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Leveraging Science, Technology and Innovation to improve food self-sufficiency in the Gambia

TECHNICAL REPORT FOR THE STI FOR SDGs ROADMAP

Rialland, P., Daniels, C.

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TABLE OF CONTENTS

ABSTRACT

Science, Technology and Innovation (STI) for SDGs roadmaps are strategic policy frameworks that leverage STI to tackle localised sustainability challenges. They are supported by analyses based on different data sources and grounded in participatory and co-creation approaches that involve various stakeholders from the public and private sectors, NGOs, and academia.

This report provides insights on gaps and opporuntities to leverage the Gambia's STI system to improve food self-sufficiency, which is a key sustainability challenge highlighted in policy documents, as well as by stakeholders. The analysis included in this report brings to design of the STI for SDGs roadmap, based on extensive inputs from official data sources on STI and food systems performance, as well as information collected from local and international stakeholders involved in initiatives relevant for food self-sufficiency and STI in the Gambia through workshops, a survey, and interviews.

The roadmap identifies key sustainability challenges within The Gambian food systems, such as low crop production and productivity, limited access to finance, and inadequate storage facilities. To tackle these challenges it highlights several initiaves, and identifies opportunities for STI investments. These initiatives include combining indigenous knowledge and research to identify productive seeds, develop frugal innovation to design cold rooms or build affordable processing machines. The roadmap also highlights the need for horizontal measures to reinforce the STI system and improve collaboration among stakeholders.

The successful implementation of the roadmap requires a coordinated approach and the involvement of various stakeholders, including government, academia, industry, and civil society. Ultimately, the STI for SDGs Roadmap aims to contribute to the achievement of the Sustainable Development Goals, particularly SDG 2 - Zero Hunger.

FOREWORD BY THE JOINT RESEARCH CENTRE OF THE EUROPEAN COMMISSION

I am pleased to share the report on the role of science, technology, and innovation (STI) for Sustainable Development Goals (SDGs) in Africa, with a spotlight on the Gambia. The report stems from a collaboration of the Joint Research Centre (JRC) and the Directorate General for International Partnerships (DG INTPA) of the European Commission (EC). This project embodies the long-standing commitment of the EC to fostering STI as a cornerstone for achieving sustainable development, in line with the African Union-European Union Innovation Agenda and Global Gateway initiative.

The challenge-oriented STI for SDGs roadmaps approach, pioneered by the JRC and based on the collaboration with the United Nations, is an innovative framework designed to align STI policies with the ambitious goals set by the 2030 Agenda for Sustainable Development. Roadmaps are strategic policy and governance frameworks based on evidence and participatory deliberation. Their goal is to ensure that STI contribute effectively to addressing localised sustainability challenges.

The development of STI for SDGs roadmaps is a participatory process that brings together diverse stakeholders, including policymakers, researchers, industry leaders, international partners, and civil society. Roadmaps capture collective knowledge and experience of these actors to respond to the specific needs and localised challenges.

The Gambia has engaged actively in developing its STI ecosystem by working together with both local and global partners. STI are important in speeding up the changes that benefit all communities. This STI for SDGs Roadmap, created in cooperation with the Ministry of Higher Education, Research, Science and Technology (MoHERST), emphasises the importance of STI in driving the transformation of the food systems to improve food self-sufficiency.

We hope that the roadmap will become a useful framework for policy makers and stakeholders engaged in transforming The Gambia's food systems, as well as for policy practitioners in other countries working on similar challenges.

I would like to express my sincere appreciation to the Gambian partners at MoHERST and all contributors who have made this report possible. Your insights and expertise are invaluable as we continue to make collective efforts to mobilise STI for sustainable development.

The JRC is proud of having supported this participatory initiative and remains committed to providing evidence-based scientific support to the policymaking process. We look forward to witnessing the positive impact of our joint efforts in the Gambia and the strengthened Africa-Europe collaboration.

Mikel Landabaso

Director – Fair and Sustainable Economy
Joint Research Centre, European Commission

FOREWORD BY THE MINISTRY OF HIGHER EDUCATION, RESEARCH, SCIENCE AND TECHNOLOGY OF THE GAMBIA

It is with profound satisfaction that I present this significant Report on the Role of Science, Technology, and Innovation (STI) for achieving the Sustainable Development Goals (SDGs) in The Gambia. This initiative, undertaken in collaboration with the Joint Research Centre (JRC) and Directorate General for International Partnerships (DG INTPA) of the European Commission (EC), represents a key milestone in our country's efforts to harness STI for the SDGs. Our partnership under the framework of the African Union-European Union Innovation Agenda reflects a shared vision that aims to leverage innovation as a driver of progress, economic resilience, and social well-being.

The development of the STI for SDGs Roadmap for The Gambia is not a mere policy framework, but a collective undertaking that brings together local and global expertise. This Report exemplifies the participatory approach we champion at the Ministry of Higher Education, Research, Science, and Technology (MoHERST), where we see STI as the cornerstone of transformative change. From policymakers and researchers to industry and civil society organisations, each stakeholder has contributed to ensuring that our national roadmap addresses the unique challenges of food security, self-sufficiency, and the broader socio-economic development aspirations.

This Roadmap is a vital tool, designed to guide our policies and strategies, particularly as we focus on transforming The Gambia's food systems to ensure sustainable agriculture and resilience in the face of growing environmental and economic pressures. The involvement of various actors, including our local and global partners, has been instrumental in integrating best practices, aligning our efforts with the SDGs, and positioning The Gambia as a leader in innovation-driven development.

On behalf of the Government of The Gambia, I extend my deepest appreciation to all the stakeholders that contributed to this initiative. Together, we are laying the foundation for a future in which STI not only accelerates progress toward the SDGs but also uplifts communities across our nation. We remain steadfast in our commitment to fostering a thriving STI ecosystem in The Gambia, and we look forward to continued collaboration with our international partners as we pursue shared goals for sustainable development.

Professor Pierre Gomez

Honourable Minister
Ministry of Higher Education, Research, Science and Technology
Republic of The Gambia

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This report was developed by the Territorial Development Unit at the Joint Research Centre (JRC), within the context of the collaboration with the Directorate-General for International Partnerships (DG INTPA) of the European Commission, on Science, Technology, and Innovation for Sustainable Development Goals Roadmaps in Sub-Saharan Africa.

At JRC, the report has benefitted from the valuable guidance of Alessandro Rainoldi and Mark Boden providing valuable guidance. JRC colleagues, Angela Sarcina and Michal Miedzinski, contributed to the report's conceptual design, structure, and methodological approach.

The authors would like to extend their gratitude to the Ministry of Higher Education, Research and Technology (MoHERST) for the fruitful collaboration. In particular, Mr. Pierre Gomez, Hon. Minister of the MoHERST for his vision and activie participation in STI for SDGs processes, as well as Mr. Yusupha Touray, Mr. Mucktarr Darboe, and Mr. Samba Sowe for providing essential data and information, feedback on the report, as well as their ongoing commitment to developing the first STI for SDGs roadmap in The Gambia.

We are extremely grateful for the enthusiast participation of the stakeholders in interviews, workshops, as well as those who esponded to surveys. Their contribution were instrumental in the design of the roadmap in the Gambia. In particular, the project benefited from key inputs from the Department of Agriculture (DoA), the Ministry of Health (MoH), the Ministry of Finance and Economic Affairs (MoFEA), the Ministry of Trade Industry, Regional Intergration and Employment (MoTIE), the Food Safety Quality Authority (FSQA), the Gambia Women's Chamber of Commerce (GWCC), the National Nutrition Agency (NANA), the Gambia Investment & Export Promotion Agency (GIEPA), the National Youth Council (NYC), the EU Delegation to the Gambia, the Millenium Challenge Corporation (MCC), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the Food and Agriculture Organization (FAO), Startup Incubation Gambia, Women In STEM (WISTEM), The Woman Boss, Innovate Gambia.

We also appreciate the constructive feedback and comments received from DG INTPA colleagues, Eleonora Rella and Jean-Michel Sers, whose support has been instrumental in the report's development.

We also acknowledge the valuable contributions of Enrica Pellacani, Evangelina Blanco Gonzalez, Buba Tamba from the EU Delegation to the Gambia, whose in-depth knowledge of national contexts facilitated information exchange and accelerated progress.

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EXECUTIVE SUMMARY

PURPOSE AND APPROACH OF THE STI FOR SDGs ROADMAP

Science, Technology, and Innovation (STI) play a key role in achieving the Sustainable Development Goals (SDGs). Since 2022, the European Commission's Joint Research Centre (JRC) and the Directorate-General for International Partnerships (DG INTPA) have collaborated with the Gambian government to develop a Science, Technology, and Innovation (STI) for Sustainable Development Goals (SDGs) Roadmap. The objective of the project was to improve directionality and effectiveness of STI policies to contribute to the SDGs in line with the EU priorities for STI cooperation with Africa as expressed in the AU-EU Innovation Agenda.

To develop the roadmap in the Gambia the JRC partnered with the Ministry of Higher Education, Research and Technology (MoHERST), which leads the design and the implemention of the STI policy and has a mandate to coordinate all STI activities in the Gambia. The analysis of the main policy documents, revealed a consensus on the urgency to achieve food self-sufficiency in the Gambia. The NDP ambitions to make "significant strides in attaining food self-sufficiency" (NDP, 2023)[1]. Following stakeholder consultations, the recommendation was to focus the project on the role of STI in achieving food self-sufficiency in the Gambia.

The project used a participatory and co-creation approach, involving stakeholders from the public and private sectors, NGOs, international partners and academia. The roadmap was informed by the stakeholder workshop held in Banjul on 29 Frebruary and 1 February 2024, and a series of interviews with the local and international stakeholders involved in initiatives relevant to improve food self-sufficiency in the Gambia.

CHALLENGES AND OPPORTUNITIES TO IMPROVE FOOD SELF-SUFFICIENCY IN THE GAMBIA

In the Gambia, food insecurity increased from 5.6 percent of the population in 2011 to 13.4 percent (or 329 189 people) in 2021 (WFP, 2021). Moreover, the NDP (2023) indicates that "multiple shocks and crises in (COVID-19, Russia-Ukraine war, etc.) have aggravated fragilities arising from the effects of climate change, which is worsening food security with growing pockets of food insecurity/malnutrition in urban areas" (NDP, 2023).

1 *The 2018 - 2028 National Seeds Policy (NSP) aims to improve "food security through seed security". Morover, the 2017 – 2026 Agriculture and National resources Policy (ANRP) highlights that "food production will be increased substantially through intensive and limited expanded cultivation of tidal and upland rice to improve the self-sufficiency level of domestic rice from 20% in 2004 to about a target of about 50%."*

In 2020, 21.6% of the population suffered from undernourishment against 10.4% in 2010 (FAO[2]).

The Gambia faces systemic challenges across the whole food value chain, from production to consumption. The current potential of the Gambia's STI system to address food self-sufficiency is limited and it is under-resourced, with low government budget allocation and heavy reliance on international donors. Research and development (R&D) expenditure is minimal, and there is a brain drain of local researchers. Low total R&D personnel[3] (FTE), and attrition among senior researchers is a barrier to building a critical mass of researchers (ANR policy, 2017). According to the World Justice Project (2021), protecting property rights is a major impediment to entrepreneurial activities, and innovation and there was no patent application in 2022 (WIPO).

EXISTING POLICIES TO IMPROVE FOOD SELF-SUFFICIENCY IN THE GAMBIA

The STI policy includes objectives that may directly contribute to improving food self-sufficiency. More specifically, it aims to "modernise agriculture through STI to create quality products and services for sustained economic growth"[4]. The STI policy emphasises the potential of STI to increase production and productivity. It also relates to the other elements of the food systems such as storage (e.g. strengthen and, where necessary, establish modern storage facilities and preservative technologies for agricultural produce) and distribution (e.g. "make innovative use of ICTs to inform, educate and sensitise farmers [...] on market prices").

According to the 2017 -2026 ANR policy, issues faced by the agricultural research system "revolve around the scope of research (programmes, research areas, disciplines) given the scale of resources (human, physical and financial) available". The over-riding constraint in this regard is lack of financial resources to implement the essentials of the Agriculture Research Master Plan to anchor the ANR policy pillars by mitigating critical research issues such as inadequate resources in terms of qualified personnel, finance and infrastructure; and dependency on funding from donor agencies and technologies developed from outside.

PROPOSED STI AREAS OF ACTION FOR THE ROADMAP

The selection of the following STI investment areas across the food value chain dwells on extensive mixed-methods analysis, including extensive feedback from stakeholder[5] :

- **Food production.** To improve food productivity, testing promising seeds selected by farmers based on their local knowledge is needed. To do

2 *FAO data available at: **https://www.fao.org/faostat/en/#data/SDGB**. Accessed October 2, 2024.*

3 *In 2018, there were 120 researchers and 220 technicians (UNESCO, 2018).*

4 *Long-term Objectives 1.5.4.3.5 and 1.5.4.3.6.*

5 *See Annex 1 for the full methodology.*

so, developing well-equipped food testing and food certification labs in all region is necessary. Moreover, adoption of drip irrigation and fertigation must be encouraged.

- **Food aggregation.** To improve access to market for small producers, and reduce food waste, stakeholders suggested to install weighbridges at strategic locations to better estimate quantities available. Quantities measured could be shared to relevant stakeholders online through a platform linked to reliable digital marketing and payment tools to ease aggregation and transactions.

- **Food processing.** Stakeholders encouraged the creation of processing centres that use solar and other forms of renewable energy as an alternative energy for food processors. They also advocated for the promotion of (frugal) innovation in storage and processing, as well as knowledge sharing through digital platforms to improve processing and conservation skills.

- **Food distribution.** To create a safe cold chain, building cold storage facilities at strategic locations was advised. Moreover, investing in tracking devices to improve food distribution may improve coordination and reduce price volatility.

- **Food consumption.** Buidling food testing to ensure food safety was highlighted as an urgent need. To enrich diets, social research to evaluate the responsiveness of the beneficiaries to government subsidies must be promoted.

In addition to specific STI investments across the food value chain, several horizontal needs were identified:

- **Build a critical mass of researchers.** Programmes incentivising researchers to stay (or move back) in the Gambia must be deployed. Relatedly, research infrastructures must be scaled up, as this will also contribute to building the critical mass of researchers to address pressing development challenges.

- **Value and protect research and innovation.** Financial support for local researchers to publish in top journals must be encouraged, and patenting procedures must be simplified to protect local innovators.

- **Leverage indigenous knowledge.** Document local knowledge through an inventory of the wealth of indigenous knowledge, testing it via scientific methods, and disseminating good practices.

- **Improve coordination.** Create a committee with representatives from relevant Ministries for food self-sufficiency to (i) identify STI projects and (ii) ensure alignment of the future STI policy prioritiy. Centralise information on STI projects, for instance through an online platform accessible to relevant stakeholders.

INTRODUCTION

Science, Technology, and Innovation (STI) are powerful tools for achieving the Sustainable Development Goals (SDGs). The European Commission, through the Joint Research Centre (JRC) and the Directorate-General for International Partnerships (DG INTPA) is actively involved in supporting African countries in developing STI for SDGs Roadmaps. STI for SDGs Roadmaps are policy frameworks whose main purpose is to leverage STI to tackle localised sustainability challenges. These roadmaps are tailored to each country's unique challenges and opportunities, enabling them to harness the potential of STI to advance sustainable development.

JRC and DG INTPA are working towards the formulation of STI roadmaps with a selection of six African countries, namely the Gambia, Mauritius, Namibia, Malawi, Rwanda and Seychelles, through methodological design and guidance. This project contributes to the goals of the EU Global Gateway, which is a connectivity strategy aimed at bolstering collaboration and investments between Europe and partner countries. It is listed among the implementing initiatives of the recently adopted AU-EU Innovation Agenda, a framework that fosters cooperation in research, science, and technology.

Since 2022, the Government of the Gambia through the Ministry of Higher Education, Research, Science and Technology (MoHERST) and the Joint Research Centre of the European Commission have engaged in a fruitful and a trustful cooperation on this project. STI for SDGs Roadmaps are the product of close collaborations between international experts and local stakeholders in a participatory and co-creation environment[6]. Besides resulting from joint processes, they also aim to initiate and improve long-lasting collaborations among local and international stakeholders that may join forces to efficiently tackle sustainability challenges.

In line with the highly participative nature of the STI for SDGs roadmaps, food self-sufficiency was selected as a sustainability challenge for this STI for SDGs Roadmap as a result of a collaborative process. First, to identify relevant sustainability challenges that could be tackled through STI in the Gambia, the JRC carried out analysis of data on the progress on sustainability issues, policy documents, and stakeholder interviews. Then, under the leadership of the MoHERST, due to the importance of food self-sufficiency as a priority in the Gambia and the potential of STI to tackle multiple weaknesses of the current food systems, this sustainability challenged was selected. Finally, to identify specific STI needs and investment areas to improve food self-sufficiency,

6 *Data and information were collected through desk research and a series of participative actions, including two workshops, group discussions, an online survey, as well as in-depth interviews.*

further analysis of STI data in relation to the sustainability challenges was carried aout along with structured dicussions and deliberations during a two-day workshop in Banjul with representative stakeholders.

In the Gambia, food insecurity is a long-lasting issue which has been worsening in the past decade. More specifically, it increased from 5.6 percent of the population in 2011 to 13.4 percent (or 329 189 people) in 2021. Food insecurity has direct social and health consequences on the Gambian population and, in 2020, 21.6% of the population suffered from undernourishment against 10.4% in 2010 (FAO). Although the prevalence of growth stunting among children under 5 decreased by more than 45% in the past decade, it is still a major issue with 13.6% of children up to the age of 5 years who are stunted (UNICEF et al., 2022[7]).

This report summarises the main findings and recommendations to improve food self-sufficiency through targeted and coordinated STI investments in the Gambia. The first chapter of this report highlights the main key sustainability issues in the Gambia. It also explains in detail the selection of food self-sufficiency as a challenge area that this *STI for SDGs Roadmap* will address. The second chapter of this roadmap describes the current strengths and weaknesses of the STI system in the Gambia to tackle food self-sufficiency. The third chapter deep dives into gaps and STI opportunities within the food systems to improve food self-sufficiency. The fourth chapter paves the way for the fourth section, which summarises STI needs to be addressed to improve food self-sufficiency in the Gambia. Finally, the fifth chapter includes concrete actions and policy instruments to tackle food self-sufficiency through STI in the Gambia.

7 *UNICEF, WHO, World Bank: Joint child Malnutrition Estimates (JME). Aggregation is based on UNICEF, WHO, and the World Bank harmonized dataset (adjusted, comparable data) and methodology. Available at:* ***https://data.worldbank.org/indicator/SH.STA.STNT.ZS***

1. SUSTAINABILITY CHALLENGES AND PROGRESS TOWARDS THE SDGs

1.1. PROGRESS TOWARDS THE SDGs AND SUSTAINABILITY CHALLENGES IN THE GAMBIA

The Gambia is a small West African country with a predominantly agricultural economy. It is a low-income country (LIC) with a gross domestic product (GDP) per capita of US$ 835 in 2021 and an estimated population of 2.4 million. Recent improvements in poverty reduction have been reversed by the COVID-19 pandemic, which in effect pushed Gambia's poverty rate to 53.4 percent in 2020, up from 48.6 percent in 2015 (World Bank, 2022).

According to the 2022 Voluntary National Review (VNR) in the Gambia[8], Covid-19 negatively impacted most sectors in the country, hence posing a threat to the achievement of the SDGs. For instance, students faced loss of teaching hours and delays in teacher training. Moreover, reduced economic activities gave rise to loss of jobs and income in the Micro, Small and Medium Enterprises (MSMEs), delay in completion of labour-intensive projects, and its wider social and economic ramifications. COVID-19 also heightened the threat to food security attributed to climate change and biodiversity loss. The Ukraine-Russia war has also increased pressure on the food system, due to its negative impact on productive inputs (fertilisers, etc.).

