaam City out of which 16,248 tonnes (17.5 percent) were exported. Moreover, there were 33 recycling industries in the City, which employed 2,021 people. The largest number of recycling industries was in the category of plastic or nylon with 24 establishments (72.1 percent). In contrast, the smallest number was in the market and vegetable waste category (3.0 percent).

Generation, storage, collection, transfer and transport, processing and disposal of SW in a manner that follows the best principles of public health, economics, engineering, conservation, aesthetics, and environmental protection is of paramount importance for ensuring that the integrity of the environment is not compromised. Contemporary approaches in SW management focus on a green economy prioritising waste avoidance, minimisation and promoting the "*Three Rs*" (Reduce, Reuse and Recycle). The Three Rs advocate that as little as possible waste goes to landfills. Furthermore, as the country progresses towards the industrial economy, the need for devising appropriate local technologies for sustainable management of SW from industrial establishments through research cannot be overemphasised.

2.5   LAND MANAGEMENT, HUMAN SETTLEMENT AND DEMOGRAPHICS

Land is an essential resource on which human beings and other living creatures depend. Despite its importance, the country lacks a detailed land-use plan for demarcating different uses. Demographic processes play a great role in the development of the countries by optimising the allocation of resources, which fuel the acceleration of economic growth. The challenges faced by the sector include inadequate surveyed and mapped land for human settlement, inadequate land parcels development and investments, as well as functional procedures for

securing and use of land. It is estimated that over 70 percent of the Tanzanian population live in unplanned settlements, and over 60 percent of the urban housing stock is recorded in these settlement areas.

Therefore, research in this area should focus on developing effective and efficient novel approaches to facilitate rapid national socio-economic development and national land-use priorities, promotion of equitable distribution and ensuring access and productive use of land together with special attention in guiding potentially hazardous activities away from the fragile areas, Oceans and Costal areas.

2.5.1 Land Registration, Administration and Tenure Systems

Secure land rights provide the owners with a sense of ownership to the land, enabling them and the investors to conserve and manage land productively. It guarantees the right of occupancy to individuals and legalises land transfer, and can be used to acquire loans. However, most land is not registered, and few people possess certificates of land registration. The target is to increase households with land certificates, e.g. certificates of title and customary right of occupancy, from 5 – 10 percent. Therefore, there is a need to research how STI can facilitate land registration, administration, and tenure systems for increased efficiency and investment while considering multiple land use and minimising land conflicts.

2.5.2 Housing Development, Finance and Market

Urban and sub-urban development in Tanzania has generally been heterogeneous, ranging from partially planned to unplanned dwellings. Studies have indicated that about 32 percent of such dwellings could be classified as bad, 51 percent as fair, and 17 percent in good condition. In urban centres, about 1,200,000 additional housing units are needed to cope with the demand. The gap between the supply and demand for housing has widened significantly over the years. Therefore, research should develop low-cost housing technologies, establish affordable housing schemes, financing models to ensure equitable access to credit facilities, and policy on quality and affordable urban settlements.

More than 70 percent of the Tanzanian population lives in rural areas where most houses are made from poles and mud or mud blocks. In addition, significant rural settlements are temporary and do not meet environmental and health requirements, hence, lack basic services. There are also inadequate and unaffordable credit facilities for building better houses. Therefore, research should be directed to

affordable models for accessing credits and environmentally friendly alternative-building materials and technologies..

2.5.3 Demography, Population and Development

The appropriate definition of the population includes two significant features, namely dynamic demographic processes and population characteristics. The former contains what are known as determinants of population change, namely, fertility, migration and mortality. The population characteristics such as size, growth rate, age-sex distribution (or structure) and geographic distribution are outcomes of the dynamic processes. There is a close relationship between these demographic processes and development at the individual, family, community and national level. Understanding these relationships helps developing countries optimise resource allocation towards accelerating economic growth and poverty reduction. Sustainable economic development can be attained if demographic dynamics are monitored to provide data and a conducive environment to lead Tanzania to a strong competitive economy by 2025. There is inadequate research on the contributions of different components of demographic processes and population characteristics to development in Tanzania, as reported in the National Population Policy - 2006.

2.5.4 Migration, Urbanization and Development

One of the major characteristics of the Tanzanian population is intense internal migration. According to the last census report, 7.8 million Tanzanians (16.4 percent) were internal migrants, and most were men. During previous censuses (1948 to 2002), males dominated in migration. Migration takes different forms, but rural exodus and migrations within rural areas are the most common. Migration varies, with some areas experiencing negative and others positive net migration. Rural exodus is associated with rapid urbanisation in Tanzania. There is inadequate knowledge about other internal migrations such as urban to rural, urban to urban and circular migrations. Research is needed on changes in internal migration modalities; demographic, economic, social, environmental and cultural implications for both origin and destination areas; the role of migration to the growth of smaller towns; the implication of migration towards urbanisation in terms of social transformation in urban family structures, urban health services, social order, housing and informal sector development as well shift towards feminism of migration.

CHAPTER THREE

BUILDING A STRONG AND COMPETITIVE INDUSTRIAL ECONOMY

Tanzania strives to build a stable and competitive economy through bio-economy, energy, mining, industry, manufacturing, agriculture and trade sectors. STI should enable Tanzania's economy to attain the following: a diverse, semi-industrialized sector comparable to typical middle-income countries; macroeconomic stability manifested by a low inflation economy and basic macroeconomic balances; the growth rate of over 8 percent per annum; adequate levels of physical infrastructure in all sectors, active and competitive standing in regional and world markets, with the capacity to articulate and promote national interests and to adjust quickly to regional and global market shifts. Relevant research on these sectors should set the pace for the country to be one among emerging economies globally.

3.1 BIO-ECONOMY (GREEN AND BLUE ECONOMY)

Bio-economy is "the production, utilisation and conservation of biological resources, including related knowledge, science, technology and innovation to provide information, products, processes and services in all economic sector aiming at sustainable economy" (Bio-economy conference, 2019). Bio-economy driven innovation using of modern bio-sciences is an important driver for future sustainable development, economic transformation and circular economic growth. This is pertinent to those sectors of the economy that use renewable biological resources from the land (green economy) and the sea (blue economy), such as agriculture, forestry, fisheries and other marine resources, animals, wildlife and micro-organisms. The Green economy underpins the role of terrestrial ecology/environment for sustainable development. On the other hand, the blue economy refers to the economic activities conducted on water bodies. The blue and green economies are underexploited in Tanzania and research is needed to improve utilisation of natural resources to ensure sustainable social, economic and environmental development.

3.2 ENERGY

Lack of reliable energy supply has been identified as the main binding constraint to Tanzania's economic growth. The elasticity between GDP growth and energy

demand in the form of electricity suggests that the current GDP average growth of 4.6percent as of 2020 needs to be matched with the power generation and maintain a buffer of at least 15 percent of the total capacity to contribute to sustainable economic growth.

