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RESEARCH

PRIORITIES FOR TANZANIA 2015 -2020

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LIST OF ABBREVIATIONS

| | |
|---------|---|
| BRN | Big Results Now |
| COHRED | Council for Health Research |
| COSTECH | Commission for Science and Technology |
| ECF | East Coast Fever |
| FMD | Foot and Mouth Disease |
| FYDP | Five Year Development Plan |
| GDP | Gross Domestic Product |
| LMIC | Low Middle Income Country |
| LTPP | Long Term Perspective Plan |
| M&E | Monitoring & Evaluation |
| MIC | Middle Income Country |
| NCD | Newcastle Disease |
| NRA | National Research Agenda |
| NSGRP | National Strategy for Growth and Reduction of Poverty |
| PI | Principal Investigator |
| R & DIs | Research and Development Institutions |
| R&D | Research and Development |
| R4D | Research for Development |
| RoGZ | Republic Government of Zanzibar |
| S&T | Science and Technology |
| STI | Science, Technology and Innovation |
| TANESCO | Tanzania Electric Supply Company |
| TDV | Tanzania Development Vision |
| URT | United Republic of Tanzania |
| ZSGRP | Zanzibar Strategy for Growth and Reduction of Poverty |

PREFACE

Research and Development (R&D) activities are necessary in order to inform, lead and guide all that needs to be done to achieve the desired transformation of the socio-economic status of a nation. However, the payback for investment in R&D by way of tangible achievements will be realized only if research is demand driven, and in that regard the outcomes are utilized to solve fundamental as well as pressing societal and development challenges which are obstacles to development. In certain cases, R&D activities may actually generate significant direct revenues and therefore give a financial return, which will contribute towards funding more research.

In considering the reality of perennial resource constraints and competing requirements to fund R&D, it is necessary to establish screening criteria for selecting the programmes to be funded; and furthermore within the selected programs to set priorities which will determine the level of resource allocation in considering the degree of transformative impact expected from the outcomes of the particular R&D activities. Since industrialization is the spearhead of the desired socio-economic transformation enshrined in the Tanzania Development Vision 2025 (“TDV 2025”), the priority programs and activities in R&D strategically in areas, which will promote innovation for economic development and technology transfer. To that end, the Tanzania Commission for Science and Technology (“COSTECH”) has set the direction and priority areas for research in Science, Technology and Innovation (STI) which will serve the purposes of development dynamics to propel the drive of socio-economic transformation over the next five years up to 2020.

This document outlines the areas of research and innovation deemed to be priority and in line with the stated development priorities and implementation strategies of the TDV 2025. The Priorities were drawn up with the participation of various key stakeholders in a consultative process led by COSTECH that culminates in the finalization of this document. The document has been prepared on the basis of a review that brought together vast and varied experiences in research promotion and coordination in 15 sectors and 5 subsectors, which are relevant in respect of R&D demand. The pertinent sectors include health, education, food quality, safety and nutrition, water and sanitation, land management and human settlements, energy, industry and manufacturing, mining, transport and logistics, agriculture, national heritage, tourism, climate change and ecosystem, forestry, and wildlife.

The priority research areas set out in this document provide guidance for STI research as a means to increase the capacity for value addition, access to and the quality of social services delivery. In that regard, during implementation due diligence will be exercised to create an inclusive environment that will

support and foster private sector participation with a view to promote technology transfer to industry and commercialization of the outcomes of R&D. In that way, the outputs of R&D will make a tangible positive contribution towards achieving the set goals of TDV 2025 and Zanzibar Vision 2020 through implementation of the 2nd Five Year Development Plan.

It is my hope that the outcomes of the work to be undertaken under the outlined areas of research will make a positive contribution towards transforming the nation's economy and the fostering of a culture of ensuring the outputs of research activities are fully utilized to inform initiatives in evidence-based policy formulation, as well as to provide the basis and solid foundation for drawing up action plans for well-grounded implementation strategies. Furthermore, it is imperative that both private and public sectors collaborate in a mutually reinforcing and complementary way of operating, so that investments in R&D work become a truly national concerted effort to support the development, production, and commercialization of products and processes which will be the outcomes of research activities.

The Research Priorities presented herein underscore the importance of innovation as a means to bring about economic transformation, because mere investment in R&D alone will not bring about the required transformative development and progress needed to realise TDV 2025 and Zanzibar Vision 2020. It will require the sum total of the cooperative and collaborative efforts of the National Innovation System to bring forth and put in place the requisite compendium of public policies, human capacities, economic services infrastructure, as well as industry and technology standards, which together will enable Tanzania to realize the objectives of industrialization as the locomotive of the desired socio-economic transformation. The critical issue is to build national adaptive capacities for receiving and domesticating technologies which are new to the local environment, and subsequently to be able to develop in optimum time, the innovative skills to be able to develop new applications of the technologies received as well as to advance the frontiers of knowledge which will be applied in the future as new technologies.

Tanzania and most of Africa is working hard to transform from being an agrarian society to become an industrial society, at a point of time in history when Mankind stands at the threshold of the 4th Industrial Revolution spearheaded by information technology and clean renewable energies. The challenge is for Tanzania and Africa to avoid the risk of falling into the pitfalls of blindly copying technology and industrial practices, which are fraught with obsolescence and environment sustainability risks, as well as unacceptable efficiency levels of energy utilization. It is my hope that each one of us will play our respective roles to ensure that through research and development outputs, we will be better equipped as a nation to steer our socio-economic transformation drive through

industrialization, in a manner that will ensure economic prosperity with environment sustainability.