In the Gambia, the national debt has traditionally been high, and amounted to almost 25% of the government budget in 2022[9]. Therefore, public finances give little margin to the government to undertake important investments in line with the achievement of the SDGs. Furthermore, any external shock such as COVID–19 can drastically increase pressure on public finances[10], and further delay necessary investments to improve long term sustainability. To achieve the 17 SDGs, more than ever, the Gambia needs support from international partners to increase strategic investments with high social and environmental impact.

At the aggregate level, although it performs better than the regional average with 58.3% of the SDGs achieved (against 53%), the Gambia ranks 129 out of 166 in terms of overall performance. Data access is however a challenge, which limits the interpretation of the results[11]. The Gambia exhibits heterogeneous performance across the 17 SDGs. ***Figure 1*** summarises the progress of the Gambia towards the SDGs.

On the positive side, a few SDGs have been achieved and display positive trends. More specifically, SDG 12 *Responsible Consumption* and SDG 13 *Climate Action* are the only two SDGs whose targets have been met[12].

8 *Available at:* ***https://hlpf.un.org/countries/gambia/voluntary-national-review-2022***

9 *Author's calculations based on the 'Budget Version: Approved Estimates (adopted Budget Law) IFMIS Reports Portal CBMS from the Government of the Gambia'*

10 *Government resources were widely mobilised to tackle the health pandemic.*

11 *For instance, in the 2020 VNR, the country was able to report on only 52% of SDG indicators (VNR report, 2022).*

12 *However, due to data limitations results must be taken cautiously. Some indicators rely on outdated data. For instance, to compute SDG 12, municipal solid waste is based on 2002 data. Moreover, only 2 out of 7 indicators to compute SDG 12 display trends. Therefore, additional analysis is needed.*

FIGURE 1.
SDGs PERFORMANCE OF THE GAMBIA (SOURCE: SDG PLATFORM 2024)

Source. SDG platform.

Notable progress has been achieved for three SDGs, namely SDG 1 *No Poverty*, SDG 10 *Reduced Inequality*, and SDG 15 *Life on Land*, but significant challenges remain on the way to achieving the targets.

On the negative side, major challenges remain for the achievement of twelve SDGs. Among these twelve SDGs, four exhibit moderate improvement: SDG 5 *Gender Equality*, SDG 8 *Decent Work and Economic Growth*, SDG 16 *Peace, Justice and Strong Institutions*, and SDG 17 *Partnerships for the Goals*. Finally, seven SDGs, namely SDG 2 *Zero Hunger*, SDG 3 *Good health and well-being*, SDG 4 *Quality Education*, SDG 6 *Clean Water and Sanitation*, SDG 7 *Affordable Land and Clean Energy*, SDG 9 *Industry, Innovation and Infrastructure*, SDG 11 *Sustainable Cities and Communities are stagnating* and SDG 14 *Life below water is decreasing*[13]. The Blue Economy – which includes fishing, tourism, sea transportation and logistics, and agriculture – is important for The Gambia. As a result, it is important that the decreasing trend in SDG 14 is addressed urgently and reversed. A key determinant of this decreasing trend is the ocean health, which relates to the cleanness of the waters. STI can help in this regard by providing tools, methods and techniques for improvements in water data capture, measurements, and quality improvements.

1.2. SUSTAINABILITY CHALLENGES IN THE STRATEGIC POLICY PRIORITIES IN THE GAMBIA

The previous section highlighted key sustainability challenges in the Gambia through the lens of the SDGs. SDGs are interconnected and sustainability issues systemic. Therefore, to identify STI investments that can contribute to the SDGs, this study opted for a challenge-oriented approach. The purpose of this section is to identify systemic challenges in national priorities that could be improved through Science, Technology, and Innovation (STI). To do so, it includes an analysis of the key national policy documents and aims to shed light on whether national priorities are aligned with SDGs at the country level.

The 2023 – 2027 Recovery-Focused National Development Plan (RF-NDP) includes seven pillars that capture sustainability priorities. The NDP is aligned with the 2030 Agenda, and refers explicitly to the Agenda. However, direct mentions to SDGs

13 *For a detailed description of the key indicators driving the results of each SDG, see Table 1 in Annex 1.*

are scarce, and we denote only eight references to specific SDGs, namely three to SDG 1 No Poverty, three to SDG 9 Industry, Innovation and Infrastructure, and two to SDG 16 Peace, Justice and Strong Institutions. To better understand indirect links between SDGs and the NDP, we analysed the descriptions of each pillar and the expected outcomes within the pillars[14]. Results show that most SDGs are covered within the seven pillars of the NDP[15]. *Table 2* from *Annex 1* shows the specific SDGs that are captured by each pillar of the NDP. The nature of the sustainability issues that each pillar intends to tackle are as follows:

- **Pillar 1 Building Community Resilience to Shocks and Crises** highlights the need to improve community resilience, in the wake of multiple shocks and crises in the form of disease epidemics (COVID-19) and the impact of food and energy crises arising from the Russia-Ukraine war that have had multifaceted and complex impacts on the economy and society. More specifically, these crises have aggravated fragilities arising from effects of climate change, which is worsening food security, livelihoods and poverty. Urban poverty has increased and there are growing pockets of food insecurity/ malnutrition in the urban areas.

- **Pillar II Governance Reforms** shows that the Gambia has registered significant progress in governance since the new Government came into power in 2017. This is recognised both internally and externally and is evidenced by the improved position of The Gambia in many internationally recognised indices of good governance. However, there are challenges regarding a new constitution, transitional justice and security sector reform.

- **Pillar III Macroeconomic Stability and Growth; Macroeconomic Stability and inclusive Growth.** Macroeconomic instability is characterised by low and volatile growth caused by shocks and low investment in the productive sectors. Other macroeconomic issues must be addressed such as high poverty rate, high public debt, limited financial inclusion, rising inflation, exchange rate fluctuation, and high trade and current account deficit. This has affected inclusive growth in the country for decades.

- Pillar IV Human Capital Development. Although some progress has been made by the Gambia with respect to developing its human capital, overall, the stock of human capital of the country remains unsatisfactory. In addition to health and education, the analysis of the national development context also underscored the need to give priority to issues related to population and demography, migration and urban planning and provision of affordable housing. These are areas that have hitherto not been accorded the place they deserve in national planning.

- **Pillar V Agriculture, Fisheries, Natural Resources and Climate Change** highlights the need to address land degradation, deforestation, salination in the lowlands, coastal erosion and traditional, unsustainable production systems in the forestry, agriculture, and fisheries industries pose a considerable threat to the production and productivity of the sector.

- **Pillar VI Empowerment, inclusion and Leaving No One Behind** emphasises the lack of empowerment, social exclusion, discrimination and stigmatization for women, girls, children, persons with disabilities and older persons. It recognizes that removing such barriers is a key to unleashing the potential of large segments of society and establishing just and equitable society.

- **Pillar VII Energy, Infrastructure and Connectivity. Energy, Infrastructure and ICT connectivity,** are critical economic and

14 *We linked key words from these descriptions to SDGs (see Table 1 from Annex 1 for the correspondences). For instance, the description of Pillar 1 includes the sentence "crises have aggravated fragilities arising from effects of climate change, which is worsening food security". We then related the key words "food security" to SDG 2 Zero Hunger.*

15 *SDG count: SDG 1 (2) , SDG 2 (2) , SDG 3 (1) , SDG 4 (1), SDG 5 (1), SDG 6 (1) , SDG 7 (2), SDG 8 (4), SDG 9 (2) , SDG 10 (2), SDG 11 (1) , SDG 12 (3), SDG 13 (3), SDG 14 (2), SDG 15 (1), SDG 16 (1), SDG 17 (0). See Table 1 from Annex 1 for the detailed classification.*

social cohesion enablers for any society. African countries infrastructure lags other countries elsewhere, mainly in "access and quality" (NDP, 2023).

The mission of the 2015 - 2024 National, Science, Technology and Innovation Policy (NSTIP) is "to build and strengthen national capacity and competencies in STI that will enhance the attainment of **economic development and national competitiveness"**. The NSTIP sets out a new and focused approach to "mobilise STI to achieve the country's economic, social and environmental goals, which have been identified in Vision 2020 and Programme for Accelerated Growth and Employment (PAGE). The National STI policy mentions once the Millennium Development Goals (MDGs[16]) but not explicit goals. However, it highlights the potential of STI to achieve national objectives for:

- Poverty reduction or wealth creation
- Industrial growth and Competitiveness
- Clean Energy and Sustainable environmental management
- Health and social well-being.

The NSTIP presents clear synergies with the NDP, and STI is perceived as a potential lever to address several sustainability challenges highlighted in the NDP. More specifically, the NSTIP includes ten sectoral priorities, and five sectoral priorities can be matched directly to NDP pillars[17] (see ***Table 3*** from ***Annex 1***).

1.3. SUSTAINABILITY CHALLENGE OF FOCUS

1.3.1. SELECTION PROCESS OF THE SUSTAINABILITY CHALLENGE

The STI for SDGs Roadmaps constitute a strategic framework for STI investments and policy instruments focused on specific sustainability challenges faced by a country. In the Gambia, through a structured selection process, food self-sufficiency was proritised as the relevant sustainability challenge that could be tackled through STI in the Gambia. The selection of the sustainability challenge for the Gambian roadmap dwelled on two activities:

- An analysis of key policy documents and literature review
- Stakeholder consultations

A first round of stakeholder interviews raised the issue of food self-sufficiency as a key challenge to prioritise in the Gambia. Moreover, key policy documents revealed a consensus on the importance of food self-sufficiency as a national priority, which has worsened in the past decade.

According to the Trade Policy (2018), "The Gambia is **not self-sufficient in its own staple** crops and needs to import food items such as cereals because it does not grow enough of its own cereals." Moreover, the NDP (2023) indicates that "multiple shocks and crises in (COVID-19, Russia-Ukraine war, etc.) have aggravated fragilities arising from effects of climate change, which is **worsening food security with growing pockets of food insecurity /malnutrition** in the urban areas" (NDP, 2023).

The NDP positions food self-sufficiency as a government priority since "at the end of the plan period, Government expects to have made significant strides in **attaining food self-sufficiency**" (NDP, 2023). Moreover, the 2017 – 2026 Agriculture and National resources Policy (ANRP) highlights that "**food production will be increased substantially** through intensive and

16 *No direct mention to SDGs since the policy started in 2015 and SDGs were implemented from 2015 onwards.*

17 *The NDP pillar Community Resilience may be addressed by the NSTIP sectors "Agriculture", "Energy", and "Infrastructure". Moreover, The Pillar Governance reform mostly refers to ICT, which may be picked up in the NSTIP through a dedicated chapter.*

BOX 1. KEY CONCEPTS AND DEFINITIONS

- According to FAO (2018) Food Systems (FS) encompass "the entire range of actors and their interlinked value-adding activities involved in the **production, aggregation, processing, distribution, consumption and disposal of food** products that originate from **agriculture, forestry or fisheries**, and parts of the broader economic, societal and natural environments in which they are embedded".
- The food system is composed of **sub-systems** (e.g. farming system, waste management system, input supply system, etc.) and interacts **with other key systems** (e.g. energy system, trade system, health system, etc.). Therefore, a structural change in the food system might originate from a change in another system; for example, a policy promoting more biofuel in the energy system will have a significant impact on the food system.
- A sustainable food system is "a food system that delivers food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised" (FAO, 2018). This means that: – It is profitable throughout (economic sustainability); – It has broad-based benefits for society (social sustainability); and – It has a positive or neutral impact on the natural environment (environmental sustainability). Food self-sufficiency is "the extent to which a country can satisfy its food needs from its own domestic production" (FAO, 1999).

limited expanded cultivation of tidal and upland rice to **improve the self-sufficiency** level of domestic rice from 20% in 2004 to about a target of about 50%." The 2018 - 2028 National Seeds Policy (NSP) aims to **improve "food Security through seed security"**.

Further discussions under the leadership of the MoHERST confirmed the interest of the Ministry in investigating the multidimensional and systemic sustainability issue, which led to the following formulation of the challenge **"Leveraging STI to tackle food self-sufficiency in the Gambia"**.

Improving self-sufficiency may also indirectly contribute to the four areas of the NDP that could be signicantly be addressed through STI[18].

1.3.2. SUSTAINABILITY ASPECTS RELATED TO FOOD SELF-SUFFICIENCY IN THE GAMBIA

Food insecurity increased from 5.6 percent of the population in 2011 to 13.4 percent (or 329 189 people) in 2021. It disproportionately affects rural households (23.9 percent) more than urban ones (10.8 percent) (WFP, 2021). The Gambia does not produce enough food and faces high import dependency for almost 50 percent of the food demand (World Bank, 2019)[19].

In line with this, the analysis of the SDGs revealed that SDG 2 *Zero Hunger* is a major challenge that is stagnating. Moreover, among the SDGs facing major challenges in terms of performance, SDG 14 *Life Below Water* is the only one whose

18 *Poverty reduction or wealth creation, industrial growth and competitiveness, clean energy and sustainable, environmental management, health and social well-being.*

19 *Food self-sufficiency is a systemic issue, and the analysis of the food systems may involve examination of the food aggregation, processing, distribution, and consumption. For more information see Box 1 at the end of this subsection.*

performance is decreasing, which is alarming for several reasons. In the Gambia, besides the environmental concerns that it raises, life below water is socially essential as the ocean and the river provide fish (and jobs) to a large number of Gambians.

Food insecurity has direct social and health consequences on the population. In 2020, 21.6% of the population suffered from undernourishment against 10.4% in 2010 (FAO[20]). Although the prevalence of growth stunting among children under 5 decreased by more than 45% in the past decade, it is still a major issue with 13.6% of children up to the age of 5 years who are stunted (UNICEF et al., 2022[21]).

The rest of this section analyses key sustainability issues within five segments of the food systems (production, aggregation, processing, distribution and storage, and consumption) that may contribute to the lack of food self-sufficiency in the Gambia. The following descriptions of sustainability issues are based on document analysis, stakeholder consultations (interviews, workshops and an online survey) and information available to the team at the time of conducting the study (January-April 2024).

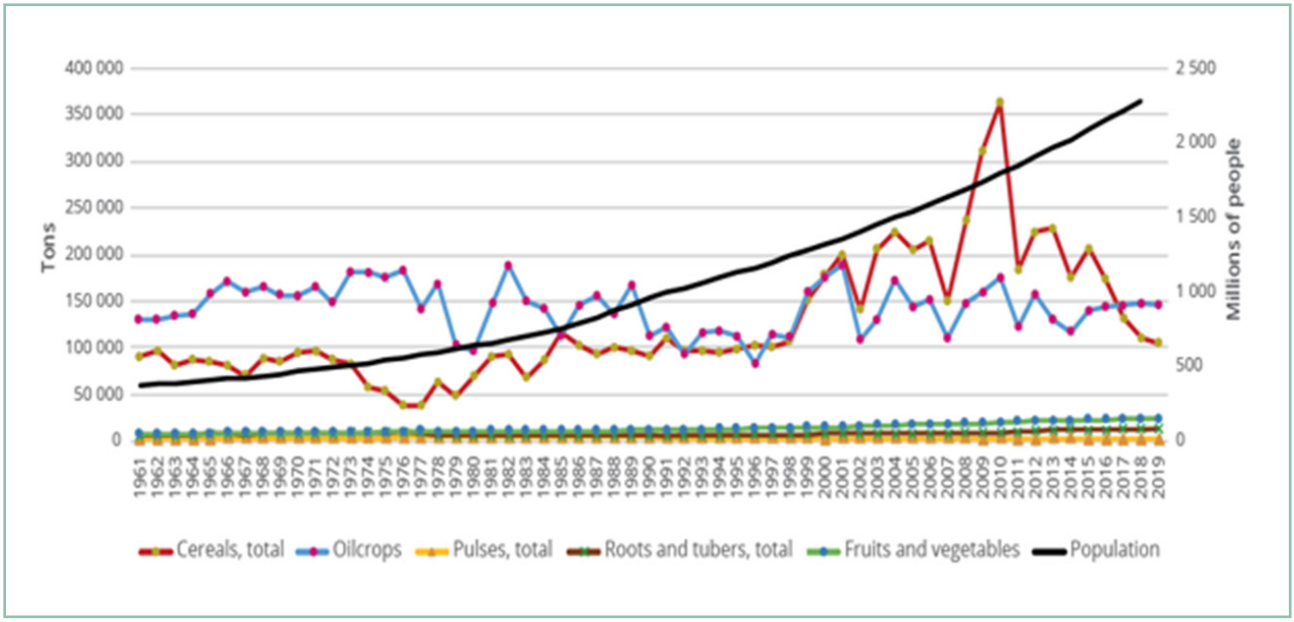
1.3.2.1. FOOD PRODUCTION

Figure 2 shows both crop production in tonnes and the total population in millions of people from 1961 to 2019. From the early 90s, population growth was faster than the growth in crop production, except from 2009 to 2011 for cereals. Therefore, the production per inhabitant decreased substantially over the same period and was divided by two for the main crops. More specifically, in 1985, the production of both cereal and oil crops was around 110,000 tonnes, for a population of 855,958 inhabitants (FAO, 2022), which corresponds to 128 kg per inhabitants per crop. However, in 2017, oil crops and cereals amounted to 150,000 tons each for a population of 2,381,182 inhabitants (WB), which corresponds to 63 kg per inhabitant of each crop.

20 *FAO data available at: **https://www.fao.org/faostat/en/#data/SDGB**. Accessed October 2, 2024.*

21 *UNICEF, WHO, World Bank: Joint child Malnutrition Estimates (JME). Aggregation is based on UNICEF, WHO, and the World Bank harmonized dataset (adjusted, comparable data) and methodology. Available at: **https://data.worldbank.org/indicator/SH.STA.STNT.ZS***

FIGURE 2.
CROP PRODUCTION IN COMPARISON TO POPULATION GROWTH



Source: FAO, European Union and CIRAD. 2022.

Access to productive inputs is an impediment to increasing productivity and, subsequently, production. In the Gambia, low production of local fertilisers forces most farmers to buy imported fertilisers at high costs and volatile prices (both organic and inorganic) (Roundtable discussions, 2024). Moreover, the government provides little subsidies to buy fertilisers while farmers have limited access to finance. Therefore, they tend to farm on soils with poor structure, which lead to low productivity and high vulnerability to climate change. When farmers have access to chemical fertilisers, food safety is a question due to the lack of testing facilities[22].

Access to quality seeds appears to be another main challenge at the country level. Ninety percent of the seeds are exchanged through informal channels among farmers[23] and local research seems able to develop varieties which are superior to indigenous cultivars (NSP, 2018). The local production of quality seeds is low, and most of the seeds available are not certified and lead to poor yields.

Despite important stocks of fresh water, access to water remains a major challenge for farmers and most of the agriculture is rain-fed. In the Gambia, the rainy season spans over four months, which coincides with the farming season. To extend the production season, irrigation techniques are then essential. However, affordability of irrigation systems remains a challenge in the Gambia. In some regions, especially the western part of the country, salinity of the water is an issue (Stakeholder interview, 2024).

Manpower in agriculture is decreasing due to several factors. First, weak mechanisations of the Gambian agriculture lead to low productivity and value added creation. Therefore, young people perceive low returns and shy away from the sector[24]. In addition, access to land is still a challenge to farmers, especially young people and women for financial and cultural reasons. These two phenomena reinforce rural to urban migration and illegal migration, which is decreasing the potential labour force in agriculture and increasing food insecurity. Relatedly, low farming skills, hinder efforts aimed at increasing agricultural yields. Stakeholders reported that the training of farmers and extension workers is not always adequate (Roundtable discussions, 2024), which hinders improvements in farming practices.

Limited investments in research and development translate into low levels of innovation needed to address the gaps in agriculture and food systems. Evidence from stakeholder consultations indicate that innovations from the Gambia tend to be patented abroad. Moreover, stakeholders reported the presence of rich indigenous knowledge that are fragmented and placed-based innovation, which seems to be an untapped potential (Stakeholder interviews and roundtable discussions, 2024). For instance, local initiatives for rice cultivation have proved to be efficient in regions facing high salinity. So, some local farmers grow successfully a certain variety of rice in fresh water for three months before transplanting plants into salty water. Moreover, to fabricate artisanal greenhouses, some local farmers also use specific fabric with good results on yields (Roundtable discussions, 2024).