Access to modern technology and the commercialisation of alternative energy in rural and urban areas of Tanzania is limited. This has an adverse impact on forest resources (de-forestation for firewood and charcoal). Thus, improved access to modern energy sources is a priority for transforming rural areas. Potential sources for the generation of affordable and reliable modern energy include renewable and non-renewable sources. Sustainable exploitation of renewable and non-renewable energy sources relies on a clear understanding of economic growth's environmental and socio-economic issues.

3.2.1   Renewable Energy Sources and Technologies

Harnessing renewable energy opportunities for industrial and domestic use in rural and urban areas can contribute to economic growth. However, biomass utilisation is predominant in Tanzania. Therefore, research interventions are needed to explore efficient use of renewable energy technologies and sources such as hydro, wind, biofuel, solar, biomass/biogas and geothermal that are effective and safe to reduce adverse impacts and attain a good energy mix.

3.2.2   Grid and Off-grid Electricity Supply

Tanzania's electrification status stands at 18.4 percent, of which only 6 percent is for the rural areas where the accustomed source of electricity supply is through the main grid and isolated grids. Besides the slow rate of electrification, the main grid is outdated and its infrastructure obsolete. Thus, it needs major maintenance and repair to avoid power loss and frequent power cuts.

RDI on technologies set to ensure electricity accessibility to the general public and industries and enhance the efficiency of existing, new and private supplies from various sources networks by reducing leaks will reduce unit costs and increase productivity. On the other hand, environmental, health, and aesthetic concerns of supply networks are critical to ensuring positive energy benefits with the growing population. The FYDPIII aims to supply electricity to all remaining villages, but the challenges of productive uses of electricity remain. Thus, research and innovation should also focus on productive use of energy and financing models to enable penetration of economic activities in rural areas where there is grid

extension. Also, for remote and rural areas not connected to the grid, research should focus on using the energy mix (e.g. wind and solar) in hybrid systems to enhance the volume and power quality and be used for productive use.

3.2.3 Energy Conservation and Efficiency

Efficient use of energy is the most effective way for its conservation and reduction of cost. Tanzania Electric Supply Company (TANESCO) reports about 25 percent of the energy generated is lost. Similarly, biomass utilisation as a source of heating and cooking has been under low efficiency in urban and rural areas. There are opportunities to reduce energy consumption through efficient energy use and industrial energy management programmes using more efficient equipment and better practices. The government has started awareness campaigns to educate the public on the importance of using energy-saving appliances. However, more information is needed on best practices and cost-effective ways.

There is a need to research and gather information on energy conservation, energy losses, and the potential to reduce energy losses through appropriate building design and consumers' awareness on using energy-efficient equipment. Also, research and innovation should focus on the best models for adaptation of energy audit practices in public facilities and renewable energy technologies such as solar PV for electricity and biogas for cooking.

3.2.4 Non-Renewable Resources and Technologies

Coal, oil, gas, and nuclear resources have great potential to alleviate the national energy demand and have a significant contribution to sustainable development in the country. Research in this area should focus on efficiently exploiting these resources through informed technical, legal and policy considerations for the entire value chain. RDI should also focus on the production of petrochemicals and fertilizers from natural gas. This can include the best models of technology acquisition and pilot for the same. Research in this area should also tackle the environmental protection and safety of consumers and e-waste disposal.

3.3 INDUSTRY AND MANUFACTURING

Industry engrosses manufacturing, agro-processing, mining and quarrying, construction, energy and water. The manufacturing sector contributed 8.5percent to Tanzania's GDP in 2019/20 compared to 7.9percent in 2015/16. The sector also grew by 8.3percent in 2019 compared to 6.5percent targeted in 2015/16. The main manufactured goods exports included cotton yarn, manufactured coffee

and tobacco, sisal products (yarn and twine), plastic items and textile apparel. STI is envisaged to build competitive drive and economic transformation towards attaining the national vision targets by the sector. Challenges in the sector include; limited local content for industrial inputs, minimal linkage with research institutions, small and medium enterprises (SMEs), which contributes to the slow growth of this sector. Therefore, research in this area should focus on addressing these challenges to augment the industrial sector's contribution to the development of the nation commensurate with the Tanzania Development Vision 2025.

3.3.1   Industrial Production Processes

Industrial production is the transformation of raw materials into finished products. This entails inputs (raw materials), production processes and systems and outputs (finished products). RDI should address the improvement of existing production processes and systems, adaption of new emerging technologies and systems, including the use of industrial digital technologies (Industrial 4.0) in automation and artificial intelligence to improve efficiency, productivity and quality to win competitive advantage. This will encourage using domestic products against imported products.

3.3.2   Value Addition

Value addition of local products and natural resources, including bee products, is an important intervention for all sectors to contribute to the nation's GDP. This includes; agro-processing, mineral processing, livestock products and by-products. The high growth rate of manufactured exports in Tanzania has been recorded annually since 2000. However, nearly half of the country's manufactured exports are resource-based products mostly agricultural and precious minerals, including gold.

Value addition should be linked to research for enhancing manufacturing capabilities, including packaging, access to internal and foreign markets, establishing/meeting standards, and increasing exports of manufactured goods. Research on value addition should also include the application of STI to improve productivity and yields in all natural resources, including but not limited to minerals, forestry, livestock and fisheries, and agricultural produce.

3.3.3   Technology Transfer and Commercialization

Industrial development is highly dependent on research and technology transfer. The success of this sector will depend on the extent to which the country would develop, consolidate and strengthen basic scientific research, technology and innovation. However, in Tanzania, technology transfer and commercialization have been inadequately exploited due to limited absorption, adoption, and transfer of technology. There is also inadequate interaction between industries and research institutions, and knowledge centres.

Thus, there is a need to research better approaches for sustainable technology development and transfer, manufacturing systems, Intellectual Property Rights (IPR) framework and models for linking R&D Institutions with industries.

3.3.4   Clusters and Incubation Development

Innovative and induced business cluster and incubation programmes intend to offer support such as modular working premises, access to technology and financial services; marketing facilitation; product development support; technical assistance, and communication and information services. There are few incubator related initiatives currently going on in Tanzania. Still, the impact of these incubation programmes has not sufficiently translated into the creation of new employment opportunities or graduate companies in the competitive market. Research and investment in this area are needed to develop more innovative incubation marketing models and innovation hubs that are effective for industrial development and sustainability.

3.3.5   Industrial Waste Management

Environmental management issues have been a major challenge in developing countries, including Tanzania. Despite ratifying international environmental treaties and developing protective policies and laws, development activities have not always complied with the set standards for environmental management. While Tanzania transitions to a higher middle-income country driven by an industrial economy, more environmental challenges may emerge. Therefore, research should focus on recycling, effective use, and evaluating the environmental impact of industrialization. Furthermore, innovative technologies to reduce industrial pollution and enhance proper waste management practices need to be explored.

