



STI4SDGs ROADMAP IN GHANA

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Abbreviations

1D1F	One District One Factory
ADP	Advance Digital Production
AFD	Agence Française de Développement
AfDB	African Development Bank
AGI	Association of Ghana Industries
AI	Artificial Intelligence
AIDS	Acquired Immunodeficiency Syndrome
AU	African Union
BoG	Bank of Ghana
BSTEM	Business Science Technology Engineering and Mathematics
CENDLOS	Center for National Distance Learning and Open Schooling
CEO	Chief Executive Officer
CFTA	Continental Free Trade Agreement
CIDA	Canadian International Development Agency
COVID	Corona Virus Disease
CPSEDP	Coordinated Programme of Economic and Social Development Policies
CSIR	Council for Scientific and Industrial Research
CSO	Civil Society Organisation
CWSA	Community Water and Sanitation Agency
DFID	Department for International Development
EPA	Environmental Protection Agency
ESIC Apps	Expanded Sanitary Inspections, Compliance Applications
ESP	Education Strategic Plan
FAO	Food and Agriculture Organisation
FARA	Forum for Agricultural Research in Africa
FM	Frequency Modulation
GBC	Ghana Broadcasting Cooperation
GDP	Gross Domestic Product
GEF	Global Environment Facility
GES	Ghana Education Service
GH	Ghana
GhAIP	Ghana Agricultural Investment Plan
GHS	Ghana Health Service
GHC	Ghana Cedi
GIRC	Ghana Innovation and Research Commercialization Center
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GRATIS	Ghana Regional Appropriate Technology Industrial Service
GSGDA	Ghana Shared Growth and Development Agenda
GSS	Ghana Statistical Service
GWC	Ghana Water Company
HTA	Health technology assessment
ICT	Information Communication Technology
IDRC	International Development Research Centre
IoTs	Internet of Things

IP	Intellectual Property
JHS	Junior High School
KNUST	Kwame Nkrumah University of Science and Technology
M&E	Monitoring and Evaluation
MDG	Millennium Development Goal
MELR	Ministry of Employment and Labour Relations
MESTI	Ministry of Environment Science Technology and Innovation
MGCSP	Ministry of Gender, Children and Social Protection
MMDAs	Metropolitan and Municipal District Assemblies
MMR	Maternal Mortality Ratio
MoC	Ministry of Communications
MOE	Ministry of Education
MoF	Ministry of Finance
MoFA	Ministry of Food and Agriculture
MoH	Ministry of Health
MoTI	Ministry of Trade and Industry
MOYS	Ministry of Youth and Sports
MSWR	Ministry of Sanitation and Water Resources
NBA	National Biosafety Authority
NBSSI	National Board for Small Scale Industries
NCCE	National Commission for Civic Education
NDPC	National Development Planning Commission
NDWQMF	National Drinking Water Quality Management Framework for Ghana
NESSAP	National Environmental Sanitation Strategy and Action Plan
NGO	Non-Governmental Organisation
NHIS	National Health Insurance Scheme
NSC	National Steering Committee
NSS	National Service Secretariat
NVTI	National Vocational Training Institute
OER	Open Educational Resources
PEF	Private Enterprise Federation
PPP	Public Private Partnership
R&D	Research and Development
REP	Rural Enterprise Programme
RTF	Rural Technology Facility
SARS	Severe acute respiratory syndrome
SDGs	Sustainable Development Goals
SHS	Senior High School
SME	Small Medium Enterprise
STEM	Science Technology Engineering and Mathematics
STEPRI	Science and Technology Policy Research Institute
STI	Science Technology and Innovation
TB	Tuberculosis
TOR	Terms of Reference
TTT	Technical Task Team

TV	Television
TVET	Technical and Vocational Education and Training
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNEVOC	United Nations International Centre for Technical and Vocational Education and Training
UN-IAAT	United Nations Inter-Agency Task Team
UNICEF	United Nations International Children's Emergency Fund
UNIDO	United Nations Industrial Development Organization
UNOICT	United Nations Office of Information and Communication Technology
US	United States
USAID	United States Agency for International Development
USD	United States Dollars
WB	World Bank
WFP	World Food Programme
WHO	World Health Organisation
WIAD	Women in Agricultural Development Directorate
WRC	Water Resources Commission

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Executive Summary

The Global Pilot Programme on the preparation of Science, Technology and Innovation for the achievement of the Sustainable Development Goals (STI4SDGs) roadmaps was launched in July 2019 by the UN Inter-agency Task Team (UN-IATT), with five pilot countries including Ethiopia, Ghana, India, Kenya and Serbia. In this regard UNESCO contracted CSIR-Science and Technology Policy Research Institute (CSIR-STEPRI) to take technical responsibility in producing the roadmap for Ghana.

This report contains the details of the execution of the second phase of the UNESCO contract with the primary goal of formulating the STI4SDGs Roadmap for Ghana. The specific objectives are to:

- (i) Define the vision, goals and targets for the STI4SDGs Roadmap;
- (ii) Detail the strategies, programmes, projects and activities necessary for STI to fast-track the achievement of the prioritized SDGs
- (iii) Elaborate on the budget, funding and coordination arrangement for the implementation of the STI4SDGs Roadmap
- (iv) Formulate the partnership and communication strategy to sustain stakeholder involvement and ensure an inclusive governance of the roadmap.
- (v) Design the Monitoring and Evaluation system to track progress on the roadmap implementation.

A National Steering Committee (NSC) comprising representatives of the relevant sector ministries and key stakeholders was constituted for the development of Ghana's STI4SDGs Roadmap. The NSC is co-chaired by the Ministry of Environment, Science, Technology and Innovation (MESTI) and the Presidential Advisor on SDGs at the Presidency. Under the auspices of the NSC, seven SDGs were prioritized for Ghana on the basis of the current trajectory of national development and the aspirations of the Government. The prioritized SDGs include No poverty (SDG1) zero hunger (SDG 2), Good Health and Well-Being (SDG3) Quality Education SDG4, Clean Water and Sanitation SDG6, Decent Work and Economic Growth (SDG8) and Industry, Innovation and Infrastructure (SDG 9).

The SDGs prioritized for Ghana are SDGs 1, 2, 3, 4, 6, 8 and 9. It is the assumption that the implementation of the programmes and activities elaborated in this roadmap will lead to accelerating the achievement of the prioritized SDGs, and the overall vision of the nation will be attained. The Coordinated Programme of Economic and Social Policies in Ghana states the vision comprehensively as:

“An optimistic, self-confident and prosperous nation, through the creative exploitation of our human and natural resources, and operating within a democratic, open and fair society in which mutual trust and economic opportunities exist for all.”

The situational analysis conducted before the actual preparation of STI4SDGs Roadmap with the support of UNESCO, highlights the key issues and challenges relating to all the prioritised SDGs for the roadmap. Progress made in relation to SDG 1 on the eradication of poverty in Ghana in the past years is commendable. However, the specific obligation in SDG1 currently is eradication of poverty using STI. The roadmap draws on a range of actions including the promotion of

technologies for creation of livelihoods and enhancement of productivity in the relevant sectors of the economy.

In achieving the SDG 2 of ending hunger through the application of Science, Technology and Innovation (STI), the areas of concern include ensuring improved public investment in agriculture; improving production efficiency and yield; improving post-harvest management; enhancing application of STI in agriculture; promoting agriculture as a viable business among the youth; promoting livestock and poultry development for food and nutrition security; modernizing the agriculture sector to drive private sector agribusinesses; scaling up e-extension and business advisory services; enhancing on-line marketing of agricultural products; promoting adoption of productivity improvement technologies such as greenhouse production systems; and promoting biotechnology applications for improved breeding.

Despite progress made in access to healthcare (SDG 3), there are challenges which can be addressed effectively through the application of Science, Technology and Innovation (STI). These challenges include huge imbalances in geographical access to quality healthcare; inadequate and inequitable distribution of critical staff, increased cost of healthcare delivery, unhealthy dietary practices and nutritional disorders, poor quality of healthcare services as well as devastating impact of the COVID-19 on the Ghana healthcare delivery system. The National Health Policy Objectives include (i) strengthen the healthcare delivery system to be resilient, (ii) encourage the adoption of healthy lifestyles, (iii) improve the physical environment, (iv) improve the socio-economic status of the population, and (v) ensure sustainable financing for health. STI programmes will be directed at achieving these objectives.

SDG 4 focuses on one of the underpinning development areas of Ghana. A major flagship policy is the Free Senior High School (SHS) policy which makes high school education completely accessible to all irrespective of geographical location, social status, economic circumstance or physical ability or disability. The principle of inclusivity underlying the SDGs drives the flagship educational policy. It is currently being implemented at substantial cost to the nation and yet, it is considered one of the important investments that the country has to make to create the valuable human resources for the transformation of Ghana. STI applications will aim at expanding access and enhancing quality to teaching and learning within and outside the educational system.

The roadmap underlines the alignment of SDG 6 targets to the policy objectives of the water and sanitation sector. Proper provision of water and sanitation are key for achieving the SDGs, including good health and gender equality. By managing water sustainably, we are also able to better manage our production of food and energy and contribute to decent work and economic growth. Despite the fact that Ghana achieved the MDG for access to improved water supply early, but not on access to improved sanitation, statistics today show that fewer than two in five Ghanaians drink safe water, two out of every five schools are without toilets, and three out of every five schools are without water supplies. Four targets of SDG 6 have been prioritized for application of specific technologies.

The focus of SDG 8 is to “Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all”. In line with this, the national development agenda seeks, among others, to build a strong and resilient economy, transform agriculture and

industry; and developing robust tourism and creative arts industries. Between 2017 and 2019, Ghana has experienced an impressive average annual GDP growth of about 7 percent. However, this growth rate declined to about 0.5 percent in 2020 largely due to the effects of the COVID-19 pandemic. Faced with the short and long-term effects of the COVID-19 pandemic, STI provides a useful vehicle for “building-back-better” through economic productivity, economic diversification and ensuring decent work for all. The roadmap details the strategies for STI applications for “building-back-better”.

Three key programmes will be vigorously pursued under the STI4SDGs roadmap to accelerate progress towards SDG9. These include i) Improving the quality and access to STI in education, with the objective of strengthening the linkages between academia and industry, providing both the youth and citizens with the skills required to participate in the global economy ii) Creating an enabling environment to support private sector development, facilitating access to innovation for all businesses, increasing productivity through the adoption of technological and non-technological innovations and improving the availability of finance to aid the process and iii) Improving infrastructure to spur economic growth and development and provide access of services to all, encouraging inclusivity.

The roadmap presents an estimated total budget of **US\$19,260,000.000** covering the envisaged programmes across all the prioritized goals and targets. Various development partners have been proposed for their partnership in funding the programme. It is hoped that all the stakeholders will show commitment in the successful implementation of the roadmap for the achievement of the national vision.

CHAPTER I – Introduction/Background, Objectives of STI4SDGs Roadmap and Scope

1.1 Background

The dovetailing of Science, Technology and Innovation (STI) underscores the composite role of STI as a driver of socio-economic advancement in all societies. Science is the generation of knowledge through experimentation and observation and exploration into natural phenomenon. Technology is the product of the application of knowledge. Innovation is the use of new knowledge to address contextual needs to the benefit of society. These may be the clear distinctions one notes in the elements of the composite STI. Yet, for their differences, the connectedness is so strong that Science, Technology and Innovation are considered integrated and in fact even referred to quite often in the singular form.

The Sustainable Development Goals (SDGs) have come to highlight in sharp relief the global and specific development agenda confronting the world and all nations of the earth. STI is the veritable tool for addressing the SDGs, which resonates with the First Ten-Year Plan of the African Union's Agenda 2063 adopted by the African Leaders. Nevertheless, for STI to effectively drive the achievement of the SDGs, there must be the requisite plan to direct its application in the respective countries. Ghana is one of the countries selected in the Global Pilot Programme for the preparation of a Roadmap for STI for SDGs.

The Global Pilot Programme on the preparation of Science, Technology and Innovation for the achievement of the Sustainable Development Goals (STI4SDGs) roadmaps was launched in July 2019 by the UN Inter-agency Task Team (UN-IATT), with five pilot countries including Ethiopia, Ghana, India, Kenya and Serbia. The programme was formulated with the recognition of the critical contributions of Science Technology and Innovation (STI) as a catalyst for achieving SDGs in the past three UN STI Fora in 2016, 2017, and 2018. The Global Pilot Programme intends to get the participating countries formulate their roadmaps and accelerate the process of developing new, or adapting existing solutions to meet the SDGs targets using STI. Following up on the launch, a joint UN guidebook was developed to support the process and to serve as a toolkit for the national roadmap development exercise. The UN-IATT agreed that UNESCO should be the UN agency to provide support and technical guidance to Ghana for the STI4SDGs Roadmap formulation. In this regard and in collaboration with the Ministry of Environment, Science, Technology and Innovation (MESTI), UNESCO contracted CSIR-Science and Technology Policy Research Institute (CSIR-STEPRI) to conduct a situational analysis regarding the targeted SDG goal(s) and assess the STI system in Ghana. The contract was executed and the report of the situational analysis has been submitted to UNESCO and the stakeholders.

Since the situational analysis is not an end in itself and that the ultimate goal is the formulation of STI4SDGs Roadmap for Ghana, there is a second phase of the UNESCO contract signed with CSIR-STEPRI that enables the actual formulation of the roadmap.

1.2 Goal and Objectives

This report contains the details of the execution of the second phase of the UNESCO contract with the primary goal of formulating the STI4SDGs Roadmap for Ghana. The specific objectives are to:

- (i) Define the vision, goals and targets for the STI4SDGs Roadmap;

- (ii) Detail the strategies, programmes, projects and activities necessary for STI to fast-track the achievement of the prioritized SDGs;
- (iii) Elaborate on the budget, funding and coordination arrangement for the implementation of the STI4SDGs Roadmap;
- (iv) Formulate the partnership and communication strategy to sustain stakeholder involvement and ensure an inclusive governance of the roadmap; and
- (v) Design the Monitoring and Evaluation system to track progress on the roadmap implementation.

1.3 The Development Challenges

Though Ghana's development challenges are typical of the countries in Africa, there are peculiar challenges coming from its history, natural resource endowments and peoples. There are challenges that constitute the hurdles constraining the achievement of the overall vision and the respective goals in development. These are evident in the Situational Analysis Report of 2020, which set the tone for the formulation of the STI4SDG Roadmap.

Ghana is classified as a lower middle-income country with a per capita GDP of about \$2,212¹ in 2019, which is a decrease in the per capita GDP of 2013 of \$2,437). In the national development framework document, the Coordinated Programme of Economic and Social Policies, per capita GDP is projected to increase from \$1,515.6 in 2016 to at least \$2,500 by 2020, rising further to at least \$3,500 by 2024. The current level of per capita GDP as determined by the Ghana Statistical Service raises caution that, unless intensive and strategic actions are taken, the goal to achieve a per capita US\$3,500 by 2024, will be elusive. However, this is a challenge that a well-crafted STI4SDG Roadmap can, all things being equal, effectively address.

Poverty remains a developmental challenge even though some strides have been made in the past to improve on the poverty incidence in the society. An important success story for Ghana is the reduction of the level of poverty by more than 50 per cent between 1990 and 2013 (NDPC and GSS, 2018). In the early 1990s, 51.7 per cent of the population of Ghana was estimated to be living in poverty and about 36.5 per cent lived in extreme poverty. However, in 2013, 24.2 per cent lived in poverty and 8.4 percent in extreme poverty. Still, it is the millions of the people in Ghana who are living in poverty that pose a major challenge to development. The disparities in regional poverty incidences are also major developmental concerns.

In relation to health and wellbeing, the challenges in the sector are captured in the National Health Policy (2020) including:

- Inadequate health facilities in terms of infrastructural and equipment including ICT infrastructure and AI-powered healthcare services;
- Need for re-tooling of existing facilities;
- Need for construction and siting of additional purpose-built facilities, promote the availability and use of high-quality assistive devices and technologies;
- Inadequate human resource particularly medical personnel – Doctor patient ratio of one doctor to 8000 patients;

¹ Unless otherwise stated, all amounts given in dollars (\$) are in US dollars (\$).

- Adoption of digital technologies for pandemic planning, surveillance, testing, contact tracing, quarantine, and health care; and
- Institutionalisation of Comprehensive Health Technology Assessments (HTA) to inform the selection and procurement of all medical technologies required.