One way the Gambia compensates crop production shortfalls is to increase imports[25]. However, ***Figure 3*** shows that the increase in imports in food products from 1985 to 2019 exhibited at best parallel trends to population growth, which did not allow to compensate the decrease in production. Only 6 percent of the staple rice requirement is met by domestic production with annual imports filling the food gap (FAO, 2022).

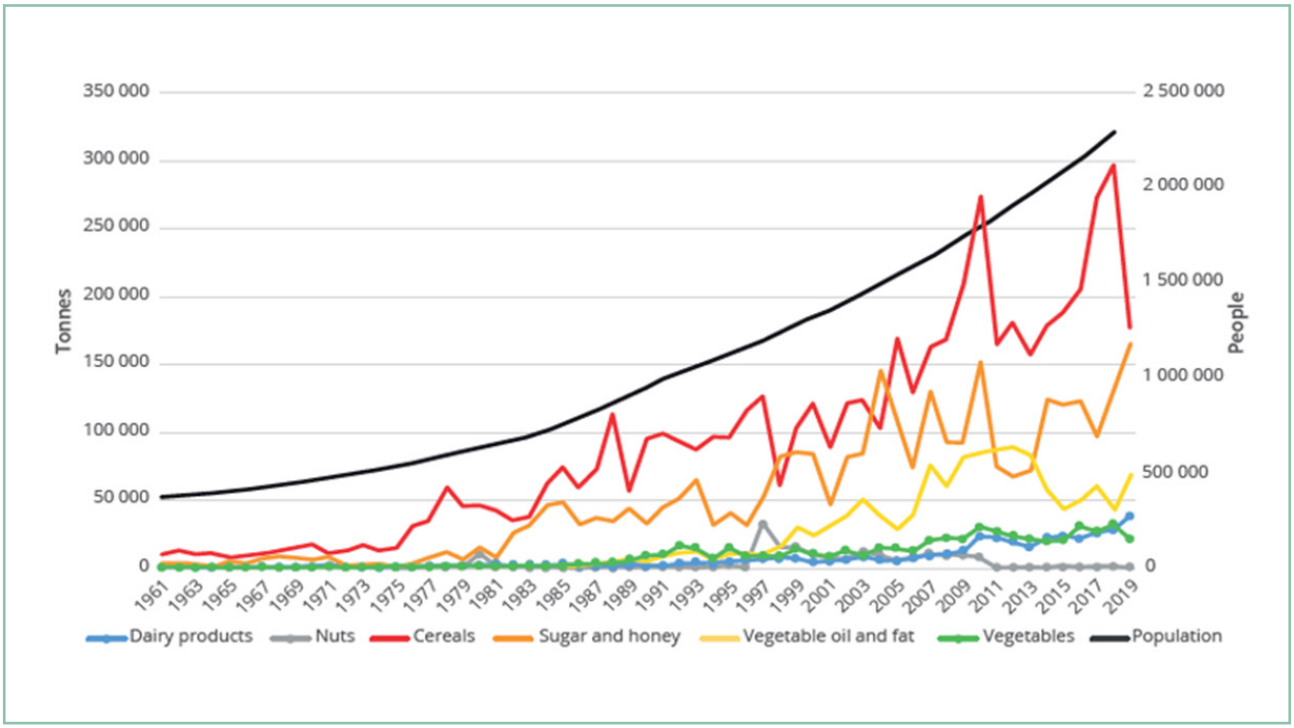
22 *This also creates impediments to increasing the export of high-value product, for instance in the horticulture sector.*

23 *"In the face of the low seed output from the formal seed sector, the informal sector remains strong and is the main source of seeds for all crops" (NSP, 2018).*

24 *Sixty-two percent of households farm for self-consumption only, 34 percent for both self-consumption and commercial sale, while only 4 percent farm for commercial sale alone (FAO et. al, 2022).*

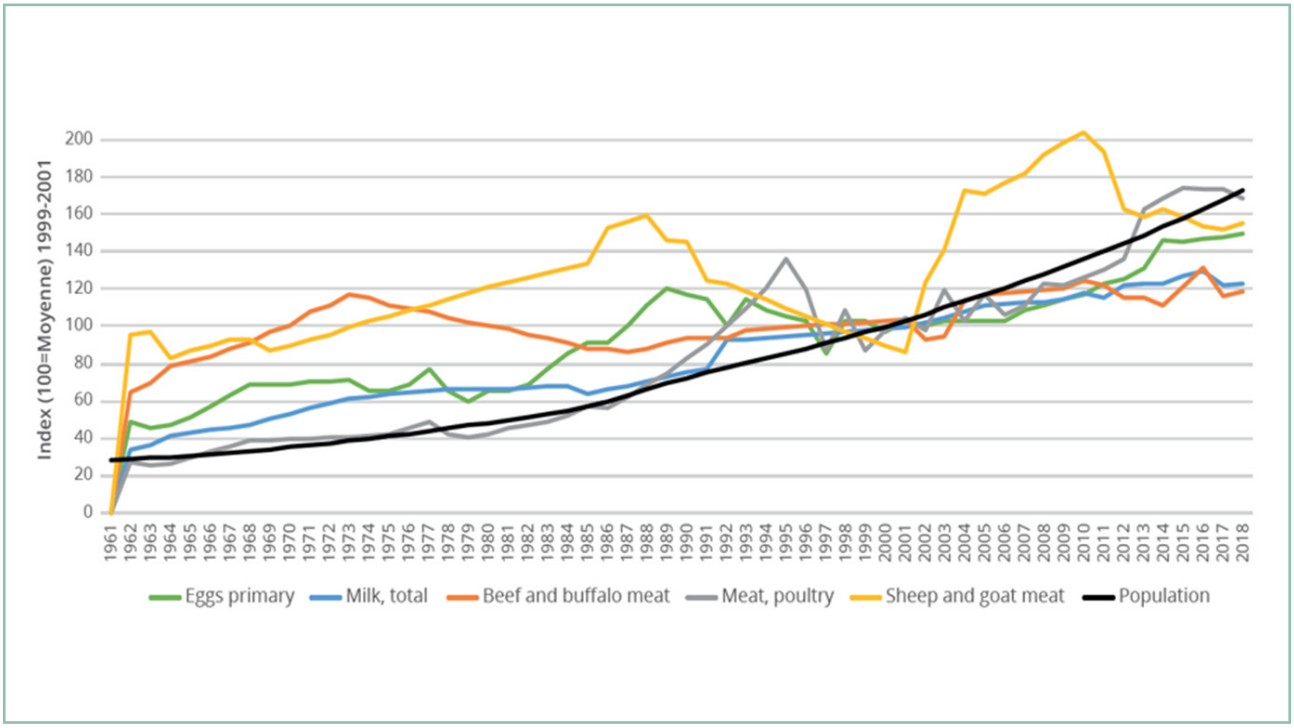
25 *Although it may not be to the most sustainable long-term approach, and it may also impact negatively the trade balance.*

FIGURE 3.
MAIN IMPORTED FOOD PRODUCTS IN VOLUMES WITH POPULATION GROWTH



Source: FAO, European Union and CIRAD. 2022.

FIGURE 4.
EVOLUTION OF THE NUMBER OF LIVESTOCK HEADS (INDEX)



Source: Source: FAO, European Union and CIRAD. 2022.

There has been a significant increase in demand for meat products in The Gambia in recent years (FAO, 2022). However, ***Figure 4*** shows that from 2002 to 2018 the number of livestock heads increased less fast than the population growth for most varieties of livestock (expect for *sheep and goat meat*). The present domestic production of beef, milk, lamb, goat meat, poultry meat and eggs are far short of the national demand (FAO, 2022). Therefore, the decrease in crop production was not compensated by an increase in meet production.

The fishing sector contributes an estimated USD 55.5 million to the economy, of which USD 38 million is derived from production and USD 16.1 million from industrial processing (FAO, 2022). Industrial fishing, however, is dominated by foreign vessels in Gambian waters[26]. Moreover, stakeholders (JRC online survey, 2024) highlighted the presence of illegal industrial fishing, mostly by foreign boats, and poor law enforcement capacity to tackle the issue.

Absorptive capacity, the ability to appropriate technology and develop incremental innovations to address common challenges remain a challenge in the Gambia. This may be coupled with the culture of innovation, entrepreneurial mentality and mindset in the Gambia. For example, it was gathered during the stakeholder consultations and focused group discussions that fishermen, especially from Mali, use locally available resources improve their fishing and gain competitive advantage over Gambian fishers at the same level, due their (ther Malians) innovative nature. Unlike Gambian fishermen, the fishermen from Mali use motorised boats, whose engines are built from reconfigured motorbikes engines or other machines. Such reconfigured motorised fishing boats could be made accessible to the Gambians in cases where industrial fishing boats are not readily available. This, again, is one practical example of where capabilities, coupled with STI, could help reduce poverty and hunder, create jobs, and improve the wellbeing of the Gambians, thereby contributing to achieving the SDGs.

Finally, stakeholders also mention overexploitation and water pollution (JRC online survey, 2024), which creates stock depletion. The decrease in fish stock is reinforced by water pollution caused by factories rejecting waste in the river. This evidence help explain the low score in the SDG 14, as presented above.

1.3.2.2. FOOD AGGREGATION

In the Gambia, the capacity of the aggregators of the agricultural products is limited and aggregation goes mainly through small and informal markets (Roundtable discussions, 2024). Informal, small-scale itinerant traders connect with retailers and wholesalers at weekly organized markets (“Lumo”) and regional agricultural markets (“Samdika”), for trading only agrocommodities (FAO et. al, 2022). To scale up, a major impediment that these small traders are facing is a lack of financial capacity to aggregate bigger quantities (Roundtable discussions, 2024). Moreover, cooperatives are scarce *(*Agriculture and National Resources policy - ANR policy, 2017), and stakeholder discussions highlighted that distrust in cooperatives from farmers hinders aggregation.

Moreover, the quality of the infrastructures, both physical and nonphysical, is another major challenge to aggregation. For instance, the quality of the roads to access farms is often low (Roundtable discussions, 2024). Another impediment, which prevents bigger actors (such as private companies or cooperatives) to enter the market, is the lack of information on quantities produced. Consequently, potential aggregators face high searching costs to identify production, which also discourages potential new entrants. Secure payment systems are also scarce, and in-cash transactions are limited to the liquidity levels of the informal traders, which are often low (JRC online Survey, 2024).

26 *According to CIRAD (Avadi et al., 2020), there were 15 licensed vessels (trawlers) operating in Gambian waters in 2017, of which 6 were Gambian registered but not owned by Gambians. The other 9 obtained licences through the reciprocal agreement with Senegal but are not necessarily owned by Senegalese nationals.*

A main consequence of the low levels of aggregation for farmers is lower prices for their harvests. First, they have less bargaining power than if they could sell through organised networks. Second, they cannot benefit from economies of scale for transformation, which would increase the value added of their products, and potentially their margins. Another common issue for smallholder farmers is the capacity to store their harvests in safe conditions, which results in important food waste and income losses.

1.3.2.3. FOOD PROCESSING

Processing is limited in the Gambia since there are only a few processing plants and farmers lack information on available facilities (Roundtable discussions, 2024). High cost of machineries appears to be the major impediment to the acquisition of processing machines in the Gambia, which hinders food transformation and increasing value-added for farmers. In practice, motorized cereal threshing and milling facilities (both communal and privately owned) are accessed by approximately 30 percent of smallholders (FAO, 2022). On-farm rice threshing mainly uses manual methods, consequently, 30 percent of harvested paddy is lost during processing (WFP, 2020). Processing skills are also limited, which further increases food waste, as well as pollution (Roundtable discussions, 2024). In addition, maintenance skills, hygiene and safety practices must also be improved at all levels (Roundtable discussions, 2024).

Local start-ups have the knowledge to produce a wide range of machines (milling machines, juice machines, etc.), which are sometimes cheaper than imported machines (Stakeholder interview, 2024), despite relying heavily on imported material for their production. Although they have the knowledge to produce such machines, they struggle to access loans from commercial banks, and they often fund specific projects through grants. Therefore, scaling up is often a challenge, which could further reduce costs. On the positive side, there is a potential local market for processed products since several imported food products are based on food components that are already grown in the Gambia (e.g. mango juices imported from Malaysia).

Access to electricity stays a clear constraint to the deployment of processing machines[27] since in the Gambia 62% of the population have access to electricity (IEA et al., 2020[28]). Moreover, processors tend to use heavy generators, which creates both air pollution (due to unburn carbon) and noise (Roundtable discussions, 2024). Access to affordable electricity is also an impediment to fish processing and preservation through adequate processing facilities including cold rooms (Stakeholder interviews, 2024).

1.3.2.4. FOOD STORAGE AND DISTRIBUTION

The storage and the distribution of perishable food products is a challenge in the Gambia, which creates many inefficiencies, missing opportunities to increase value added, and generates waste. Adequate storage facilities (and storage bags) are lacking, for highly perishable products. Moreover, the quality of the roads and the limited number of adequate vehicles to transport highly perishable products makes it difficult to make timely deliveries and to set up a safe cold chain.

One sector that is heavily impacted by issues relating to the distribution and storage is the fishing value chain. Since the number of cold rooms is scant (Roundtable discussions, 2024), as well as equipped vehicles for keeping fish fresh or frozen is challenging. Drying fish or smoking is often an easier option (Stakeholder interviews, 2024), which also has its own limitations (e.g. pollution generated through smoking the fish).

Another example in which the lack of storage facilities gives rise to untapped opportunities is the melon value chain. After the harvest, melons are abundant but local farmers lack storage facilities.

27 *In 2021, 63.7% of the population had access to electricity (IEA, IRENA, UNSD, World Bank, WHO).*

28 *Data available at: **https://datatopics.worldbank.org/sdgatlas/goal-7-affordable-and-clean-energy/?lang=en. Accessed October 2, 2024**.*

Therefore, they sell some of their production to foreign traders, for instance from Senegal, who preserve them abroad in adequate facilities, before exporting them back to the Gambia off season at a higher price (Roundtable discussions, 2024).

The distribution of food lacks organisational structures and planning. For instance, uncoordinated in-country movements of goods from one region of the country to another trigger price volatility, which is detrimental to both consumers and farmers (Roundtable discussions, 2024).

Finally, some segments of the value chains are underdeveloped such as packaging and marketing. Lack of adequate packaging leads to unsafe products and food waste. Improving marketing could also increase value added.

1.3.2.5. FOOD CONSUMPTION

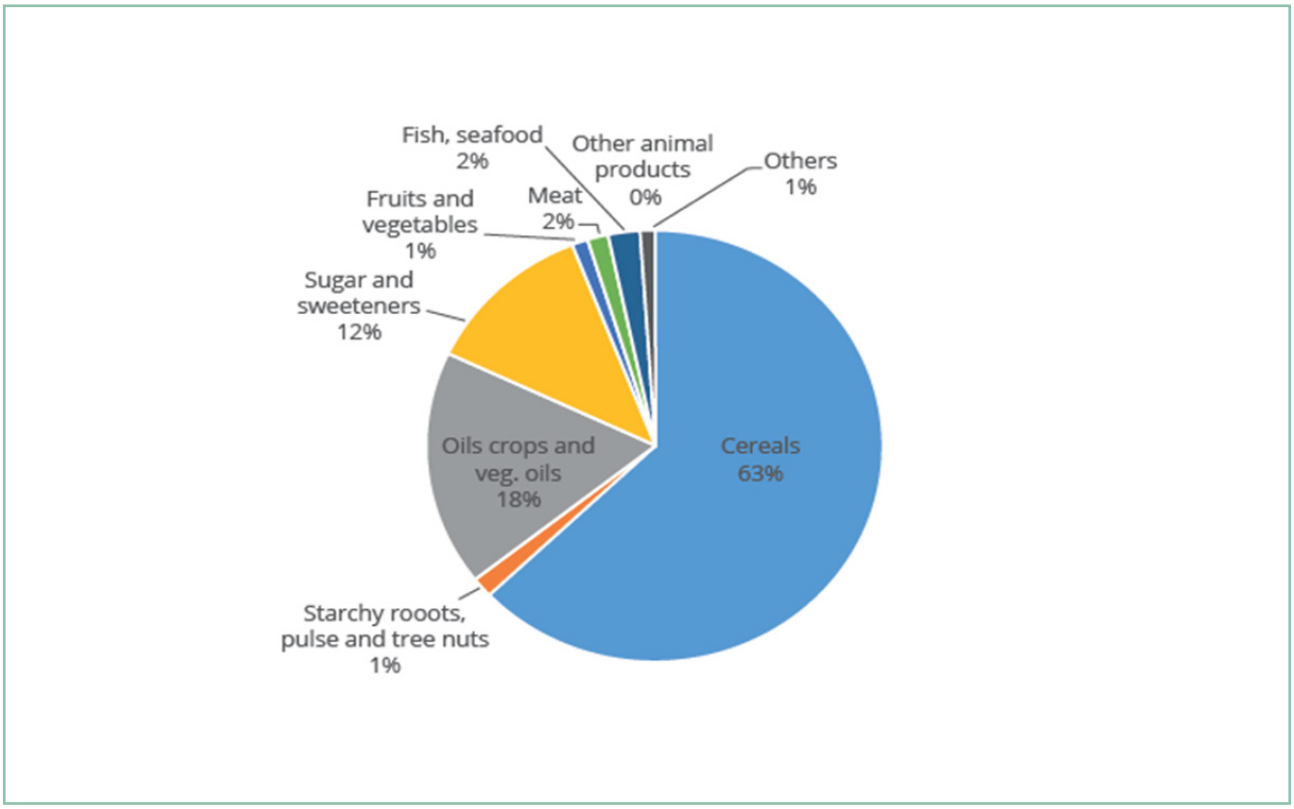
The main sustainability issues relating to food consumption are as follows:

- Lack of diversification in diets
- Food preparation
- Safety and quality of food

Food diets in the Gambia lack diversity, and the sources of the calories consumed by the Gambians are limited and rely on a few staple crops (Stakeholder interviews, 2024). On average, the Gambian derive most of their calories from cereals (63%), and the estimated per capita consumption of cereals in The Gambia is 175 kg, of which rice constitutes 117 kg[29] (see ***Figure 5***).

29 Followed by coarse grains like millet, maize and sorghum (58 kg). There has been a major shift from coarse grains to rice in recent years.

FIGURE 5.
FOOD AVAILABILITY BY COMMODITY GROUPS (IN CALORIES)



Source: FAO, European Union and CIRAD. 2022.

Although inadequate knowledge on the benefits of consuming a balanced diet is an issue, the major impediment to more balanced diets is food affordability. So, vegetables and fruits are very expensive to most Gambians.

Food preparation is constrained by low access to energy (and clean energy) for cooking. Therefore, households mainly use charcoal, which creates pollution, but also deforestation. Another challenge in food preparation relates to traditional cooking methods that tend to harm nutrients, which negatively impacts food quality (Roundtable discussions, 2024).

The residues from the chemical used by farmers such as pesticides or fumigants for food preservation are unsafe for human consumption (e.g. aflatoxins). An obstacle to safer food consumption in the Gambia is the lack of food testing facilities, which is an issue to ensure quality assurance of both local and imported food. Such facility would also enable to improve the safety of street food which is often prepared relying on poor hygience practices.

2. FITNESS OF INNOVATION SYSTEM TO ADDRESS THE SUSTAINABILITY CHALLENGE

2.1. STI POTENTIAL AND PERFORMANCE WITH A FOCUS ON FOOD SELF-SUFFICIENCY

In the Gambia, expenditures on Research and development (R&D) represented 0.07% of the GDP in 2018 (UNESCO), which is far below the 1% target recommended by STISA-2024. The government budget of the MoHERST is limited, with only 1.2%[30] (see ***Figure 6***) for the government budget allocated to the MoHERST within which 2.7% are allocated to STI (see ***Figure 7***).

Due to the lack of government funding allocated to STI, the MoHERST relies heavily on international donors to finance STI.Total R&D personnel[31] (FTE) in the Gambia amounts to 1,442 among which only 120 are researchers and 220 technicians (UNESCO, 2018). When dividing these figures per the total number of inhabitants, we obtain 632 total R&D personnel per million inhabitants (FTE) and 53 researchers per million inhabitants (FTE). ***Table 1*** summarises general research indicators.