3.4 TRANSPORTATION

Transportation is crucial for supporting industrial development to ensure sustainability as reflected in the National Development Plans, sectorial policies, and Regional and International Conventions Strategies. However, transportation systems (water, air, rail, road and pipeline) in Tanzania have high costs and low-quality services due to the high backlog of infrastructure maintenance and rehabilitation. Research in transportation systems should focus on infrastructure development, transportation equipment technologies, and efficient logistics and transport operations.

3.4.1 Infrastructure Development

Transport infrastructure has improved over the past decade. However, the county is vast, and there is still a need to improve the quality and capacity of the infrastructure to realise socio-economic development. High-performing infrastructure and operation networks may be crucial for the large-scale implementation of newly emerging transport technologies. In addition, high-performance infrastructure networks can improve the efficiency of transport processes and positively influence the overall sustainability of the transport system. Therefore, Research areas need to focus on transport modelling and simulation, innovative technologies for quality infrastructure development, demand and supply, transport infrastructure planning and development, public-private partnership. In addition, the research should also focus on using the ICT transportation decision to use multi-model transportation effectively.

3.4.2 Innovative Transportation Equipment and Technologies

Global industrialization development has led to advancement in transport technologies that need investment in motive power technology, marine vessels and aircraft.

Transport equipment (assets) consists of equipment for moving people and objects, other than any equipment acquired by households for final consumption. They are very important assets for handling industrial cargo and farms products to simplify load, off-load and shifting cargo in a short distance, also used in contraction and harvesting. This area contributes to the facilitation of industries and agriculture production and the realisation of country development. Research should focus on investigating innovative power technologies for transportation,

maintenance on transportation equipment and capacity building. Research should also focus on reverse engineering and fabrication of equipment for improving efficiency and reduce cost.

3.4.3   Logistics and Transport Operations

Public transportation systems provide the most efficient means of moving number of people, which plays a vital role in urban productivity. Urban transport challenges have been associated with urbanisation, economic activities, and population growth, resulting in poor accessibility. Furthermore, all imported goods are subject to customs clearance in every destination country. Export and import trade plays a crucial role in promoting economic growth for developed and developing countries. It is an important source of foreign exchange that relieves the balance of payments pressure and creates employment opportunities. Despite efforts made by urban transport planners, clearing and forwarding agents, congestion deliverance of goods from port to the final destination is frequently delayed causing congestion. Therefore, research should focus on integrated transport system models, innovative logistics operations, Integrated transport systems; Electronic ticketing; Smart city transport; City Logistics; Transport safety and security; Urban transport systems; Eco-mobility transport systems; Sustainable transport systems; Rural transport systems; Multi-modal and inter-modal transport systems.

3.5   EXTRACTIVES

Tanzania is endowed with large deposits of gold, diamond, tanzanite, ruby, tin, copper, nickel, iron, phosphate, gypsum, coal, natural gas, uranium and oil. Extractives of large and small scale are important to the economy. Before 2007, the mining sector grew at about 15 percent annually. The sector dropped to 2.5 percent in 2008 and a further 1.2 percent in 2009 due to declining diamond export and gold production. In June 2019, Tanzania discovered about 55 Trillion Cubic Feet (TCF) of natural gas of (MEM 2015) in on and off-shore basins.

In 2019, the mining sector contributed about 4.8 percent of the GDP, and was projected to increase by over 6 percent annually. The TDV 2025 anticipates a strong vibrant mining sector that is well-organized and private sector-led. It is expected that large and small-scale mining is conducted in a safe and environmentally sound manner. The sector should contribute to industrialisation and export by strategically exploiting the energy and industrial mineral resources

and processed and/or semi-processed mineral outputs. Therefore, research in this area should develop sustainable technologies for extraction of the existing mineral and explore more opportunities for other undiscovered minerals, oils and natural gas.

3.5.1 Mineral Exploitation

Finding commercially viable concentrations of minerals for mining is a continuous process in the mining sector. Most of the companies involved are foreign, while local experts mostly participate as employees. Therefore, research in this area should aim at promoting modern and affordable technologies for exploitation of onshore mining on surface or underground and offshore mining underneath of the seabed for value addition that can be utilized by local small scale miners and/ collaborative models with investors.

Research should also focus on strengthening the planning, design, management and control of large-scale and medium scale mining, establishment of demo centres and centres of excellence as well as enhance local content contribution to development operations and management of mine waste and closure.

3.5.2 Artisanal and Small-Scale Mining

Tanzania has many artisanal and small-scale miners whose activities are concentrated on gold and gemstone mining, salt and construction materials production. The Mineral Policy of 2009 recognises the positive contribution of the artisanal and small-scale mining sub-sector to the economy. Small-scale miners face many challenges such as technology, marketing and financing.

Therefore, Research on technology development and deployment, optimisation and adaptation, to maximise productivity in mining is essential to contribute to sustainable economic development. Research efforts should also be directed towards developing mining and mineral processing for value addition, improving geological information techniques, marketing and sustainable environmental management strategies to small and medium-scale mines and beneficiaries.

3.6 AGRICULTURE

Agriculture remains one of the most important sectors accounting for over 28.4 percent of the GDP. The sector employs approximately 65.5percent of the population, but it features very slow growth rates. Smart interventions are needed

to ensure that the country continues to be food secure and produce sufficient raw materials for industries. More than 90 percent of agricultural products are sold as raw materials, and there is a need to ensure value-added commodities reach the international markets. The interventions should ensure the produced raw materials and manufactured products participate competitively in regional and global markets. Strategic, targeted, well-sequenced research, advanced technologies and innovations in crops, livestock, fisheries, soil, water and biodiversity, placing emphasis on the use of modern technologies such as the application of IT in agriculture, biotechnology, and nuclear sciences, would be of benefit.

3.6.1 Crops

Crop production remains the most important undertaking in the country's agricultural sector. Besides accounting for significant agricultural output, the sub-sectors' contribution to food and nutrition security, raw material for industries, and income generation cannot be underscored. Crop productivity and yield is 20-30 percent potential productivity per unit area that affect national food security and competitiveness of agricultural products in the world market. Research is required to develop better and new crop varieties, judicious water use, soils and biodiversity. Research should also focus on developing efficient technologies for plant nutrition, crop protection, and post-harvest management. Special focus should be given to the needs of local and international markets. The Government should also ensure that special attention is afforded to strategic and commercial crops such as maize, rice, roots and tubers, round potatoes, wheat, soybean, sesame, palm, sugarcane, sunflower, and legumes. Traditional cash crops such as cotton, tea, coffee, tobacco, sisal, cashew will continue to contribute to the economy strategically. Horticulture and Floriculture are growing areas that would benefit attention. The emphasis on research should consider agricultural land use planning, the spread of invasive alien species, modern farming technologies, non-traditional high-value crops such as macadamia, characterisation and conservation of indigenous germ plasm, value addition, exotic legumes, cereals and indigenous crops of cultural significance such as coconut.