In Higher Education the challenges (identified from Policy Symposium organised by CSIR-STEPRI in 2016 and GIRC Business case studies Report in 2019) are:

- Inadequate research capacity and inequitable assets;
- Weak relationship between academia/research and Policy makers;
- Inadequate resources to transform the economy into a knowledge-based one;
- High demand for tertiary education creating huge supply gap situation;
- Inadequate facilities and aging faculties;
- Imbalance between Sciences and Humanities;
- Unwillingness of the private sector to offer training in technical skills to fresh graduates;
- Differences in the meaning of Excellence for academics and the public; and
- Need for a cultural change with respect to the teaching model, re-training of trainers, effective communication and constant interaction with industry.

In the water and sanitation sector, there are challenges with the following:

- Water quality monitoring and management systems;
- Inadequate facilities for water quality testing;
- Inadequate ICT infrastructure for better targeting and inefficiencies in cost recovery approaches;
- Capacity gaps in management of water and sanitation service delivery;
- Awareness creation and behavioural initiatives on sanitation and good hygiene practices;
- Ineffective Planning of Cities and challenges with monitoring of environmental sanitation services; and
- Plastic menace and issues with sustainable plastics management.

One may further illustrate the nature of the development challenges in analysing the policy environment. There are a number of challenges that even constrain the implementation of policy directly. These include:

- Weak linkage between policy formulation and national development planning;
- Ineffective coordination of the STI system;
- Inadequate budget and resource allocation to STI;
- Weak linkages between various agencies and organizations in STI;
- Weak linkage between industry and the R&D system; and
- Over reliance on the use of foreign expertise to the neglect of the use and development of local expertise.

1.4 Approach to the Formulation of the STI4SDG Roadmap

A key principle in the formulation of the STI4SDG Roadmap for Ghana is to aim at buying-in by the relevant stakeholder institutions. In this regard, a Technical Task Team (TTT) chaired by the Ministry of Environment, Science, Technology and Innovation (MESTI) and the SDGs Unit at the Presidency was established to coordinate and provide strategic and substantive inputs to the development of STI-SDGs Roadmap for Ghana. The Task Team is composed of the (i) Chief Director, MESTI (Chairperson), (ii) Head, Office of President SDG Unit (Co-Chair), (iii) Director STI, MESTI; representatives from (iv) National Development and Planning Commission, (v) Ministry of Finance, (vi) Ministry of Food and Agriculture, (vii) Ministry of Monitoring and Evaluation, (viii) Ministry of Health, (ix) Ministry of Water and Sanitation, (x) Ministry of Business Development, (xi) Ministry of Trade and Industry, (xii) Ministry of Education, (xiii) Ghana Statistical Services, (xiv) Association of Ghana Industries and (xv) CSIR-Science and Technology Policy Research Institute. A core team from among the membership carried out the practical task of drafting the chapters of the Roadmap for discussion and inputs by the Technical Task Team. The Roadmap was then validated at a national stakeholders' consultative workshop. The list of members of the TTT is shown in Annex 1.

The drafting of the constituent chapters follows from the conduct of the situational analysis of STI in Ghana. The report provided the empirical analysis of the state of STI in the country and defines the gaps to which the roadmap should aim at addressing. The review of the policy documents and current programmes of national priority enabled the elaboration of the relevant

1.5 The Scope

The thrust of the SDG4SDGs Roadmap is the elaboration of strategies and programmes to use STI to accelerate the achievement of the SDGs. In this regard, the roadmap will be formulated within the broad domain of STI. The national context of Ghana in terms of its natural resource endowments, the social and economic attributes and the political and cultural conditions will inform the formulation of the roadmap. In the course of the work on the roadmap, certain SDGs were prioritized taking account of the present development goals of the nation. These are SDGs 1, 2, 3, 4, 6, 8 and 9. The roadmap will largely be limited to discussions of these SDGs and the strategies, programmes and activities to ensure STI accelerate the achievement of these prioritized SDGs.

1.6 Organisation of the Chapters

The roadmap comprises seven chapters. Chapter 1 is the Introduction, which gives background to the roadmap, states the objectives and defines the scope among other things. Chapter 2 presents a concise report of the situational analysis. It shows the extent of STI integration in development plans and critical contributions of STI with potential to accelerate the achievement of SDGs in Ghana. Chapter 3 states the vision, goals, and targets of the Roadmap. To build long-term technological capabilities and all-inclusive STI ecosystem in Ghana, the vision will seek to mainstream STI in the prioritized sectors of the Ghanaian economy. Chapter 4 presents the detailed STI strategies, programmes and projects for achieving the prioritized SDGs. The chapter will cover the full description of selected innovation pathways and technology areas, explaining how the roadmap supports their deployment at scale with expected timelines of implementation. In Chapter 5, there will be the budget and funding arrangement for the Implementation of the STI4SDGs. Chapter 6 presents the partnership and communication strategy to sustain stakeholder involvement

and ensure an inclusive governance of the roadmap. Chapter 7 elaborates on the M & E framework for the roadmap. It discusses the monitoring and evaluation system to track progress on the roadmap implementation. The narrative will cover the milestones to achieving goals, feed-back loops using monitoring and evaluation to review the roadmap with the consequential adjustments.

CHAPTER 2: Situational Analysis

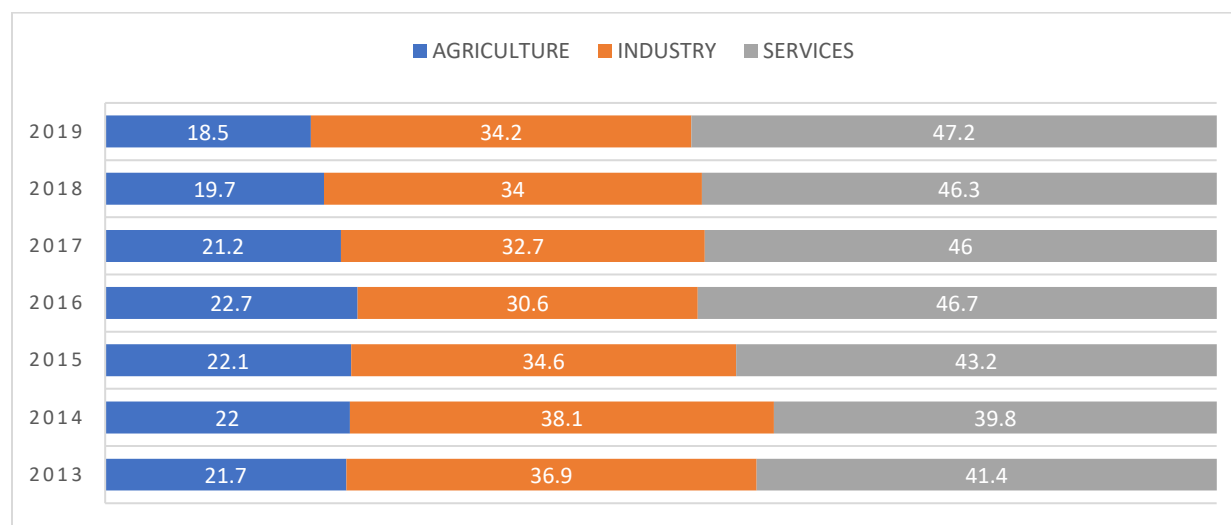
2.1 Assessment of STI capabilities to meet Prioritized SDGs for Ghana's STI4SDGs Roadmap

Seven SDGs were prioritized for Ghana on the basis of the current trajectory of national development and the aspirations of the Government. The prioritized SDGs include No poverty (SDG1) zero hunger (SDG 2), Good Health and Well-Being (SDG3) Quality Education SDG4, Clean Water and Sanitation SDG6, Decent Work and Economic Growth (SDG8) and Industry, Innovation and Infrastructure (SDG 9). This chapter presents the current situation of the prioritized SDGs and the critical contributions of STI in accelerating the achievement of SDGs in Ghana.

2.1.1 Agriculture: Addressing Zero Hunger and Employment Creation to Eradicate Poverty through Effective Application of STI

SDG 2 (with strong linkages to SDGs 1, 3, 5, 8 and 9) is one of the important priority SDGs. Agriculture's contribution to GDP in 2019 is estimated to be 18.5 percent, with the Service and Industry sectors accounting for 47.2 percent and 34.2 percent respectively (Figure 1).

Figure 1: Percent Contribution to GDP by Sectors



The current Ghana Agricultural Investment Plan (GhAIP 2018-2021) focuses on (i) promoting a demand driven approach to agricultural development; (ii) ensuring improved public investment; (iii) improving production efficiency and yield; (iv) improving post-harvest management; (v) enhancing application of STI; (vi) promoting agriculture as a viable business among the youth; and (vii) Promoting livestock and poultry development for food and nutrition security and income generation. The sector, which is mainly private sector led, plays a critical contribution to poverty reduction. An overall goal is the modernization of the sector to drive private sector agribusinesses to provide decent and rewarding jobs along the agricultural value chain especially for the youth. In addition to provision of food to the growing population, agriculture provides raw materials to industries. Yet, agriculture is predominantly on small scale with majority of farm holdings less than 2 hectares per farmer.

Principal agricultural exports commodities include cocoa, timber, horticultural products, fish/sea foods. Despite the critical contribution of the agricultural sector to socio-economic development of the country, the sector is beset with challenges including low agricultural productivity; poor construction and management of irrigation infrastructure; inadequate post-production infrastructure; limited funding of food and agricultural research and extension services; low use of improved technologies in crops, livestock and fisheries; inadequate quality feed and water standards for livestock and poultry; lack of modern housing for livestock and poultry production; inadequate disease monitoring and surveillance system; low use and high cost improved inputs; low access to mechanization services along the value chain and low use of intermediate technologies; negative impact of climate change; and inadequate disaggregated data /statistics on the sector.

COVID-19 has opened up opportunities for innovation in agricultural value chain systems including e-extension and business advisory services, product development to meet consumer needs – increasing demand for organic products, on-line marketing of agricultural products, local production of import substitute commodities such as rice and poultry in Ghana, packaging convenient foods for special delivery services and taking advantage of new consumer lifestyle and new food products to build immune systems of the weak and vulnerable. Taking advantage of such opportunities however will come with productivity improvement technologies such as greenhouse production systems and biotechnology for improved breeding. It also calls for building capacity in e-Agriculture, innovation platforms and strengthening the research-extension linkage system.

2.1.2 Health Sector: Good Health and Well-being through Effective Application of STI

The Ghana National Health Policy (2020) is aimed at ensuring universal access to health services and healthy lives for all. It is directly linked to the national efforts at achieving SDG 3. The health policy is anchored in the Coordinated Programme of Economic and Social Development Policies (2017-2024) and aligned to global and regional policy frameworks such as the African Union (AU) Vision 2063: “The Africa We Want” and the African Health Strategy (2016-2030). The health policy objectives seek to (i) strengthen the healthcare delivery system to be resilient; (ii) encourage the adoption of healthy lifestyles; (iii) improve the physical environment; (iv) improve the socio-economic status of the population; and (v) ensure sustainable financing for health.

A 5-year National Healthcare Quality Strategy (2017-2021) to develop a robust and sustainable quality culture institutionalized in the healthcare delivery system has been launched with clear measurable standards in terms of safety, efficiency, effectiveness, timeliness, equity and patient-centeredness. As a financial risk management strategy, the healthcare quality strategy seeks to strengthen the National Health Insurance Scheme (NHIS) as well as encourage the population to subscribe to the NHIS and other private insurance schemes where appropriate. The Universal Health Coverage (UHC) Roadmap (2020 -2030) for Ghana also has components on improving health financing, health services delivery systems, the health workforce and communications networks, health technologies, information systems, quality assurance mechanisms, and governance and legislation. Other health sector policy related documents including National Strategic COVID-19 Response Plan (2020-2024), Private Health Sector Development Policy,

Ghana E-Health Policy and Health Sector ICT Policy and Strategy provide framework for the improvement of health delivery systems in Ghana.

Under emergency readiness and management, the policy seeks to strengthen surveillance and response systems to prevent, detect, investigate, protect against, control and provide a public health response to the spread of diseases resulting from epidemics and disasters such as the COVID-19. The use of drones to augment the health commodity supply chain – blood and blood products and essential medicines have been emphasized.

2.1.3 Digital Health

Digital health can improve access and quality of inclusive health services, enhance diagnostics, training and better prevention of diseases. ICT and digital health solutions offer the prospect of using digital health services to accelerate the achievement of SDG 3 and making universal health coverage for all a reality by 2030. According to WHO (2018), over 63% of countries have implemented digital health policies and national strategy through the World Health Organization-International Telecommunication Union (WHO-ITU) co-created National E-Health Strategy Toolkit. The initiative is aimed towards establishing the foundations in countries to sustainably implement digital health initiatives and scale up the use of digital technologies in the health sector including use of electronic records system, integrated electronic platforms for budgeting and planning and use of Surveillance Outbreak Response Management and Analysis System (SORMAS). All these, to improve quality, accessibility and affordability of health services for all and bring impact of SDG 3 to scale.

The importance of integration and interoperability is key to allow for digital programs to transfer and retrieve information and data across systems. Capacity building in the area of software engineering, technical capacity to design systems that response to end-user needs, and to adapt systems for local needs are important. Strategic direction and leadership at the highest level is required to create the enabling environment and regulatory system for effective management of digital health care systems and ICT4D.

Challenges in the health sector as captured in the National Health Policy (2020) are:

- ✚ Inadequate health facilities in terms of infrastructural and equipment including ICT infrastructure and AI-powered healthcare services;
- ✚ Need for re-tooling of existing facilities;
- ✚ Need for construction and siting of additional purpose-built facilities, promote the availability and use of high-quality assistive devices and technologies;
- ✚ Inadequate human resource particularly medical personnel – Doctor patient ratio of one doctor to 8000 patients;
- ✚ Adoption of digital technologies for pandemic planning, surveillance, testing, contact tracing, quarantine, and health care; and
- ✚ Institutionalization of comprehensive Health Technology Assessments (HTA) to inform the selection and procurement of all medical technologies required.

2.1.4 Inclusive and Equitable Quality Education through Effective Application of STI

2.1.4.1 *Human Capital for Sustainable Development*

Ghana's Educational sector has undergone various reforms over the years in an attempt to improve equity, quality, availability, accessibility and affordability of education in line with SDG4. Access to quality early development and basic education through strengthened management systems of the schools by 2030 has been the strategic policy direction. The Education Strategic Plan (ESP) 2018-2030 seeks to establish a sustainable and accountable system to improve quality in basic education through an improved quality of teaching and learning materials in the education service delivery. Ghana has formulated an Inclusive Basic Education Policy to provide universal design for learning framework, which is free, compulsory and accessible to all school-aged children including children with special education needs. Government of Ghana initiated the free Senior High School (SHS) programme to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. Some of the polytechnics have been upgraded to technical universities in order to respond to job market demands. There has been a steady improvement in gross enrolment at all levels of education since 2017. In particular, enrolment at SHS level (public, private and GES TVET) for 2018/19 increased by 14.1 percent over the 2017/18 level. The free SHS policy contributed to this increase in enrolment.

Currently, the diversity of tertiary educational institutions is evidence of the efforts the country is making to ensure that it has the needed skills and competences to drive the national development agenda. In the specific area of STI, the evidence of diverse tertiary institutions training STI human resources is strong. Public tertiary institutions are dominating the training of STI human resources. For example, an institution such as KNUST still addresses its fundamental mandate in STEM education even though it has extended into teaching-and-learning in non-STEM disciplines. Other tertiary institutions have also strengthened their efforts in STEM education. For instance, the University of Ghana now runs engineering programmes.

The developmental issue has been ensuring quality education that produces problem-solvers in order to reduce over-reliance on foreign experts, employable skills and competence-based lifelong learning that offer opportunities for home-grown solutions to developmental challenges. There is human resource capacity-gap in emerging technologies such as biotechnology, photonics, microelectronics nanotechnology, material science and engineering. At the basic education level, there is the need for training of basic school teachers in the delivery of BSTEM and equipping basic schools with Science, Technology, Engineering and Mathematics (STEM) equipment in line with Government's policy of strengthening and generating interest in Mathematics, Science and Technology. There is need for stimulation of creativity at all levels of education.