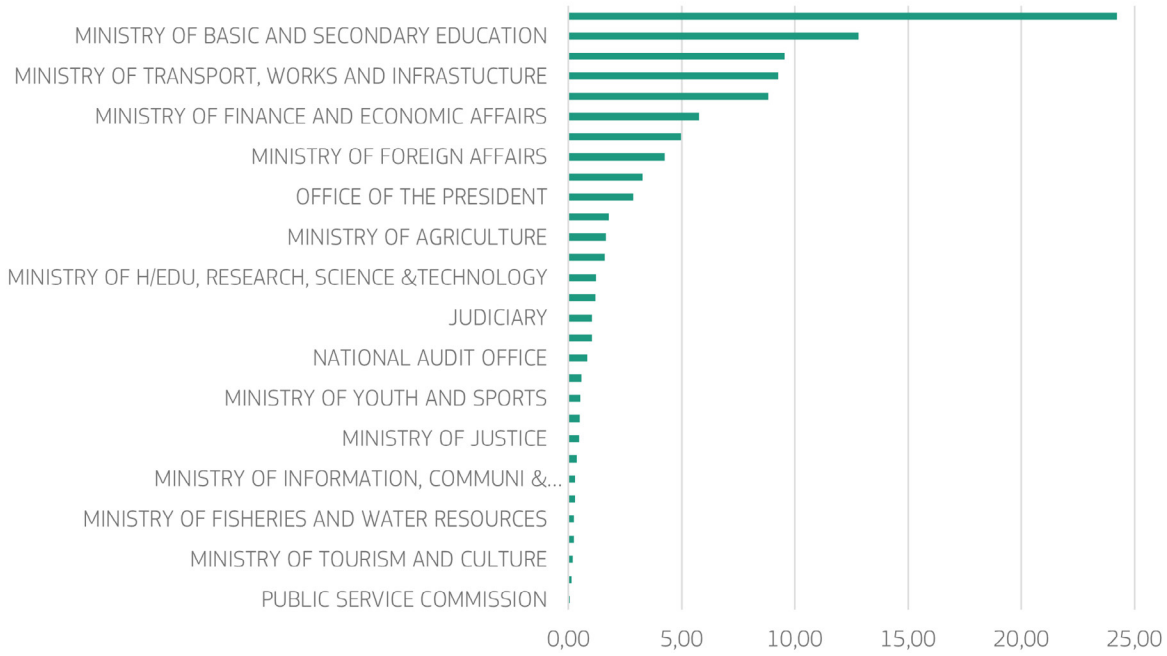
According to the UNESCO Institute for Statistics (UIS) most researchers are employed in the medical and health sciences (58.4 %) and agriculture (26.4 %), while only a few researchers are involved in the natural sciences (12 %), and engineering and technology (0.8 %). This implies that less than 32 researchers FTE work in the field of agriculture, 14 researchers FTE in natural sciences and 10 researchers FTE in engineering and technology. The Gambia faces a brain drain of the local researchers who often move abroad to benefit from better working conditions (Stakeholder discussions, 2024). Therefore, attrition among senior researchers, in agriculture, is a barrier to building a critical mass of researchers (Agriculture and National Resources policy, 2017). This highlights the current low potential of research to contribute to improving food self-sufficiency in the Gambia[32].

30 *Total budget in Dalasi in 2022: 23,692,226,645 (or $349 million). Budget allocated to the MoHERST: 287,684,247 (or $4.2 million). Share of the allocation of the budget to the MoHERST: (287,684,247 /23,692,226,645) *100= 1.2%.*

31 *The UNESCO Glossary (available at: https://uis.unesco.org/en/glossary) defines R&D personnel in a statistical unit include all persons engaged directly in R&D, whether employed by the statistical unit or external contributors fully integrated into the statistical unit's R&D activities, as well as those providing direct services for the R&D activities (such as R&D managers, administrators, technicians and clerical staff). Persons providing indirect support and ancillary services, such as canteen, maintenance, administrative and security staff, should be excluded, even though their wages and salaries are included as an overhead cost when measuring R&D expenditure. Two main groups of individuals who potentially contribute to the R&D activities can be identified in a statistical unit: 'Internal R&D personnel' and 'external R&D personnel'. Both groups of R&D personnel are classified according to their R&D function: 'Researchers', 'technicians' and 'other supporting staff'.*

32 *According to the ANR, the problems and constraints of agricultural research in The Gambia are the ''lack of financial resources to implement the essentials of the Agriculture Research Master Plan to anchor the ANR policy pillars by mitigating critical research issues such as inadequate resources in terms of qualified personnel, finance and infrastructure; and dependency on funding from donor agencies and technologies developed from outside''. Other weaknesses of The Gambian NARS are "inexperienced research personnel and high attrition rates*

FIGURE 6.
GOVERNMENT BUDGET ALLOCATION 2022 (IN%)



Source: Author's calculations based on the Budget Version: Approved Estimates (adopted Budget Law) IFMIS Reports Portal CBMS from the Government of the Gambia

FIGURE 7.
SHARE OF INVESTMENT PROGRAMME BY COMPONENTS OF INSTITUTIONAL TRANSFORMATION

Component		Percentage Share
1.	Equitable Access	44.11%
2.	Quality and Relevance	7.85%
3.	Research and Technology Development	2.67%
4.	Sector Management	45.37%

Source: MoHERST Simulation Model, 2021.

TABLE 1.
GENERAL RESEARCH INDICATORS IN THE GAMBIA

Indicator	Value for The Gambia
Total R&D personnel (FTE)	1,442
Total R&D personnel per million inhabitants (FTE)	632
Researchers (FTE)	120
Researchers (FTE) per million inhabitants (FTE)	53
Technicians (FTE)	202
Technicians (FTE) per million inhabitants (FTE)	89
Research and development (R&D) expenditure (% of GDP)	0.07

Source: UNESCO (2018).

According to the 2017 -2026 ANR policy, issues faced by the agricultural research system "revolve around the scope of research (programmes, research areas, disciplines) given the scale of resources (human, physical and financial) available". The over-riding constraint in this regard is lack of financial resources to implement the essentials of the Agriculture Research Master Plan to anchor the ANR policy pillars by mitigating critical research issues such as inadequate resources in terms of qualified personnel, finance and infrastructure; and dependency on funding from donor agencies and technologies developed from outside.

Table 2 shows research outputs in absolute terms in 2021 based on Scopus data. In line with the employment distribution across fields, research is specialised in two main fields, Agriculture and Health Sciences. In 2021, there were forty-eight publications in Agriculture and the same number of citations, and research outputs do not suggest a high creation of knowledge to address all the aspects of food self-sufficiency in the Gambia. Low research outputs in other fields such as Social Science and Humanities also suggest the potential need for more studies to understand for instance food consumption patterns or response to subsidies fertilisers.

Figure 8 shows the annual relative prevalence of scientific publications in the Gambia compared to the 54 other African countries[33]. Results show that research in the Gambia is relatively highly specialised in a few SDGs. More specifically, compared to the other 54 African countries, research publications are more specialised in SDG 3 *Good Health and Well-being* and SDG 5 *Gender Equality*.

According to WIPO there was no patent application in 2022 (and two from abroad in 2018). According to the World Justice Project (2021), protecting property rights is a major impediment to entrepreneurial activities, and innovation. According to the 2017 -2026 ANR Policy, in the Gambia there is a slow rate of technological development and innovation in agriculture with regards to product development, process and packaging, production systems and varietal improvements.

Trademarks applications fluctuated in the past ten years, going from 531 in 2015 (mostly from

of senior scientists which undermines the availability of the required critical mass of highly trained Gambian ANR scientists; low level of production systems input resource management research activities; and inadequate research resources to investigate the management of post-harvest crop residues".

33 This analysis is based on publication on Scopus more unpublished research on Scopus may be done in the Gambia.

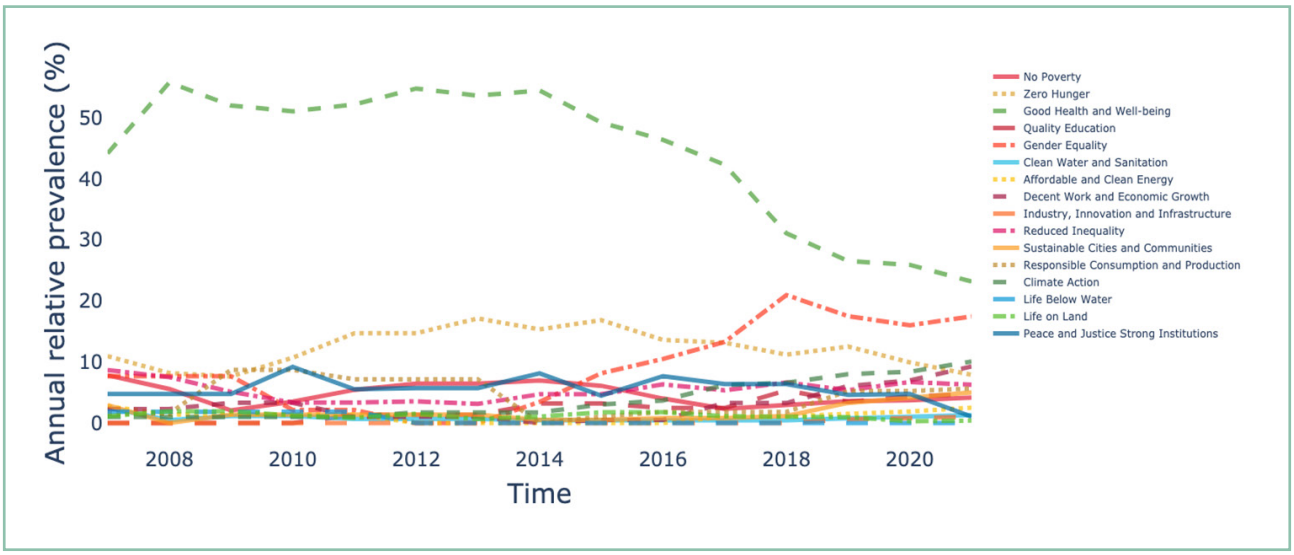
TABLE 2.
RESEARCH OUTPUTS ON SCOPUS PER FIELD

Field	Research citations (Scopus)	Research publications (Scopus)
Agriculture	48	48
Health Sciences	99	102
Multidisciplinary	9	12
Physical Sciences & STEM	1	6
Social Sciences and Humanities	3	20

Source: authors' analysis based on Scopus data from 2021

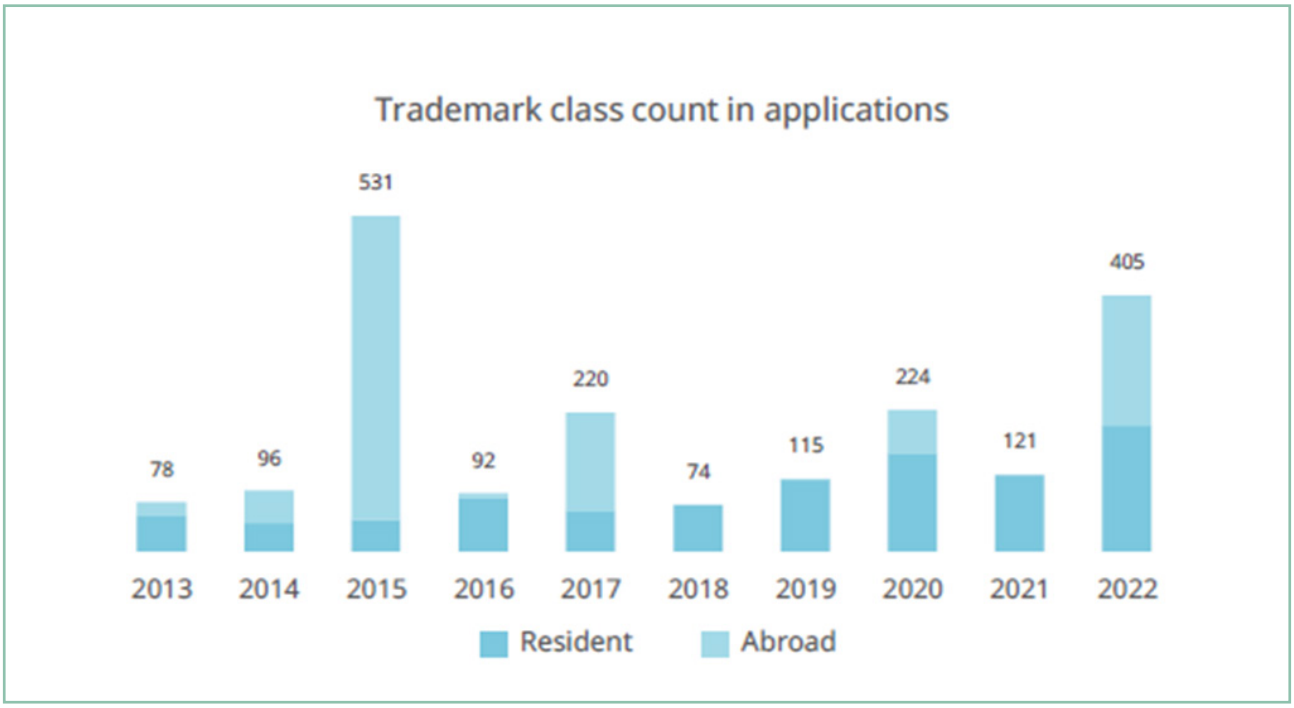
abroad) to 74 in 2018 (only from residents). In 2022, there were 405 trademarks applications (with 199 resident fillings). However, numbers are very volatile and there were for instance 531 applications in 2015, mostly from abroad, while in 2018 and 2019 there were respectively 74 and 115 applications, and only from residents. ***Figure 9*** summarises trademark applications in the Gambia across resident status.

FIGURE 8.
SCIENTIFIC PUBLICATIONS AND THE SDGs IN GAMBIA



Source: Janosov et al. analysis for the JRC based on Scopus data.

FIGURE 9.
TRADEMARK APPLICATIONS IN THE GAMBIA



Source: WIPO Intellectual property statistical country profile 2022

According to Daniels et. al (2024), there were eight innovative and tech hubs in 2022 in the Gambia, as well as twenty-five start-ups targeting SDGs that operate mostly in fintech, cleantech and jobs. Although the start-up landscape appears dynamic (Stakeholder interview, 2024), one of the main challenges is accessing reliable data.

One of the main constraints that both innovative hubs and start-ups face is the lack of direct funding from the government (Stakeholder interviews, 2024). Moreover, other major impediments are (i) the lack of financial incentives to support innovation, (ii) the lack of credit or private equity to support SMEs and R&D and, (iii) the lack of technical skills (OACPS et. Al., 2022). To operate, some start-up, for instance in the food processing sector, rely on grants from donors for funding and operate on a project basis and do not manage to scale up (Stakeholder interview, 2024).

Accessing reliable data on technology and innovation is a challenge in The Gambia. For instance, there is no Global Innovation Index (GII)[34] data. Moreover, indigenous knowledge is not well captured by the available data, which may also give rise to an underestimation of the actual level of innovation in the Gambia.

2.2. MAIN STI ACTORS AND INNOVATION COLLABORATIONS

The section provides an overview of key actors and collaboration in The Gambia's national system of innovation (NSI), with emphasis on stakeholders that are active in the STI and food system. With the NSI as the guiding theoretical and underpinning framework, this section covers actors that are representative[35] of four stakeholder groups: i) academia – which are the primarily knowledge and skills producers and central to capacity building; ii) government – ministries, departments and agencies involved in STI and food systems; iii) industry and private sector actors – primarily involved in commercialisation of knowledge, science and technology, drives innovation performance, and in some cases involved in knowledge production; and, iv) civil society organisations (CSOs) at national, regional and international levels. Specific attention is paid on grassroots innovation actors in The Gambia's local innovation ecosystems while highlighting organisations engaged in addressing sustainability challenges.

Starting with actors in the knowledge and skills production quadrant, the newly established University of Science, Engineering and Technology (USET)[36], with the Center of Excellence on Science, Technology, and Engineering for Entrepreneurship[37] produces knowledge on STI and entrepreneurship, alongside capacity building that also includes engineering. Another key actor in this stakeholder group is the University of the Gambia, with the School of Agriculture and Environment Sciences, which "provide the human resource base required to manage and develop the country's agriculture and natural resources (land, marine and aquatic) in a sustainable manner in order to provide food, employment, income and recreational resources for the people of The Gambia"[38].

The Ministry of Higher Education, Research, Science and Technology (MOHERST), and the Ministry of Basic and Secondary Education (MoBSE) are prominent in the government group of stakeholders. With the food system and environmental sustainability as the focus of this exercise, other key actors include the Ministry of Agriculture (MoA), Ministry of Environment, Climate Change, Water Resources, Parks and Wildlife, Ministry of Health (MOH) and National Nutrition Agency (NaNA).

34 *See information available at:* ***https://www.wipo.int/global_innovation_index/en/****.*

35 *The goal is to present a representation of actors in the relevant stakeholder groups rather than a comprehensive and exhaustive list.*

36 *Which is developed from The Gambia Technical Training Institute (GTTI)*

37 ***https://ace.aau.org/ace-impact-centers/****,* ***https://gtti.gm/center-o-excellencec/***

38 ***https://www.utg.edu.gm/schools-faculties/agriculture-and-environment-sciences/***

During the in-person workshop, the participants emphasised the importance of a strong linkage between food and health, alongside environmental and social implications – in line with the SDGs.

Concerning the industry, private sector, and innovation performers stakeholders group, key actors include the Gambia Chamber of Commerce and Industry (GCCI), Gambia Investment and Export Promotion Agency (GIEPA), Tropingo Foods Ltd, National Food Security Processing and Marketing Corporation, the Senegalo-Gambian Network of Women Entrepreneurs and Leaders, Women Breeders Association and innovation and digital hubs/labs, incubators and start-ups. ***Box 2*** describes the activities and the key challenges faced by Start-up incubator Gambia whose activities reflect the dynamic start-up ecosystem in the Gambia.

Lastly, we have actors from international organisations and civil society organisations (CSOs) at national, regional and international levels. These actors shape the STI ecosystem in several ways including agenda setting in relevant policies and regulations, advocacy, ensuring alignment with social issues, climate change and the SDGs, and funding. Actors in this group include the African Development Bank (AfDB), the Economic Community of West African States (ECOWAS), the European Union (EU) and European Commission (EC), which funds the STI for SDGs initiative and OACPS Policy Support initiative that has supported the Gambia in developing the National Research and Innovation Fund; FAO: Food and Agricultural Organisation of the UN, the French Agricultural Research Centre for International Development (CIRAD)[39], World Bank (WB); International Finance Corporation (IFC) and International Fund for Agric. Development (IFAD) and several UN agencies: UNFPA, UNDP, UNCTAD, UNESCO, UNCDF, UNICEF, WFP.

Combined, these actors in the four quadrants (see ***Figure 4***) shape the regulatory and policy space on STI and food systems, and are responsible for policies such as the National STIP (1524), National Nutrition Policy (2018-2025), the Agriculture and Natural Resources Policy (ANRP 2017-2026), the Social Protection Policy (2015-2025), National Health Policy (2021-2030), National Trade Policy (2018-2022), the National Gender Policy (2010-2020), Recovery-Focused National Development Plan (RF-NDP 2023-2027), and The Gambia National Agricultural Investment Plan II – Food and Nutrition Security (GNAIP II-FNS 2017-2026). Figure 10 below presents a summary of the governance and specific linkages/interactions among the stakeholder groups is presented in ***Section 2.3***.

There are very few initiatives to reinforce coordination within the key stakeholders of the STI ecosystem that could join forces and contribute towards improving food self-sufficiency, including accross Ministries. For instance, through the higher education institutions, the innovation and entrepreneurship hubs are being linked with mixed farming centres in the regions. However, stakeholder consultations revealed that innovators still lack knowledge of the needs of the end beneficiaries to build viable products with market potential.