I would like to express my appreciation for the tireless work of the seasoned researchers, scientists, innovators, policy and decision makers, and other stakeholders who worked selflessly towards accomplishing the task of preparing this document, which sets out the priority areas of research for the next five years. Furthermore, I also wish to acknowledge the Swedish Development Cooperation Agency (SIDA) in support of this initiative through COSTECH. This Research Priorities Document represents Tanzania's commitment to striving for excellence, inclusiveness, and economically sustainable Science, Technology and Innovation ("STI") initiatives for socio-economic transformation and development of the Country, while paying due attention to the compelling imperatives of environmental sustainability.

Lastly, and on a more personal note, let me take this opportunity to thank you all who, in any way whatsoever, have made some contribution towards the preparation and production of this important document, for continuing to be part of the STI community, and welcome you to contribute to other initiatives of some similar vision whenever need will arise going forward.



Col. (Rtd) Joseph Leon Simbakalia
Chairman of the Board – COSTECH

August, 2016

1 INTRODUCTION

1.1 BACKGROUND

Evidence from countries that have attained economic and social transformation indicates that effective implementation of R&D Agenda is an important driving force for realisation of national development visions. Robust functional research agenda helps to identify and prioritize development obstacles and subsequently engage human and financial resources from academia, private sector, and other partners to search for innovative solutions that contribute to inclusive economic and social development.

The National Research Agenda (NRA) for 2015-2020 is the second in a series that have been prepared by the Tanzania Commission for Science and Technology (COSTECH) since its establishment in 1986. This is an effort to consolidate and coordinate research activities within the National Science, Technology and Innovation Ecosystem to realize the Tanzania Development Vision (TDV) 2025 and that of Zanzibar 2020. It is equally important to acknowledge the fact the ambitious goal set by the development visions in transforming the economy from an agricultural led growth to one led by industries and service activities, cannot be achieved without using Science, Technology and Innovation (STI) which embeds research in all sectors of development. This transformation would be complete if application of the acquired knowledge for the improvement of products and services were to be widespread and hence contribute to the formation of a knowledge-based economy.

The NRA was prepared through participatory and consultative processes, which involved various stakeholders from government, private, academia and group representatives. In the process key national documents were used including the; TDV 2025, Zanzibar Vision 2020, Sectoral policies and strategies relevant to STI; National Strategies for growth and Poverty Reduction (NSGPR) I and II, Zanzibar Strategy for Growth and Reduction of Poverty (ZSGPR) I and II; and international agreements and or declarations to which Tanzania is signatory were considered. Contemporary social and economic challenges from R&D discourses such as climate change, inclusive economic growth, urbanization, management of natural resources and job creation are thus also reflected in the NRA.

1.2 RATIONALE

To achieve long-term economic growth and realize TDV 2025 and Zanzibar 2020, Tanzania acknowledges that investment in R&D is imperative.

Furthermore, as a signatory to the Lagos Plan of Action, in 2007, African Governments promised to spend 1% of their Gross Domestic Product (GDP) into R&D activities and Tanzania is committed to the requisite investment. The NRA is government effort mediated through COSTECH to facilitate the use of R&D for solving societal and developmental problems, and to educate, fuel invention and discoveries leading to development of commercially viable technologies that will stimulate economic growth.

The NRA indicates priority areas as identified through the consultative process to effectively mobilize financial and human resources to concentrate in selected areas where there is high impact potential in stimulating socioeconomic development. Thus the focus areas research articulated that are human development; strong and competitive economy; natural tourism and cultural heritage; natural resource management; environment and climate change; and in cross cutting areas such as governance and accountability; entrepreneurship and leveraging technology provide an overarching framework for promoting and coordinating STI research activities in the country in order to fuel economic transformation as set by the two national development visions. It is expected that the anticipated research outputs will help to improve skills and capacity building, give rise to new knowledge, technology, products and processes that will improve upon the existing ones and enhance job creation, generate revenue and eventually increase in GDP.

By consolidating the role of both private and public institutions working towards a common goal, it is envisaged that the NRA will be able to comprehensively guide research activities and indirectly direct funding priorities for both public and private institutions. In this way the Agenda will serve to mutually reinforce complementary investments in R&D to work in concert to support economic transformation by development, production and commercialization of new products and processes through research.

Although prioritization is important when resources are scarce and when there are known areas where intervention would have the greatest socio-economic impact, the agenda is for the next five years given the forecast of priority needs. Nevertheless, it has been set to incorporate dynamic changing needs as they arise. In the prospective subsectors of the NRA, efforts have been made to have overarching research themes that would be used to conduct research as the demand arises. The NRA is designed to be responsive to priority needs, societal dynamic needs in all aspects and provide creative solutions to existing problems and also set the pace where socio-economic transformation can be realised.

2 RESEARCH PRIORITIES

2.1 HUMAN CAPITAL DEVELOPMENT AND QUALITY LIVELIHOOD

Research in this area will focus on attaining quality livelihood for every Tanzanian. Socio-economic transformations depend on human capital development built on access to and quality in education, health, settlement, water and sanitation; and food security and nutrition. For Tanzania to attain quality livelihood for her populace and equitable access of quality services, it must be guided by informed social policies that cater for all social groups across the life span in various communities.

Research in this area serves to complement and enhance on-going initiatives by providing evidence to ensure cost effectiveness and innovations in the sectors of education, health, settlement, water and sanitation; and food security and nutrition.