Creating appropriate infrastructure for STI human resource development is vital particularly digitalization and e-infrastructure. The central government budgetary allocation to the educational sector should be adequate for maintaining the needed professionals and workers in the sector and ensuring continuous enrolment into the educational institutions at all levels. However, without the infrastructures and emphasis on practical teaching and learning, STEM education is unable to achieve the desired goal of building competences.

2.1.4.2 Digital Education

Digital technology, ICT and mobile applications improve access to education particularly those in remote areas. Smart learning solutions contribute to ensuring inclusive and equitable quality education and lifelong learning opportunities for all, bringing impact to SDG4 at scale. From the online survey conducted in this study, majority (over 80%) of respondents considered ICT and digitalization as extremely relevant in delivering quality education at all levels of the educational system.

2.1.5 Facilitating the Achievement of SDG6 through Effective Application of STI

The Ministry of Sanitation and Water Resources (MSWR) is responsible for ensuring that all Ghanaians have access to safe water, sanitation and hygiene practices and sustainable management of water resources. Given that the SDG 6 is a key priority for Ghana, a number of developmental challenges that confront MSWR need to be addressed. These include limited access to safe drinking water in rural and some urban areas, poor water quality, low water-use efficiency, poor sanitation and improper hygienic practices, and barriers to reuse of water.

Several factors contribute to the lack of safe water access in Ghana (Agyeman, 2019). For instance, most people rely on surface water sources, lack of basic training and capacity to maintain wells, hand pumps and other systems, and lack of proper sanitation and hygiene frequently compound contamination of existing water sources. In order to increase targets under SDG goal 6 to 100 percent by 2030, a number of policies and programmes have been put in place to ensure efficient management of water resources, accelerate the provision of safe, adequate and affordable drinking water, and speed-up the provision of adequate and equitable sanitation and hygiene for all. The most recent ones include the National Drinking Water Quality Management Framework for Ghana (NDWQMF) introduced in 2015 and the new mining policy framework (2018) that seeks to regularize and reform mining activities in Ghana. Mining generally has deleterious effects on the lakes and rivers and their tributaries, which are the sources of drinking water for local communities. In the 2020 Budget Statement, expansion of nationwide water quality monitoring network, implementation of water governance, ecosystem restoration and conservation as well as groundwater monitoring and management are some of the activities budgeted for by the Water Resources Commission of Ghana.

Sanitation is a major challenge. About 20 per cent of the entire country's population practice open defecation. The practice is much more widespread in the three regions of Northern Ghana (Northern, Upper East & Upper West Regions) where more than 70 per cent of the population practice open defecation. A high proportion (almost 51 per cent) of Ghanaians use communal latrines which, according to the Joint Monitoring Programme of WHO/UNICEF, are classified as unimproved. Poor sanitation has negative implications on health, soil and water contamination, life on land and water among others. One of the key causes of poor sanitation is poverty and low prioritization of sanitation at all levels of development planning – district, regional and national. MSWR with support from the World Bank is constructing sustainable toilets using bio fill technology. For accelerated impact, the Ministry is considering construction of central Sewage Systems, Community-led Total Sanitation and support to the poor and vulnerable including the aged, PLWDs, widows and female headed-households without adequate social-support system.

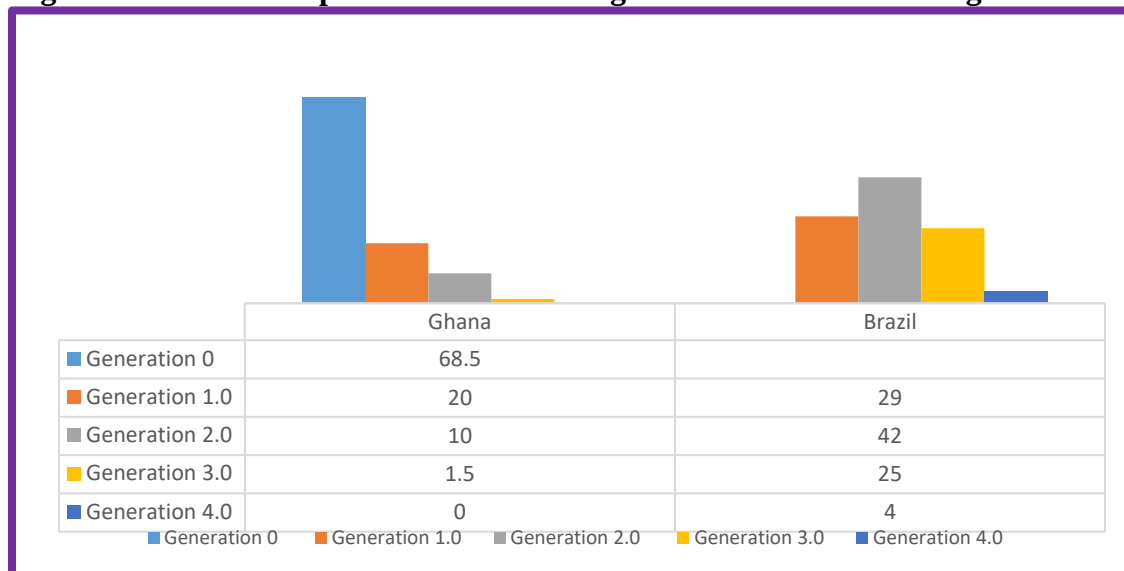
The National Environmental Sanitation Strategy and Action Plan (NESSAP) is a response to the need to refocus attention on environmental sanitation in Ghana and provide clear strategies and action plans that will guide implementation by Metropolitan, Municipal and District Assemblies (MMDAs). The NESSAP covers: Awareness creation, improvements in all aspects of environmental sanitation services targeting the reduction of wastes for final disposal, effective coordination, and resource use efficiency and reduction in MMDA's cost of managing waste. Technology options considered in targeting the poor and vulnerable for basic sanitation services in Ghana include improved pit latrines, ventilated improved pit latrine, pour-flush latrines and aqua privy latrines and bio-digesters. Another area for consideration is sanitation related by-laws enforcement and the use of indigenous knowledge as well as local institutions in implementing sustainable sanitation options to ensure social and community acceptance.

One of the worrying concerns in Ghana has been the issue of plastic waste, which impacts negatively on water, sanitation and the environment. The Ministry of Environment, Science, Technology and Innovation in January, 2020 published the National Plastics Management Policy with the vision to ensure sustainable plastics management through Science, Technology and Innovation (STI). The document outlined the processes of creating public awareness, building management capacity, promoting the adoption of innovative practices, identifying innovative financial sources and promoting effective inter-institutional collaboration as the objectives of effective plastics management. The policy identified STI as the first important systematic pillar for achieving its objectives. There are emerging technologies to manage waste including pyrolysis, gasification and thermal hydrolysis for processing solid waste into useful and marketable products. Technologies for recycling plastic waste are particularly important.

2.1.6 Industry, Innovation for Creation of Decent Employment through Effective Application of STI

SDG 9 aims to build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation. The industrial sector is of particular importance for Ghana's socio-economic development given that it underpins sustainable job creation, import substitution and exports. The contribution of the industrial sector to Ghana's GDP was estimated at 34.2 per cent in 2019 (GSS, 2020) with the manufacturing sub-sector contributing 11.2 per cent, mining & quarry (14.9 per cent) and construction (6.4 per cent). Industrialization enables countries to build and strengthen the skills and capabilities to compete and succeed within new technological paradigms.

Figure 2: Level of Adoption of Advanced Digital Production Technologies



Considering the fact that the growth rate in the manufacturing subsector has been dwindling (from 9.5 in 2017 to 4.1 in 2018), a focus on the level of use of Advanced Digital Production Technologies such as Advanced Robotics, Artificial Intelligence, Big Data and the Internet of Things for smart manufacturing was conducted (UNIDO Industrial Survey Report 2019) in Ghana. The survey covered 200 firms in the food products and beverages, textiles, furniture and wood, metal, and plastics and rubber industries in Greater Accra and Ashanti regions of Ghana. Majority of the manufacturing firms surveyed were using industry 1.0 and 2.0 generation technologies. Globally, the firm-level data showed Ghana as a laggard in the use of Advance Digital Production (ADP) technologies. Only 1.5% of firms surveyed were using 3.0 and 4.0 generations digital technologies (Figure 2). Compared to Brazil, this is a rather poor industrial performance. In the manufacturing sector, there is the need to leverage on ongoing initiatives using ADP Technologies and strengthen uptake of R&D.

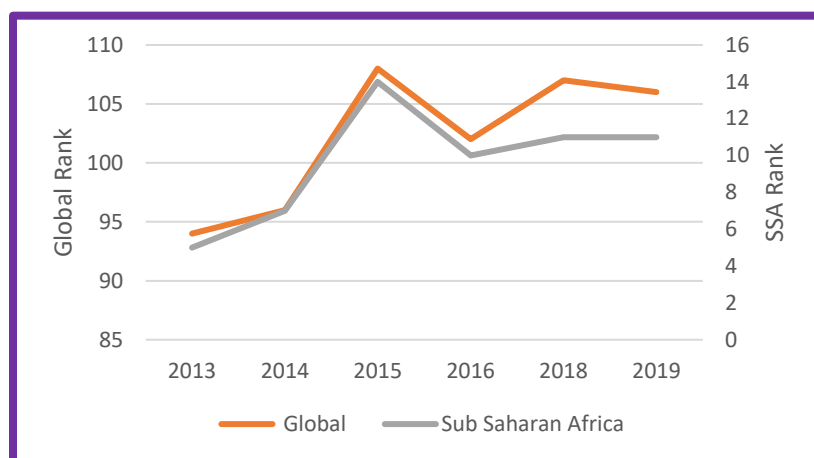
The relatively poor performance of the industrial sector and particularly the manufacturing sub-sector is attributed, but not limited, to:

- ✚ High cost of capital and electricity;
- ✚ Limited access to medium and long-term financing;
- ✚ Unreliable power supply and limited access to land for industrial activity;
- ✚ Weak logistics and weak infrastructure support for industrial development;
- ✚ Cyber security and internet fraud;
- ✚ Influx of foreign competitive products and downward pressure on prices of locally produced goods and services; and
- ✚ Bureaucratic delays in certification by regulators.

Ghana is vigorously pursuing an industrialization agenda through: (i) a stimulus package/fund arrangement for selected distressed but viable local companies; (ii) one district, one factory flagship programme; (iii) strategic anchor industrial initiatives focusing on petrochemicals, iron and steel, integrated aluminum, pharmaceuticals, automotive, industrial salt, garment and textiles, among others; and (iv) industrial subcontracting exchange programme that seeks to link SMEs to

feed large-scale enterprises. The implementation of the industrialization agenda is at the heart of Ghana's socio-economic growth.

Figure 3: Global Innovation Index - Ghana



The Global Innovation Index benchmarks 129 countries according to 80 indicators divided into innovation inputs and innovation output. In 2019, Ghana was ranked 106 and 11 at Global and Sub-Saharan Africa respectively (Figure 3). Clearly, more efforts at promoting innovation have to be made. The Ministry of Environment, Science, Technology and

Innovation (MESTI) will need to mobilize its agencies for a more effective cross-sectoral innovative impact especially in relation to the industrialization strategy.

2.2 Constraints and Opportunities in the STI Ecosystem

The principal thrust of Ghana's National Science, Technology and Innovation Policy is to ensure that STI drives all sectors of the economy. However, a number of STI-related challenges still exist that require policy attention. Some of these challenges have been flagged in the STI Policy including:

- ✚ Inadequate scientific expertise in the country and over reliance on the use of foreign expertise
- ✚ Lack of effective advocacy for STI at the highest political and policy levels and Low science and technology culture among the populace;
- ✚ Weak structures for the management of STI and Ineffective coordination of the STI system;
- ✚ Inadequate budget and resource allocation to STI;
- ✚ Weak mechanisms for implementation, evaluation and review of STI policies, projects and initiatives;
- ✚ Weak linkages between various agencies and organizations in STI. For example, Poor Collaborations between CSIR and Universities, weak linkage between industry and the R&D system;
- ✚ The inadequate science teaching and learning in our pre-tertiary education system;
- ✚ Poor remuneration and conditions of service for science and technology personnel of research institutions;
- ✚ Lack of data on technological opportunities; and
- ✚ Difficulty with maintenance of imported technologies and lack of local content concept in deploying ICT solutions in Ghana.

Despite the challenges, opportunities exist to leverage on emerging technologies and minimize their disruptive effects. There are innovation and technology hubs to drive generation of home-grown innovation and capacities to incubate entrepreneurs and small businesses. Other opportunities include:

- ✚ The Continental Free Trade Agreement (CFTA), which offers huge opportunity for technological capability development;
- ✚ Availability of STI Policy and National Entrepreneurial and Innovation Plan that needs resources for sustainable implement
- ✚ On-going digitization interventions and opportunity to assess impacts and possibility of up-scaling;
- ✚ Available research findings that can be transformed into commercial products;
- ✚ Opportunity to coordinate international cooperation, collaboration and partnerships;
- ✚ Opportunity for Ghanaian scientists and technologists to link up with international research centres and world class research programmes;
- ✚ Private sector involvement in R&D to respond to demand driven research; and
- ✚ Possibility of using Ghanaian experts in the Diaspora and other skilled persons living in foreign lands.

2.3 Concluding Remarks

A sectorial approach has been used to assess the STI capabilities available and the STI gaps for considerations in facilitating the achievement of the prioritized SDGs namely goals 1, 2, 3, 4, 6, 8 and 9. The chapter highlighted the need for Ghana to make necessary effort (from both public and private sectors) to boost research and development, enhance the skills base of the current and future workforce, develop new infrastructure and create capacities in new technologies to establish the Launchpad for accelerating the achievement of the SDGs. For effective human capital formation to drive the STI agenda especially for the accelerated achievement of the SDGs, there must be a rejuvenation of the educational system with emphasis on stimulating curiosity, creativity and enhancing competence-building. At the tertiary level in particular, institutions must be well-equipped to effectively deliver teaching and learning in STEM. Research and development in the established institutions must be enhanced with adequate human resources and infrastructure.

Recommendations:

The STI capability needs regarding human capital, infrastructural and delivery systems for fast tracking the achievement of prioritized have been assessed and the following policy recommendations are made:

- ✚ Develop strategies to take advantage of innovations in agri-food system, health and education delivery systems, and regulate Ghana's technological space;
- ✚ Invest in Advance Digital Production (ADP) technologies and strengthen uptake of R&D;
- ✚ Address infrastructural gaps in irrigation, low adoption rates of climate smart technologies and inadequate human resources;
- ✚ Invest in STEM education, scientific equipment and e-learning facilities at all levels;
- ✚ Build local capacity and workforce in industrial equipment maintenance to reduce over-reliance on foreign expertise, and initiate equity law to protect local industries; and
- ✚ Invest in water quality monitoring and management systems as well as behavioral initiatives on sanitation and good hygiene practices.

CHAPTER 3: Vision, Goals and Targets of the Roadmap

3.1 Introduction

The situational analysis conducted in the first phase of working the STI4SDGs Roadmap, provides a logical basis for the formulation of the roadmap. However, in formulating the roadmap, there is need to crystallize the vision and elaborate on the goals and targets in a manner that brings clarity to the connections between the STI applications and the drive to accelerate to the SDGs. This chapter crystallizes the vision for the roadmap with the analysis of the vision statements in the requisite documents, deliberates on the developmental goals and targets with specific reference to the prioritized SDGs.

3.2 The Vision

The development vision of Ghana derives from the national socio-economic, political and cultural context of the nation. The 1992 Constitution of Ghana envisions a *just* and *free* society. This kind of vision statement however is open to wide interpretation. The Coordinated Programme of Economic and Social Policies translates the constitutional vision into more specific statements of intents for the overall development of the country.

“An optimistic, self-confident and prosperous nation, through the creative exploitation of our human and natural resources, and operating within a democratic, open and fair society in which mutual trust and economic opportunities exist for all.”

For the purposes of the STI4SDGs Roadmap, the critical part of the vision statement is the “creative exploitation of our human and natural resources”. Such exploitation will be on the wheels of STI taking into consideration the prioritized needs of the economy and society. STI will also drives the achievement of the specific goals set in connection with the vision, namely:

- Creating opportunities for all Ghanaians;
- Safeguarding the natural environment and ensuring a resilient built environment;
- Maintaining a stable, united and safe country; and
- Building a prosperous country.