Although stakeholders and policy documents are aligned on the significant potential of STI to improve food self-sufficiency, stakeholder consultations highlighted weak cooperation among actors of the STI ecosystem, who tend to work in siloes (Stakeholder interviews, 2024). Insufficient cross-sectoral alignment and coordination result in missing opportunities and inefficiencies. Researchers must better coordinate with end users to align their investigation with key priorities to increase food self-sufficiency. For instance, cooperation with farmers to improve current food conservation techniques or develop new seeds.

2.3. STI POLICY AND GOVERNANCE IN RELATION TO THE FOOD SYSTEMS

The NDP positions STI as a clear means to tackle the sustainability issues, and STI instruments are mentioned in each of the eight pillars of the

39 *Centre de coopération Internationale en recherche agronomique pour le développement (CIRAD)*

BOX 2. START-UP INCUBATOR GAMBIA

Description of this activities

- Established in 2015 as the first business incubator in The Gambia, the Startup Incubator Gambia offers entrepreneurship training programmes to Gambian entrepreneurs and startups, including six (6) month Incubation, Acceleration, and Scale up programme, seed funding opportunities, and business development advice, access to mentors and resources to enable their business growth.
- The incubator works with industry experts to provide mentoring services and has in its network 25 coaches spread across all regions of the Gambia that provides handholding support to entrepreneurs as they work through their businesses to improve their survival rate.

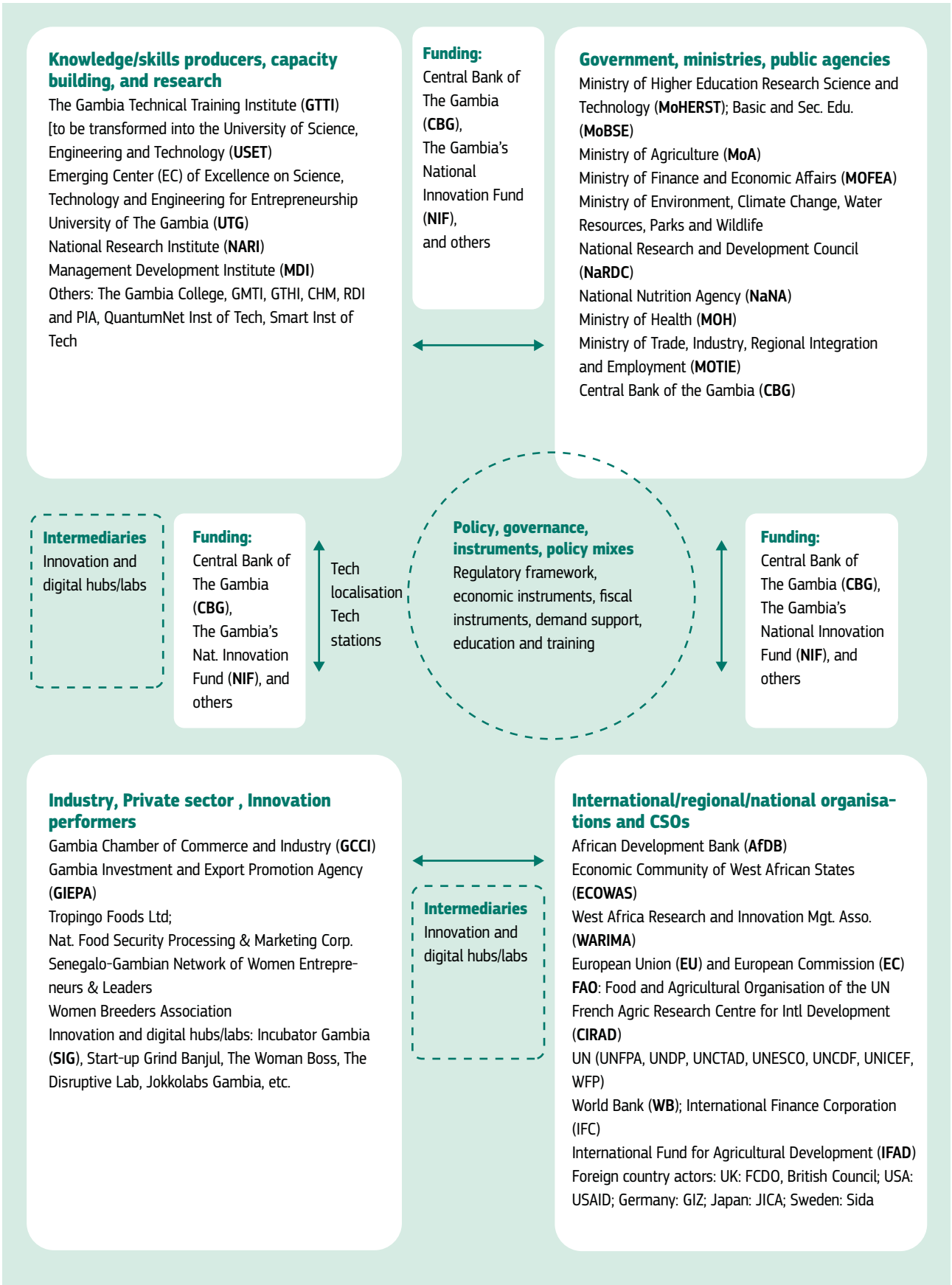
Outreach

Through its numerous programmes, the incubator has supported over 3000 entrepreneurs including youth women and returnee migrants and created over 2000 jobs in diverse sectors of the Gambia's economy.

Key challenges

- Inadequate source of sustainable funding.
  - As an NGO, they rely on donor funding to support the businesses that require their services. There is no direct support from the government.
  - Part of the business model dwells on consulting services and rentals of coworking spaces supports operations and overhead expenses (rentals, internet and electricity which comes at a very high cost).
  - Low financial capacity of the start-ups to contribute financially
- Access to technology and equipment.
  - 3D printers to support the product development efforts of the businesses.
- Information. Identifying promising ideas from remote areas with high business potential (e.g. indigenous knowledge in agriculture, etc.)

FIGURE 10.
ACTORS AND STAKEHOLDERS IN THE GAMBIA STI SYSTEM IN RELATION TO THE FOOD SYSTEMS



Source: JRC

NDP. More specifically, according to the NDP, STI can contribute directly to 21 of the 30 outcomes prioritised within the plan. Moreover, the NDP highlights that producing scientific knowledge and research may contribute to tackling climate change, to improve the benefits from the tourism potential and the inclusion of persons with disabilities.

The mission of the 2015 – 2024 STI policy does not emphasise the role of STI as a direct means to tackle sustainability challenges. More specifically, the mission of the STI policy is to "build and strengthen national capacity and competencies in STI that will enhance the attainment of economic development and national competitiveness." However, some general objectives of the STI policy mention the clear role of STI to tackle sustainability challenges.

The STI policy includes objectives that may directly contribute to improving food self-sufficiency. More specifically, it aims to modernize agriculture through STI to create quality products and services for sustained economic growth[40]. Through a dedicated section, the STI policy highlights the role of STI in improving "Agriculture, the Environment and Natural Resources (AENR)". It emphasises the potential of STI to increase production and productivity (e.g. "increase the human resource capacity in agricultural research and transfer of technologies", or "develop research in areas such as soil and water management and conservation, rice genetics and management"). It also relates to the other elements of the food systems such as storage (e.g. strengthen and, where necessary, establish modern storage facilities and preservative technologies for agricultural produce) and distribution (e.g. "make innovative use of ICTs to inform, educate and sensitise farmers [...] on market prices").

Specific objectives of the STI policy regarding Research and Development (R&D) include elements that may directly increase food self-sufficiency such as "strengthening ethical standards and regulatory mechanisms to monitor, evaluate and control food, [...] as well as in the conduct of research", "provide a sustainable research and high performance computing space needed to support scientific research at all levels in order to enhance crop and livestock production, reduce environmental degradation", or "provide incentives for pro-poor agro-processing technology development". Promoting "research in conservation programmes, including biodiversity, ecology, habitat and wildlife management" and strengthening "STI R&D capacity to monitor, predict and mitigate the adverse effects of climate change, agriculture, disaster management, renewable energy, health and hazardous chemicals".

The ANR Policy highlights the kep role of STI in addressing food self-sufficiency through increasing productivity. The need to improve productivity and efficiency in the production of food, which will "necessitate the realization of production processes and methods that are highly intensive in technology usage". R&D will be based upon the following considerations: R&D activities will be restructured to be conducive to creativity and innovation, they will be more focussed on areas that need immediate solutions and identified potential winners; and, they will promote the development of high technology but low-input system such as integrated pest management. All R&D activities must promote investment in pro-poor, pro-environment programmes to mainstream poverty-environment into national, sectoral and sub-sectoral developments from policy making to budgeting, implementation and monitoring.

The analysis of key policy documents also revealed recommendations to address similar STI needs across policies. For instance, the STI policy encourages the development of "an efficient pesticide application through research and development in recycling technology to minimise pollution" while the ANR policy promotes "the development of high technology but low-input system such as integrated pest management". Information on STI projects is dispersed and one first step to improve collaboration would be to centralise relevant projects within an online plaform.

40 Long-term Objectives 1.5.4.3.5 and 1.5.4.3.6.

The commitment of The Gambia to harness, utilise and advance STI is reflected in the establishment of the Ministry of Higher Education, Research, Science and Technology (MoHERST) in 2007, University of The Gambia (UTG) in 1999, the formulation of the Programme for Accelerated Growth and Employment (PAGE) 2012 – 2015 and the Presidential Declaration of 2012 as the Year of STI in The Gambia.

The MoHERST is the sector ministry mandated to coordinate the implementation of the National STI Policy. This mandate is delivered through the various relevant institutions that have critical stakes in STI. The Ministry provides policy direction in consultation with the established structures contained in the STI policy (2015 -2024 STI policy).

More specifically, the MoHERST has a coordination, monitoring and evaluation role for STI activities in the Gambia. It strengthens the national innovation system, for instance through facilitating the establishment of STI entities and encouraging the commercialisation of the R&D outcomes of public research institutions. Moreover, it enhances cooperation in the fields of STI with other countries, international organizations and agencies. Through its activities and programmes, it also contributes to improving the capacities and capabilities of the Gambian industries. Moreover, it gathers and disseminates STI intelligence through data collection and analysis.

The National Council for STI (NCSTI) comprises members from government ministries and other sectors. It provides advice to the ministries on STI issues and implementation strategies to ensure that STI is responsive to the needs of the country. It facilitates the harmonisation and coordination of the country's STI policy so that its activities are comprehensive, complementary and reinforcing across all the sectors and ministries. It also contributes to the monitoring and evaluation of the implementation of the STI policy to ensure that the activities initiated are relevant and beneficial to The Gambia.

The National Assembly Select Committee on STI serves as an auditing arm and an oversight function of the government on STI. It carries out a quarterly review and assessment of the impact of STI in the country. It also assists in the promotion and development of STI in the country.

The main functions of the Ministry of Agriculture are to formulate policies for the development of the agricultural, fishing and rural development sectors; and to manage the formulation of plans, programmes and projects needed to develop these sectors.

2.4. POLICY IMPLEMENTATION AND SUPPORT PROGRAMMES

In line with the limited resources allocated by the government budget to STI through the MoHERST, there is a limited number of instruments to finance STI in the Gambia. The MoHERST can directly leverage two main instruments: the *MoHERST Strategic Plan 2021 – 2025 and the National Research and Innovation Fund Bill 2024*.

MOHERST STRATEGIC PLAN 2021 - 2025

Strategic Plan for the MoHERST sector ensuring scientific research and technology development serves as a critical enabler in the development of the country. The objectives of the Srategic Plan are as follows:

- Increasing access
- Ensuring quality and relevance of scientific programmes
- Strengthening scientific research and technological development
- Ensuring a coordinated approach and systems for STI in The Gambia

The instrument gives great prominence to agricultural productivity and food self-sufficiency drive of The Gambia. The Strategic Plan is funded by international donors such as the European Union (EU), World Bank (WB), United Nations Educational, Scientific and Cultural Organization (UNESCO), and Korea International Cooperation Agency (KOICA).

For instance, KOICA supported the a USD 3 Million TVET development project, which focussed on bringing all TVET actors and harmonising interventions, developed policies and strategies, and supported the procurement of equipment, as well as several capacity development initiatives.

Moreover, the World Bank through the Africa Higher Education Centres of Excellence is supporting the establishment of an emergent Centre of Excellence for Science, Technology and Engineering for Entrepreneurship (STEE), which serves as the first phase of the establishment of the Gambia University of Applied Sciences and Technology (USET). This support is at a tune of USD 12 Million and includes construction of facilities, equipment, mentorship support, and several capacity development packages to support the establishment of the USET.

The European Union also supported several TVET and entreprenruship related programmes accross diverse sectors of the economy aimed at addressing youth un-employment and curbing irregular migration to Europe. Also, the EU supported the development of a consultancy to assess the Gambia's readines for the establishmnent of a National Innovation Fund, which set the stage for the the legislation and establishment of a National Research and Innovation Fund.

NATIONAL RESEARCH AND INNOVATION FUND BILL 2024

The Ministry of Higher Education, Research, Science and Technology (MoHERST) manages the National Research and Innovation Fund Bill and funding will be provided by the Ministry of The Gambia, and potential funders from International Organisations. The bill seeks to propose a funding model for scientific research, technological development, as well as innovation and entrepreneurship projects in The Gambia. The bill has identified priority areas for funding research and innovation projects in line with the MoHERST Strategic Plan (2021 – 2025) and the prevailing National Development Plan. The NRIF will fund in priority research and innovation activities in agriculture and food self-sufficiency.

Several international donors finance initiatives that contribute to food self-sufficiency, including:

- **EbA project.** This project has three main components: (i) Restoring degraded forests and agricultural landscapes with climate-resilient plant species that provide goods for consumption or sale, (ii) Facilitating the establishment of commercially viable natural resource-based enterprises to be managed by community-based organizations, (iii) Policy support, institutional strengthening, knowledge generation and management to support large-scale implementation of EbA in The Gambia. It is a collaboration between (i) The Ministry of Environment, Climate Change and Natural Resources, (ii) The United Nations Environment Programme (UNEP), (iii) the Green Climate Fund (GCF), the World Agroforestry (ICRAF), and Prime Africa. One contribution is a multipurpose centre (possible sample centres – to process, package, labelled and access to market).

- **Shonghai – Agricultural Training Centre.** Through the support of the United Nations Development Programme (UNDP) the centre aims to improve their training facilities with structures/ infrastructures. It supports the initiatives of the undergoing development of laboratories for product testing and certification for access to markets. It works closely with Ministry of Trade, Regional Integration and Employment (MOTIE), The Gambia Standards Bureau (TGSB), National Agricultural Research Institute (NARI), and Food Safety and Quality Authority (FSQA).

- **World Bank.** The World Bank supports several projects with the Ministry of Agriculture all aimed at building capacities for food self-sufficiency. Specifically, they are aimed at providing farmers with the relevant skills and competencies that will ensure enhanced productivity in all fields of agriculture.

3. STI GAPS AND AREAS OF OPPORTUNITY TO IMPROVE FOOD SELF-SUFFICIENCY

This section highlights STI opportunities to address the sustainability issues within all the relevant segments of the food system, namely in food production, food aggregation, food processing, food distribution and storage, and food consumption.

3.1. FOOD PRODUCTION

STI investments may enable to remove several barriers to increasing crop production and farmers' productivity. Stakeholder consultations highlighted three main impediments to higher crop production and productivity in farming[41]: limited access to productive inputs and technology, decreasing labour force, low skills. To improve access to productive inputs in the Gambia, there may be several cost-efficient avenues to explore.

High costs of fertilisers result in low adoption rates, and stakeholders mentioned several ways to decrease the costs (and the volatility in prices) of both organic and inorganic fertilisers. First, the local production in fertilisers is low, and transfering adequate technology to produce local fertilisers at low cost may improve adoption while reducing dependency on imported fertilisers whose prices are volatile. Moreover, promoting (and providing training) fertigation techniques to optimise use may minimise wastage (Roundtable discussions, 2024). Designing innovative financial schemes to enable farmers to pre-finance the purchase of their fertilisers may also result in higher adoption rates. In parallel, developing well-equipped testing labs to ensure that inorganic fertilisers are not harmful to soils may improve the long-term impact of measures promoting the adoption of chemical fertilisers.

Finding quality seeds is often a challenge for farmers who mostly exchange seeds among each other through informal channels. To support farmers to access quality seeds, stakeholders mentioned the need to improve the capacity of the seed testing secretariat, including to set up regional testing labs (Roundtable discussions, 2024). This would enable all farmers to better benefit from the indigenous knowledge accumulated by other farmers[42], while contributing to integrate the informal seed sector into the informal seed sector by identifying quality seeds to duplicate on a larger scale[43]. In addition, to reduce financial barriers to access quality seeds, developing innovative financial schemes and products may benefit smallholder farmers.

To address the issue of low access to fresh water besides the rainy season, hence allowing farmers to grow more food and over a longer period of time, improving access to irrigation techniques is essential. Stakeholders highlighted the need for frugal innovation to develop innovative and affordable irrigation systems to transport water from sources to farmers. Moreover, they mentioned the need for research and innovation to develop technology to transform salty water into fresh water (Stakeholder group discussions, 2024).

41 Stakeholders were consulted through an online survey, interviews and two workshops.

42 The informal exchanges of seeds among farmers represent 90% of the seeds used (NSP, 2018).

43 Such gaps has also been identified within the 2018 – 2028 National Seed Policy (NSD).

Finally, leveraging technology to train farmer on water-saving practices (e.g. drip irrigation), for instance through mobile phone extension services, may empower them at low cost.

Stakeholder consultations reported the need to improve the skills of the technicians to translate "modern day scientific knowledge agricultural practices" (Roundtable discussions, 2024). Moreover, grassroots innovation appears to be an untapped potential. For instance, local initiatives for rice cultivation have proved to be efficient to grow rice in regions facing high salinity. More specifically, some local farmers successfully grow a certain variety of rice in fresh water for three months before transplanting plants into salty water. Such initiative could be scaled up through adequate knowledge diffusion. In the same fashion, to fabricate artisanal greenhouses, some local farmers also use specific fabric with good results on yields (Roundtable discussions, 2024). Awareness of such techniques among farmers could enable to improve farming practices at low cost.

Like in crop production, the lack of technology to produce meat production is also a predominant impediment to increase productivity. Stakeholder consultations highlighted the limited availability of state-of-the-art farm machinery for animal production such as milking parlours (JRC Roundtable discussions, 2024), hence advocating for technology transfer and training for farmers. Affordability seems to be another impediment to adoption, and frugal innovation may play an important role in improving accessibility, hence uptake.

In the fishing sector, the lack of access to technology (even low tech) is preventing local fishermen to compete with small scale farmers from abroad, for instance from Mali. Unlike Gambian fishermen, foreign fishermen have access to motorised boats, whose engines are built from the recycling of motors from motorbikes or other machines. To improve the productivity of fishing, connecting fishing organisations with innovators who could produce low-tech engines for fishing boats could drastically improve productivity and decrease the adverse effects of foreign competition from fishermen from neighbouring countries.

3.2. FOOD AGGREGATION

Technology and innovation may enable to improve food aggregation in several manners. First, access to finance is a major impediment to food aggregation. To help small traders (who are mainly working informally) to increase capacity, developing innovative financial schemes that are tailored to their business may allow them to purchase bigger quantities of agricultural products, which would also be benefitial to farmers.

In addition, measuring food production is a challenge, and installing weighbridges in strategic location could benefit the whole value chain. Moreover, connecting these weighbridges with an online platform enabling farmers to easily record available quantities produced within their geographical location could help aggregators to anticipate financial needs and better plan, while reducing searching costs.

Securing payment is also an issue for all stakeholders, and developing innovative payment systems may drastically improve aggregation. For instance, a system in which retailers or wholesalers prepay harvests on an online state-owned platform, with the payment to farmers and traders being released once traders bring quantities to retailers or wholesalers, could guarantee security for both farmers and traders, and remove liquidity constraints for traders. It would also improve transparency on prices, which may be benefitial to farmers.