3.6.1.1 Seed and Seed Systems

Accessibility to high-quality seeds from a wide range of varieties and crops in Tanzania requires investment in research, development, technology transfer and innovation for the entire value chain from breeding to seed multiplication, gene/ seed bank and distribution. In addition, for competitiveness, focused breeding

efforts on developing demand-driven varieties of exotic and indigenous germ plasm are necessary.

3.6.1.2 Soil Management and Irrigation Systems

Moisture stress and decline of soil fertility are major constraints for crop production. These are associated with climatic change, poor crop husbandry, improper use of chemicals, poor conservation of catchment areas and deforestation. Additionally, small portions of arable land are exploited for irrigation despite the huge potential of inland water masses. Research would benefit the development and adoption of technologies that mitigate the effects of climate change, conserve and preserve soil health, including conservation agriculture, land management and erosion control, irrigation efficient technologies, bio-fertilizers, water harvesting, management and utilisation.

3.6.1.3. Indigenous Crops and Crops of Cultural Significance

Spices, herbs and medicinal crops are important sources of food and phytochemicals for traditional and modern medicines. These products do not feature often in mainstream R&D. Interest in local and international markets has exposed job creation opportunities and increased income.

Crops such as coconut are facing challenges as a result of new diseases and climate change that need address. Coastal areas where such crops are grown provide an opportunity for synergy by promoting eco-tourism and related services. Dedicated research focused on enhanced productivity, value addition and marketing of these crops would benefit the economy while strengthening cultural values.

3.6.1.4. Pre- and Post-Harvest Losses Management

Pre- and post-harvest losses are among the constraints to Tanzania's agricultural productivity and food and nutrition security. An estimated 30 percent of the losses occur post-harvest. This is mainly due to poor agronomic practices, handling and post-harvest technologies. Research should establish improved agronomic practices, harvesting, post-harvest handling and storage, and processing techniques to increase productivity and minimise losses.

3.6.1.5. Crop Pests and Diseases

Pests and diseases account for significant crop losses, which affect productivity in both pre- and post-harvest. Research should focus on developing and use of

conventional and emerging technologies with Integrated Pest Management (IPM) to address these challenges.

3.6.2   Livestock

Tanzania has an estimated population of about 33.4 million cattle, 21.65 million goats and 5.65 million sheep. Other livestock includes 2.1 million pigs, 38.8 million traditional chickens and 44.5 million improved/hybrid chickens. About 90percent of the livestock population is indigenous. The nation's average annual per capita consumption is estimated at 12 kg of beef, 49 litres of milk and 75 eggs, which is below the world food organization's standard of 50 kg of beef, 200 litres of milk and 300 eggs per annum, respectively. The presence of diseases, such as the Foot and Mouth Disease (FMD), the Contagious Bovine Pleuropneumonia (CBPP), the African Swine Fever (ASF), the Newcastle Disease (ND) and other transmittable animal diseases, act as barriers to productivity, consumption and export of livestock and related by-products.

To increase productivity in the subsector and make a significant contribution to the economy, research evidence to develop and adopt appropriate technologies, innovations, enabling policies, and sustainable production systems is important.

3.6.2.1 Animal Health Disease Management and Public Health

Livestock diseases pose the most severe constraint limiting the development of the livestock industry in the country. The inability of local producers to comply with sanitary and phytosanitary conditions stipulated in international regulators limits export trade in livestock, livestock products and by-products. Moreover, failure to set up disease-free zones also contributes to low investment in commercial livestock production. About 30-40 percent of calves die each year due to mainly preventable vector-borne diseases (East Coast Fever and Trypanosomiasis), and the Newcastle disease (ND) alone kills between 80 and 100 percent of affected flocks. The prevalence of livestock diseases in the country can be reduced by targeted research on vaccinology and diagnostic techniques for livestock diseases of economic importance.

3.6.2.2 Pastures and Forages, Feeds and Feeding Systems

In Tanzania, livestock production mainly depends on natural and established pastures. However, livestock production in the country is hampered by seasonal variation of quantity and quality of forage, uncontrolled burning, overstocking,

over grazing and land degradation. Pasture production fluctuation influenced by seasonal changes leads to decreased quantity and reduced quality of pastures during the dry season and improved situation during wet seasons. Similarly, the varieties of grass and leguminous species are affected by drought, uncontrolled fires and over grazing. With climate changes and variability, there has been an increase of invasive species (IPS) in most grazing lands of the country.

Research on the areas of rangeland improvement and utilisation, adaptable and resilient forages, management and control of invasive plant species in grazing areas, feed conservation, utilisation of crop residue, substitute feed sources for animals, emerging feed production biotechnologies, feed formulations, quality, safety and cost-effectiveness, manufacturing and develop feeding standards for livestock is indispensable.

3.6.2.3 Breed Improvement and Reproductive Technologies

Low production and reproductive performance of indigenous and improved breeds of livestock can be enhanced through various measures, including adopting appropriate breeding programmes and innovative feeding systems regimes. Much of the breeding efforts to address breed inventory and characterization is focused on indigenous livestock types such as cattle, goats, sheep and poultry. Selection of breeds within indigenous livestock, breeding techniques, selection and improvement of livestock breed-types according to agro-ecological zones (AEZs) and special market needs, germplasm multiplication and conservation of farm animal genetic resource as well as development of appropriate breeding systems.

3.6.2.4 Non-Conventional Livestock Species

Tanzania is endowed with abundant animal diversity, inclusive of non-conventional animal species such as rabbits, ostriches, crocodiles, guinea fowls and insects. This diversity opens opportunities to produce/domesticate unique, non-conventional livestock/animal/insect and related products of exceptional value in domestic and export markets. Research in this area will increase the diversity of meat sources for food security, nutrition and income generation.

3.6.2.5 Livestock by-products and Value Addition

Livestock by-products value addition has paramount importance because it reduces post-harvest losses through increased product shelf life, quality and

biosafety, attracts consumer preferences and increases income to key actors along the value chain. However, despite awareness on the importance of adding value to livestock and livestock products, there has been limited progress to attain the intended goal. Livestock by-products of economic importance include hides and skins, blood, offal, bones, horns, wool, hooves, bristles, feathers, hair, and fur. Hides and skins are among the important by-products of livestock, which can form a potential input to the industrial sector and export market.

The potential raw materials available in Tanzania are about 2.6 million cattle hides and 2.5 million goat/sheepskins. However, Tanzania exports 95percent of raw hides and skins while few tanneries are working under capacity resulting in the export of processed hides in the form of wet blue being less than 60,000 pieces per annum. The existing leather capacity is limited to six tanneries, some of which are not working or working below 30percent of their installed capacity. Furthermore, the slaughtering of animals, subsequently the flaying of hides and skins, are carried out under poor conditions using improper flaying tools and, therefore, they are often damaged. Poor conditions also apply during the curing and preservation process.

Other livestock by-products such as blood, bones, hooves and horns can be used to manufacture animal feeds, medicines (blood) and garments (feathers, wool, hair and fur). However, the production, handling, processing and better use of these by-products are not highly researched and there is virtually no clear obligation and provision for best practice designed to ensure quality, safe production and disposal. Research should be directed towards developing appropriate technologies for improved livestock by-products from healthy animals, handling, storage, value addition and manufacturing of various quality products.