The national vision is further elaborated by other important national documents aside the Constitution and the Coordinated Programmes. The *Ghana Beyond Aid* policy is a transformation agenda based on the manufacturing and provision of high value services from an increased production of raw materials for export and local consumption. The policy is based on the premise that, Ghana must grow out of the aid dependency to properly reflect its status of over 60 years of political emancipation. The policy envisages creating a modernized, competitive, and resilient economy of equal opportunities for Ghanaians. The objectives target investors and donors to reorient investments streams to the productive sectors of the economy with potential to transition the country to beyond aid. The overall goal is to achieve a “W.I.S.E.R” Ghana:

W - Wealthy Ghana;
I - Inclusive Ghana;
S - Sustainable Ghana;
E - Empowered Ghana; and
R - Resilient Ghana.

Given the cross-cutting nature of STI, its direct impact on the efforts to achieve the respective objectives stated in the Coordinated Programme can be anticipated. However, within the broad scope of the goals spelt out in the Coordinated Programme, the formulation of the Roadmap will focus specifically on the SDGs. In this regard, an important step in the conduct of the situational analysis for the roadmap is the prioritization of the SDGs taking account of the national context. The SDGs prioritized for Ghana are SDGs 1, 2, 3, 4, 6, 8 and 9. Table highlight the prioritized SDGs and the points of emphasis in the development agenda of Ghana. All of these prioritized SDGs are important for Ghana's sustainable development. For example, SDG 2 is one of the important priority SDGs. Agriculture's contribution to GDP in 2019 is estimated to be 18.5 percent, with the Service and Industry sectors accounting for 47.2 percent and 34.2 percent respectively. Aside the contribution to GDP, the agricultural sector provides direct and indirect employment and livelihoods to about 65 percent of the population. The significance of agriculture stretches to other SDGs as well.

3.3 The Goals and Targets

The domestication of the SDGs and targets is in line with what member states of the UN and in particular those committed to 2030 Agenda are expected to do. Ghana participated in the formulation of 2030 Agenda for Sustainable Development in the inter-governmental negotiations making strong submissions on poverty, gender, climate change, food security and other development themes. The 17 SDGs came with 169 targets when they were adopted in September 2015 to guide national developments around the globe. However, the UN resolution of the adoption provides for each country to take into consideration the realistic conditions of the country, capacities, levels of development and the respect national priorities and policies. In this regard, one may expect variations among the member countries in the implementation of the SDGs and their respective targets.

The current development policies and programmes illustrate the extent to which Ghana has domesticated or localized the SDGs. Beginning with the Ghana Shared Growth and Development Agenda (GSGDA II, 2014 -2017) and moving on to the Coordinated Programme of Economic and Social Development Policies (2017 – 2024), the national development goals are consistent with the SDGs. There have been cases of adaptation of targets and indicators, with the amendment of the original targets made in consideration of national circumstances, data requirement, statistical capabilities and national aspirations (NDPC and GSS, 2018). The SDG targets and indicators requiring no modifications were adopted for use in national and sub-national development plans and M&E frameworks. Without dwelling too much on the details of the computation of the applicable indicators linked with the targets Ghana is focused on, some key targets are highlighted here in Table 1. The aim is to illustrate the connections with STI deployment as will be elaborated in Chapter 4 as well as providing guideposts to Chapter 7, which presents the M&E framework for the roadmap and discusses the objectives, the means and methodologies of monitoring, evaluation and reporting.

Table 1: Ghana's Prioritized SDGs and Targets for the Roadmap

SDG	Description	Targets	Remarks
1	No poverty – eradicate poverty in all its forms everywhere	1.1 By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than \$1.90 a day. 1.2 By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions. 1.4 By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance 1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters 1.a Ensure significant mobilization of resources from a variety of sources, including through enhanced development cooperation, in order to provide adequate and predictable means for developing countries, in particular least developed countries, to implement programmes and policies to end poverty in all its dimensions.	Achieving no poverty implies deploying STI to enhance income generation for all people everywhere; formulation and implementation of programmes and projects to improve productivity in all sectors of the economy, streamlining access to financial and other resources for businesses to thrive and for sustainable participation in economic activities.
2	End hunger, achieve food security and improved nutrition and promote sustainable agriculture	2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round. 2.2 By 2030, end all forms of malnutrition, including achieving by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional	STI impact on food and nutrition security can be enhanced; sustainable agriculture can be promoted with expanded access to appropriate technology and resources; promotion

SDG	Description	Targets	Remarks
		needs of adolescent girls, pregnant and lactating women and older persons. 2.a Increase investment, including through enhanced international cooperation in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries, in particular least developed countries.	of consumption of nutritious foods and local food products with emphasis on better feeding of children and young people; promotion of agricultural research and development with strong linkages between the National Agricultural Research System and all actors in the agricultural value chain.
3	Ensure healthy lives and promote well-being for all at all ages	3.1 By 2030, reduce the global maternal mortality ratio to less than 70 per 100,000 live births. 3.2 By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1,000 live births and under-5 to at least as low as 25 per 1,000 live births. 3.3 By 2030, end the epidemics, HIV and AIDS, tuberculosis, malaria and neglected tropical diseases; combat hepatitis, water-borne diseases and other communicable diseases.	The targets and their respective indicators illustrate the opportunities for STI intervention; enhanced health care delivery coming with increasing trained health professionals and adequate health infrastructure are necessary requisites to attain SDG3; provision of tools for diagnostics and therapeutics come with STI application.
4	Ensure inclusive and equitable education and promote lifelong learning opportunities for all.	4.1 By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes. 4.2 By 2030 ensure that all girls and boys have access to quality early childhood development, care and pre-primary education so that they are ready for primary education. 4.3 By 2030, ensure equal access for all women and men to affordable and quality	The targets can be achieved with STI-based reforms of the educational systems especially the digitalization for relevant and effective learning outcomes. STI can drive the efforts to instill a culture of curiosity, creativity and innovativeness in the

SDG	Description	Targets	Remarks
		technical, vocational and tertiary education, including university. 4.a Build and upgrade education facilities that are child, disability and gender sensitive and provide safe, non-violent, inclusive and effective learning environment for all.	graduates of educational institutions at all levels.
6	Ensure availability and sustainable management of water and sanitation for all.	6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all. 6.2 By 2030, achieve access to adequate sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations. 6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.	The solution to the challenges of sustainable management of water and sanitation management is in STI. Existing technologies for water treatment and supply can be improved, new technologies adopted and technologies for sanitation can be promoted with attendant public education.
8	Promote sustained, inclusive economic growth, full and productive employment and decent work for all.	8.1 Sustain per capita economic growth in accordance with national circumstances and, in particular, at least 7 percent GDP growth per annum in the least developed countries. 8.5 By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value. 8.6 By 2030, substantially reduce the proportions of youth not in employment, education or training. 8.7 Take immediate and effective measures to eradicate forced labour, end modern slavery and human trafficking and secure the prohibition and elimination of the worst forms of child labour, including recruitment and use of child soldiers, and by 2025 end child labour in all its forms.	The government flags Agenda for Jobs as its clarion call for support. STI deployment in the economic sectors particularly agriculture, industry and services can lead to job creation to reduce unemployment.

SDG	Description	Targets	Remarks
		8.10 Strengthen the capacity of domestic financial institutions to encourage and expand access to banking insurance and financial services for all.	
9	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.	9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all. 9.2 Promote inclusive and sustainable industrialization and gross domestic product, in line with national circumstances and double its share in least developed countries. 9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities. 9.5 Enhance scientific research, upgrade the technological capabilities of industrial sectors of all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending.	Innovation is the key for sustainable development. In building infrastructures and in industrialization, STI is becoming more and more relevant. The emerging technologies such as the ICT, Internet of Things, robotics, biotechnology, nanotechnology and big data science are determining competitiveness in the economic space. Ghana needs to strategize for the deployment of these emerging technologies.

3.4 Issues of STI deployment in achieving the SDGs

As illustrated in Table 1, the prioritized SDGs come with their particular targets as contextualized in the Ghanaian socio-economic and cultural conditions. STI adoption, promotion and deployment to achieve these targets must necessarily be relevant and appropriate to the conditions. Most technologies used in the productive sectors of the economy such as in agro-processing, manufacturing, construction and in services are imported. There are issues of the type of technology, which is appropriate for the country. The operation and maintenance of the technologies need to be considered as well as the availability of trained human resources.

This chapter, and in particular Table 1, does not state the indicators. But there are indicators coming with the targets. In all, Ghana is tracking 70 indicators across all the adopted SDGs. In the Chapter 7 on the M&E, these indicators will be elaborated on to highlight their relevance and utility. However, the effect of these indicators beyond their particular targets needs to be emphasized. For example, the percentage of total annual public expenditure allocated to the agricultural sector goes beyond target 2.a given in Table 1 and even beyond SDG2. The effect touches on the national efforts to eliminate poverty (SDG1) and create jobs (SDG8). The cross effects of the targets and indicators present opportunities for strategic adoption of technologies that would contribute to the achievement of multiple development goals.

Chapter 4 – Detailed STI Strategies/Programmes/Projects/Activities for Achieving the Prioritized SDGs and their Respective Targets

Chapter 4 elaborates on the specific strategies and programmes for each of the prioritized SDGs and their respective targets. This is at the heart of the roadmap. Each of the prioritized SDGs come with specific targets not only adopted from the internationally prescribed but also targets that are crafted to suit the context of Ghana. Table 2 highlights the targets, the activities envisaged to address the respective targets, the expected outputs and the responsibilities of the lead and collaborating institutions.

4.1 Detailed STI Strategies/Programmes/Projects/Activities for achieving SDG 1– No Poverty

Table 2: SDG 1 Framework for Developing Strategies and Programmes for STI4SDG Roadmap

Targets	Objectives	Activities	Outputs	Responsibility*
Target 1.1 By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than \$1.90 a day.	- Eradicate extreme poverty in Ghana measured as people living on less than \$1.90 a day; - Ensure means of income for all.	- Promote technology and innovation for livelihoods; - Strengthen technology promotion centers e.g. Rural Technology Facility (RTF) to provide agric. technologies for rural industries - Promote ICT-based business e.g. mobile money transfers in 50 selected communities in 5 regions.	- rural agric. Technologies - established ICT- based businesses	CSIR , Ministry of Finance, Ministry of Trade and Industry, Ministry of Local Governments, GRATIS, REP.
Target 1.2 By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions.	- Ensure inclusivity in poverty eradication programmes erasing all bias by gender, age and disability.	- create an ICT-based system for monitoring poverty-eradication programmes to ensure inclusivity.	- an ICT-based system for monitoring implementation of poverty eradication	Ministry of Gender and Social Protection , Ministry of Finance, NDPC, GSS, Ministry of Local Government.

Targets	Objectives	Activities	Outputs	Responsibility*
Target 1.a Ensure significant mobilization of resources from a variety of sources, including through enhanced development cooperation to implement programmes and policies to end poverty in all its dimensions.	- Mobilize resources for poverty eradication	- Convene a conference (physical and or virtual) of development partners on resource commitment for poverty eradication. - Track resource contributions for poverty eradication and provide information on achievement and gaps.	- Conference proceedings - Information system on poverty eradication.	NDPC,

Note - * lead institutions in bold

Target 1.1 By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than \$1.90 a day.

Ghana's efforts aimed at poverty eradication is in line with the SDG focus on national definitions of poverty and the reflecting local socio-economic dynamics and capabilities. Poverty incidence emanates from across sectors of production and therefore the eradication efforts have to take that into account. The proposal for adoption and promotion of technologies will therefore cut across sectors to take advantage of the attributes of technology for income generation.

Promoting technology and innovation for livelihoods will include the adoption of technologies generated by the CSIR and other R&D institutions. Innovations developed in the private sector will also be promoted. It means that a fund will be created specifically for this.

The Rural Enterprises Programme also establishes the Rural Technology Facilities (RTFs) to provide technologies for rural industries. It is envisaged that in collaboration with these facilities there will be greater infusion of technologies of the micro and small scale industries to improve their productivity.

Since the emergence of ICT, various businesses have been founded around ICT. There were the communication centres, which are still operating in some communities. However, currently, mobile money transfers have become popular especially in the urban centres. It is an indication of the potential of ICT applications for business in the service sector. Thus the roadmap envisages to promote ICT-based business e.g. mobile money transfers in 50 selected communities in 5 regions.

Target 1.2 By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions.

Ensuring gender equity and sensitivity to the needs of children and the disabled are very important in poverty eradication. The Ministry of Gender, Children and Social Protection (MGCSP) has been set up to address the issues in gender equity and to ensure an all-embracing socio-economic development in the country. In this regard, the MGCSP is expected to lead in the programme for applying STI for the achievement of target 1.2. The main effort is creating an ICT-based system for monitoring poverty-eradication programmes to ensure inclusivity. The specific features here are the capacity to track gender and children sensitive outcomes in the execution of the programmes and inform the executors for corrective measures as may be necessary.

Target 1.a Ensure significant mobilization of resources from a variety of sources, including through enhanced development cooperation to implement programmes and policies to end poverty in all its dimensions.

Resource mobilization is always a major challenge for developing countries. Fortunately however, there is international understanding for the need for richer countries to help the poor. In spite of the COVID 19 pandemic which has put pressure on all countries economically, the willingness for assisting developing countries remain. What is envisaged to achieve target 1.a is building a technological system to track and ‘direct’ resource mobilization for poverty eradication. The first step is convening development partners and other stakeholders to discuss with government the specific commitments to poverty eradication. A system will be built to track the execution of these commitments, the implementation of the respective programmes and provide information for review.

4.2 Detailed STI Strategies/Programmes/Projects/Activities for Achieving SDG 2 – Zero Hunger

In Chapter 2, key issues and challenges relating to ending hunger (SDG2) in Ghana were outlined. However, for the purpose of achieving the SDG2 using STI, the areas of concern include ensuring improved public investment in agriculture; improving production efficiency and yield; improving post-harvest management; enhancing application of STI in agriculture; promoting agriculture as a viable business among the youth; promoting livestock and poultry development for food and nutrition security; modernizing the agriculture sector to drive private sector agribusinesses; scaling up e-extension and business advisory services; enhancing on-line marketing of agricultural products; promoting adoption of productivity improvement technologies such as greenhouse production systems; and promoting biotechnology applications for improved breeding. These areas align with Ghana’s agriculture sector policy objectives as follows in Table 3.

Table 3: Alignment of Policy Objectives of Ghana’s Agriculture Sector with Areas of Focus

No.	Agriculture Sector Policy Objectives	Identified Areas for STI Focus (Situational Analysis)
1.	Strengthen institutional and organisational capacity	- Improved public investment in agriculture

No.	Agriculture Sector Policy Objectives	Identified Areas for STI Focus (Situational Analysis)
2.	Modernize and enhance production systems	- Improving post-harvest management; - Enhancing application of STI in agriculture; - Improving production efficiency and yield - Modernizing the agriculture sector to drive private sector agribusinesses; - Scaling up e-extension and business advisory services; - Promoting adoption of productivity improvement technologies such as greenhouse production systems; - Promoting biotechnology applications for improved breeding - Improved public investment in agriculture
3.	Create an enabling agribusiness environment	- Promoting agriculture as a viable business among the youth; - Promoting livestock and poultry development for food and nutrition security - Enhancing on-line marketing of agricultural products;

In addition to the areas outlined in Table 3, there is recognition that climate change and disasters (humanmade and natural) are threats that can derail or impeded progress in the agriculture sector. Hence, it is important that STI be brought to bear on efforts to mitigate climate change effects and enhance sustainable land and water resources management in Ghana. This is indeed a policy objective of the sector. Aligning the focal areas, the policy objectives, and the targets for SDG2 in the light of STI intervention, Table 4 is presented.

For the SDG 2, Targets 2.1, 2.2, 2.4, and 2.a have been prioritised as shown in table 4. Target 2.1 is to end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round by 2030. It has been noted that hunger arises in Ghana out of limited food availability, accessibility, affordability and stability. Moreover, even though the area planted to the various crops in Ghana seems to have been stagnant, production of crops has tended to increase over time but lack of market and wide price fluctuations of produce continue to be constraints to farmers.² On this score, STI intervention in this area will activities such as technical support in the production of quality and well packaged food products to enhance post-harvest management through the one-district-one-factory initiative; and support for the application of Internet of Things (IoTs) in agriculture to enhance on-line marketing of agricultural products.