3.3. FOOD PROCESSING

Despite a dynamic start-up ecosystem with a few innovators managing to produce food processing machines, several impediments prevent the Gambia from having higher food processing rates.

Access to finance is a major constraint for innovators and stakeholder discussions (Stakeholder interview, 2024) mentioned the need

to design innovative financial schemes to help innovators reducing dependency on donors for their development. For instance, public schemes supporting promising innovators to access loans from commercial banks without collateral (e.g. guarantee fund, etc.) may be explored.

Despites the fact that local innovators manage to produce processing machines at lower costs than imported processors, accessibility to processing machines for local farmers is still an issue. Due to low levels of trust in cooperatives in the Gambia, which usually enable smallholder farmers to process their goods and increase the value added of their products, developing innovative types of farmers' organisations to allow farmers to share the costs of the processing machines may be needed.

Developing processing machines using renewable energy (e.g. solar) would enable to remove the constraint of access to electricity in rural areas in the Gambia, while decreasing the use of heavy generators, which create both air pollution (due to unburn carbon) and noise.

Finally, stakeholders reported the need to improve processing and maintenance skills, as well as hygiene and safety practices. Developing trainings at all levels of processing, including on waste management practices and processes, may also reduce pollution (Roundtable discussions, 2024).

3.4. FOOD DISTRIBUTION AND STORAGE

In the Gambia, adequate storage facilities (and storage bags) are lacking, in particular for highly perishable products. Stakeholders mentioned the need to develop regional storage facilities, such as cold rooms, which would highly benefit the fishing industry, and other value chains such as the melon value chain (Roundtable discussion, 2024).

To better control price volatility due to uncoordinated in-country movements of goods from one region of the country to another, an online platform to record quantities available and traded within regions may be impactful. Besides enabling farmers to increase access to market, it may also bring insightful information to the government to prevent trade movements that may be detrimental to consumers.

There is a substantial amount of indigenous knowledge on food preservation (e.g. smoking fish, meat drying, etc.), and stakeholders suggested to launch research programmes with Universities to scientifically evaluate indigenous knowledge (Roundtable discussions, 2024). Such programme could also enable to improve such conversation techniques based on scientific evidence.

3.5. FOOD CONSUMPTION

The main sustainability issues related to food consumption in the Gambia are: lack of diversification in diets, food preparation, and safety and quality of food.

To provide access to a higher variety of food items to all Gambians, leveraging regional specificities (fish, rice, horticulture, etc.) is an untapped potential. More specifically, investigating new types of social organisations to better coordinate food distribution across regions may be promising (Roundtable discussions, 2024). To do so, a precondition is the improvement of the roads, as well as food production measurement facilities (see *Section 3.2* on food aggregation).

Besides food accessibility, cultural norms play a role in the lack of variety in Gambian diets (Stakeholder interview, 2024). Behavioural reesearch on food habits to better understand food consumption habits may enable to improve current awareness campaigns on nutrition.

Traditional cooking methods mainly rely on charcoal, which negatively impacts food quality and creates pollution (Roundtable discussions, 2024). Innovative and affordable cooking utensils relying on clean energy must be developed.

Finally, to ensure safe food consumption, developing regional testing facilities (i) to measure residues of pesticides or fumigants and (ii) test a variety of pathogen agents in street food may also enable to design adequate trainings for both farmers and street sellers.

4. PARTICIPATORY DELIBERATION OF THE CHALLENGE-ORIENTED STI AREAS

Chapter 3 highlighted sustainability gaps in the food system that could be addressed through science, technology and innovation to improve food self-sufficiency in the Gambia. Roundtable discussions during the in-person workshop enabled the stakeholders to select the STI areas that can contribute to improve food self-sufficiency in the Gambia. This section summarises the STI needs selected by stakeholders across the five segment of the food system, as well as how they fit with current policy priorities.

4.1. STI NEEDS IN FOOD PRODUCTION

Chapter 3 highlighted that most seeds available lead to poor yields, which impedes the productivity and, subsequently, the level of production of the farmers. Moreover, climate change is harming yields and poses a further threat to food self-sufficiency.

Table 3 summarises the selected areas established by the stakeholders during the workshop in terms of sustainability issues related to production, identified STI needs, and how it fits into the relevant policy priorities.

4.2. STI NEEDS IN FOOD AGGREGATION

Food aggregation is an important challenge in the Gambia as it prevents smallholder farmers from accessing markets and getting fair prices for their harvests. Two major impediments to aggregation are the lack of data on available production and marketing products and limited access to financial services.

To help aggregators to estimate potential quantities, positioning weighbridges at strategic locations may be an efficient intervention. Quantities measured could then be shared to relevant stakeholders online to ease aggregation, which would also help them marketing their products. Increasing the penetration of mobile banking may facilitate transactions, but providing internet connectivity in rural areas is a precondition.

Table 4 summarises the selected areas indicated by the stakeholders during the workshop, considering sustainability issues identified STI needs, and how they align with the relevant policy priorities.

4.3. STI NEEDS IN FOOD PROCESSING

Two major impediments to food processing are the high cost of machineries, and access to electricity. Local start-ups have the capacity to produce suitable machines. However, to decrease costs they need financial support to scale up, which may enable them to decrease costs. Creating processing centres that use solar and other forms of renewable energy as an alternative energy for food processors would benefit the value chain. Processing skills are also lacking and knowledge sharing through digital platforms may be a useful tool (e.g promoting sustainable processing practices that improve food safety and environmental health). Food waste during processing is an important issue, and promoting innovation in storage is needed.

Table 5 summarises the selection established by the stakeholders during the workshop in terms of sustainability issues relating to food processing, identified STI needs, and how it fits into the relevant policy priorities.

TABLE 3.
SUMMARY OF THE STAKEHOLDER SELECTION AND RELATED POLICY PRIORITIES – PRODUCTION

Challenge-oriented STI area	Short description of the issue and underlying causes	Environmental and social consequences	Suggested STI need	Related priorities in key policy documents
Availability of quality seed	Most of the seeds available are not certified and lead to poor yield. Weak seed testing secretariat.	The seeds may not be resilient to environmental impacts. Low level of production and productivity	• Well-equipped food certification lab in the regions. • Dissemination of indigenous knowledge	NDP[44]. Introduction and promotion of hybrids. NSP. Ensuring adequate and timely availability of quality seed to farmers at reasonable prices and at appropriate locations. ANR. Enhancement of the role of farmer-based seed initiatives including on-farm see selection and multiplication, community seed farms and village seed stores[45]. NSP. Improve seed quality and testing. NDP[46]. Labs to test and certify products. NSTIP. 3.5.8.7 build specialized centres of agricultural research, specifically biotechnology, molecular biology, entomology and plant genetics;
Low level of irrigation	Access to available water for irrigation	Vulnerability to droughts. Low level of production, income.	• Technology to maximize the usage of water (eg promote through drip irrigation)	NDP[47]. Promoting water - labour efficient technologies. NSTIP. 3.5.8.4 promote the use of modern irrigation technologies and methods to better utilize the fresh waters of the River Gambia for an all-year-round agricultural production;
High cost of fertilizer	The cost of fertilizer (organic and inorganic) is very expensive	Poor soil structure. Low output.	• Fertigation techniques to minimize wastage	NSTIP. 3.5.8.10 strengthen soil and water resources management on all croplands to improve and sustain the agriculture sector;

44 Outcome 5.1: A modern, productive and sustainable agriculture for food and nutrition security, economic growth and poverty.

45 Supported by technical efforts in improving germplasm base of farmer-saved seeds, incorporation of relevant seed quality control elements into the informal seed sector practices and reduction of post-harvest losses and deterioration.

46 Outcome 3.2: A Private Sector-Led Growth with enhanced Trade and Services, Inclusive and Sustainable Industrialization, and increased Employment.

47 Outcome 5.1: A modern, productive and sustainable agriculture for food and nutrition security, economic growth and poverty.

TABLE 4.
SUMMARY OF THE STAKEHOLDER SELECTION AND RELATED POLICY PRIORITIES – FOOD AGGREGATION

Challenge-oriented STI area	Short description of the issue and underlying causes	Environmental and social consequences	Suggested STI needs	Related priorities in key policy documents
Measuring available production	Potential aggregators (cooperatives, traders, etc.) are not aware of the exact quantities produced. They need information to make better decisions on both imports and export products.	Lack of access to market for small producers, which results in lower incomes. Lower potential profit for aggregators. Food waste.	Weighbridges at strategic locations. Quantities measured could then be shared to relevant stakeholders online to ease aggregation.	NDP[48]. Connectivity platform to the regional and continental markets NSTIP. 3.5.8.15 invest in R&D to develop market information systems for agricultural products; NDP[49]. Facilitate and organize producers into groups or cooperatives
Ease market linkages	Help farmers marketing their products.	Lack of access to market for small producers, which results in lower incomes. Lower potential profit for aggregators. Food waste.	Reliable digital marketing and payment platforms (e.g. wave, digital banking, etc.)	NDP[50]. Agricultural value chain financing and agriculture-centred financial products. Mobile banking/ Digital Financial Services (DFS).

48 *Outcome 3.2: A Private Sector-Led Growth with enhanced Trade and Services, Inclusive and Sustainable Industrialization, and increased Employment.*

49 *Outcome 5.1: A modern, productive and sustainable agriculture for food and nutrition security, economic growth and poverty reduction*

50 *Outcome 3.2: A Private Sector-Led Growth with enhanced Trade and Services, Inclusive and Sustainable Industrialization, and increased Employment*

TABLE 5.
SUMMARY OF THE STAKEHOLDER SELECTION AND RELATED POLICY PRIORITIES – FOOD PROCESSING

Challenge-oriented STI area	Short description of the issue and underlying causes	Environmental and social consequences	Suggested STI needs	Related priorities in key policy documents
1. Food Processing Capacity	Inadequate access to electricity (erratic) for processing, storage (inadequate or non-existent) and processing centres.	Air pollution (unburn carbon) Low processing rates and low value added creation. Noise from heavy generators	Creation of processing centres that use solar and other forms of renewable energy as an alternative energy for food processors	NDP[51] Invest in research and adoption of renewable energy from carbon-free sources. NSTIP. 5.4.1.20 provide incentives for pro-poor agro-processing technology development and for entrepreneurs/ MSMEs that commercialize technological ideas and research findings;
2. High Cost of processing equipment and packaging	High cost of machinery (Modern), low potential start-ups.	Low processing rates and low value added creation Food waste	• Promote and boost innovation in storage and processing • Promote knowledge sharing through digital platforms	NDP. Establish incubation centres, and science and technology parks. NSTIP. 3.5.8.15 invest in R&D to develop market information systems for agricultural products;

51 *Outcome 5.3: Sustainable environmental and natural resources management, enhanced climate action and disaster risk reduction*

4.4. STI NEEDS IN FOOD DISTRIBUTION

Safe food distribution faces a systemic lack of infrastructures for safe food preservation, which makes it difficult to set up a safe cold chain. Access to cold rooms would enable to improve the management of the fishing value chain, and better value fish products while decreasing waste.

Table 6 summarises the selection by the stakeholders during the workshop of the sustainability issues related to food distribution, identified STI needs, and how they fit into the relevant policy priorities.

4.5. STI NEEDS IN FOOD CONSUMPTION

According to the stakeholders, the two main issues relating to food consumption that must be addressed in priority are food safety and quality and affordability.

Table 7 summarises the selection established by the stakeholders during the workshop in terms of sustainability issues related to food consumption, identified STI needs, and how it fits into the relevant policy priorities.

TABLE 6.
SUMMARY OF THE STAKEHOLDER SELECTION AND RELATED POLICY PRIORITIES - FOOD DISTRIBUTION

Challenge-oriented STI area	Short description of the issue and underlying causes	Environmental and social consequences	Suggested STI needs	Related priorities in key policy documents
Conservation of perishable products	Lack of cold rooms (for the fisheries, etc.). Hard to set up a safe cold chain.	Unsafe products Waste	Build cold storage facilities at strategic locations	NDP[52]. Improve management and ensuring the sustainability of fisheries resources of The Gambia. NSTIP. 3.5.8.5 strengthen and, where necessary, establish modern storage facilities and preservative technologies for agricultural produce
Efficient food distribution	Timely food distribution is an issue. Inadequate timing increase food volatility in prices.	Higher prices and lower access	Invest in tracking devices to improve food distribution (reduce turnaround)	NSTIP. 3.5.8.15 invest in R&D to develop market information systems for agricultural products;

52 *Outcome 5.2: A vibrant fisheries and aquaculture sector contributing to economic growth and employment creation.*

TABLE 7.
SUMMARY OF THE STAKEHOLDER SELECTION AND RELATED POLICY PRIORITIES – CONSUMPTION

Challenge-oriented STI area	Short description of the issue and underlying causes	Environmental and social consequences	Suggested STI needs	Related priorities in key policy documents
Safety and quality of food	Reliance on inorganic fertilizers. Residue from pesticides and fumigants used for food preservation Limited quality assurance for street foods, imported foods, processed foods	Food borne illnesses because of consuming unsafe food Malnutrition	• Build food testing laboratories • Build capacities, both human and institutional (labs) • Put in place a robust monitoring using online and other digital technologies (toll free lines), verification, reporting and response	NDP[53]. Labs to test and certify products NSTIP. 3.5.8.7 build specialized centres of agricultural research, specifically biotechnology, molecular biology, entomology and plant genetics to strengthen the agriculture sector;
Affordability	Limited purchasing power for nutritious food.	Malnutrition	• Giving priority to agricultural sector within the national research and innovation fund to find ways to produce cheaper and more diverse food • Evaluate the responsiveness of the beneficiaries to government subsidies through social researc	NDP[54]. Develop year-round integrated food production schemes NDP[55]: Supporting social and behavioural change communication to promote the production and consumption of micronutrient-rich vegetables.

53 *Outcome 3.2: A Private Sector-Led Growth with enhanced Trade and Services, Inclusive and Sustainable Industrialization, and increased Employment.*

54 *Outcome 1.1 Community level resilience to shocks and crisis enhanced.*

55 *Outcome 5.1: "A modern, productive and sustainable agriculture for food and nutrition security, economic growth and poverty".*

5. PROPOSED ACTIONS FOR THE STI FOR SDGs ROADMAP

This section presents an action plan that outlines essential investment areas and policy instruments aimed at addressing the challenge of food systems transformation through STI, with the goal of contributing to the SDGs. The actions identified are based on comprehensive inputs from stakeholders, gathered through workshops, interviews, and surveys, ensuring that they are contextually relevant and feasible. The following table categorises these actions by specifying responsibilities, expected outputs, and timing.

Food system Segment – Challenge-oriented STI Area	Actions	Lead	Partners	Output and outcomes	Timing for initiation
Production – improving access to quality seeds	1) Undertake district farmer consultations to capture indigenous knowledge and identify the most productive seeds for the main staple crops.	NARI research stations and MoHERST	University of the Gambia and regional NARI research stations	**Output:** Report on the most productive seeds for the main staple crops in each region	Six months
	2) Launch partnerships with research institutions (and/or Universities) and analyse promising seeds and develop guidelines with best practices to use the seeds (and potentially to develop new varieties from the promising seeds).	National Agricultural Research Institute (NARI)	MoHERST University of the Gambia		One year
	3) Build regional certification labs to certify the adequate seeds (which involves providing adequate and up-to-date training to staff, potentially through partnerships with research institutions and Universities)	Food Safety and Quality Authority (FSQA)	MoHERST	**Output:** Well-equipped labs to certify adequate seeds	Two years
	4) Build a platform with extension services through mobile phones to inform farmers on the availability of the seeds and train them on the usage (see other synergies with plaform needs from other segments as all needs could potentially be addressed through one single platform)	Ministry of Communications and Digital Economy/private service provider & Ministry of Agriculture (MoA)	NARI and MoHERST	**Output:** Information platform with seeds availability and advice on adequate usage **Outcome:** improvement in yields	Two years

Food system Segment – Challenge-oriented STI Area	Actions	Lead	Partners	Output and outcomes	Timing for initiation
Production – water management	1) Train all extension workers on drip irrigation and fertigation techniques	Ministry of Agriculture (MoA)	Relevant training institution MoHERST	**Output:** more farmers have access to irrigation **Outcome:** improvement in yields	Six months
	2) Develop a national programme to develop and diffuse affordable energy and water-efficient irrigation techniques (e.g. focus on water harvesting and resuse)	MoHERST	MoFEA		One year
Aggregation - Measuring available production	1) Undertake regional farmer consultations to identify strategic location to install weighbridges	MoHERST	University of the Gambia	**Output:** Weighbridges in strategic location improve aggregation, farmers' access to market, hence incomes. **Outcome:** increased quantities traded. Higher incomes for farmers	Six months
	2) Create an online platform in order to share quantities (and market their products) registered at strategic locations with aggregators	Ministry of Communications and Digital Economy/private service provider & Ministry of Agriculture (MoA)	Farmer associations MoHERST		Two years
Aggregation - Ease market linkages	1) Raise awareness on current payment platforms	1) Ministry of Communications and Digital Economy	Ministry of Agriculture (MoA) MoHERST	**Output:** payment platforms to meet farmers' needs are available, which **Outcome:** increased traded quantities. Higher incomes for farmers	Ongoing
	2) Development partnerships with payment platforms to secure payments for farmers and traders, as well as to develop features enabling farmers to receive information on current market price for their products	2) Ministry of Communications and Digital Economy	Ministry of Agriculture (MoA) MoHERST		One year

Food system Segment – Challenge-oriented STI Area	Actions	Lead	Partners	Output and outcomes	Timing for initiation
Process-ing - Food Processing Capacity	1) Identify and test alternative processing machines based on re-newable energy (solar, etc.), both currently available in the Gambia and abroad	MoHERST	Relevant Uni-versity	**Output:** Report	One year
	2) Developing processing skills on current and new processing machines	Ministry of Agriculture	MoHERST	**Output:** N trainings de-livered (TBD)	Two years
	3) Development processing cen-tres at strategic location in rural areas (using solar energy)	Ministry of Agriculture	Start-up and innovation hubs MoHERST	**Output:** Five to ten **Outcomes:** higher process-ing rates, hence value added created. Higher incomes for farmers.	Two years
Processing/ Distribution -Storage	1) Organise a prize competition promoting frugal innovation to design affordable prototypes of intelligent storage (including cold storage) units. The prize would enable winners to develop their first storage units through financial support and partenrships with relevant research institutions.	MoHERST	Innovation hubs	**Output:** Identification of new cost-effec-tive solutions for storage re-ceive a prize to develop a first production	One year
	2) Undertake regional research study including extensive farmer consultations to identify strategic locations for the storage units	Ministry of Ag-riculture (MoA)	Universities & NARI MoHERST	**Output:** report	Two years
	3) Develop knowledge to install, maintain and repair these units; explore if key spare parts can be produced locally	Ministry of Ag-riculture (MoA)	Local or international funders / inves-tors MoHERST	**Output:** Installation of 5 to 10 storage units	Two years

Food system Segment – Challenge-oriented STI Area	Actions	Lead	Partners	Output and outcomes	Timing for initiation
Processing/ Distribution – Storage	1) Undertake district farmer consultations to capture indigenous knowledge and identify alternative ways to store food (e.g. drying, fermenting, etc.)	Ministry of Agriculture	NARI/Universities MoHERST	**Output:** Report	One year
	2) Launch partnerships with research institutions (and/or Universities) to (i) analyse promising methods, (ii) potentially improve them, and (iii) develop guidelines with best practices.	Ministry of Agriculture	Food Safety and Quality Authority (FSQA) and Food Safety and Quality Authority (FSQA) MoHERST	**Output:** new partnerships	
	3) Train farmers and relevant stakeholders on improved conservation techniques	Ministry of Agriculture	MoHERST	**Outcome:** lower food waste	
Food distribution	1) Organise a prize competition to create tracker devices for food trucks	MoHERST	NGO/Start-up and innovation hubs	**Output:** prize for companies to develop a first production of intelligent devices	Six months
	2) Develop a platform to track trucks to improve collection and delivery of food items	Ministry of Communications and Digital Economy	Ministry of Agriculture (MoA) MoHERST	**Output:** Well operating platform informing relevant stakeholder in real time about food transportation **Outcome:** reduction in food waste.	Two years
Food consumption – Food safety	1) Train agents to perform food testing	Food Safety and Quality Authority (FSQA)	Relevant Universities MoHERST	**Output:** Sufficient staff are trained	TBD
	2) Build regional food testing laboratories	Food Safety and Quality Authority (FSQA)	MoHERST	**Output:** Equipped regional laboratories that can test	TBD
	3) Develop a robust monitoring system to monitor testing and food-related diseases	Food Safety and Quality Authority (FSQA)	MoHERST	**Outcome:** decrease in food-related diseases	TBD