3.6.2.6 Crops-Livestock Interaction and Integration

Increased agriculture and urbanization have caused the decrease of available grazing land and source of feeds for livestock. In many parts of agricultural land in the country, inadequate planning for communal grazing and farming land has been exercised. This has resulted in conflict between livestock keepers and farmers vying for land. Research should address conflict resolution, improve livestock productivity, conservation and utilisation of crop residues and agro-industrial by-products as an alternative source of animal feed. Research should also consider nutrient recycling through the utilisation of farmyard manure for

the cultivation of field crops to increase land productivity and land use planning in the rangelands.

3.6.2.7 Zoonosis

Veterinary public health deals with monitoring and control of zoonotic diseases and the quality of animal products to safeguard human health. Common zoonotic diseases include Rabies, Trypanosomiasis, Brucellosis, Tuberculosis, Anthrax, Cysticercosis and Salmonellosis. Furthermore, zoonotic transmissions are usually a precursor to emerging pandemics such as Ebola and COVID-19. Challenges facing veterinary public health include baseline data on the prevalence of many zoonotic diseases in Tanzania, knowledge of the diseases, infrastructure, and skilled human resources.

Research should be geared at improving veterinary public health to safeguard human and animal health and ensure safety and quality food of animal origin. Research should also focus on establishing the magnitude and trends of zoonotic diseases, modern diagnostic techniques, early warning systems and device mechanisms for control.

3.6.3   Fisheries

The fisheries sector contributed about 1.7percent of the GDP in 2020, mainly from capture fisheries. Artisanal fishing produces about 90percent of the total fish catches in the country, while only 10percent is derived from industrial fishing. The aquaculture industry is growing at a slow pace but holds the potential to increase fish production to meet the ever-increasing demand for fish in the country. To increase fish production from capture fisheries and aquaculture, solutions for the development of the fisheries industry are needed. This will ensure maximum benefit from the blue economy and contribute to the industrialisation process.

3.6.3.1   Capture Fishery

With increasing fishing pressure and declining fish catches in the wild, management measures to sustain the fishery are needed urgently. However, the formulation of appropriate management strategies demands information on the status of the existing fish stocks. Likewise, innovation on new fishing technology to maximize fishing efficiency and minimise unintended fishery resources is vital for a sustainable fishery. Therefore, there is a great need to research the status of fish stocks and their dynamics, biology and ecology, marine biodiversity and conservation, exploitation patterns and effects of alien species, suitable fishing

technology (gears, methods used), habitat rehabilitation and restoration, and reducing post-harvest losses.

3.6.3.2 Aquaculture

Tanzania has underexploited its aquaculture production. The industry is dominated by freshwater fish farming, in which small-scale farmers practice both extensive and semi-intensive fish farming and has pertinent production barriers. Moreover, mariculture is only mainly small-scale seaweed and sea cucumber farming, despite the production potential of marine aquaculture. The current challenges towards a sustainable aquaculture industry in Tanzania include limited extension services mirroring the limited knowledge by farmers on pond management practices; lack of quality and affordable feeds and seeds, inadequate funds to carry out fish disease research or implement surveillance systems; little expertise in fish disease diagnosis and treatment; and poor management options.

There is an increasing demand for protein with population growth. In addition, the demand for fish by the tourism industry, declining wild fish catches due to fishing pressure, has now influenced the development of aquaculture production systems. Research on the development of high efficiency and environmentally friendly aquaculture production technologies, availability of quality and affordable fish feeds and seeds, identification and treatment of fish diseases, identification of new candidate aquaculture species while mitigating the effects of invasive species and the changing climate would benefit the industry.

3.6.3.3 Fishery and Aquaculture Products Quality, Standards and Marketing

Fishery and aquaculture contribute to the socio-economic development of the country. Efficient fishery and aquaculture need proper marketing systems for their sustainability. Therefore, poor quality fish, fishery and aquaculture products lead to poor markets, raising the need to improve the quality of these products. The quality of fish and products from fishery and aquaculture should be improved to meet market standards. To improve quality, standards and hence, values of fish and fishery and aquaculture products, research is required to find ways to address the existing challenges throughout the fishery and aquaculture value chains by introducing new innovative technologies that can contribute to industrial processing and production of fish products.

3.6.4   Agricultural Marketing Systems and Entrepreneurship

With liberalisation, the role of the Government has involved creating conducive environments for the private sector to take a lead in marketing agricultural inputs and products. However, marketing constraints like weak institutional, legal and regulatory frameworks, poorly developed and maintained marketing infrastructure, limited agro-processing and the need to enhance quality and standards, entrepreneurial skills, limited access to finance, and inter-institutional coordination remain a challenge.

Marketing systems and entrepreneurship of local produce have not been exploited to their full potential. Therefore, agricultural research should develop innovative marketing systems that would enhance competitiveness through agro-based industries and value addition throughout the supply chain. Research should focus on building capacity to supply agro-processed products in response to new opportunities in the domestic and export markets. Other relevant areas of focus include value addition in agricultural produce, grades, standards and quality in agricultural products marketing, institutional set-up marketing research and intelligence, marketing risk management approaches, access to financial services for agricultural marketing activities, marketing linkage as well as capacities to utilise opportunities emerging in the domestic, regional and international markets, including preferential markets.

3.7   DOMESTIC, REGIONAL AND GLOBAL TRADE

Realising a sustainable industrial economy requires Tanzania's local, regional and international trade participation as part of the global economy. Tanzania's signing of the SADC-COMESA-EAC Tripartite agreement is expected to increase the share due to the opening and easing of trade barriers. Preferential trade windows for Tanzania such as the African Growth and Opportunity Act (AGOA) of the United States of America (USA), Everything but Arms (EBA) –of the European Union (EU), and bilateral agreements with several countries will also expand export trade.

Maximum exploitation of these potentials requires research to determine comparative and competitive advantages in trade, identify trade barriers, enhance trade negotiation, promotion, lobbying strategies, regional export and import markets and international politics.

CHAPTER FOUR

NATIONAL TOURISM AND HERITAGE

The tourism sector in Tanzania has a great potential to contribute to socio-economic growth. Its contribution to the country's GDP was approximated to be 17.5 percent and 25 percent of the foreign currency in 2019/20. The country's competitive strength in tourism lies in the abundant and diverse wildlife, spectacular landscape, scenery, clean environment, friendly people and the existence of other economic sectors that can support the tourism sector. Similarly, cultural heritage is yet another area that compliments the growth of national tourism. However, the tourism and cultural heritage industry require a diversified and commercialized feature. Consequently, there is a need to increase the participation of locally owned enterprises in the top-notch tourism and heritage market. Therefore, research should propose ways to effectively optimise these opportunities.