2.1.1 EDUCATION

Education access; relevance; efficiency; management; financing; quality; and equity are extremely fundamental in measuring the success of any country. Tanzania has instituted interventions in the education sector intended to increase access guided mainly by Primary and Secondary Education Development Programmes, Vocational Education and Higher Education Policies. Whilst these interventions have increased access evidenced by enrolment at all levels, they have nevertheless impinged on quality due to several factors including overstretched educational infrastructure as well as human resource capacity. In order to attain inventiveness, innovativeness and high level quality education; the following attributes should be addressed;

2.1.1.1 Quality curriculum development and implementation

Designing and implementation of appropriate curriculum models focusing on education for sustainable development to ensure a competitive harmonious society is a prerequisite. Innovative and flexible modes of delivery such as e-learning, tele-presence need to be evaluated to demonstrate how they cater for the diverse needs of learners through:

- i. Identifying relevant learning outcomes to reorient curriculum to address sustainability at all levels from early childhood through university and adult education.
- ii. Development and application of effective pedagogies for teaching sustainability at different age levels including standardized pre-primary

education packages to increase internal efficiency of primary school.

- iii. Expansion of quality vocational training to guarantee production of graduates equipped with appropriate knowledge, skills and attitudes sets for competitive job market.

2.1.1.2 Improving access and retention in quality basic education

Tanzania has implemented several strategies for improving access to education including; fees elimination in primary education and reduction of secondary education costs but there is still a challenge of enrolment in early childhood education and drop outs in primary and secondary schools. The country's intention to become a nation whose people are built with development mind set and competitive spirit can be achieved by ensuring quality basic education for all by considering the appropriateness of interventions such as:

- i. Means of ensuring that early childhood education is availed to all children in both urban and rural areas
- ii. Methods to improve quality basic education using appropriate learning platforms
- iii. Intervention methods to ensure quality education that engages diverse learners and makes the classroom a more equitable place for all learners.
- iv. Preventive intervention on school dropouts for primary and secondary schools.
- v. Rehabilitative educational models for school drop outs, street children and youth by age groups to salvage the missed opportunities in education.

2.1.1.3 Innovative funding models

Public funding cannot sustain demand for access to quality education. Understanding of innovative funding models that can be used to address educational costs and financing from primary to higher education needs to be supported by evidence generated by research.

2.1.1.4 Equity and equality

Tanzania education policies recognize the need of equal access to education for all but availing quality education to the disadvantaged groups especially in low-income households and rural areas is a continuous challenge. Providing innovative strategies to increase education access need address.

2.1.2 HEALTH

Epidemiological and demographic transitions impose a complex burden of infectious diseases alongside the increased incidence of non-communicable diseases, mental health, and injuries in Tanzania. The rapid spread of risk factors to many emerging infectious diseases and chronic diseases not limited to life style changes and urbanization consequences, requires multi-disciplinary actions guided by the evidence from research. Health sector reforms in Tanzania aim at ensuring availability of equitable high quality health care services focusing on reduction of 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 the existing developed technologies, scientific discovery and technological innovation to maintain, treat and improve the health of Tanzanians in fundamentally new ways. These developments entangled with other national response strategies identified in other sectors – form interdisciplinary efforts and critical convergences that will decisively address challenges in health.

2.1.2.1 Social determinants of health

The aforementioned transitions affecting health are additionally compounded by other internal and external societal factors in human populations that may span from conception to the end of life. Over the years global and local contextual changes in the political, social and economic arenas have had substantial contributions in influencing public health directly or indirectly. These influences have at times, been adverse for some societies determining on the position of the country globally, nationally and locally. It is imperative that research should focus on delineating unknown adverse social determinants of health and find solutions for the persistent adverse social determinants of health (for example, defined inequalities, underserved populations, geographical areas, vulnerable populations). Research should also establish contextual social determinants that would 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.

2.1.2.2 Health Systems

The need for robust research on health outcomes resulting from successful efforts to offer integrated care is needed to relieve the overburdened health system. Research should focus on; solutions to bridge the gaps pertaining to access and delivery of health services (general or specified) within catchment areas by person (inclusive of emerging vulnerable populations) and time; innovative training systems for generating competent human resource

for health; alternative health financing mechanisms that would improve access and delivery of health services for the underserved and correct the equity gap between rural and urban areas; developing and testing models for maximizing use of health information systems for clinical decision making; application of emerging technologies to improve preventive interventions and health promotion by measuring outcomes related to community interventions, anticipatory guidance; enhancing adoption of, adherence to health promotion; and disease prevention practices.

2.1.2.3 Medical diagnostics and product safety

Advances in technology creates opportunity for development of new diagnostic kits, test existing biomarkers for enhancing early diagnosis to avert morbidity, promote better prognosis, hasten recovery and improve quality of life and increase survival in time. Research should focus on the current impact of existing technology in diagnostic efficiency to enhance disease prevention; identify the future need to selectively invest on specific technologies that are contextually safe, cost effective, and friendlier to the environment for diseases prevention and better health outcomes. Studies should explore pharmacologic properties of natural products for preventing or treating high burdened diseases and guide product commercialization.

2.1.3 FOOD QUALITY, SAFETY AND NUTRITION

The research in this area should focus on addressing food quality, safety and nutrition as a means of improving health and increase opportunities for the poor to pursue sustainable livelihoods and consequently improve the daily living condition.

2.1.3.1 Food toxicology

The increase in prevalence of non-communicable disease is associated with food consumption. Adding non-nutrient additives processes several food commodities on the market in Tanzania, the long-term effects and impacts of these would benefit further investigation. Research should aim at initiating and developing techniques and equipment to measure toxicity along food chain and its associated health impact.