SDG 2, Target 2.2 puts emphasis on “the indicators of the triple burden of malnutrition, that is, Protein-Energy Malnutrition, Micronutrient Malnutrition and Overweight & Obesity.” The target also aims at zero stunting and wasting in children under five and at addressing the nutritional needs of adolescent girls, pregnant and lactating women and older persons, as well as micronutrient

² Matilda Steiner-Asiedu et al., “Addressing Sustainable Development Goal 2: Ghana Zero Hunger Strategic Review” (Accra, 2017), https://docs.wfp.org/api/documents/WFP-0000071730/download/?_ga=2.47054116.2038938788.1535558371-1957203229.1486643929.

malnutrition.³ In the light of this, therefore, STI should be employed to promote biotechnology applications for improved breeding of crops and to develop formulae for food supplementation and bio-fortification (with sound biosafety systems in place).

Target 2.4 is to ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality. No matter the scale of production, any food production system should aim at being sustainable. That is, “the system should get better in terms of soil improvement (or the ecosystem as a whole), be profitable (that is returns must be in excess of costs), be equitable (that is provide a reasonable livelihood to all involved) and have the potential of being resilient (that is being able to withstand climate, disease, market and other shocks).”⁴ Therefore, STI intervention activities identified developing and supplying quality seeds and improved varieties of crops, livestock, fisheries and poultry to farmers; promoting the adoption of and scaling-up of productivity improvement technologies such as greenhouse production systems; and developing a programme to implement an early warning and emergency preparedness system for agriculture.

Target 2.a. seeks to increase investment, including through enhanced international cooperation in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries, in particular least developed countries. In furtherance of this target, the role of STI in SDG 2 can be amplified by intensifying advocacy and communication activities, developing a science agenda for agriculture in Ghana, and scaling up e-extension and business advisory services.

Table 4: SDG 2 Framework for Developing Strategies and Programmes for STI4SDG Roadmap

TARGETS	OBJECTIVES	ACTIVITIES	OUTPUT	RESPONSIBLE ENTITY
2.1 By 2030, end Hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food	Promote the patronage of locally produced and processed foods and their products Develop and implement potential	Support the adequate and efficient production of quality and well packaged/ managed food products to enhance post-harvest management Support the establishment of	Improved Post harvest management	MoFA, MESTI, MoC, MoTI, MoFAD, CSIR, DPs, NDPC, Private Sector

³ Steiner-Asiedu et al., 12.

⁴ Steiner-Asiedu et al., 28–29.

	domestic market oriented products in the interest of the youth to encourage their interest in agribusiness	grain warehousing system Support the application of Innovative/Internet of Things (IoTs) in agriculture to enhance on-line marketing of agricultural produce/products		
2.2 By 2030, end all forms of malnutrition, including achieving by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant women and older persons	Promote the development of appropriate programmes to reduce the incidence and prevalence of nutritional disorders	Promote biotechnology applications for improved breeding Develop formulae for food supplementation and bio-fortification (with sound biosafety systems in place)	Reduced nutritional disorders	MoFA, MESTI, NBA, MoH/GHS, MoTI, MoFAD, CSIR, DPs, NDPC, Private Sector
2.4. By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to	Improve production efficiency and yield Modernize the agricultural sector to drive private sector agribusinesses Establish early warning systems and	Develop and supply quality seeds and improved varieties/breeds of crops, poultry, livestock and fisheries Identify resilient indigenous food systems (agrobiodiversity systems)	Sustainable food production systems	MoFA, MESTI, MoC, MoTI, MoFAD, CSIR, DPs, NDPC, Private Sector

climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality	emergency preparedness	Promote adoption of and scaling up productivity improvement technologies such as soil management techniques/ greenhouse /mariculture/ and other efficient production systems Develop programmes to implement an early warning and emergency preparedness system		
2.a. Increase investment including through enhanced international cooperation in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries, in particular least developed countries	Improve Public investment in agriculture Enhance application of STI in agriculture	Intensify advocacy and communication Develop science agenda for agriculture in Ghana Scale up e-extension and business advisory services	Increased investment in STI for Agriculture	MoFA, MESTI, MoC, MoTI, MoFAD, CSIR, DPs, NDPC, Private Sector

4.3 Detailed STI Strategies/Programmes/Projects/Activities for Achieving SDG3: Universal Access to Healthcare Services by 2030

Ghana has made a considerable progress in SDG3 indicators (Ghana VNR 2019 Report). Access to healthcare services improved with the proportion of the population using valid National Health Insurance Scheme (NHIS) cards estimated at 40 percent in 2019, an increase from 35.7 percent in 2018. Access to modern family methods continue to increase with the proportion of women age between 15-49 years having their family planning needs met increased from 23.5 percent in 2008 to 42 percent in 2017. Maternal deaths declined from 580 per 100,000 live births in 2007 to 310 per 100,000 live births in 2017. Under Five and neonatal mortality rates also declined with the number of children dying within 28 days of birth dropping from 43 per 1, 000 live births in 2003 to 27 deaths per 1, 000 live births in 2017.

Despite progress made in access to healthcare, there are challenges which can be addressed effectively through the application of Science, Technology and Innovation (STI). These challenges include huge imbalances in geographical access to quality healthcare; inadequate and inequitable distribution of critical staff, increased cost of healthcare delivery, unhealthy dietary practices and nutritional disorders, poor quality of healthcare services as well as devastating impact of the COVID-19 on the Ghana Healthcare delivery system. The National Health Policy Objectives include (i) strengthen the healthcare delivery system to be resilient (ii) encourage the adoption of healthy lifestyles (iii) improve the physical environment (iv) improve the socio-economic status of the population, and (ensure sustainable financing for health.

To this end, four key programmes will be vigorously pursued under the STI4SDGs Road map including (i) Improving quality of healthcare delivery and public health through the application of STI, (ii) Improving emergency preparedness and management of epidemics and pandemics such as Severe Acute Respiratory Syndrome (SARS), Ebola, Lassa Fever and COVID-19 (iii) Strengthening technological capability needs and capacity building, and (iv) Improving nutrition and healthy dietary practices and lifestyles. These programmes and actionable strategies are aligned to health sector objectives articulated in Ghana's STI-Policy, Coordinated Programme of Economic and Social Development Policies (CPSEDP), National Health Policy, COVID-19 Response Plan and the Ghana COVID-19 Alleviation and Revitalization of Enterprises Support.

1. Improving access to quality healthcare delivery and public health through the application of STI

Actionable Strategies

- Enhance healthcare infrastructural development including ICT infrastructure and AI-powered healthcare services;
- Improve doctor-to-patient ratio through increase enrolment particularly at the tertiary level;
- Improve maternal and child health services, mental health and prevention of communicable and non-communicable diseases;
- Educate the general populace on scientific basis of health issues, correct misconceptions, ignorance and superstitious beliefs and practices to reduce the national healthcare cost burden;

- Promote the development of domestic pharmaceutical production and local industrial production of some consumables in health care service delivery; and
 - Establish specialized health centres to promote health tourism.
2. Improving emergency preparedness and management of epidemics and pandemics such as Severe Acute Respiratory Syndrome (SARS), Ebola, Lassa Fever and COVID-19

Actionable Strategies

- Invest in digital technologies for epidemics and pandemic planning, surveillance, testing, contact tracing, quarantine, and health care;
 - Promote e-health services delivery and technological capability through investment in ICT infrastructure and AI-powered healthcare services;
 - Re-tooling of existing health facilities and construction of new ones;
 - Promote research and development in the area of bio-medical engineering and instrumentation;
 - Research into public health, clinical characterization and management of pandemics to inform policy; and
 - Research into transmission dynamics of viruses including environmental and sociocultural conditions associated with transmission.
3. Strengthening technological capability needs and capacity building

Actionable Strategies

- Institutionalize the Comprehensive Health Technology Assessment tool to inform the selection and procurement of needed medical technologies;
- Promote adoption and deployment at scale of selected innovation pathways and emerging technologies (AI, Blockchains, 3D Printing, tele-health platforms. Robotics and drones);
- Build the capacity of health professionals and other actors in the adoption and deployment of emerging technologies and innovations;
- Enhance access to accurate, timely and reliable data on health care delivery system and information management; and
- Promote public-private partnerships in the healthcare delivery system.

4. Improving nutrition and healthy dietary practices and lifestyles

Actionable Strategies

- Educate the general populace on improved nutrition and healthy dietary practices;
- Promote the development of appropriate programmes for reducing the incidence and prevalence of nutritional disorders;
- Encourage the adoption of healthy lifestyles and physical activity; and
- Promote safe and responsible sexual behavior

Table 5: SDG3 Framework for Developing Strategies and Programmes for STI4SDG Roadmap

Targets	STI Objectives	Activities	Outputs	Responsibility
End the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases. Reduce maternal mortality ratio (MMR), under-five mortality and neonatal mortality rates Increase proportion of births attended by skilled health personnel and proportion of women of reproductive age) who have their need for family planning satisfied with modern methods; and Reduce death rate due to road traffic injuries	-identify technologies/ innovations in preventive measures against epidemics; - improve early detection and diagnostics of such diseases; - enhance therapeutics - strengthen human resources - strengthen M&E systems	- create ICT-based systems for public education - adopt electronic records and application of digital health platforms (tele-consultation, tele-radiology, m-health, big data analytics, artificial intelligence - innovate for tests of the key diseases e.g. TB, hepatitis, AIDS, - promote production of drugs including herbal; - capacity building in diagnostics and therapeutics - provide tools for follow-up random tests in communities	- ICT-based programmes for public education - diagnostic tools - therapeutics -technologies and innovations (AI, Blockchains, 3D Printing, tele-health platforms. Robotics and drones) - M&E systems - R&D publications - mass media programmes - capacity-building/ training modules - trained human resources.	Lead – MOH Others GHS, FBOs, Private Health Facilities, NGOs in Health, Health Regulatory Agencies, Health Training institutions

4.4 Detailed STI Strategies/Programmes/Projects/Activities for Achieving SDG4: "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" by 2030

SDG 4 focuses on one of the underpinning development areas of Ghana. A major flagship policy is the Free Senior High School (SHS) policy which makes high school education completely accessible to all irrespective of geographical location, social status, economic circumstance or physical ability or disability. The principle of inclusivity underlying the SDGs drives the flagship

educational policy. It is currently being implemented at substantial cost to the nation and yet, it is considered one of the important investments that the country has to make to create the valuable human resources for the transformation of Ghana.

STI impact in the educational sector is critical the achievement of SDG4. Table 6 highlights the key activities envisaged in addressing the targets Ghana has committed itself to.

Table 6: SDG4 Framework for Developing Strategies and Programmes for STI4SDG Roadmap

Targets	Objectives	Activities	Outputs	Lead & Collaborating Institutions
Target 4.1 – By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes.	provide girls and boys with free, equitable quality education for effective learning outcomes	Provide appropriate ICTs to girls and boys to access virtual learning programmes; support the development of science and maths teaching and learning programmes for free electronic mass communications (radio, television and on the internet); Capacity building for science and maths teachers.	science and maths teaching and learning programmes for mass communication retrained science and maths teachers	MoE, GES, Ministry of Communication, Mass media e.g. GBC radio and television
Target 4.2 – By 2030 ensure that all girls and boys have access to quality early childhood development, care and pre-primary education so	Create access to quality early childhood development	Develop STI-based programmes for all pre-primary boys and girls; Pilot the use of locally produced games to stimulate children's	STI-based programmes for pre-primary boys and girls; Piloted locally produced games	MoE, GES, private schools, innovators in animations, cartoons and games for pre-schools (early childhood education)

that they are ready for primary education.		curiosity and creativity.		
Target 4.3 – By 2030, ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university.	Create equal access for women and men to affordable and quality TVET.	Promote use of the internet in teaching and learning for all in technical, vocational and tertiary institutions; Organize clinics to produce audio-visual aids for STEM teaching and learning.	Internet-based TVET teaching and learning programmes Clinics to produce audio-visuals	MoE, GES, entrepreneurs, innovators in audio-visuals, animations for educational purposes
Target 4.a – Build and upgrade education facilities that are child, disability and gender sensitive and provide safe, non-violent, inclusive and effective learning environment for all.	Provide inclusive and effective learning environment for pupils.	Carry out a study to assess the building, renovation and upgrading of education facilities for inclusive and effective learning environment for appropriate policy direction. Sensitize authorities in schools and universities to the importance of inclusive and effective learning environment for all.	Report of the study assessing state of educations facilities for policy direction. Sensitized authorities of educational institutions for effective learning environment for all	MoE, GES, private school owners, Ministry of Finance
Target 4.4 – By 2030, substantially increase the number of youth and adults who have relevant	Upgrade skills improvement for youth and adults Promote entrepreneurship	Launch an internship programme in collaboration with private sector to improve identifiable skills	Internship programme entrepreneurship programme	MoE, GES, NVTI, University of Education at Winneba, AGI

skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship	among youth and adults on basis of upgraded skills.	in selected industries; Prepare entrepreneurship programme based on STI innovations. Select educational institutions and launch prepared programme.	selected institutions running prepared programmes	
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The proposed activities for the achievement of SDG 4 are derived from the broad national development context. Education is generally meant as a tool for developing the human resources of the nation from the pre-school stage through basic and secondary and to tertiary levels. For the targets, the activities aim to create the enabling environment as well as direct or indirect impact of STI impact on education. Further elaboration of the activities with the corresponding targets are given below.

Target 4.1 – By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes:

The specific details of providing appropriate ICTs to girls and boys to access virtual learning programmes can be set in the current efforts of the Ministry of Education to promote online learning in Ghanaian schools. The Ministry of Education and the Ghana Education Service (GES) operates a Ghana Learning TV, which is a free-to-air channel solely dedicated to virtual learning for primary and junior high schools (JHS) and senior high schools (SHS). The programme is broadcast in collaboration with the Ghana Broadcasting Corporation (GBC). The Centre for National Distance Learning and Open Schooling (CENDLOS), which is one of the institutions working on virtual learning programmes. CENDLOS has currently developed an online programme on all the core contents in the senior high school curriculum and had given every student a password and access to an iCampus platform. Already an estimated SHS and TVET students of about 1.2 million students are on the iCAMPUS system. The resources on the system include 810 notes with exercises, 20,800 interactive quizzes, 600 audio-visual lessons, 540 units interactive lessons, virtual laboratory practical sessions and simulations and over 3,000 sets of notes and audio-visual Open Educational Resource (OER) materials. The key activities envisaged for the STI4SDG Roadmap are contributing to enriching the platform and other virtual learning systems with development of content on crucial STI topics. The following are some of the more specific activities envisaged towards the achievement of the target:

- Identify key informants in virtual learning and conduct interviews with them to understand the gaps to address in the STI4SDG Roadmap;
- Develop a programme for enhancing virtual learning with STI content;
- Organize a stakeholders consultation workshop towards the implementation of the enhancement programme which has been developed;

- Implement the programme with inclusion of content in the appropriate platforms such as the iCAMPUS.

The related activity in Table Y is to support the development of science and maths teaching and learning programmes for free electronic mass communications (radio, television and on the internet). It is envisaged that the pupils and students will be encouraged to use all available means including the internet to freely access the content developed towards addressing target 4.1.

There is need for capacity building for science and maths teachers who have the responsibility to guide learning their respective schools. The teachers, through their professional associations, will be taken through capacity building workshops with resource persons to ensure effective teaching and learning.

Target 4.2 – By 2030 ensure that all girls and boys have access to quality early childhood development, care and pre-primary education so that they are ready for primary education.