4.1 TOURISM

Tanzania is endowed with tourist attractions such as natural, cultural, historical and archaeological sites in high demand in international tourism markets. However, there are limited tourism linkages to other subsectors such as agriculture, transport, industry and services. The challenges in this sector include unpredictable business environment; inadequate regional and international tourist linkages; inadequate land for tourism investment outside protected areas leading to uncontrolled tourism development, unskilled personnel, limited budgetary allocations for tourism development and promotional activities, ineffective institutional setup, technical capabilities and coordination among various stakeholders involved in tourism development.

The priority research areas for the sector should address the application of science and technology for tourism marketing and labour skills information, tourism socio-culture and environment, domestic tourism development, product development and diversification, and quality service delivery in the tourism industry.

4.1.1   Tourism for Socio-Economic Development

One of the barriers for tourism to contribute to poverty alleviation is poor linkage and integration with other subsectors such as local business, agriculture,

transport, service and culture. There are various local products such as food, vegetables, seafood, furniture, local handicrafts and hospitality, tourism-oriented skills, and services that promote the tourism industry for sustainable socio-economic development of the country. However, tourism products and services are still underdeveloped with inferior branding and packaging and a low level of marketing promotion, which do not meet international standards and reduce access to the tourism market. Investment from public and private sectors in tourism products and services is still a challenge.

To enable tourism to significantly contribute to socio-economic development, research on economic analysis on the tourism products and services; product and service diversification; indigenous knowledge, branding diversity; comparative competition in the tourism industry; marketing of products and services, and investment options in tourism is needed.

4.1.2 Eco-Tourism and Tourism Integration

Eco-tourism refers to integrating conservation, communities and sustainable travel to ensure socio-economic, environmental benefits and empowerment of local communities while ensuring tourists' satisfaction. Research will determine how these sectors can be linked; conduct tourism value chain analysis; actor assessment, relationship and profit margins; and sustainable carrying capacity of the ecosystems.

Furthermore, the sustainability of the tourism industry depends on the protection and conservation of the environment. Growing the tourism industry without environmental consideration may lead to significant wastes and improper disposal, degradation of the physical environment such as erosion and deforestation, and excessive waste of water resources that have an adverse effect on the environment. Research should develop harmonised systems that enhance and sustain tourism while preserving the environment. There should be a focus on relationships between tourism and the environment; community attitudes and behaviour to create awareness, application of ICT and tools for eco-tourism promotion, service provision, business and market linkages.

4.1.3 Marine Tourism

Marine resources are some of Tanzania's comparative advantages, with the potential to boost the tourism industry. Marine tourism occurs along the coast and in marine environments such as coral reefs, mangroves, coastal forests, sea, islands, islets and beaches. To promote marine tourism and value chain analysis

and improvement, there is a need to conduct research on the sustainable utilisation of coastal and marine resources and demand and supply of sea foods and marine resources.

4.2. NATIONAL HERITAGE

Promoting and preserving our cultural heritage for national identity and heritage can effectively be used for social and economic development. National heritage engrosses cultural and natural heritage. However, globalization, economic transformation and infrastructure development threaten the preservation of heritage. The identifiable research areas in this subsector include heritage management; historical building sites and materials; historical and archaeological studies; natural heritage; geological heritage, intangible cultural heritage; artists and works of art; culture and religion plus innovative marketing of the heritage sites.

4.2.1 Natural Heritage and Management

Tanzania's national parks and game reserves are home to an incredible variety of flora, fauna and culture. Examples of these are the African violet plant and East African camphorwood, endemic to Usambara mountains, fauna in the Serengeti where millions of wildebeest and zebra migrate annually; the Ngorongoro crater; Gombe stream reserve; Selous and Ruaha soon to be Africa's largest national park, the red Colobus monkey (Kima Punju), and Adder's Duiker (Paa Nunga) in Jozani national park. Research is needed to address harmonisation of natural heritage with human activities including settlement and utilization of natural resources, architectural, historical and aesthetic heritages for proper management.

4.2.2 Historical Buildings and Archaeological Sites

Tanzania is endowed with many historic buildings, sites and materials, some of which have a long maritime connection with the outside world, especially Asia. There are many documented historical sites; a rich archive of manuscripts; books and documents in Arabic, French and German; old and contemporary maps and plans; family histories; private papers and old stamps. However, most of the mentioned sites are not well maintained.

Tanzania is best known for its cultural and historical resources reflecting the diversity of the cultural history of the East African coast. The resources include ruins, monuments, historical sites, caves drawings, footprints and maritime

archaeological sites. It is estimated that more than 70 percent of historical sites are not in good condition while others are not well preserved and are in deterioration. Hence, there is a need to research effective ways to preserve and coordinate heritage sites, restoration of historic buildings as well as archival materials to improve their conditions. Archaeological research is needed to preserve and discover more historical resources.

4.2.3 Intangible Cultural Heritage

Intangible cultural heritage entails using traditional knowledge, languages, skills, performing arts, theatre arts, folklore, traditions and mythology by various communities. It is understood that most of these intangible cultural heritage elements have either disappeared or been forgotten. Therefore, there is an urgent need for anthropological studies to explore related phenomena for documentation and restoration. Research should recapture the lost skills and craftsmanship of practitioners and bearers of the intangible cultural heritage and devise mechanisms for their preservation and improvement into the modern creative industry.

4.2.4 Fine and Performing Arts

Works of art play a major role in the cultural development of any country. However, in Tanzania, this sector's visibility needs to be enhanced to contribute to socio-economic development. Research is needed in carving craftsmanship, documentation, filming, children plays and games, weaving, traditional dressing, dancing and food, traditional knowledge and skills; theatre arts; and models for commercialization.

4.2.5 Culture and Religion

Cultural, religious tolerance and harmony is an aspect that has a substantial impact on unity, peace and democratic development of a country. Tanzania has a variety of culture and belief patterns. Citizens are free to adhere to any religious belief provided they do not breach the laws. However, there has been violence involving people of different beliefs and the decline of traditional cultures in recent times. Nevertheless, there has also been neglect of parental roles. This has led to the deterioration of cultural values. Therefore, research needs to address how to value and restore acceptable culture, religious tolerance, and free worship. Further, research should address mindset changes, self-reliance, confidence and patriotism, the reading culture, adherence to ethical conduct, attitude towards work, entrepreneurship, and savings to fully assess the contribution of culture to development.

CHAPTER FIVE

SUSTAINABLE NATURAL RESOURCES AND THE ENVIRONMENT

Sustainability requires balancing the use of natural resources to meet changing human needs while ensuring their long productive potential and conservation of environmental functions. Society depends significantly on natural resources for attaining basic needs, livelihoods and industrial development. Due to limited incentives for sustainable management, limited alternative livelihoods and unsustainable land management practices, environmental degradation continues to propagate the poverty vicious cycle further. Research on access and sustainable use of natural resources is crucial to address growing pressure triggered by emerging issues such as climate change, urbanisation, population increase, and invasiveness.