2.1.3.2 Food fortification

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 is particularly 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 and food fortification 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.

2.1.4 WATER AND SANITATION

Freshwater is a basic natural resource, which sustains life and provides for various social and economic needs. Although nearly 70% of the earth is covered by water, only 2.5% of this is fresh water. Water sources in Tanzania include rivers, lakes, wetlands, springs, reservoirs and groundwater aquifers, and many water bodies that are shared with neighbouring countries. Tanzania's annual renewable water source is 89 cubic kilometres and about 40 cubic kilometres of groundwater reserve. It is projected that by the year 2025, the annual average of available water per capita which is 2,700 cubic meters, will be reduced by 45% to about 1,400 cubic meters per person per year which, implies that the country will face water stress.

On the other hand, coverage of improved latrines in urban and rural areas of Tanzania is as low as 32% and 25%, respectively. Poor management of wastewater can result into contamination of water sources leading to water borne diseases. In addition, water supply and sanitation coverage are challenged by dilapidated infrastructure, infrastructure vandalism, rapid population increase, inefficient water uses, pollution of water sources and low investment in development of water sector.

2.1.4.1 Water demand and supply

Availability of water in the country is highly dependent on rainfall. More than half of the country receives on the average less than 800 mm of rain per year. 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 tap; and carrying heavy containers on their heads of about 20 to 25 litres per trip. In the year 2012 the demand of water for only 19 capitals of regions was 463,543 m³ per day while the supply was 305,195 m³ per day. Water production in the 19 regional Urban Water Supply and Sanitation Authorities reached the average of 341.77 million litres per day in March 2013.

In the year 2010 about 86% of the residents in regional towns had access to water, compared to 53% in district townships and 55% for Dar es Salaam, Kibaha and Bagamoyo. The situation in Dar es Salaam is characterized by dilapidated water supply infrastructure and increased demand for both industrial and domestic use. Coverage of water supply in rural areas was 57.8% in 2010. The trend reveals that there is still a substantial size of the population lacking water supply services hence; there is a need to research on more water sources which will then increase access to water in both urban and rural areas.

2.1.4.2 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 activity including poor land use practices as well as uncontrolled abstractions and pollution of water bodies, impact on the quantity and quality of the available water sources. Most villages share common point water sources, i.e. wells, which is a risk factor when contamination occurs. Therefore, research on better approaches of water quality monitoring and assessment as well as practical and cost effective water quality and pollution control mechanisms is needed.

2.1.4.3 Waste water management

Water supply services in urban areas result in the production of wastewater estimated at about 80% of water supplied. The common methods of disposal of public wastewater are through septic tanks and pit latrines. Disposed wastewater leads to contamination of groundwater sources and the environment. The national water policy of 2002 stipulates some interventions on how waste management should be dealt with 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 out-falls; and others. These interventions need to be backed up with research by developing cost effective technologies for wastewater treatment and recycling.

2.1.4.4 Integrated water sources management

The Water Utilization (Control and Regulation) Act No. 42 of 1974 and its subsequent amendments govern water source management systems. Management of water sources generally aims at developing a sound water sources management and development framework for optimizing the utilization of water sources in a sustainable manner as well as promoting good governance of water sources through empowering water users, encouraging participatory and transparent decision-making in the allocation, utilization, protection and conservation of water sources, devolving ownership to the user level, and

granting secure water rights with responsibilities to the water users, community groups and local government. Therefore, research should come up with innovative models on establishing comprehensive community integrated water sources management.

2.1.5 LAND MANAGEMENT AND HUMAN SETTLEMENT

Land is a basic 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. The challenges faced by the sector include; inadequate surveyed and serviced land for human settlement, development and investments, as well as functional procedures for securing and use of land. In 2001 an estimated 70% of the Tanzanian population was reported to live in unplanned settlement and 60% of urban housing stock recorded in these settlement areas. Rapid urbanization over the last four decades has increased and continues to increase the proportion of the country's population living in urban areas. This has an implication on delivery of social services and infrastructure development.

In order to facilitate rapid national socio-economic development and national land use priorities, promotion of an equitable distribution and ensuring access and productive use of land is imperative.

2.1.5.1 Land and urbanization

Rapid urbanization has resulted in the pollution increase, haphazard housing and settlement development, environmental degradation, land tenure insecurity, and poor infrastructure maintenance. Transformation of the country's settlement pattern that is characterized by numerous scattered small villages to that of large villages, towns, municipalities and cities poses a threat on health and productivity. Research should be geared to address issues that arise as a result of urbanization.

2.1.5.2 Land registration, administration and tenure systems

Secure land rights provide the owners with a sense of ownership to the land that in turn enable them and the investors to conserve and manage land productively. It guarantees the right of occupancy to individuals and to legalized transfer of land 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 the proportion of households with land certificates e.g. certificates of title and customary right of occupancy from 5 - 10%. Therefore, there is a need to research on how STI can facilitate land registration, administration and tenure systems for increased efficiency and investment.

2.1.5.3 Housing development finance and market

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

2.1.5.4 Rural housing development

More than 70% of the Tanzanian population lives in rural areas where most houses are made from poles and mud or mud blocks. Significant rural settlements are temporary and do not meet environment and health requirements and hence lack basic services. There are also inadequate and unaffordable credit facilities for building better houses. Therefore research should be geared towards affordable models for accessing credits, alternative-building materials and technologies at low cost.

2.2 STRONG AND COMPETITIVE ECONOMY

Tanzania has the potential to build a strong and competitive economy through energy, mining, industry and agricultural sectors. Science, technology and innovation should enable Tanzania's economy to attain; diversity, semi-industrialized with a substantial industrial sector comparable to typical middle-income countries; macroeconomic stability manifested by a low inflation economy and basic macroeconomic balances; growth rate of over 8% 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.