Two main activities are specified to address target 4.2. The two are strongly linked and are set in the policy context of strengthening pre-primary education of children. For example, UNICEF works in collaboration with other partners on Early Childhood Development emphasizing five main elements – health, nutrition, early stimulation, learning opportunities and protection. In Ghana, primary education starts from the age of six. Early stimulation and exploiting learning opportunities are very important to orientate children to STI. The development of the STI-based programmes for all pre-primary boys and girls will entail the use of cartoons, games and rhymes among other things. Some pre-schools will be selected in three regions, e.g. Greater-Accra, Eastern, Central, Ashanti and Northern to pilot the STI based games developed for pre-school children. In this regard the specific activities will include the following:

- Identify learning opportunities for pre-school children less than six years old to exploit to stimulate children's curiosity and creativity;
- Organize a stakeholder's workshop to determine innovations for stimulation of pre-school children's interest in STI including games, cartoons, pictures and objects.
- Capacity building workshops for key stakeholders such as teachers, animators and game innovators.
- organize meetings/ workshops with policy makers in the education sector.

Target 4.3 – By 2030, ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university.

- promote use of the internet in teaching and learning for all in technical, vocational and tertiary institutions;
- organize clinics to produce audio-visual aids for STEM teaching and learning.

Target 4.a – Build and upgrade education facilities that are child, disability and gender sensitive and provide safe, non-violent, inclusive and effective learning environment for all.

- Carry out a study to assess the building, renovation and upgrading of education facilities for inclusive and effective learning environment for appropriate policy direction.

-Sensitize authorities in schools and universities to the importance of inclusive and effective learning environment for all.

Target 4.4 – By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship

- Launch an internship programme in collaboration with private sector to improve identifiable skills in selected industries;
- Prepare and initiate an entrepreneurship programme based on STI innovations.

4.5 Detailed STI Strategies/Programmes/Projects/Activities for Achieving SDG 6 – Clean Water and Sanitation

With respect to SDG6, a number of key issues were identified in the situation analysis. The issues that emerged with potential for STI interventions include limited access to safe drinking water in rural and some urban areas, poor water quality, low water-use efficiency, poor sanitation and improper hygienic practices, and barriers to reuse of water. Accordingly, some identified interventions include the following strategic objectives:

1. Ensure efficient management of water resources,
2. Accelerate the provision of safe, adequate and affordable drinking water,
3. Speed-up the provision of adequate and equitable sanitation and hygiene for all
4. Expand nationwide water quality monitoring network,
5. Implement water governance, ecosystem restoration and conservation
6. Monitor and manage groundwater

Table 7 illustrates the alignment of SDG 6 targets to the policy objectives of the water and sanitation sector. Proper water and sanitation are key for achieving the SDGs, including good health and gender equality. By managing our water sustainably, we are also able to better manage our production of food and energy and contribute to decent work and economic growth. Despite the fact that Ghana achieved the MDG for access to improved water supply early, but not on access to improved sanitation, statistics today show that fewer than two in five Ghanaians drink safe water, two out of every five schools are without toilets, and three out of every five schools are without water supplies.⁵ Four targets of SDG 6 have been prioritized.

Target 6.1 is to achieve universal and equitable access to safe and affordable drinking water for all. The proportion of Ghana’s population using improved drinking water services including piped water into dwelling, yard or plot, bottled water and sachet water which is available when needed increased from 37.3 percent in 2013 to 44.3 percent in 2017. However, when the measurement of

⁵ UN Communications Group in Ghana and CSO Platform on SDGs, “The Sustainable Development Goals (SDGs) in Ghana: Why They Matter and How Can We Help?” (New York, 2017), gh.one.un.org/content/dam/unct/ghana/docs/SDGs/UNCT-GH-SDGs-in-Ghana-Avocacy-Messages-2017.pdf.

faecal contamination is factored in, the evidence is that only 19 percent of the population has access to safely managed water services.⁶ Therefore, it is envisaged that STI can be deployed to provide technical assistance and guidance in the construction of water supply systems for communities and small towns in order to increase access to safe drinking water.

The aim of Target 6.2 is to achieve access to adequate sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations by 2030. In Ghana, improving access to adequate sanitation facilities is a priority, given that about 20 percent of the entire country's population practice open defecation; the practice is more widespread in the [6] regions of northern Ghana where more than 70 percent of the population practice open defecation.⁷ The envisaged role for STI in this regard is to provide technical assistance and guidance for the construction of latrines in communities and small towns and develop programmes to create public awareness.

Target 6.3 is to improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally. Ghana adopted the Water Quality Index as a proxy for assessing ambient water quality. Available data shows that there has been marginal improvement in water quality indices for the Coastal, South-western and Volta basins between 2017 and 2018. The Coastal and Volta basins recorded significant improvement from 51.1 percent and 54.3 percent in 2017 to 57 percent and 57.2 percent in 2018 respectively.⁸ In addition to ongoing efforts to improve water quality, STI can be rolled out for water quality assessments, groundwater assessments, and implementing water governance, ecosystem restoration and conservation schemes

Target 6.4 is to substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity by 2030. Water availability per capita in Ghana has been decreasing over the years from 1,976 m³/person in 2013 to 1,930 m³/person in 2018; however, this remains above the threshold for water stress (1700m³ per capita). In general, Ghana is not water stressed but parts of the country, particularly the Savannah and Sahel zones, are experiencing water scarcity.⁹ To contribute to the sustainable management of water resources, STI activities will include ecological monitoring; buffer zone enrichment; and strengthening of transboundary cooperation

Table 7: SDG6 Framework for Developing Strategies and Programmes for STI4SDG Roadmap

⁶ NDPC, "Voluntary National Review Report on the Implementation of the 2030 Agenda for Sustainable Development" (Accra: National Development Planning Commission (NDPC), 2019), https://ghana.un.org/sites/default/files/2019-10/23420VNR_Report_Ghana_Final_print.pdf.

⁷ NDPC.

⁸ NDPC, 45.

⁹ NDPC, 46.

Targets	Objectives	Activities	Output	Responsibility
6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all.	Accelerate the provision of safe, adequate and affordable drinking water	Provide technical assistance and guidance in the construction of water supply systems for communities and small towns	Increased access to safe and affordable drinking	MSWR, MESTI, MLGRD, CWSA, CSIR, GWC, NDPC, Development partners (UNICEF, USAID, etc.)
6.2 By 2030, achieve access to adequate sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations.	Speed-up the provision of adequate and equitable sanitation and hygiene for all	Provide technical assistance and guidance for the construction of latrines in communities and small towns Develop programmes to create public awareness	Improved access to adequate sanitation and hygiene	MSWR, MESTI, MLGRD, GWC, CWSA, CSIR, NDPC, Development partners (UNICEF, USAID, etc.)
6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.	Expand nationwide water quality monitoring network Monitor and manage groundwater	Water quality assessments Groundwater assessments Implement water governance, ecosystem restoration and conservation schemes	Improve water quality	MSWR, MESTI, MLGRD, GWC, CWSA, CSIR, WRC

Targets	Objectives	Activities	Output	Responsibility
Target 6.4: By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	Ensure efficient management of water resources	Ecological monitoring Buffer zone enrichment Strengthen transboundary cooperation	Ensure sustainable management of water resources	MSWR, MESTI, MLGRD, GWC, CWSA, CSIR, WRC,

4.6 Detailed STI Strategies/Programmes/Projects/Activities for Achieving SDG 8 – Decent Work and Economic Growth by 2030

The focus of SDG 8 is to “Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all”. In line with this, the national development agenda seeks, among others, to build a strong and resilient economy, transform agriculture and industry; and developing robust tourism and creative arts industries. Various innovative initiatives by government and businesses resulted in Impression average annual GDP growth of about 7 percent between 2017 and 2019. Ghana’s economic growth over the last decade has been driven by the services sector which contributed about 47.2 percent of GDP in 2019, compared to 34.2 percent by Industry and 18.5 percent by Agriculture. The national agenda is to pursue aggressive industrialization, in strategic areas with high job creation potential to boost economic growth, while generating decent jobs and reducing the high level of unemployment among the youth.

The COVID-19 pandemic has adversely impacted on all sectors of the economy with growth for 2020 declining to 0.9 percent as against the projected rate of 6.8 percent. In response to the pandemic, the government is embarking on the Ghana COVID-19 Alleviation and Revitalization of Enterprises Support (GhanaCARES) program to stabilize the economy and provide a strong foundation for accelerated economic growth and transformation. Government’s emphasis is to build stronger institutions to deliver efficient services, provide the necessary infrastructure to support business and improve access to long term finance, build skills to deepen the quality and impact of services and maintain financial sustainability. STI provides a useful vehicle for “building-back-better” through economic productivity, economic diversification and ensuring decent work for all.

Despite the disruptions occasioned by the COVID-19 pandemic, the SDGs remain relevant and serves a practical framework for responding to the immediate effects, recovering, and building resilience. Government will therefore continue to work towards achieving its commitments under the 2030 Agenda, as well as Agenda 2063. Government's COVID-19 response and recovery are consistent with the SDGs and is guided by a careful balance of the economic, social and environmental considerations and ensuring that no one is left behind. The key STI-related activities proposed to accelerate the achievement for selected SDG8 targets are presented in the table 8 below.

Table 8: SDG 8 Framework for Developing Strategies and Programmes for STI4SDG Roadmap

SDG/ Targets	Objectives	Activities	Outputs	Implementing Agencies
8.1 Sustain per capita economic growth in accordance with national circumstances and, in particular, at least 7 percent GDP growth per annum in the least developed countries.	Increase economic diversification, productivity, and efficiency	- Promote the adoption of Intelligent irrigation technologies - Promote the use of greenhouse technology for all-year-round farming - Promote high-value addition to raw materials - Skills development in STI - Increase use of artificial intelligence (AI) - Deepen the deployment of ICT in the services sector - Deepen R&D partnership between research and business stakeholders. - Advocate for the expansion	- Intelligent irrigation systems - Increase in the number greenhouse farms - Increase in the number of high value-added products - STI skills development centers - Increased application of artificial intelligence (AI) - Increase in the number of R&D partnerships	MESTI, MoFA, MoTI, MoE, MoC, PEF, academia
8.2: Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labor-intensive sectors				

SDG/ Targets	Objectives	Activities	Outputs	Implementing Agencies
		of infrastructure to support E-work and E-commerce		
8.5 By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value.	Improve	- Revamp Ghana's ICT-based labour market information system - Set-up an ICT-based system for reporting and tracking decent work infractions.	- A comprehensive national labour market information system - An ICT-based system for reporting and tracking decent work infractions	MELR, MESTI MoC, academia
8.6 By 2030, substantially reduce the proportions of youth not in employment, education or training	Increase access to affordable education and skills development	- Modernize vocational and technical training - Carryout entrepreneurial skills development programs - E-learning platforms	- Modern and skillful vocational and technical workforce - Entrepreneurial skills development programs - Widely accessible E-learning platforms	MoE, MELR, MESTI, MoC, MoYS, academia
8.7 Take immediate and effective measures to eradicate forced labour, end modern slavery and human trafficking and	Stop forced labour, modern slavery, child labour and other similar practices.	- Create ICT-based systems for public education on forced labour, child labour; human trafficking, and modern slavery	- Digital educational materials on forced labour, child labour; human trafficking, and modern slavery	MELR, NCCE, MoC, CSOs, academia

SDG/ Targets	Objectives	Activities	Outputs	Implementing Agencies
secure the prohibition and elimination of the worst forms of child labour, including recruitment and use of child soldiers, and by 2025 end child labour in all its forms.		- Set-up an ICT-based system for reporting and tracking child labour	- Awareness creation campaigns - ICT-based system for reporting and tracking child labour	
8.10 Strengthen the capacity of domestic financial institutions to encourage and expand access to banking, insurance and financial services for all.	Achieve universal access to financial services	- Train financial institutions on new and emerging digital financial services	- Increased knowledge on new and emerging digital financial services	BoG, Association of Bankers, Telcos

4.7 STI Programmes and Strategic actions for achieving SDG9: Industry, Innovation and Infrastructure by 2030.

Sustained investment in infrastructure and innovation are key to economic growth and development. Continuous effort at bridging the digital divide in Ghana has been critical in ensuring access to information and knowledge which has spurred innovation and entrepreneurship. For instance, the single act of liberalizing the state-controlled telecommunication industry and the subsequent investments in the sector over the years has led to several innovations and stimulated economic growth. Access to mobile networks has led to mobile phone penetration soaring above 132.8% in 2020. The introduction of mobile money and the way in which governing bodies have embraced the innovation and supported the industry with providing the necessary regulatory framework. Due to the nature of its convenience and accessibility, the total value of mobile money transactions has increased from GHC20.9 billion in February 2019 to GHC30.1 billion in February 2020 while the volume of other traditional forms of payment like cheques continue to decline. This innovation has had a cascading effect on the economy through the facilitation of payments, trade,

creation of jobs, formalization of the informal economy, among others. Digital payments have opened the doors for various other innovations in financial technology, health and insurance providing access of basic financial services to many which in the past have been unreachable therefore providing solutions to our developmental challenges mainly financial inclusion. Furthermore, industrialization has an impact on all areas of the economy. For a country that imports the majority of its consumable goods, industrial developments present the opportunity for economic growth. Reduction in the value of import bills is critical for development. Industry also creates jobs, investment into industry is the route that many countries have taken to tackle unemployment.

In light of the efforts being made to embrace innovation and support the SDG agenda, we must recognize that the done in building capabilities of the workforce of the future. Moreover, there should be a focus on strengthening the inter-linkage between academia and industry. Failing to improve infrastructure and promote technological innovation could translate into continued lack of access to health care and education, in addition to that, quality of both could be compromised should technology not be used to advance methods However, through the application of Science, Technology and Innovation (STI), solutions can be designed to scale the achievement of SDGs 9.

Three key programmes will be vigorously pursued under the STI4SDGs Road map to accelerate progress towards Goal 9. These include i) Improve the quality and access to STI in education, with the objective of strengthening the linkages between academia and industry, providing both the youth and citizens with the skills required to participate in the global economy ii) Creating an enabling environment to support private sector development, facilitating access to innovation for all businesses, increasing productivity through the adoption of technological and non-technological innovations and improving the availability of finance to aid the process and iii) Improvements in infrastructure to spur economic growth and development and provide access of services to all, encouraging inclusivity.

Table 9: SDG 9 Framework for Developing Strategies and Programmes for STI4SDG Roadmap

Targets	Objectives	Activities	Outputs	Responsibility
9.B Support domestic technology development and industrial diversification 9.C Universal access to information and communications technology	Improve the quality and access to STI in education, with the objective of strengthening the linkages between academia and industry, providing both the youth and citizens with the skills required to participate in the global economy.	-Reform of education systems/ curriculum -Revise curriculum to develop critical thinking skills, to spur innovation and entrepreneurial behavior - Incorporation of technology into delivery mechanisms, digital access to course materials and increased availability of hardware. -Emphasis on the importance of arts, creativity and science and technology, through communication and awareness campaigns. -Better preparation of students for the workplace through structured National Service scheme - continual learning workplace readiness program. - Increased collaboration between private sector training providers and public sector educational institutions,	-5G services spectrum availability, 100% broadband & internet penetration. -STI incorporated into mainstream education -Use of technology such as the use of digital and interactive e-learning platforms, whiteboards and tablets. -Increased hands-on science education by using low-cost and locally produced materials for practical. - National STEM campaigns which encourages youth to choose STEM options at secondary level, - STEM internships and apprenticeship programs	MOE, GES, NSS, MOC, Public & Private Schools, tertiary and training institutions, Edtech Entrepreneurs

Targets	Objectives	Activities	Outputs	Responsibility
		developing new business and delivery models to increase access to STI education. An annual platform should be created where stakeholders will converge to assess the progress made in their collaboration strategy.	- Collaborative platforms which promotes, and assesses collaboration between private, public sectors and academia - Future-ready youth who are globally competitive and prepared for the future of work.	
9.2 Promote inclusive and sustainable industrialization 9.3 Increase access to financial services and markets 9.4 Upgrade all industries and infrastructures for sustainability 9.5 Enhance research and upgrade industrial technologies	Creating an enabling environment to support private sector development, facilitating access to innovation for all businesses, increasing productivity through the adoption of technological and non-technological innovations and improving the availability of finance to aid the process	Ecosystem Development - Improve or establish Innovation systems, increasing the opportunity for knowledge transfer between multiple actors -Deepening of Entrepreneurial Culture and Mindset - Foster collaboration between private sector, universities and other research institutions - Introduction of a Startup Act to encourage and promote innovation and entrepreneurship	- Stronger ecosystem, increased collaboration resulting in increased efficiencies - Entrepreneurial-minded youth -Increased access to quality entrepreneurial support services - Improved access to innovation. - Protection of intellectual property of innovators	MOT, NBSSI, MOF, Exim Bank, 1D1F, Venture Capital Trust Fund, Office of Attorney General and Ministry of Justice, Entrepreneurial Ecosystem Enablers (Investors, Service Providers)