5.1 FORESTRY AND BEEKEEPING

5.1.1 Forestry

Forest and tree resources in Tanzania play significant roles in the economy and nature conservation through their diverse products and services. The forest sector ensures sustainable wood and non-wood production that meets the needs of the country with a surplus for export. By 2015, forest and woodlands were estimated to cover about 48.1 million ha in Tanzania mainland. The contribution of forests to the Gross Domestic Product (GDP) through wood products is estimated at 3.5 percent. By 2019/20, biomass is the primary domestic energy source and accounts for 92 percent of energy consumption. In addition, forests sequester carbon from the atmosphere, provide diverse wildlife habitats and unique natural ecosystems and biological diversity, harbour water sources and support livelihoods.

Despite the importance of forests to the national economy and livelihoods, several challenges prevail, including rapid deforestation due to the intensification of human activities. Currently, the deforestation rate is estimated at 469,420 ha per annum, leading to the loss of forest products, biodiversity, and water sources. Hence, innovative research to address the drivers of deforestation, degradation as well as forest restoration approaches are needed.

Reforestation and afforestation activities need to use high-quality germplasm. Also, the potential of forest plantations, woodlots and trees on farms requires high-quality germplasm and proper tree growing techniques. Thus, research on tree breeding and improvement, germplasm multiplication and seed quality control is needed. Forests and woodlands are vulnerable to infestation by pests, diseases and invasive species, which is aggravated by the changing climate. Hence research should be geared to improving forest health and set up advice mechanisms for monitoring and control of forest fires, exotics invasive species, forest insects and diseases.

Processing technologies for both wood and Non-Wood Forest Products (NWFPs) need to be explored. Wood energy materials are produced using poor and inefficient technologies. Similarly, this applies to other industries that process NWFPs. Currently, there are about 630 primaries wood-based industries across the country. Further, research is needed to unlock the potential in the forest sector, including efficient processing technologies in NWFPs.

5.1.2 Beekeeping

Beekeeping is a long-established traditional economic activity in Tanzania. It is a source of food, raw materials for various industries, medicine and source of income. and employs about 2 million people. Estimates suggest that the production potential of bee products in the country is about 138,000 MT of honey and 9,200 MT of beeswax per annum from 9.2 million honey bee colonies. Although the beekeeping sector has the potential to contribute to livelihoods, its contribution is limited by low production in terms of quality and quantity, poor processing technology, inadequate investment in skills and equipment. Therefore, there is a need to research beekeeping in the following areas, innovating beekeeping technologies and commercialization.

5.2 WILDLIFE

Tanzania boasts a huge wildlife resource that comprises a protected area network covering 31.3 percent of the total land. The protected areas and wetlands network are important to the national economy and are critical for sustainable development. Despite the abundance of wildlife resources and their contribution to the economy, there is inadequate understanding of the potential of wildlife biodiversity and how best to conserve them. Challenges still exist on; sustainable use of wildlife, Human-wildlife conflicts and technology in wildlife conservation.

Impact of human activities on wildlife resources, encroachment to protected areas, insufficient data and information, growing human population, land-use changes, the spread of invasive alien species, habitat loss, emerging and re-emerging wildlife diseases, zoonosis and competition with other land users.

Research is essential to enhance wildlife inventory and population dynamics, protection of wildlife corridors and dispersal areas, human-wildlife interaction, traceability, utilisation, management and infrastructures development in protected areas, wildlife diseases, ecosystem processes and services, ecosystem restoration, studies on invertebrates and contribution of the wildlife subsector to the GDP.

CHAPTER SIX
CROSS-CUTTING AREAS

Cross-cutting issues refer to elements that traverse the specific research areas and should be considered in all sectors. This includes governance and accountability, Climate changes, disaster and risk management, leveraging technology for development, Information and communication technology, local content, entrepreneurship, gender, and policies and legislations.

6.1 GOVERNANCE AND ACCOUNTABILITY

Good governance and accountability are fundamental components for creating a favourable environment for inclusive economic growth, justice and poverty reduction. It ensures equitable access to and control of economic opportunities and social services. Despite the implementation of numerous political, economic, legal, and social reforms over the past decade, Tanzania still faces challenges in corruption and law enforcement and respect for human rights.

Research in this area should contribute to achieve a favourable environment for national economic development, including closing gap for corruption, effective and efficient justice delivery systems; effectiveness of reforms in politics, address peace, security and political stability; address democracy, political and social tolerance; the developmental role of the state in economic governance; economic, legal and access to social services, community participation in development processes adherence to and respect for the rule of law, human rights and absence of corruption

6.2 CLIMATE CHANGE

Climate change is a global threat to the survival of human beings as it has adverse effects on the environment, crop production, and water resources and livestock production. Increased temperature resulting from climate change is likely to influence wilting and drying of plants, multiplication of pests, weeds, and diseases that would result in increased cost of production and failures in crop yields. Climate change is likely to increase the intensity, duration, severity, and frequency of extreme weather and climatic events such as droughts and floods that might significantly damage infrastructure, properties and destruction

of the environment and livelihood. The Intergovernmental Panel on Climate Change (IPCC) assessment reports consistently predict that developing countries (Tanzania included) are particularly more vulnerable to impacts of climate change. Therefore, there is a need for research on mitigating and adapting the impacts of climate change to provide relevant information and evidence that would guide decisions and policymakers.

6.3 DISASTER AND RISK MANAGEMENT

Tanzania has experienced a variety of natural disasters. Experience has shown that drought, floods, epidemics, windstorms, landslides, earthquakes and pest infestation are major natural disasters in Tanzania. However, windstorms, landslides, volcanoes, and earthquakes are rare; others occur more regularly, especially drought, epidemics, pandemics, and floods. The country is also not spared from technological disasters such as boat accidents, building collapse and bomb blasts. Some of these disasters have resulted in the loss of lives, displacement of victims, damage to properties and infrastructure, consequently disrupting the development gains made over the years. From 2001 to 2017, the total number of people who died from the disasters has been estimated to be 1,203, with flood disasters claiming the majority of hazardous victims' lives (387), followed by boat accidents (380), train accidents (283) and bomb blast (56) (URT, 2019). Floods have affected more people than all the other natural disasters in Tanzania except for drought. An increase in the frequency and magnitude of floods in some areas of Tanzania has been attributed to climate change and variability featured with extremely heavy rainfall affecting areas such as Dar es Salaam, Manyara, Morogoro, Arusha, Mwanza, Dodoma, Tanga and Mbeya.

Most of the population in the country are vulnerable to various disasters because prevention, mitigation, preparedness and response measures to disasters are inadequate. Public resource paucity, low priorities, and lack of knowledge and insensitivity or unawareness among most actors on matters pertinent to hazards and threats complicate the problem further. Moreover, information on disasters and hazards (such as frequency, spatial distribution, losses, vulnerability levels and mitigation measures applied) is scarce, disjointed and unreliable, thus making it difficult to put in place informed strategies to reduce disaster risks and respond effectively to disaster events. Therefore, there is a need to carry out research on disaster risk reduction, geodynamics and geo-hazards, vulnerability and risk assessments, mitigating technologies and early warning systems.