2.2.1 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 of 7% power generation needs to match this growth and maintain a buffer of at least 15% of the total capacity to contribute to sustainable economic growth.

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

2.2.1.1 Renewable energy sources and technologies

Harnessing renewable energy opportunities for both industrial and domestic use in rural and urban areas can contribute to economic growth. However, biomass utilization is predominant in Tanzania. Interventions are needed to explore alternative renewable energy sources that are efficient and safe to reduce adverse impacts.

2.2.1.2 Grid and off-grid electricity supply

Tanzania's status of electrification stands at 18.4%, of which only 6% 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 very old and its infrastructure is obsolete and needs major maintenance and repair to avoid power loss as well as frequent power cuts. Research and innovation on technologies set to ensure electricity accessibility to more people as well as enhance the efficiency of existing, new and independent supply networks by reducing leaks will reduce unit costs and increase revenue. Environmental, health and aesthetic concerns of supply networks are critical on ensuring positive benefits of energy with the growing population.

2.2.1.3 Energy conservation and efficiency

Efficient use of energy is the most effective way to conserve energy and reduce cost. According to the Tanzania Electric Supply Company (TANESCO) reports, about 24% of the energy generated is lost. Similarly, the utilization of biomass as a source of heating and cooking has been under low efficiency in both urban and village areas. There are opportunities to reduce energy consumption through efficient use of energy and industrial energy management programs using more efficient equipment and better practices. The government has started awareness campaigns to educate 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, energy and building design and consumer education on using energy efficient equipment.

2.2.1.4 Non-renewable resources and technologies

Coal, oil and gas resources have a great potential to contribute to alleviation of the national energy demand and have significant potential for development. Exploitation of these resources requires informed technical and policy considerations for the entire value chain.

2.2.2 INDUSTRY AND MANUFACTURING

Industry in its broadest sense engrosses manufacturing, mining and quarrying, construction, energy and water. The sector makes a significant contribution to GDP. In 2012/2013 it contributed 9.85% compared to the increase of 9.7% in 2011, this is attributed to the increase in production activities especially in food processing, vegetable oils, drinks, cement and iron production. However, GDP contribution from this sector is still lower than the targeted value of 15% as stipulated in the TDV 2025. STI is envisaged to build competitive drive and economic transformation towards attaining the national vision targets by the sector. Challenges in the sector include, minimal linkage with research institutions, small and medium enterprises (SME'S), which contributes to the slow growth of this sector.

2.2.2.1 Value addition

Value addition of local produce and natural resources 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. High growth rate of manufactured exports in Tanzania have been recorded annually since 2000. However, nearly half of the country's manufactured exports are resource-based products mostly agricultural, base and precious metals, particularly gold. Value addition to natural resources should be linked to research for enhancing manufacturing capabilities and hence increase exports. research for enhancing manufacturing capabilities and hence increase exports.

2.2.2.2 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 capacity in absorption, adoption and transferring of technology. There is also inadequate interaction between industry and research institutions and knowledge centres. Thus, there is a need to research on better approaches, IP framework and models for engaging R&D in industrial activities.

2.2.2.3 Clusters and incubation development

Innovative and induced business cluster and incubation programs are intended to offer support such as modular working premises; access to technology and financial services; marketing facilitation; product development support; technical assistance; as well as communication and information services. There are a number of incubator related initiatives currently going on in Tanzania but the impact of these incubation programs has not sufficiently translated into creation of new employment opportunities or graduate companies in the competitive market. Research and investment in this area is needed to come up with more innovative incubation models that are effective and sustainable.

2.2.2.4 Environmental management

Managing industrial pollution has been a major challenge in the developing countries including Tanzania. Despite ratification of national environmental treaties and development of environmental policies and laws, the industry sub sectors have not complied with the set standards for the management of waste. Thus, research is needed to come up with technologies that will reduce industrial pollution to the environment and adjacent communities.

2.2.3 TRANSPORTATION

Transportation engineers plan and design street and highway systems, transit systems, airports, and railroads needed for the safe and efficient movement of people and goods. In Tanzania research in this area is limited. To effectively respond to the growing population, vast area and industrialisation strategy it is necessary to develop local solutions to ensuring transport and logistics are addressed. Areas of focus include modelling and prediction of transportation demands; analysis of the traffic impact from new and existing developments such as cities like Dar es Salam to cater for industrial complexes, business centres; or in the design of traffic control and other operational measures for surface, air and water ways.

2.2.4 MINING

Tanzania is endowed with large deposits of gold, diamond, tanzanite, ruby, tin, copper, nickel, iron, phosphate, gypsum, coal, natural gas, uranium and oil. Mining can be of large or small scale, both are important. As of June, 2013 natural gas discoveries of about about 55 Trillion Cubic Feet (TCF) (MEM 2015) were found from both on- and off-shore basins. Before 2007, the mining sector grew at about 15% annually, dropped to 2.5% percent in 2008 and to a further 1.2% in 2009 due to decline in export of diamonds and gold production.

The sector currently contributes about 4.0% of the GDP, which is projected to account for 10% of GDP in 2025 as stated in the Development Vision 2025.

It is envisaged in TDV 2025 that the mining sector should be a strong, vibrant, well-organized, private sector led, large and small-scale mining industry, conducted in a safe and environmentally sound manner. It should contribute significantly to industrialization and to export, the former through the strategic exploitation of its energy and industrial mineral resources and the latter mainly through processed and/or semi-processed mineral outputs.