Targets	Objectives	Activities	Outputs	Responsibility
		- Strengthen IP laws to protect innovators and their innovations and encourage collaboration. Financing Innovation - Build the capacity of local fund managers to enable them to support early-stage innovations - patient capital - Tax reform allowing for taxes generated from private sector activity to support R&D and Innovation at a country level. - Re-introduce policies to encourage private sector finance to flow to innovation and entrepreneurship relating to Act 680 - Regulatory amendments to allow for the allocation of pension funds into medium to long term investments - Patient Capital Improved Productivity for Industry -Policy reform/incentives for businesses that wish	-Increase access to affordable finance for small scale businesses (9.3.2) -Financial services that use AI for SME creditworthiness assessment. -Retail management tools such as software developed by Kudigo which allows businesses owners with basic literacy to keep sufficient records. -Fintech solutions that enhances the efficiency of SMEs -Geometric Economic growth - Blockchain-enabled technology public systems. Blockchain offers permanent and tamper-evident record	

Targets	Objectives	Activities	Outputs	Responsibility
		to adopt technologies that promote sustainability - renewable energy waste management systems, reduction of plastic consumption -Policy reform that encourages the adoption of technology within industry. Lowering the cost of the acquisition of technologies	keeping, real-time transaction transparency and auditability features. -Increased access of small-scale industries and other enterprises, to value chains and markets via the use of - commerce platforms (9.3.1)	
9.1 Develop sustainable, resilient and inclusive infrastructures 9.4 Upgrade all industries and infrastructures for sustainability	Improvements in infrastructure to spur economic growth and development and provide access of services to all, encouraging inclusivity	-Introduction and promotion of PPP law to stimulate the interest in Public Private Partnerships - PPPs to improve telecommunications infrastructure, enabling access to wider groups and reducing the cost of access to services. -Develop the framework for Ghana to sell Green & Blue bonds. -Investment into feasibility studies, project preparatory fund.	- Equitable economic development due to provision of infrastructure to the citizens. - Increased access to more diverse sources of finance for development. Government and Corporates issue green and blue bonds to facilitate development and growth. -Provide impact investors with attractive investment opportunities -ICT platforms which supports access to investment opportunities	MOF, Ghana Venture Capital Trust Fund, Development Bank of Ghana and other Development Finance Institutions, Development Agencies (GIZ, AFD etc.)

1. *Improve the quality and access to STI in education, with the objective of strengthening the linkages between academia and industry, providing both the youth and citizens with the skills required to participate in the global economy.*

Actionable Strategies

- Reform of education systems/ curriculum, in the short term this could include the development and implementation of electives in STI from Primary to Tertiary level. In the long term this would include a curriculum overhaul infusing STI into our core subjects from Primary to Secondary school and increasing the number of courses available in STI at Tertiary level.
- Revise curriculum to develop critical thinking skills, the development of such skill sets spur innovation and entrepreneurial behavior.
- Increase emphasis on the importance of arts, creativity and science and technology, through communication and awareness campaigns to normalize participation in such subjects
- Incorporation of technology into delivery mechanisms, including digital access to course materials and having the required hardware available for practical learning experiences.
- Better preparation of students for the workplace through the introduction of a structured National Service scheme that can encourage continual learning and expand STI knowledge.
- Increased collaboration between private sector training providers and public sector educational institutions, developing new business and delivery models to increase access of STI education.

2. *Creating an enabling environment to support private sector development, facilitating access to innovation for all businesses, increasing productivity through the adoption of technological and non-technological innovations and improving the availability of finance to aid the process.*

Actionable Strategies

Ecosystem Development

- Improve or establish Innovation systems, increasing the opportunity for knowledge transfer between multiple actors that are developing or are consumers of innovation.
- Foster collaboration between private sector, universities and other research institutions with the objective of creating opportunities for the onboarding and commercialization of innovations

- Introduction of a Startup Act to encourage and promote innovation and entrepreneurship, formally recognizing innovation as part of the business ecosystem.
- Strengthen IP laws to protect innovators and their innovations and encourage collaboration.

Financing Innovation

- Build the capacity of local fund managers to enable them to support early-stage innovations and small and growing businesses, increasing the availability of patient capital
- Tax reform allowing for taxes generated from private sector activity to support R&D and Innovation at a country level. An example could be taken from South Africa, 2.5% of corporate tax is apportioned to R&D and Innovation through innovation parks, innovation funds etc.
- Re-introduce policies to encourage private sector finance to flow to innovation and entrepreneurship relating to Act 680, offering the private sector an option to offset the risk of investing in innovation in this volatile market.
- Regulatory amendments to allow for the allocation of pension funds into medium to long term investments, globally the participation of pension funds in the venture capital and private equity markets provide access to patient capital.

Improved Productivity for Industry

- Policy reform/incentives for businesses that wish to adopt technologies that promote sustainability such as renewable energy, improved waste management systems, reduction of plastic consumption
- Policy reform that encourages the adoption of technology within industry. Lowering the cost of the acquisition of technologies to boost interest and move players away from analog processes

3. Improvements in infrastructure to spur economic growth and development and provide access of services to all, encouraging inclusivity.

Actionable Strategies

- Introduction of PPP law to stimulate the interest in Public Private Partnerships, promoting investments into infrastructure by creating avenues for additional sources of capital.

- Promote PPPs to improve telecommunications infrastructure, enabling access to wider groups and reduce the cost of access to services.
- Develop the framework for Ghana to sell Green & Blue bonds, green and blue bonds have become a way for countries to raise capital to address environmental and sustainability issues. There is a ready market for this type of financing.
- Investment into feasibility studies for SDG related projects both public and large scale private sector projects through a project preparatory fund.

Chapter 5: Budget, Funding and Coordination Arrangement for the Implementation of the STI4SDGs Roadmap

Chapter 5 presents the estimated budget, funding and coordination arrangement for the Implementation of the STI4SDGs Roadmap in line with the prioritized SDGs. The key to effective implementation of the roadmap is funding. Although the government of Ghana will definitely be investing in the implementation of the envisaged activities, funding from development partners and other stakeholders are crucial. This chapter outlines the budget and related expectations from possible development partners.

5.1 Proposed Budget for Implementation of SDG 1 Roadmap Activities

This estimated cost for carrying out the SDG 1 related activities which focuses on No Poverty. That is "to end poverty in all its forms, everywhere"

Table 10: Proposed Budget for Implementation of SDG 1 Roadmap Activities

SDG Targets	Key Activities*	Estimated Budget (US\$)	Proposed Donor Partners
Target 1.1 By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than \$1.90 a day.	- Promote technology and innovation for livelihoods;	100,000	World Bank, Dfid, UNDP.
	- Strengthen technology promotion centres e.g. Rural Technology Facility (RTF) to provide agric. technologies for rural industries - Promote ICT-based business e.g. mobile money transfers in 50 selected communities in 5 regions.	100,000	
Sub-total		200,000	

Target 1.2 By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions.	- create an ICT-based system for monitoring poverty-eradication programmes to ensure inclusivity.	40,000	UNDP, World Bank, IDRC
Sub-total		40,000	
Target 1.a Ensure significant mobilization of resources from a variety of sources, including through enhanced development cooperation to implement programmes and policies to end poverty in all its dimensions.	- Convene a conference (physical and or virtual) of development partners on resource commitment for poverty eradication. - Track resource contributions for poverty eradication and provide information on achievement and gaps.	25,000 40,000	UNDP, UNESCO, Sida, DANIDA
Sub-total		65,000	
Total		305,000	

5.2 Proposed Budget for Implementation of SDG 2 Roadmap Activities

This estimated cost for carrying out the SDG 2 related activities which focuses on Zero Hunger. That is “End hunger, achieve food security and improved nutrition and promote sustainable agriculture”.

Table 11: Proposed Budget for Implementation of SDG 2 Roadmap Activities

SDG Targets	Key Activities	Estimated Budget (US\$)	Proposed Donor Partners
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture	- Support in the production of quality and well packaged food products to enhance post-harvest management	- 1,500,000	GoG (MoFA, MESTI, MoC, MoTI), WB, GIZ, Master Card Foundation, UNICEF, WFP, Canada, USAID
	- Support the application of Internet of Things (IoTs) in agriculture to enhance on-line marketing of agricultural products	- 600,000	
	- Promote biotechnology applications for improved breeding	- 1,500,000	
	- Develop formulae for food supplementation and biofortification (with sound biosafety systems in place)	- 300,000	
		- 600,000	

SDG Targets	Key Activities	Estimated Budget (US\$)	Proposed Donor Partners
	- Develop and supply quality seeds and improved varieties of crops, livestock, fisheries and poultry - Identify resilient indigenous food systems (agro-biodiversity systems) - Promote seed security and agro-biodiversity - Promote adoption of and scaling-up productivity improvement technologies such as greenhouse production systems - Develop programme to implement an early warning and emergency preparedness systems - Intensify advocacy and communication - Develop science agenda for agricultural in Ghana - Scale up e-extension and business advisory services	- 250,000 - 300,000 - 1,000,000 - 200,000 - 50,000 - 200,000 - 200,000 - 200,000	
Total		6,900,000	

5.3 Proposed Budget for Implementation of SDG 3 Roadmap Activities

This estimated cost for carrying out the SDG 3 related activities which focuses on Good Health and Well Being. That is "To ensure healthy lives and promote well-being for all at all ages."

Table 12: Proposed Budget for Implementation of SDG 3 Roadmap Activities

SDG Targets	Key Activities*	Estimated Budget (US\$)	Proposed Donor Partners
SDG 3: Ensure healthy lives and promote well-being for all at all ages 3.3 By 2030, end epidemics of AIDS, TB, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases.	- improve early detection and diagnostics of such diseases; - enhance therapeutics - strengthen human resources - strengthen M&E systems	250,000 200,000 200,000 50,000	World Health Organization, B&MGF, Governments of e.g. India, China and Japan.
Total		700,000	

5.4 Proposed Budget for Implementation of SDG 4 Roadmap Activities

This estimated cost for carrying out the SDG 4 related activities which focuses on Quality Education. That is "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all".

Table 13: Proposed Budget for Implementation of SDG 4 Roadmap Activities

SDG Targets	Key Activities*	Estimated Budget (US\$)	Proposed Donor Partners
SDG4: Ensure inclusive and equitable education and promote lifelong learning opportunities for all. Target 4.1 – By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes.	- Provide appropriate ICTs to girls and boys to access virtual learning programmes; - support the development of science and maths teaching and learning programmes for free electronic mass communications (radio, television and on the internet); - capacity building for science and maths teachers.	100,000	Governments of Korea, UK, India, China, Germany, Russia, US and EU and the key UN agencies e.g. UNESCO, UNDP and UN Office of Information and Communications Technology (UNOICT).
		80,000	
		50,000	
Sub-total		230,000	
SDG 4: Target 4.2 – By 2030 ensure that all girls and boys have access to quality early childhood development, care and pre-primary education so that they are ready for primary education.	- Develop STI-based programmes for all pre-primary boys and girls; - pilot the use of locally produced games to stimulate children’s curiosity and creativity.	50,000	UNICEF and other UN agencies and Governments of Australia and EU.
		50,000	
Sub-total		100,000	
SDG 4: Target 4.3 – By 2030, ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university.	- promote use of the internet in teaching and learning for all in technical, vocational and tertiary institutions; - organize clinics to produce audio-visual aids for STEM teaching and learning.	40,000	UNOICT, UNESCO, UN Women and other UN agencies and governments of Japan, The
		120,000	

sustainable management of water and sanitation for all	- supply systems for communities and small towns - Provide technical assistance and guidance for the construction of latrines in communities and small towns - Develop programmes to create public awareness - Water quality assessments - Groundwater assessments - Implement water governance, ecosystem restoration and conservation schemes - Ecological monitoring - Buffer zone enrichment - Strengthen transboundary cooperation	- 250,000 - 50,000 - 1,000,000 - 1,000,000 - 200,000 - 2,000,000 - 1,000,000 - 500,000	USAID, Canada, UNICEF, UNEP (GEF)
Total		6,250,000	

5.6 Proposed Budget for Implementation of SDG 8 Roadmap Activities

This estimated cost for carrying out the SDG 8 related activities which focuses on decent work and Economic growth". That is "Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all".

Table 15: Proposed Budget for Implementation of SDG 8 Roadmap Activities

SDG Targets	Key Activities	Estimated Budget (US\$)	Proposed Donor Partners
8.1 Sustain per capita economic growth in accordance with national circumstances and, in particular, at least 7 percent GDP growth per annum in the least developed countries.	- Promote the Intelligent irrigation technologies	50,000	Agricultural Dev. Bank FAO, UNIDO
	- Promote the use of greenhouse technology for all-year-round farming	50,000	
	- Promote high-value addition to raw materials	100,000	
		300,000	

SDG Targets	Key Activities	Estimated Budget (US\$)	Proposed Donor Partners
8.2: Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labour-intensive sectors	- Undertake skills development in STI - Promote use of artificial intelligence (AI) in industry and service sectors - Deepen R&D partnership between research and business stakeholders. - Promote the expansion of infrastructure to support E-work and E-commerce	350,000 350,000 100,000	
8.5 By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value.	- Revamp Ghana's labour market information system - Set-up an ICT-based system for reporting and tracking decent work infractions, including public education.	150,000 250,000	UNDP, European Union, Government of Germany.
8.6 By 2030, substantially reduce the proportions of youth not in employment, education or training	- Modernise vocational and technical training - Carryout entrepreneurial skills development programmes - Develop innovative E-learning platforms	350,000 200,000	UNIDO, UNDP, European Union, Government of Germany
8.7 Take immediate and effective measures to eradicate forced	- Create ICT-based systems for public education on forced labour, child labour;	250,000	USAID, UNICEF, Government of Germany

SDG Targets	Key Activities	Estimated Budget (US\$)	Proposed Donor Partners
labour, end modern slavery and human trafficking and secure the prohibition and elimination of the worst forms of child labour, including recruitment and use of child soldiers, and by 2025 end child labour in all its forms.	human trafficking, and modern slavery - Set-up an ICT-based system for reporting and tracking child labour	250,000	
8.10 Strengthen the capacity of domestic financial institutions to encourage and expand access to banking, insurance and financial services for all.	- Train financial institutions on new and emerging digital financial services	80,000	The World Bank, AfDB Government of Germany
Total		2,830,000	

5.7 Proposed Budget for Implementation of SDG 9 Roadmap Activities

This estimated cost for carrying out the SDG 9 related activities which focuses on Industry, Innovation and Infrastructure. That is “To build resilient infrastructure, promote sustainable industrialization and foster innovation”.