6.4 LEVERAGING TECHNOLOGIES FOR DEVELOPMENT

Transformations in socio-economic sectors can benefit from leveraging technologies in fields such as education, health, transportation, agriculture, manufacturing, mining, finance, governance, or management. Application of STI is necessary to increase competitiveness for middle-income status as envisioned by TDV 2025 and Zanzibar Vision 2020. Research on technologies must explore the different platforms and opportunities such as biotechnology, nanotechnology, mechatronics, robotics, cybersecurity and material sciences.

Research priorities in this area will include but are not limited to the following; technology development and acquisition models, technology unpacking, leveraging digital technologies to foster business development and stimulation of spending (special commercial, economic zones), formulation and implementation of technology roadmaps for productive sectors; artificial intelligence, big data techniques, methods, analysis and applications, and modern biotechnology.

6.5 INFORMATION AND COMMUNICATION TECHNOLOGY

Information and Communication Technologies (ICT) has facilitated the nation's socio-economic development process. Tanzania recognizes that the effective use of ICT is a critical factor for rapid economic growth, wealth creation and improving socioeconomic well-being. Tanzania should realise that a nation's capability to accelerate its development processes and gain global competitiveness depends very much on the extent to which it can develop, use, and exploit ICT in various forms. There is a need to develop Tanzania's digital economy and society as part of accelerating the nation's socio-economic development in the technological age. However, Tanzania makes low usage of advanced and modern technologies, including ICT, primarily due to the high costs of sourcing and updating to modern technologies.

Tanzania has constructed 7,910 km out of 27,912 km of optic fibre cable (OFC) backbone through the National ICT Infrastructure Backbone Project covering 24 regions in the Mainland. OFC provides a solid base for scaling up broadband access, connectivity, and efficient services nationally and in the region and ultimately provides 40 percent of the communications services available to land-locked countries in the region. Connectivity to submarine cables (EASSy & SEACOM) and cross-border connectivity with neighbouring countries, namely Kenya, Uganda, Rwanda, Malawi, Burundi and Zambia, have been successfully

implemented. However, limited education level and human resources to adapt, manage, and operate new technologies, weak monitoring of quality and hardware and software standards, and low awareness and usage of open-source software are among the challenges facing the sector. Instances of vandalism on infrastructure have also been reported.

Focusing on indigenous products commensurate with the modern industrialization drive, responding to the current mining industry, transportation, agriculture, health, and education requires much attention. Research priority shall be directed towards the design and development of software tools and applications for industrial control and service provision and cyber/digital security for these systems.

6.6 LOCAL CONTENT

Local content is government trade policies requiring firms to use domestically produced raw materials, manufactured goods, or domestically supplied services, including technology and expertise in undertaking economic activities. Tanzania is facing limited local content in trade participation, especially in manufacturing, tourism, mining, and other sectors that hinder other sectors' growth and reduce employment and other opportunities. Tanzania targets to increase local content in priority sectors of the industrial economy. However, imposing uninformed local content requirements may undermine long-term industrial competitiveness, inefficiencies, increasing costs that are subsequently imposed to other sectors and may ultimately lead to a decline in import and export.

Therefore, research on economic analysis of local content in each sector and production supply chain and certified skills is needed to inform requirement that maximizes national benefits while promoting industrial economy and trade.

6.7 ENTREPRENEURSHIP

Economies of the developed world have benefitted R&D investment in entrepreneurship, which focused on improving quality and standards to produce competitive products and services, among other aspects of the value chains. More recently, developing countries such as Tanzania have likewise initiated R&D in entrepreneurship to stimulate industrial sector. Therefore, research should focus on finding ways to improve entrepreneur skills, linkages between academia

and enterprises, technology transfer, start-up financing, products and services competitiveness.

6.8 GENDER

Tanzania is still progressing towards attaining gender balance, including access to and control at all levels; the proportion of women in managerial and political positions, physically challenged individuals, youth in decision making and representation in the Parliament and eliminating gender-based violence. Furthermore, the TDV 2025 aims to attain gender equality and empowerment of women in all socio-economic and political relations. However, there are still wide disparities within the population regarding research opportunities, access to research resources, and the benefit of research findings.

Major areas for research on gender should include; equitable access to STI processes, products and services and equality of opportunities in employment.

6.9 POLICIES AND LEGISLATION

Policies and legislation have a profound effect on investment, including research. These equally affect the overall social and economic development of a society and the country at large. Therefore, informed decisions based on research before or during the implementation of policies and legislation need to be emphasized while developing, reviewing, and improving existing policies and legislation.

Research should address the; review of sectorial policies and legislation establish the existing R&D institutions reform STI systems, data and information management; to improve the effectiveness and efficiency of the R&D system. Furthermore, the research should focus on development of capacity in socio-economic discipline, commercialization and dissemination of innovative research results, facilitate establishment of legal and administrative framework to promote partnership, networking and collaboration across disciplines, the private sector and R&D institutions.

CHAPTER SEVEN

IMPLEMENTATION PLAN OF THE NRP

7.1 INTRODUCTION

This chapter outlines the implementation plan of the NRP. It provides the institutional set-up in the implementation of the NRP, identifies key actors and their roles. It also describes the monitoring, evaluation and review process and the financing mechanisms for the implementation of the NRP.

7.2 INSTITUTIONAL SET-UP OF NRP IMPLEMENTATION

COSTECH is the overall national coordinator of the NRP. R&D and HLIs, MDAs, NGOs, DPs and the private sector will develop research priorities that align with the NRP. The Regional Secretariats and LGAs will be responsible for facilitating the sectorial implementation of the NRP in their programme activities.

7.3 MONITORING OF NRP IMPLEMENTATION

Monitoring aims at ensuring adoption and efficient implementation and assessing the performance of the NRP. R&D institutions shall submit annual progress reports on the implementation of the NRP to COSTECH. The STI data collection will be done using the National STI indicators that are used to assess the performance of R&D activities in the country.

7.4 EVALUATION OF NRP IMPLEMENTATION

The NRP will be evaluated in two broad categories, that is, mid-term and end-line evaluation. The mid-term evaluation will be done after two and half years of implementation to monitor progress and assess the realisation of the intended objectives of the NRP. The end-line evaluation will be conducted after five years of implementation to assess the overall effectiveness of the NRP to ensure that 80 percent of research conducted in the country is aligned with the NRP.

7.5 REVIEW OF NRP IMPLEMENTATION

The review of the NRP will be carried out on midway to reflect lessons learnt from the midway evaluation and the changing conditions in the country to which the NRP shall need to adapt to.

7.6 FINANCING THE IMPLEMENTATION OF NRP

The financial resources to support the implementation of the NRP will depend on various sources, including the Government budget, the private sector and development partner's contributions, R&D and HL institutions incomes, and individuals with a passion for driving research and development activities in the country.

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