2.2.4.1 Mineral exploitation

Finding commercially viable concentrations of minerals for mining is a continuous process in the mining sector. Most of the companies involved in this activity are foreign while local experts mostly participate in the processes as employees.

Therefore, research in this area should aim at promoting better and affordable technologies that can be utilized by local small-scale miners.

2.2.4.2 Artisanal and small-scale mining

Tanzania has a significant number of artisanal and small-scale miners and their activities are mostly concentrated on gold and gemstone mining, salt and construction materials production. The mineral policy of 2009 recognizes the positive contribution of the artisanal and small-scale mining sub-sector to the economy. However, there are many challenges that face small-scale miners in Tanzania with one key challenge being technology.

The technology used by local small-scale miners is inefficient to trap substantial amount of minerals during processing. Thus research on technology development, optimization and adaptation to maximize productivity in mining is essential to make this sector achieve vital contribution to the economic development of the country.

2.2.5 AGRICULTURE

Agriculture is the backbone of the national economy accounting for around 27.6% of the GDP. The sector employs approximately 70% of the population, but it features very slow growth rates. Interventions in the sector are needed to ensure that the country attains food sufficiency and participates competitively in regional and global markets with value added products. Achievement of these targets requires strategic, targeted and well-sequenced research, technology and innovations.

2.2.5.1 Crop

Crop production is the most important undertaking in the country's agricultural sector. Besides accounting for a significant amount of agricultural output, the sub-sectors' contribution to food security, and income generation cannot be overemphasized.

i. 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 and distribution. For competitiveness, focused breeding efforts on development of demand driven varieties of exotic and indigenous germplasm are necessary.

ii. 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, excessive use of chemicals, poor conservation of catchment areas and deforestation. On the other hand, small portions of arable land are exploited for irrigation despite the huge potential of land water masses. Development and adoption of technologies that mitigate the effects of climatic change conserve and preserve soil moisture and nutrients; these include conservation agriculture, land management and erosion control, water harvesting and utilization are necessary.

iii. Indigenous crops and crops of cultural significance

Crops such as coconuts and spices are an important aspect of the history of coastal areas and isles contributing to revenue from sales of products and eco-tourism. Dedicated programmes focusing on enhanced productivity and value addition and marketing of these crops would benefit the economy of the country.

iv. Post-harvest losses management

High post-harvest losses are among the constraints to agricultural productivity and food and nutrition security in Tanzania. It is estimated that over 75% of the losses occur after crops have been harvested. This is mainly due to poor handling practices and limited post-harvest technologies. Research should come up with improved handling and storage techniques in order to reduce such losses.

v. Crop protection

Pests, diseases and weed account for significant losses, which affect productivity in both pre and post-harvest. Research should focus on the use of conventional and emerging technologies to address these challenges.

2.2.5.2 Livestock

Tanzania has an estimated population of about 25 million cattle, 16.7 million goats and 7 million sheep. Other livestock include 2.4 million pigs, 36 million local chickens and 24.5 million improved chickens. About 90% of the livestock population is of indigenous types. The nation's average annual per capita consumption is estimated at 12 kg of beef, 45 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. 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.

In order to increase productivity in the sub sector and make significant contribution to the national economy, there is a need to develop and adopt appropriate technologies, innovations, enabling policies and sustainable production systems.

i. Animal health and disease management

Livestock diseases pose the most serious constraint limiting development of the livestock industry. The inability of local producers to comply with stringent sanitary and Phyto-Sanitary 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% of calves die each year due to mainly preventable vector borne diseases (ECF and Trypanosomiasis), for example the New castle disease (NCD) alone kills over 80 -100% of affected flocks. The high prevalence of livestock diseases in the country can be minimized through purposive research and developing vaccines for important livestock disease. Other major barriers for development of the livestock subsector are feeds and poor productive potential of animals.

ii. 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 quality and quantity of forage, uncontrolled burning, overstocking, and overgrazing and land degradation. Pasture production fluctuation influenced by seasonal changes leads to decreased quantity and reduced quality of pastures during dry season and improved situation during wet seasons. Similarly, the varieties of grass and leguminous species are affected by drought, uncontrolled fires and overgrazing. Research work is required on substitute feed sources for monogastric animals, rangeland improvement and utilization, feed formulations and feeding standards.

iii. Breed improvement and technology adoption

Low production and reproductive performance of indigenous and improved breeds of livestock can be improved through various measures including adopting appropriate breeding programmes. Much of the breeding efforts need to address breed inventory and characterization of indigenous livestock; improvement of livestock breed-types according to agro-ecological zones (AEZs); germplasm multiplication and conservation of farm animal genetic resource as well as development of appropriate breeding systems and strategies.

iv. Crops -livestock interaction

Increased agriculture and urbanization has 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 into conflict between livestock keepers and crop farmers vying for land. Research should address improvement of livestock breeds in which farmers could keep few animals with better productivity; utilization of crop residues and agro-industrial by-products as an alternative source of animal feeds; and nutrient recycling through utilization of farm yard manure for cultivation of field crops to increase land productivity.

v. Zoonosis

Veterinary public health deals with monitoring and control of zoonotic diseases and quality of animal products with a view to safeguard human health. Common zoonotic diseases are Rabies, Trypanosomiasis,

Brucellosis, Tuberculosis, Anthrax, Cysticercosis and Salmonellosis. Challenges, which face veterinary public health, include baseline data on 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 health and ensure safety and quality food of animal origin. Research should focus on establishing the magnitude and trends of zoonotic diseases and device mechanisms for control.