Table 16: Proposed Budget for Implementation of SDG 9 Roadmap Activities

Targets	Key Activities	Estimated Budget (US\$)	Proposed Donor Partners

9.B Support domestic technology development and industrial diversification	-Reform of education systems/ curriculum -Revise curriculum to develop critical thinking skills, to spur innovation and entrepreneurial behavior - Incorporation of technology into delivery mechanisms, digital access to course materials and increased availability of hardware.	125,000	The World Bank, African Development Bank, UN agencies
9.C Universal access to information and communications technology	-Emphasis on the importance of arts, creativity and science and technology, through communication and awareness campaigns. -Better preparation of students for the workplace through structured National Service scheme - continual learning workplace readiness program. - Increased collaboration between private sector training providers and public sector educational institutions, developing new business and delivery models to increase access to STI education. An annual platform should be created where stakeholders will converge to assess the progress made in their collaboration strategy.	150,000	
9.2 Promote inclusive and sustainable industrialization	Ecosystem Development - Improve or establish Innovation systems, increasing the opportunity for knowledge transfer between multiple actors	100,000	The World Bank, African Development Bank, UN agencies
9.3 Increase access to financial services and markets	-Deepening of Entrepreneurial Culture and Mindset	25,000	
9.4 Upgrade all industries and infrastructures for sustainability	- Foster collaboration between private sector, universities and other research institutions - Introduction of a Startup Act to encourage and promote innovation and entrepreneurship	200,000	
9.5 Enhance research and upgrade industrial technologies	- Strengthen IP laws to protect innovators and their innovations and encourage collaboration. Financing Innovation - Build the capacity of local fund managers to enable them to support early-stage innovations - patient capital	80,000	

	- Tax reform allowing for taxes generated from private sector activity to support R&D and Innovation at a country level. - Re-introduce policies to encourage private sector finance to flow to innovation and entrepreneurship relating to Act 680 - Regulatory amendments to allow for the allocation of pension funds into medium to long term investments - Patient Capital Improved Productivity for Industry -Policy reform/incentives for businesses that wish to adopt technologies that promote sustainability -renewable energy waste management systems, reduction of plastic consumption -Policy reform that encourages the adoption of technology within industry. Lowering the cost of the acquisition of technologies		
9.1 Develop sustainable, resilient and inclusive infrastructures	-Introduction and promotion of PPP law to stimulate the interest in Public Private Partnerships	15,000	The World Bank, African Development Bank, UN agencies
9.4 Upgrade all industries and infrastructures for sustainability	- PPPs to improve telecommunications infrastructure, enabling access to wider groups and reducing the cost of access to services. -Develop the framework for Ghana to sell Green & Blue bonds. - Investment into feasibility studies, project preparatory fund.	695,000	
	OVERALL BUDGET TOTAL	1,390,000	

Chapter 6: Partnership and Communication Strategy to sustain stakeholder involvement and ensure an Inclusive Governance of the Roadmap

The Target Audience for the partnership and communication strategy to sustain the STI4SDGs Roadmap consists of National Task Team, Government Ministries, Educational Institutions, Public sector, Private sector, UN Agencies, Financial Institutions, NGO's (Referenced as all stakeholders). The table below explains the implementation and activities of the strategy.

Table 17: Partnership and Communication Strategy

Objectives	Activities	Channels	Target audience	Unit cost/descriptive	Budget (USD)
1. To create an online presence and social media outreach.	Develop a central interactive portal to share information on the STI4SDG roadmap. Providing key stakeholders with information pertaining to policies, services and opportunities.	-A Central Internet portal for STI4SDG	All Stakeholders	Design and Development of online portal	1,800
				Maintenance of online portal	4,200 pa
	Social Media accounts can be created to engage with stakeholders in conversations on STI4SDGs, the importance of dialogue and continual learning and iteration must be fostered.	Social Media platforms; -LinkedIn -Twitter -Instagram	- Business Professionals - The Youth - Ambassadors -Activists -Key industry players	Creation and management of social media platforms	4,200 pa
	Informational videos maybe uploaded and could be used as a tool for education.	-YouTube - Facebook	- Educational Institutions -Youth - Private Sector	Content Creation 800 per video Minimum of 12 per year	1,700

			- General public - Public Sector		
2. Develop a visual representation of the STI4SDG Roadmap	Develop an official Logo for the STI4SDG Roadmap. This logo will be used on all STI4SDG related communication materials. Creating a strong brand will create a reference point for the roadmap	-Print Media eg, Daily Graphic, Business and Financial Times - Television (TV) eg; GBC, Joy News, Citi TV etc. -Social Media Platforms (LinkedIn, Twitter, Instagram).	All Stakeholders	Design	500
	Visual representation to highlight the goals and gaps and how STI can support. These visuals will highlight the deficiency in the prioritized SDGs.	-Info graphics -Social Media platforms (LinkedIn, Twitter, Instagram) -Videos	All Stakeholders		900
	Branding at events such as conferences, workshops and media soirees.	- Pull up Banners - Flags - Branded Materials	All stakeholders		1,100
3. Engage main stream media to promote and create awareness of the STI4SDG roadmap.	-Press/Media soirees will be organized to launch the roadmap.	-Television (TV) eg; GBC, Joy News etc. - Radio eg; Citi FM, Joy FM etc - Newspapers eg; Daily Graphic, Business and Financial Times	All Stakeholders	Travel expenses @250 for 10 stations	500
	Interviews will be conducted with key stakeholder groups across selected media houses to educate the public	-Television (TV) eg; GBC, Joy News etc. -Radio eg; Citi FM, Joy FM etc.		2,500 per interview	1,800

	and stakeholders and demonstrate that this is a collaborative initiative which requires the participation of all.				
	Periodic Thought leadership pieces published in main stream press and online news portals to promote the agenda for the STI4SDGs.	Television (TV) e.g.; GBC, Joy News etc. - Radio e.g.; Citi FM, Joy FM etc. - Newspapers e.g.; Daily Graphic, Business and Financial Times		1,000 per article	700
	Continual engagement of selected media houses to cover STI4SDG related events.			1,000 per month	2,100
4. Develop strategies to promote specific STI4SDG roadmap events.	A launch event to outdoor the roadmap to key stakeholders.	-Main stream media (TV, Radio, newspaper) - Online streaming platforms (YouTube, Facebook)	Public Sector Private Sector	100 participants	11,000
	Identify upcoming events locally and globally that could present opportunities to further communicate around the roadmap, speaking engagements etc.	-Main stream media (TV, radio, newspaper) - Social media platforms (LinkedIn, Twitter, Instagram)			
	Stakeholder specific engagements that can support the dissemination and onboarding of the roadmap into	-Social media platforms. - Scheduled meetings.		6,000 per meeting	4,200

	organizational strategies.				
5. Strategic partnerships and repurposing content.	Develop partnerships with stakeholders to catalyze the onboarding of the roadmap.	-Using Social media platforms to engage in conversations.	All Stakeholders		1,100
	Develop a partnership with the High Level Ministerial Committee appointed by the President on the SDGs, positioning them as ambassadors of the roadmap.	- Quarterly Round table discussions		4 meetings @ 6000	4,200
6. Global outreach in the promotion of STI4SDG Roadmap.	Engage Agencies, Development Partners and donors globally.	-Online Platforms - Social media Platforms - Representation at Industry Specific Events / Speaking engagements	- UN agencies - International NGO's - Development Partners		
Total					40,000 USD

The total financial commitment to the implementation of Ghana's STI4SDGs Roadmap is quite modest. Across all the prioritized goals and targets as detailed in Chapter 5 and Chapter 6, a total amount of **US\$19,260,000.000** is required. The Government of Ghana must necessarily bear part of this commitment. However, the nation will be grateful for substantial support from development partners.

Chapter 7: M&E Plan/Framework – Monitoring and Evaluation System to Track Progress on the Roadmap Implementation

7.1 Introduction

Monitoring and Evaluation (M&E) is an essential management tool that provides incentives for the pursuit of agreed targets, as well as ensuring accountability, responsiveness, and transparency in the allocation of resources. This section outlines the arrangement that will be put in place to guide the continuous tracking, periodic review, and evaluation of the implementation of the roadmap. It provides a set of agreed indicators, linked to the key activities, outcomes, outputs, and impact that must be tracked. Also indicated, are the roles of specific institutions in the monitoring and evaluation the implementation of the roadmap.

7.2 How will monitoring be done?

In accordance with the requirement of National Development Planning Systems Act, MDAs and MMDAs prepare and submit quarterly and annual progress reports (APRs) to NDPC. These reports track the implementation of policy initiatives in the sectors' and districts' four-year medium-term development plans, based on agreed sets of indicators and targets. Lessons from the APRs informs the Annual Action Plans of MDAs and MMDAs. The system for preparing the APRs is well tested and has the legal basis to involve all the MDAs and MMDAs to track implementation of policy initiatives in their medium-term plans.

Monitoring of the STI4SDGs Roadmap will be anchored on the existing national and sub-national monitoring arrangement. MESTI, with support from NDPC will liaise with relevant MDAs and MMDAs to include indicators for tracking the implementation of the STI4SDGs Roadmap in their respective M&E plans. This will ensure that the APRs contains information on the agreed set of indicators for tracking the implementation of the roadmap. In addition, private sector organizations, academia and other non-state actors that play important roles in the implementation of the roadmap will be supported to generate data and report on the relevant STI4SDGs Roadmap indicators.

The sector and district APRs, together with reports from relevant non-state actors will constitute the primary source of data for preparing annual reports to track the implementation the roadmap. The data will be complemented with information from key informant interviews, focus group discussion, and field visits as appropriate. The annual progress reports on the implementation of the roadmap will be discussed at stakeholder fora and lessons therein will form the basis of revising the roadmap, where necessary. A set of indicators and targets for tracking the implementation of the STI4SDGs Roadmap is shown in Appendix 2.

7.3 How will evaluation be done?

The purpose of the evaluation process to answer more in-depth questions about how and why interventions are achieving or not achieving the expected results. It will also identify changes in internal and external conditions (social, political, technology, economic and environmental) that may affect the successful achievement of the targets in the STI4SDGs Roadmap. The evaluation activities will not attempt to establish direct attribution of implementation actions to outcomes and impact but will rather seek to provide robust information on the contribution intermediate outcomes are making

towards objectives of the Roadmap. The evaluations will therefore serve a learning purpose for MESTI and other stakeholders.

The evaluations will be based on five criteria; namely:

- a) **Relevance:** The extent to which the STI4SDGs Roadmap is suited to the priorities and policies of the key sectors.
- b) **Effectiveness:** A measure of the extent to which actions in the STI4SDGs Roadmap achieved their intended objectives.
- c) **Efficiency:** This measures the qualitative and quantitative outputs in relation to the input efforts. It provides a value for money assessment of the implementation actions.
- d) **Impact:** The positive and negative changes produced directly or indirectly by the implementation actions in the STI4SDGs Roadmap. The changes could be intended or unintended and related to social, economic, environmental, and other development indicators.
- e) **Sustainability:** This is concerned with measuring whether the benefits of the implementation actions are likely to continue after the initial support has been completed.

A mid-term evaluation is proposed by 2024. The feedback will be used to inform the medium-term development plans for 2025 to 2028. Lessons from this evaluation will influence the revision of the roadmap to ensure the achievement of the targets and objectives. A terminal evaluation is scheduled for 2030 to examine the overall impact of the STI4SDGs Roadmap in contributing to the achievement of the SDGs. It is anticipated that the findings from the terminal evaluation will significantly shape the use of STI in Ghana's development pursuit.

A proposed set of evaluation questions is shown in Appendix 3.

7.4 Roles and responsibilities

7.4.1 Ministry of Environment Science Technology and Innovation (MESTI)

The Ministry of Environment, Science, Technology and Innovation is the ministry responsible for the development of environment & science in the country. The Science, Technology and Innovation Directorate is the technical wing charged to formulate Science, Technology and Innovation policies, communicate and coordinate Science, Technology Innovation programmes and activities. As part of its duties, STI Directorate coordinates, monitor and evaluate Science, Technology, and Innovation policies and programmes being implemented by MDAs in support of government's development Agenda.

The STI directorate will oversee the implementation, monitoring and evaluation of the roadmap. It will approve the workplan of the STI4SDGs Roadmap Committee and mobilize resources for preparing the annual monitoring reports, as well as the mid-term and terminal evaluation reports. The directorate will also ensure that findings from the reports are discussed with key policy makers and influencers at national and sub-national levels.

7.4.2 STI Roadmap committee

The STI4SDGs Roadmap committee will coordinate and supervise the preparation of the annual reports, as well as mid-term and terminal evaluation reports. The committee shall develop the Terms of Reference (TOR) for the preparation of these reports and engage the services of a competent team(s) to carry out the assignment. Furthermore, the committee shall see to the dissemination of the report to key stakeholders and ensure that the lessons and proposed actions are followed through.

7.4.3 National Development Planning Commission (NDPC)

The National Development Planning Commission (NDPC) is mandated to advise the President on national development policies and strategies and is responsible for coordinating the decentralized planning system. It is also responsible for formulating, coordinating the implementation, monitoring and evaluation of national development policies and plans. NDPC will provide technical support to MDAs and MMDAs in integrating activities from the STI4SDGs Roadmap into their development plans, as well as M&E plans.

7.4.4 Ministries, Departments and Agencies (MDAs)

The MDAs are mandated to undertake development planning functions based on the prevailing national development agenda. Against this background, the MDAs will prepare and execute their respective sector medium-term development plans which will include the assigned STI Roadmap initiatives. The MDAs based on the sectoral medium-term development plans will also design a monitoring and evaluation framework, including agreed set of the objectively verifiable indicators to track the progress of programmes, outcomes, outputs, objectives, targets and activates. The MDAs will prepare and submit their APRs which contains information on the STI4SDGs Roadmap to NDPC.

7.4.5 Metropolitan, Municipal and District Assemblies (MMDAs)

Per the decentralised approach to governance and development planning, the MMDAs are the basic planning units in Ghana. They form the administrative and the political authority at the local levels and therefore, to realise the national development agenda, the MMDAs drawing from the medium-term national development policy framework by the NDPC will ensure the preparation and implementation of development plans. The MMDAs using a set of agreed indicators will implement an M&E plan to track the results of their development initiative against an agreed set of targets.

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APPENDICES

Appendix 1: Members of the Technical Task Team

Name	Position/ Institution/ Address
Mrs. Cynthia Asare	Chief Director, MESTI
Dr. Eugene Owusu	Head, Office of the Presidential Advisor on SDGs
Dr. Felix Addo-Yobo	Director, National Development Planning Commission
Mrs. Gladys Mamtee Osabutey	Director, Ministry of Finance
Dr. Simon Sovoe	Deputy Director, EPA, Office of Research, Technology and Innovation
Ms. Paulina Addy	Director of Women in Agricultural Development (WIAD), MOFA
Dr. George Owusu Essegbey	CEO, CSIR – Technology Development and Transfer Center
Dr. (Mrs) Wilhemina Quaye	Director, CSIR – Science and Technology Policy Research Institute
Mr. Bernard Ayensu	Ministry of Education, Accra
Mr. Apollonius Osei-Akoto Asare	Ghana National Commission for UNESCO, Accra
Dr. Emmanuel Newman	National Council for Tertiary Education
Mr. Raymond Mensah	Ministry of Monitoring and Evaluation, Accra
Mr. Ben Anin Adjei	Association of Ghana Industries (AGI), Accra
Mr. Victor Owusu Boateng	Ghana Statistical Service, Accra

Appendix 2: Proposed List of Indicators

	Proposed List of Indicators	Data Source
1	Number of new rural agriculture technologies developed by technology type	MoTI, MoFA, MSWR
2	Number of ICT-based businesses established by sector	Min. of Communication, NCA, MoTI
3	Number of greenhouse farms by crop type	MoFA, MoTI
4	Annual investment in STI	Min. of Finance, MESTI, GIPC
5	Status of ICT-based system for public education	MoC, MoE, GES
6	Number of R&D publications	MESTI and its Agencies
7	Number of free electronic platforms for teaching and learning of science and mathematics	MoEand GES
8	Number of STI-based programmes for pre-primary boys and girls	MoEand GES
9	Number of Internet-based TVET teaching and learning programmes	MoE, GES, MELR
10	Number of Entrepreneurial skills development programmes established	MELR and MESTI
11	Number of intelligent irrigation systems by type and region	MoFA, MoTI and EPA
12	Number of high-value added products produced locally by region	MoFA, MoTI and EPA
13	Number of STI skills development centres by region and district	MELR and MoTI
14	Number of R&D partnerships by Sector	MESTI and its Agencies
15	Number of patent applications by sector	MESTI annumber of patent its Agencies
16	Status of National Labour Market Information System	MELR, GSS and Fair Wages
17	Status of ICT-based system for reporting and tracking decent work infractions by Sector	MELR and MoC
18	Number of awareness creation events organized by region by Sector	MESTI
19	Status of ICT-based system for reporting and tracking child labour by Sector	MELR and MoC.
20	Number of training events on new and emerging digital financial services organised by sector	MoF and BoG

Appendix 3: Evaluation Questions

Evaluation Criteria	Evaluation Questions
Relevance	How relevant is the STI4SDGs Roadmap to the development priorities of country? To what extent does the program and activities meet social, economic, and environmental development needs?
Effectiveness	Is the STI4SDGs Roadmap accomplishing its intended objectives and planned results? What are the challenges and opportunities?
Efficiency	How well are the implementing agencies using their human and financial resources to achieve the intended results? What can be done to ensure a more efficient use of resources and information?
Impact	What impact has the implementation of the STI4SDGs Roadmap had on the progress towards achieving the selected SDGs?
Sustainability	To what extent can the benefits and activities in the Roadmap be sustained?