Food system Segment – Challenge-oriented STI Area	Actions	Lead	Partners	Output and outcomes	Timing for initiation
Food consumption – behavioural response	1) Launch a social science research programme to understand behavioural responses to food subsidies (increase in consumption, substitution, higher diversity in dieats, change in habits, etc.)	University of the Gambia	MoHERST	**Output:** Report laying out key benefits of the susbsidies and potential improvements	One and a half year
Horizontal – improve coordination	1) Create a committee with representatives from key Ministries for food self-sufficiency to ensure (i) identify all current STI activities, (ii) verify alignment of the future STI policy priorities within the various policies and, (iii) improve the coordination of the current and future STI activities.	MoHERST	MoA, MoFEA, MoTIE, etc.	**Output:** mapping of all STI activities addressing food self-sufficiency in the Gambia. **Outcome:** creation of joint programmes (involving Universities, research centre, NGOs and firms too) to address food self-sufficiency.	One year TBD
Horizontal – support to researchers	Develop financial schemes to incentivise researchers to stay in the Gambia or to move back me be deployed (special research grants in priority sectors, support for publication, tax rebates for returning researchers).	MoHERST	MoFEA	**Output:** Number of grants **Outcome:** Number of returning researchers	Two years
Horizontal – patenting	1) Technical and financial support to young entrepreneurs for patenting	MoHERST	MoFEA	**Outcome:** Number of patents	One year
Horizontal – improve cooperation	1) Build physical and online platform to connect innovators, entrepreneurs, and researchers in fields relevant to food self-sufficiency.	MoHERST	MoA, start-up hubs, incubators, Universities	**Output:** relevant stakeholder meetings. Online plarform.	Two years
	2) Develop three to five relevant research programmes that respond to a market need identified by entrepreneurs.	MoHERST and Universities	Start-up hubs and incubators	**Output:** research programmes	Three years

6. CONCLUSIONS

In the Gambia, there is consensus on the need to leverage STI to address pressing challenges, such as those encapsulated in the SDGs: “no poverty”, “zero hunger” and “decent work and economic growth”. An important SDGs challenge for the country is the issue of food self-sufficiency. A large number of policy documents converge around the need to prioritise this multidimensional sustainability challenge – strengthening food system in the Gambia to ensure self-sufficiency. Since the Gambia does not produce enough food, it faces high import dependency of almost fifty percent of the domestic food demand. Moreover, recent crises such as Covid-19 and Russia-Ukraine war have worsened food security with growing pockets of food insecurity and malnutrition, especially in urban areas.

Various factors must be accounted for while analysing solutions to improve food self-sufficiency, such as trade policies, infrastructures, education, or households’ food tastes. Although STI could contribute to addressing several underlying causes of the food insufficiency challenge in the Gambia, STI remains an untapped potential due to the low capacity of the STI system. The government budget that the MoHERST can allocate to STI is limited, with the Ministry reliant on international donors to finance STI. This reduces the number of STI instruments available to the MoHERST to improve food self-sufficiency.

As the number of researchers is low, coupled with brain drain, building a critical mass to address the country’s research priorities and improve food self-sufficiency pose a significant challenge. In addition, adequate STI infrastructures such as well-equipped research and testing labs are scarce, which is a major constraint that prevents the Gambia from fully leveraging its innovation potential. Therefore, programmes incentivising researchers to stay in the Gambia or to move back must be deployed. Relatedly, research infrastructures must be scaled up, as this will also contribute to building the critical mass of researchers needed for the country to address her pressing development challenges.

The evidence highlights low STI capacity in the Gambia, which translates into low research outputs and low levels of innovation. However, analysing mainstream STI data may be misleading for two reasons. First, local researchers often lack funding to publish in renowned scientific journals. Financial support to help local researchers to publish in top journals must then be encouraged. Second, promising innovation in the Gambia often get patented abroad. Procedures for patenting must, therefore, be simplified to help innovators to protect their innovations locally.

Stakeholder consultations revealed that the Gambia has developed an important wealth of indigenous knowledge in the field of agriculture, which often stays undocumented. Undertaking an inventory of the wealth of indigenous knowledge, test such knowledge via scientific methods, and disseminating the good practices embedded is a promising avenue to explore. Stakeholder consultations also highlighted weak cooperation among actors of the STI ecosystem, who tend to work in silos.

Currently, there are very few initiatives to reinforce coordination within the STI ecosystem, including between Ministries. Identifying STI activities seems highly challenging even for key stakeholders since information on STI projects is dispersed. We recommend creating a committee with representatives from relevant Ministries for food self-sufficiency to (i) identify STI projects and (ii) ensure alignment of the future STI policy prioritiy. Then, we suggest centralising information on STI

projects, for instance through an online platform accessible to relevant stakeholders. This may reduce duplication of efforts and fragmentation, enhance synergies among programmes and projects, and improve funding effectiveness. It may also enable an increase in the likelihood to scale up projects, and trigger more transformative changes through STI. Horizontal measures to reinforce the STI system and improve collaboration, may be thought of as preconditions to targeted sectoral interventions.

This STI for SDGs roadmaps proposes several initiatives focused on mobilising STI to address specific sustainability challenges within the segments of the food systems, namely: production, aggregation, processing, distribution and storage, and consumption. Suggested actions include developing frugal innovation, leveraging indigenous knowledge, as well as promoting social and financial innovation. The suggestions are based on the empirical evidence gathered, which demontrated low agricultural productivity, mainly due to low access to productive inputs for farmers such as quality seeds, water and fertilisers. To make agriculture more profitable, leveraging indigenous knowledge to identify quality seeds, test and certifify them through well-equipped labs and research programmes must be considered. Access to fresh water besides during the four-month rainy season poses contraints to longer farming periods, while the lack of affordable irrigation systems for farmers hinders production. Therefore, water-saving techniques such as drip irrigation must be encouraged. In addition, to reduce the cost per acre of the fertilisers, irrigation systems could also be enabled to promote fertigation techniques.

Low aggregation levels prevent farmers from accessing markets and generating higher value for their products. Estimating quantities produced is a challenge, and potential aggregators face high searching costs. Installing weightbridges in strategic locations, combined with an online platform to inform traders on quantities available may drastically improve aggregation. Moreover, improving access to payment through platforms, as well as developing innovative features to secure payments may reduce the liquidity constraints of the informal traders, and trigger positive impact on quantities traded.

To improve food processing and, subsequently, value added (while reducing food waste), improving access to processing machines is an utmost priority. Frugal innovation to produce cheaper processing machines may enable producers to meet a market demand for processing machines. Priority must be given to machines relying on renewable energy to reduce current dependency on electricity and fuel. Adequate skills for processing and waste management must be developed accordingly. To further reduce waste, designing afforable intelligent storage units is essential. Finally, the untapped accumulation of indigenous knowledge in food preservation needs to be exploited for socioeconomic development. Deleveloping research programmes to analyse indigenous knowledge may enhance and improve evidence prior to dissemination.

Food distribution is highly uncoordinated, which creates volatility in prices and inefficiencies in food collection and delivery. STI can be deployed in developing trackers on food trucks as this would enable the generation of useful insights for the government to improve food distribution through targeted actions. Moreover, designing an online platform to inform farmers on the availability of food truck to collect their harvest would improve their planning, reduce waste, and increase sales.

High prices in various food items such as vegetables are a major impediment to diversity in food diets. Improving all segments of the food systems aforementioned is a precondition to more balanced diets. Moreover, cultural habits seem to play an important role in the lack of diversity in the consumption of food items. Therefore, more social research is needed to improve the effectiveness of awareness campaigns on food consumption. Finally, to improve food safety, well-equipped testing labs must be developed to increase testing, in particular for street food.

To facilitate the implementation of such inverventions, the JRC may carry out further research on STI financing for sustainability. In particular, identifying adequate STI funders and funding mechanisms is paramount to improve funding effectiveness. It may not only help local authorities to capture funding, but also to improve coordination, and avoid duplication of efforts. Such research exercise would support EU initiatives such as the Global Gateway in the identification of high-impact STI investments.

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LIST OF ABBREVIATIONS

AATF	Africa Agricultural Technology Foundation
ANR	Agriculture and Natural Resources
ANRP	Agriculture and National Resources Policy
AU	African Union
CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement (French Agricultural Research Centre for International Development)
CPI	Corruption Perceptions Index
CSO	Civil Society Organisation
DFI	Development Finance Institutions
EC	European Commission
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FGDs	Focused Group Discussions
FSQA	Food Safety and Quality Authority
GBoS	Gambia Bureau of Statistics
GCCI	Gambia Chamber of Commerce and Industry
GDP	Gross Domestic Product
GEAP	Gambia Environmental Action Plan
GEWE	Gender Equality and Women Empowerment
GGC	Gambia Groundnut Corporation
GHE	Gambia Horticultural Enterprise
GIEPA	Gambia Investments and Exports Promotion Agency
GMA	Gambia Maritime Administration
GMNS	Gambia Micronutrient Survey
GoTG	Government of The Gambia
GRA	Gambia Revenue Authority
GRTA	Gambia River Transport Authority
GSRB	Gambia Strategic Review Board
GTHI	Gambia Tourism and Hospitality Institute
GTSC	Gambia Transport Service Company
GTTI	Gambia Technical Training Institute
HCI	Human Capital Index

HePDO	Health Promotion and Development Organisation
HPAG	Health Policy Advisory Group
ICT	Information and Communications Technology
IMF	International Monetary Fund
IPU	Inter-Parliamentary Union
IUU	Illegal, Unreported, and Unregulated
IWRM	Integrated Water Resources Management
KMC	Kanifing Municipal Council
KOICA	Korea International Cooperation Agency
KPIs	Key Performance Indicators
LGAs	Local Government Areas
LMICs	Low and Middle Income Countries
M&E	Monitoring and Evaluation
MDGs	Millennium Development Goals
MDI	Management Development Institute
MMR	Maternal Mortality Rate
MoA	Ministry of Agriculture
MoBSE	Ministry of Basic and Secondary Education
MoCDE	Ministry of Communication and Digital Economy
MoD	Ministry of Defense
MoFEA	Ministry of Finance and Economic Affairs
MoGCSW	Ministry of Gender, Children and Social Welfare
MoH	Ministry of Health
MoI	Ministry of Interior
MoJ	Ministry of Justice
MoPE	Ministry of Petroleum and Energy
MoPS	Ministry of Public Service
MoTC	Ministry of Tourism and Culture
MoTIE	Ministry of Trade, Regional Integration and Employment
MoTWI	Ministry of Transport, Works and Infrastructure
MoUs	Memorandum of Understandings
MPAs	Marine Protected Areas
MSMEs	Micro Small and Medium Enterprises
NaNA	National Nutrition Agency

NARI	National Agricultural Research Institute
NAQAA	National Accreditation and Quality Assurance Authority
NAWEC	National Water and Electricity Company
NDP	National Development Plan
NEET	Not in Education, Employment, or Training
NEMA	National Environment Management Act
NEP	National Energy Policy
NFE	Non-Formal Education
NFSPMC	National Food Security Processing and Marketing Corporation
NFSS	National Food Security Survey
NGOs	Non-Governmental Organisations
NHIS	National Health Insurance Scheme
NHRC	National Human Rights Commission
NMP	National Migration Policy
NMS	National Multimodal Strategy
NMTS	National Multi-modal Transport System
NODD	National Observatory on Demographic Dividend
NPA	National Plan of Action
NPBFA	National Public Building and Facilities Authority
NPCS	National Population Commission Secretariat
NPP	National Population Policy
NQF	National Quality Framework
NRA	National Roads Authority
NRM	National Referral Mechanism
NSDS	National strategy for the Development of Statistics
NSPSC	National Social Protection Steering Committee
NSPP	National Social Protection Policy
NSPS	National Social Protection Secretariat
NSS	National Statistical Systems
NTP	National Transport Policy
OACPS	Organisation of African, Caribbean and Pacific States
OECD	Organisation for Economic Co-operation and Development
PETS	Public Expenditure Tracking Systems
PPPs	Public-Private Partnerships

SDGs	Sustainable Development Goals
SEZ	Special Economic Zone
SMEs	Small and Medium Enterprises
STI	Science, Technology, and Innovation
TGSB	The Gambia Standards Bureau
TVET	Technical and Vocational Education and Training
UNECA	United Nations Economic Commission for Africa
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNFPA	United Nations Population Fund
UNICEF	United Nations International Children's Emergency Fund
USET	University of Applied Science, Engineering and Technology
UTG	University of The Gambia
VNR	Voluntary National Review
WB	World Bank
WHO	World Health Organization
WIPO	World Intellectual Property Organization
WJP	World Justice Project

LIST OF BOXES

LIST OF FIGURES

LIST OF TABLES

ANNEXES

ANNEX 1: METHODOLOGY

I.1. OVERALL METHODOLOGICAL APPROACH

The STI for SDGs roadmap methodology is based on a challenge-oriented research design based on desk research and participatory methods to identify STI areas relevant for addressing selected sustainability challenges. The approach uses quantitative and qualitative data and participatory deliberation methods.

The methodology consists of three interconnected components laying the ground for the roadmap:

- Situational analysis;
- Selection and scoping of sustainability challenge;
- Deliberation of key STI areas to address the challenge.

The approach follows the underlying logic of roadmap in a sense that it addresses three lead questions: Where are we? Where do we want to go? How do we get there? The challenge-oriented approach allows to identify STI gaps and opportunities based on comparing the current and emerging needs related to the sustainability challenges in focus and to analyse the fitness of STI system and policy to address those needs. The approach is by design iterative and interactive. For example, situational analysis prepares the ground for the selection of the key challenge addressed by roadmaps but then dives into the selected challenges (see ***Figure 11***).

The overall approach relies on a close collaboration between JRC and the country team. The process is designed to encourage and enable the country team to take ownership and influence the process by selecting and scoping the challenge area and by co-organising the fieldwork and consultations.

FIGURE 11.
KEY COMPONENTS OF STI FOR SDGs ROADMAP

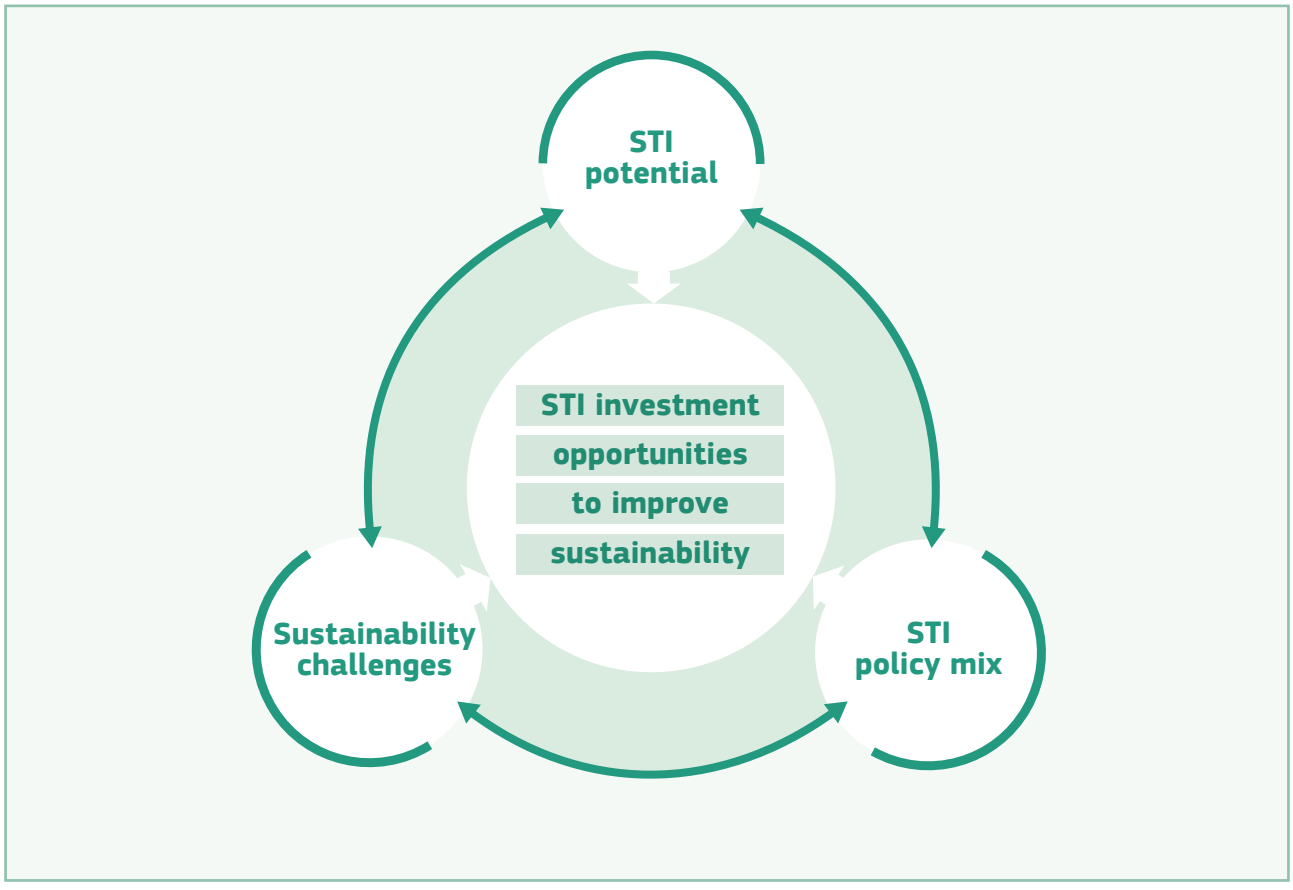

TABLE 8.
DATA COLLECTED FOR THE SITUATIONAL ANALYSIS

Elements of analysis	Quantitative analysis	Qualitative analysis
Sustainability challenges	• Socio-economic indicators • SDG indicators (targets) • Quantitative evidence used in diagnostic documents underpinning NDP and policy documents	Primary data • Face-to-face and online stakeholder interviews • Web-based stakeholder survey • In-person and hybrid stakeholder workshop Secondary data • Qualitative evidence used in diagnostic documents underpinning NDP and policy documents • Literature review (including academic and grey literature)
STI potential	• Scientific performance (e.g., bibliometric data on publications and citations; R&D personnel) • Technology and innovation indicators (e.g. R&D expenditures; patent data, Global Innovation Index (GII))	Primary data • Face-to-face and online stakeholder interviews • Web-based stakeholder survey • In-person and hybrid stakeholder workshop Secondary data • Literature review (including academic and grey literature)
STI policy mix		Primary data • Face-to-face and online stakeholder interviews • Web-based stakeholder survey • In-person and hybrid stakeholder workshop Secondary data • innovation ecosystem actor mapping • Document analysis (strategies and plans, instruments, and investment programmes)

Source: authors' elaboration

SITUATIONAL ANALYSIS

The situational analysis of the STI for SDGs roadmaps prepares the evidence base for the roadmap. It focuses on three key areas:

- Sustainability challenges faced by the country;
- STI potential to tackle sustainability challenges;
- Policy mix and governance mechanisms focused on STI.

The analysis enables to identify gaps and opportunities in the STI ecosystem to address sustainability challenges at the country level. The initial desk research enables to identify key sustainability challenges faced by the country and the existing STI capacity to address these challenges. The in-depth analysis allows to co-define areas for STI investments with high social and environmental impact. The analysis of each pillar relies on quantitative and qualitative data. *Table 8* describes a non-exhaustive list of the data collected for the STI for SDGs roadmaps.