2.2.5.3 Fisheries

The fisheries sector contributed about 1.4% of the GDP in 2013 mainly through capture fishery while aquaculture industry is still at an infancy stage. The artisanal fishermen produce about 90% of the total fish catch in the country only 10% is derived from industrial fishing. To increase capture fishery or aquaculture would entail resolving problems that have hampered development in the fisheries sub-sector in the past.

i. Aquaculture

With increasing fishing pressure and declining fish catches in the wild stocks, attention has now turned into developing aquaculture systems capable of meeting demand of growing human population. Therefore, there is a need to carry out research on the development of high efficiency and environmental friendly aquaculture technologies, identify type of feeds and new species that can be efficiently cultured.

ii. Capture fishery

Capture fishery sources are highly diverse and their sustainability depends on responsible management decisions that are based on scientific information available. To arrive to the best scientific advice, research in the EEZ, territorial waters, rivers, large and small water bodies (including satellite lakes) is required. This encompasses the status of fish stocks, including their biology and ecology, exploitation patterns, gears and methods used.

iii. Biodiversity conservation

Human activities (such as illegal fishing methods/gears, poor agricultural practices, mining, deforestation, biomass burning) and natural processes have an impact on the sustainability of aquatic ecosystems. Therefore, research is needed to establish status of human activities, and

how these together with natural processes may affect ecosystem components, structure and functioning in the future in order to devise mitigation measures.

iv. Climate change and environment

Climate change has significant impacts on aquatic ecosystems. It modifies biological, chemical and physical conditions in the marine and freshwater, which affects the sustainability of human uses of aquatic resource. Consequently, research is needed for better understanding, detecting, and forecasting changes and providing scientific rationale for interventions.

v. Fishery and fish products quality, standards and marketing

Fishery and fish products contribute to the socio-economic development of the country. However, poor quality of fish and fish products lead to poor market. Therefore, the quality of fish and fish products should be improved to meet market standards. In order to improve quality, standards and hence values of fish and fish products, research is required to find ways that can address the existing challenges through introduction of new innovative technology.

2.2.5.4 Agricultural marketing systems and entrepreneurship

Marketing systems and entrepreneurship of the local produce have not been exploited to its full potential. Agricultural research should develop innovative marketing systems that would enhance competitiveness through agro-based industries and value addition throughout the supply chain. Furthermore, research should seek to build capacity to supply agro-processed products in response to new opportunities in the domestic and export markets.

2.3 NATIONAL TOURISM AND CULTURAL HERITAGE

The tourism sector in Tanzania has a great potential to contribute to socio economic growth. The country's competitive strength in tourism lies in the abundant and diverse wildlife, spectacular landscape, scenery, an unspoiled environment, friendly people and the existence of other economic sectors that have the potential to support the tourist sector. Similarly, cultural heritage is yet another area that compliments the growth of national tourism. However, tourism and cultural heritage industry is inadequately diversified, under commercialized and there is limited participation of local owned enterprises in

the top-notch tourism market. Therefore, research should propose ways to address these challenges.

2.3.1 NATIONAL HERITAGE

National Heritage engrosses cultural and natural heritage. There is little knowledge on protection and management of heritage in the community. Globalization, economic transformation and infrastructure development threaten preservation of heritage. The promotion and preservation of our cultural heritage for national identity and heritage can effectively be used for social and economic development. The identifiable research areas in this subsector include, heritage management; historical building sites and materials; historical and archaeological studies; nature heritage; intangible cultural heritage; artists and works of art; culture and religion.ge; intangible cultural heritage; artists and works of art; culture and religion.

2.3.1.1 Heritage management

Government institutions manage heritage resources. The resources face threats linked to human and environmental pressures because there is little awareness on how to protect and conserve them. Hence, there is a need to research on architectural, historical and aesthetic heritages for proper management.

2.3.1.2 Historical buildings, sites and materials

Tanzania is endowed with many historic buildings, sites and materials some of which have long maritime connection with the outside world especially Asia. There are many documented historical sites; a rich archival 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. Hence, there is a need to research on effective ways to preserve and coordinate heritage sites, restoration of historic buildings as well as archival materials with the aim of improving their conditions.

2.3.1.3 Historical and archaeological studies

Tanzania is best known for its cultural and historical resources reflecting the diversity of cultural history of the East African coast. The resources include ruins, monuments, historical sites, footprints and maritime archaeological sites. With regard to historical sites, it is estimated that more than 70% of them are not in good condition while others are not well preserved and in deterioration. Thus, archaeological research is needed to preserve and discover more historical resources.

2.3.1.4 Intangible cultural heritage

Intangible cultural heritage entails the use of traditional knowledge, 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 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.

2.3.1.5 Fine and performing arts

Works of art play major role in cultural development of any country, however, in Tanzania this sector's visibility needs to be enhanced in order to contribute to social economic development. Research is needed in areas of carving craftsmanship; filming; children's' plays and games; weaving; traditional dressing and food; traditional knowledge and skills; and theatre arts.

2.3.1.6 Family integrity and parenting

Raising and looking after children is the responsibility of parents and or guardians. Nevertheless, in the recent years there has been neglect on parental roles. This has led to deterioration of cultural values. Research in this area needs to address issues like mind set changes, self-reliance, confidence and patriotism, the reading culture, adherence to ethical conduct, attitude towards work, entrepreneurship and, savings with a view to assess fully the contribution of culture to development.

2.3.1.7 Culture and religion

Cultural, religious tolerance and harmony is an aspect that has a strong 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, in the recent times, there has been violence involving people of different beliefs as well as decline of traditional cultures. Research needs to address on how to value and restore acceptable culture and religious tolerance and free worship.

2.3.2 TOURISM

Tanzania is endowed with world-class tourism assets such as natural, cultural, historic and archaeological sites that are in high demand in international tourism markets. However, there is limited tourism linkages to other sub sectors such as agriculture, transport, industry and services.

The challenges in this sector include poor infrastructure; inadequate regional and international tourist linkages; lack of planned land for tourism investment outside protected areas leading to uncontrolled tourism development; shortage of appropriate and specialized core and skilled personnel; limited budgetary allocations for tourism development and promotional activities; ineffective institutional setup, technical capabilities and co-ordination among various stakeholders involved in tourism development.

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

2.3.2.1 Tourism and environment

The tourism industry generates a significant amount of wastewater that has an implication to environment, none if not few tourist facilities have water treatment plants. It also uses a lot of packaged products in plastic materials accompanied with improper disposal. Some facilities collect sand from the beaches to decorate hotel pavements and indirectly contribute to soil erosion, which is exacerbated by climate change. On the other hand tree cutting and usage of coconut leaves for thatching roofs has increased. Research should develop harmonized systems that would concurrently enhance tourism and preserve environment.

2.3.2.2 Marine tourism

Marine tourism is taking place along the coast and in marine environments such as coral reefs, mangroves, coastal forests, sea, islets, beaches and seaweed. There is a need to conduct research on the impacts of marine clubs and sports; sustainable utilization of coastal and marine resources; and demand and supply of sea foods and marine resources in tourist hotels in order to promote marine tourism.

2.3.2.3 Natural Heritage

Tanzania's national parks and game reserves are home of an incredible variety of flora, fauna and cultures; examples of these are 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 Colobus red monkey (Kima Punju) and Adder's duiker (paa nunga) in Jozani national park. Research is required to address harmonization of natural heritage with human activities including settlement and utilization of natural resources.

2.4 NATURAL RESOURCE MANAGEMENT, ENVIRONMENT AND CLIMATE CHANGE

Sustainability requires balancing of the use of natural resources to meet changing human needs while ensuring long productive potential of these resources; and conservation of environmental functions. Society depends significantly on the natural resources for attaining basic needs and livelihoods. Due to limited incentives for sustainable management, limited alternative livelihoods and unsustainable land management practices, environment degradation continues to further propagate poverty vicious cycle. Research in sustainable uses of natural resources is crucial to address growing pressure triggered off by changing climate, urbanization and population increase.

2.4.1 CLIMATE CHANGE AND ECOSYSTEMS

Climate change poses hazardous effects on the ecosystems structure, function and productivity. Absence of a healthy ecosystem leads to vulnerability to community wellbeing, water availability, sustainable agriculture, health, and biodiversity. In addition human activities and natural processes affect ecosystem components, structure and functioning. Research needs to address how Tanzanian communities can adapt and adjust to climate change.

2.4.2 FORESTRY

Forests and woodlands are estimated to cover about 38% of the total land area in Tanzania and the forestry sector's contribution to the GDP is 2.3%. This contribution is underestimated because of unrecorded consumption of wood fuels, catchment and other forest products. Biomass is the main source of fuel for rural population and accounts for 92% of the total energy consumption in the country. In spite of its importance to the national economy and livelihood, a number of challenges prevail; rapid deforestation due to intensification of human activities; climate change; conflicts; unsustainable utilization including illegal trafficking of these resources. Thus research is intended to contribute innovative solutions to challenges in the forestry sector.

2.4.3 WILDLIFE

Tanzania is endowed with a number of wildlife resources, which include a protected area network of 31.3% of the total land. The sector, which is the number one tourism attraction in the country, contributes about 5% to the GDP. The network of protected areas and wetlands are important to the national economy in terms of game viewing; tourist and resident hunting; wildlife farming, breeding and ranching; eco-tourism; and zoos, game sanctuary and

ecological support critical for sustainable development. Despite the abundance of wildlife resources and their contribution to the economy, there is limited understanding of the potential of wildlife biodiversity and how best to conserve them. Little is known on the impact of tourism on ecosystems; sustainability of live animal trade and the impact of human activities on wildlife resources; encroachment to protected areas; lack of baseline data and information; increased human population; land-use changes; spread of invasive alien species; habitat loss; emerging and re-emerging wildlife diseases; zoonoses and competition with other land users. Thus research is essential to enhance wildlife protection, utilization, management and development in protected areas; and increase on contribution of the wildlife sub sector in the GDP.

2.5 CROSS CUTTING AREAS

2.5.1 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. Research in this area should contribute in achieving favourable environment for national economic growth and poverty reduction, civic engagement, adherence to and respect for the rule of law, human rights and absence of corruption. Despite the implementation of numerous political, economic, legal and social reforms over the past decade, Tanzania still faces challenges in reducing poverty, corruption and enforcement of laws and respect of human rights. There is a need for research on the effectiveness of reforms in politics, economic, legal and access to social services.

2.5.2 LEVERAGING TECHNOLOGIES FOR SOCIO-ECONOMIC DEVELOPMENT

Transformations in socio-economic sectors can benefit leveraging technologies in fields such as education, health, transportation, agriculture, manufacturing, mining, finance, governance or management among others. 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 information communication and technology (ICT), biotechnology, nanotechnology, megalronics, robotics and material sciences.

2.5.3 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. Research should focus on finding ways to improve linkages between academia and enterprises; technology transfer; start up financing; products and services competitiveness.

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