SELECTION AND SCOPING OF SUSTAINABILITY CHALLENGE

Based on the initial diagnosis and preliminary stakeholder consultations, the country teams proposed a challenge area for the roadmap. The initial diagnosis was conducted by JRC and independent experts and shared with country team for feedback. JRC and independent experts engaged in a series of meetings with country team to discuss alternatives and scope the roadmap. An online workshop was conducted to consult the choice and scope the focus.

Considering the resources and time available for the STI for SDGs project, the decision was to focus roadmaps on one challenge in order to demonstrate and to further co-develop the overall approach. The selected challenges were to be among challenges recognised in strategic national policy documents and should be framed to highlight the potential role of STI in addressing specific localised sustainability challenges. The areas were not selected based on their relative importance (e.g. they did not have to be of the highest political priority).

DELIBERATION OF STI INVESTMENT AREAS

To identify promising STI areas where mobilising research and innovation could help respond to the selected challenges, JRC in collaboration with the country teams conducted country visits including a multi-stakeholder workshop (20-50 participants) and a series of stakeholder interviews (10-20 interviews). The situational analysis provided essential material for the workshops designed to identify STI challenges and opportunities, and highlight potential investment opportunities. Based on these consultations and a close collaboration between the experts and the country teams, the technical reports propose tailor-made action plans to leverage variety of policy and governance tools to mobilise STI for the selected sustainability challenges.

I.2. COUNTRY-SPECIFIC OBSERVATIONS

SUSTAINABILITY CHALLENGE

The country team proposed the following challenge: Leveraging STI to improve food self-sufficiency in the Gambia.

SITUATIONAL ANALYSIS

The country report is based on the qualitative evidence sourced, see *Table 9*.

The sources of quantitative data included:

- SDG Platform
- UNESCO
- FAO
- World Bank Indicators
- WIPO

DELIBERATION OF STI INVESTMENT AREAS

The respondents to survey and workshop participants were asked to identify areas for investment based on the comprehensive list of areas prepared based on desk research. Both survey and workshop included open questions allowing stakeholder to formulate their own areas. The stakeholder were asked to share their view on impact and existing capacity level in the country to mobilise STI in the areas. Based on the workshop materials, interviews and the desk research, the experts highlighted STI areas for investment and further development.

TABLE 9.
SOURCES OF THE QUALITATIVE DATA SUPPORTING THIS STI FOR SDGs ROADMAP

Method	Qualitative analysis
Stakeholder interviews	• 16 face-to-face interviews conducted between 30/01 and 1/02 2024 • 4 online interviews conducted between 5/01 and 25/01 2024 • Stakeholder profiles (8 government, 5 academia., 2 NGOs, 3 IOs and donors, 2 companies)
Stakeholder workshops	Hybrid stakeholder workshop • 47 stakeholders (28 government including agencies, 9 academia, 3 NGOs, 5 IOs and donors, 2 companies) • Workshop held in on 27/11/2023 In-person stakeholder workshop • 52 stakeholders (36 government including agencies, 3 academia., 3 NGOs, 8 IOs and donors, 5 companies) • Workshop held on 30/01 and 01/02 2024
Stakeholder survey	• 20 responses received (survey open between 02/01 and 29/01 2024)

ANNEX 2: PROGRESS TOWARD SUSTAINABLE DEVELOPMENT GOALS (SDGs) IN THE GAMBIA

SDG status	Trend	SDG	Underlying indicators driving the results
Achieved	On track of maintaining SDG achievement	SDG 12 Responsible Consumption	The positive performance of SDG 12 Responsible Consumption is driven by low solid waste produced (WB, 2002) and electronic waste (UNU-IAS, 2019[56]) low exports of plastic and electronic waste (UN Comtrade[57], 2013), as well as low SO2 emissions (UNEP) and nitrogen emissions (UNEP[58]).
Achieved	On track of maintaining SDG achievement	SDG 13 Climate Action	The Gambia has reached SDG 13 Climate Action, due to low CO2 emissions from the combustion and oxidation of fossil fuels and from cement production, low CO_2 emissions embodied in imported goods and services (ICOS, 2022[59]). Moreover, CO_2 emissions embodied in the exports of coal, gas, and oil are equal to 0.
Significant challenge remains	Moderately improving	SDG 1 No Poverty	On the positive side, the percentage of the population below the poverty headcount ratio at $2.15/day (2017 PPP) decreased from 15% in 2015 to 10% in 2023 (World Data Lab[60]). Although these results are encouraging, the percentage of the population below the poverty headcount ratio at $3.65/day (2017 PPP) is still very high and amounts to 35%.
Significant challenge remains	Moderately improving	SDG 10 Reduced Inequality	Inequality are also relatively high, and the Gini coefficient (World Bank)[61] reached 36 in 2015[62]. Moreover, the Palma coefficient, which corresponds to the share of all income received by the 10% people with highest disposable income divided by the share of all income received by the 40% people with the lowest disposable income is equal to 1.5 (OECD - UNDP[63]).
Significant challenge remains	Moderately improving	SDG 15 Life on Land	Indicators relating to SDG 15 *Life on Land* exhibit positive mixed results. So, almost all freshwater key biodiversity areas are protected[64] (Birdlife International et al., 2022[65]). However, only 42% of the area in terrestrial sites important to diversity are protected (Birdlife International et al., 2022).

56 *Source:* ***https://www.itu.int/en/ITU-D/Environment/Documents/Toolbox/GEM_2020_def.pdf****. Accessed October 2, 2024.*

57 *Data available at:* ***https://comtrade.un.org/data/****. Accessed October 2, 2024.*

58 *Data available at:* ***http://scp-hat.lifecycleinitiative.org/module-2-scp-hotspots/****. Accessed October 2, 2024.*

59 *Data available at:* ***https://www.icos-cp.eu/science-and-impact/global-carbon-budget/2022****. Accessed October 2, 2024.*

60 *Data available at:* ***https://worldpoverty.io/****. Accessed October 2, 2024.*

61 *The Gini coefficient measures the extent to which the distribution of income among individuals or households within an economy deviates from a perfectly equal distribution. Available at:* ***https://data.worldbank.org/indicator/SI.POV.GINI****. Accessed October 2, 2024.*

62 *The long-term objective of this indicator is 27.5.*

63 *The long-term objective for this indicators is 0.9.Data available at:* ***https://data-explorer.oecd.org/vis?df[ds]=DisseminateFinalDMZ&df[id]=DSD_WISE_IDD%40DF_IDD&df[ag]=OECD.WISE.INE&dq=.A.INC_DISP_GINI..._T.METH2012.D_CUR.&pd=2010%2C&to[TIME_PERIOD]=false****. Accessed October 2, 2024.*

64 *99% is protected according to the SDG platform. However, law enforcement seems weak and there is little data on compliance (Stakeholder interview, 2024).*

65 *UN STATS (****https://unstats.un.org/sdgs/indicators/database/?indicator=15.1.2****) cited by the SDG platform to measure SDG 15 (available at:* ***https://dashboards.sdgindex.org/profiles/gambia-the****). Accessed October 2, 2024.*

SDG status	Trend	SDG	Underlying indicators driving the results
Major challenges remain	Moderately improving	SDG 5 Gender Equality	Although female participation in the labour force has increased from 79% in 2015 to 87% in 2022 (ILO[66]), men stay more educated and the ratio of female-to-male (aged 25 or older) mean years of education received amounted to 68% in 2021 against 60% in 2015 (UNDP[67]). Women are also underrepresented in parliament with only 8% of the seats held by women in 2021 (IPU[68]).
Major challenges remain	Moderately improving	SDG 8 Decent Work and Economic Growth.	The unemployment rate is low with 4.7% (ILO[69]) of the labour force was unemployed in 2023 (ages 15+). However, future employment prospects are not favourable as the growth rate of GDP adjusted to income levels[70] was -4.12% in 2021. More must be done to guarantee fundamental labour rights as the indicator on "fundamental labour rights effectively guaranteed" of the World Justice Project (WJP[71]) amounted to 0.46 in 2021, which is way below the long-term objective for this indicator (0.85). Boosting quality jobs is then needed.
Major challenges remain	Moderately improving	SDG 16 Peace, Justice and Strong Institutions.	The perceived levels of public sector corruption is high and the Corruption Perceptions Index (CPI[72]) was 34 in 2022 (with 100 being the lowest level of perceived corruption). Major challenges also remain to protect property rights according to the World Justice Project. These are two major impediments to entrepreneurial activities, and innovation.
Major challenges remain	Moderately improving	SDG 17 Partnerships for the Goals.	The fiscal base of the government is low and the revenue of the government (excluding grants) represented less than 12% of the GDP in 2018 (IMF et al.[73]).
Major challenges remain	Stagnating	SDG 2 Zero Hunger	SDG 2 Zero Hunger highlights key issues in the capacity of the Gambian food system to meet the needs of the local population. Undernourishment has doubled from 2010 to 2020 (SDG platform, FAO, 2024), and although the percentage of children up to the age of 5 years that are stunted has decreased in the past 20 years, it still relatively high since almost 14% are still stunted (UNICEF, WHO and WB). Cereals yields, measured as tonnes per hectare of harvested land, have decreased from 0.79 in 2015 to 0.49 in 2021 (FAO), and do not enable to meet the needs of a growing population.

66 *ILO Data cited by the SDG platform at:* ***https://dashboards.sdgindex.org/profiles/gambia-the****. Accessed October 2, 2024.*

67 *Data available at:* ***https://hdr.undp.org/data-center****. Accessed October 2, 2024.*

68 *Inter-Parliamentary Union (IPU) data (available at:* ***ipu.org*** *). For the year of 1998, the data is as of August 10, 1998.*

69 *ILO Data cited by the SDG platform at:* ***https://dashboards.sdgindex.org/profiles/gambia-the****.*

70 *Where rich countries are expected to grow less) and expressed relative to the average growth rate of high income countries.*

71 *Data available at:* ***https://worldjusticeproject.org/our-work/wjp-rule-law-index****. Accessed October 2, 2024.*

72 *The CPI is developed by Transparency International (****https://www.transparency.org****) and cited by the SDG platform to measure SDG 16 (available at:* ***https://dashboards.sdgindex.org/profiles/gambia-the****).*

73 *International Monetary Fund, Government Finance Statistics Yearbook and data files, and World Bank and OECD GDP estimates, available at:* ***https://data.worldbank.org/indicator/GC.REV.XGRT.GD.ZS?view=chart****.*

SDG status	Trend	SDG	Underlying indicators driving the results
Major challenges remain	Stagnating	SDG 3 Good health and well-being	SDG 3 Good health and well-being is also a major challenge in the Gambia, and indicators show stagnating trends. In particular, maternal mortality rates remain relatively high despite a decrease from 534 per 100,000 live births in 2015 to 458 per 100,000 per live births in 2021 (WHO[74]). Moreover, access to essential health service remains an important issue, and universal health coverage is low, with a performance of 48 out of 100 in the WHO Universal health coverage (UHC) index of service coverage. Mortality rate that attributable to the joint effects of fuels used for cooking indoors and ambient outdoor air pollution is a major issue. According to WHO, in 2019, the age-standardized death rate attributable to household air pollution and ambient air pollution amounted to 220 per 100,000 population (with a target of 0).
Major challenges remain	Stagnating	SDG 4 Quality Education	SDG 4 Quality Education faces major challenges. Participation rate in pre-primary organized learning is low and only 55% of children aged 4 to 6 were enrolled in pre-primary in 2022. On the positive side, the percentage of children of the official school age population who are enrolled in primary education increased from 76% in 2015 to 86% in 2022 (UNESCO). Lower secondary completion rate is however relatively low as only 62% of the children reached completion. The literacy rate of the population aged 15 to 24 has been moderately improving (from 67% in 2015 to 73% in 2021, UNESCO[75]) and remains a major challenge.
Major challenges remain	Stagnating	SDG 6 Clean Water and Sanitation	SDG 6 Clean Water and Sanitation, 80% of the population used at least basic drinking water services in 2021 (with almost no improvement since 2015). Access to sanitation services is a challenge as only 46% of the population used at least basic sanitation services in 2020. Fresh water is relatively abundant, and freshwater withdrawal represented only 2.2% of the available freshwater resources, which is way below 12.5% target for the indicator. Sectors such as agriculture, forestry and fishing, manufacturing, electricity industry, and services could then benefit from such resources.
Major challenges remain	Stagnating	SDG 7 Affordable Land and Clean Energy	SDG 7 Affordable Land and Clean Energy is a major challenge for many Gambian households. The percentage of the population primarily using clean cooking fuels and technologies for cooking was only 1.7% in 2020 (WHO[76]). Only 62% of the population had access to electricity in 2020, with almost 0% of renewable energy in the total final energy consumption. This is also an important issue for industries and processing activities.

74 *Data available at:* ***https://www.who.int/data/gho/data/indicators/indicator-details/GHO/maternal-mortality-ratio-(per-100-000-live-births****). Accessed October 2, 2024.*

75 *UNESCO Institute for Statistics (UIS). Data available at:* ***apiportal.uis.unesco.org/bdds****. Accessed October 2, 2024.*

76 *Data available at:* ***https://www.who.int/data/gho/data/indicators/indicator-details/GHO/gho-phe-primary-reliance-on-clean-fuels-and-technologies-proportion****. Accessed October 2, 2024.*

SDG status	Trend	SDG	Underlying indicators driving the results
Major challenges remain	Stagnating	SDG 9 Industry, Innovation and Infrastructure	SDG 9 Industry, Innovation and Infrastructure requires measures to tackle major challenges. In particular, expenditure on research and development amounted to only 0.07% of the GDP in 2018 (UNESCO[77]), which is way below the 3.7% objective, and hinders the production of knowledge and innovation. Infrastructures for trade and transport must also be improved (e.g. ports, roads, railroads and information technology, etc.) as captured by the World Bank Logistics Performance Index[78], which is low and decreasing (1.8 out of 5 in 2018 with a target of 3.8). Access to the internet is low and only 30% of the population used the internet in the past three months in 2021.
Major challenges remain	Stagnating	SDG 11 Sustainable Cities and Communities	SDG 11 Sustainable Cities and Communities. In urban areas, the proportion of the households living in slums is very high (39% in 2021, UN Habitat[79]), and cities are not prepared to absorb high levels of migration from rural areas. The percentage of the population that has access to improved water source (piped) is decreasing and less than 84% of the population had access to infrastructures adequately protecting the source from outside contamination.
Major challenges remain	Decreasing	SDG 14 Life below water	SDG 14 Life below water is facing major challenges with worsening performance. Water pollution is a key issue, and marine waters under national jurisdictions have been largely contaminated by chemicals, excessive nutrients (eutrophication), human pathogens, and trash . Considering the role of fisheries in providing quality nutrients and jobs to a large number of Gambians (EC, 2021), the situation is both preoccupying in terms of social and environmental impacts.

77 *Source: UNESCO Institute for Statistics (UIS). UIS.Stat Bulk Data Download Service. Accessed April 24, 2024.* ***apiportal.uis.unesco.org/bdds****.*

78 *Data available at:* ***https://lpi.worldbank.org/international/global****. Accessed October 2, 2024.*

79 *Data available at:* ***https://data.unhabitat.org/pages/housing-slums-and-informal-settlements****. Accessed October 2, 2024.*

ANNEX 3: PROGRESS TOWARD THE SUSTAINABLE DEVELOPMENT GOALS (SDGs)

National Development Plan Imperative	National Development Plan Pillar	Main sustainability issues	Related Sustainable Development Goals (SDGs)	Sustainable Development Goals (SDG) status
Address fragility, vulnerability and build resilience of households and communities to shocks and crisis.	Building Community Resilience to Shocks and Crises	Food insecurity, poverty and vulnerability over the past five years, as well as environmental and climate change. Strong impact of Covid-19 and the Ukraine war.	SDG 2: Zero Hunger	Major challenges remain. Stagnating
			SDG 14: Life Below Water	Major challenges remain. Decreasing.
			SDG 1: No Poverty	Challenges remain. Moderately improving
			SDG 12: Responsible Consumption and Production	SDG achieved. On track or maintaining SDG achievement. *Note: limited data*
			SDG 13: Climate Action	SDG achieved. On track or maintaining SDG achievement. *Note: limited data*
Consolidate gains made in democratic governance and address the outstanding gaps.	Governance Reform	Corruption is perceived to have risen significantly. Accelerating transitional justice and security sector reform needed. Decentralisation needed.	SDG 16: Peace, justice, and strong institutions	Major challenges remain. Stagnating
			SDG 13: Climate Action *Note: climate change and climate governance focus*	SDG achieved. On track or maintaining SDG achievement. *Note: limited data*
Vigorously pursue macroeconomic reforms to ensure stability and inclusive growth	Macroeconomic Stability and Inclusive Growth	Low and volatile growth caused by shocks and low investment in the productive sectors, high poverty rate, high public debt, limited financial inclusion, rising inflation, exchange rate fluctuation, and high trade and current account deficit	SDG 8: Decent work and economic growth	Major challenges remain. Moderately improving
			SDG 1: No Poverty	Challenges remain. Moderately improving
			SDG 9: Industry, Innovation and infrastructure	Major challenges remain. Stagnating
			SDG 12: Responsible Consumption and Production	SDG achieved. On track or maintaining SDG achievement. *Note: limited data*

National Development Plan Imperative	National Development Plan Pillar	Main sustainability issues	Related Sustainable Development Goals (SDGs)	Sustainable Development Goals (SDG) status
Prioritize Human Capital Development for economic and social transformation	Human Capital Development	Human Capital Development is a key priority given the growing importance of the knowledge economy worldwide. It can help end extreme poverty and create more inclusive societies. When human capital increases in areas such as science, education, and management, it leads to increase in innovation, social well-being, equality, productivity, and participation, all of which contribute to economic growth.	SDG 4: Quality education	**Major challenges remain.** Stagnating
			SDG 1: No Poverty	**Challenges remain.** Moderately improving
			SDG 8: Decent work and economic growth	**Major challenges remain.** Moderately improving
			SDG 10: Reduced inequality	Significant challenge remain *Note: limited data*
			SDG 3: Good Health and Well-being	**Major challenges remain.** Stagnating
			SDG 6: Clean water and Sanitation	**Major challenges remain.** Stagnating
			SDG 11: Sustainable cities and communities	**Major challenges remain.** Stagnating

National Development Plan Imperative	National Development Plan Pillar	Main sustainability issues	Related Sustainable Development Goals (SDGs)	Sustainable Development Goals (SDG) status
Strengthen productivity of, and integration and linkages within the Agriculture and Natural Resources (ANR) sector for enhanced economic growth and productivity, increased incomes, jobs and climate action.	Agriculture, Fisheries, Natural Resources, Environment and Climate Change	Opportunities for increased production and productivity of the agriculture and natural resource sector (ANR) and improved contribution to economic growth. Environmental problems such as land degradation, deforestation, salinity in the lowlands, coastal erosion and traditional, unsustainable production systems in the forestry, agriculture, and fisheries industries pose a considerable threat to the production and productivity of the sector.	SDG 8: Decent work and economic growth	**Major challenges remain.** Moderately improving
			SDG 15: Life on land	**Challenges remain.** Moderately improving
			SDG 12: Responsible Consumption and Production	**SDG achieved. On track or maintaining SDG achievement.** *Note: limited data*
			SDG 13: Climate Action Note: climate change and climate governance focus	**SDG achieved. On track or maintaining SDG achievement.** *Note: limited data*
			SDG 14: Life Below Water	**Major challenges remain. Decreasing.**
			SDG 2: Zero Hunger	**Major challenges remain.** Stagnating
			SDG 7: Affordable and clean Energy	**Major challenges remain.** Stagnating
Act to advance the empowerment and social inclusion of women, girls, children, youth, persons with disabilities and older persons for a more productive, better and fairer society	Empowerment, Social Inclusion – Leaving No One Behind	Issues of lack of empowerment, social exclusion, discrimination and stigmatisation for women, girls, children, persons with disabilities and older persons	SDG 5: Gender Equality	**Major challenges remain.** Moderately improving
			SDG 10: Reduced inequality	Significant challenge remain *Note: limited data*
Build our infrastructure to boost connectivity, promote growth and render Gambia more competitive, especially in the context of the African Continental Free Trade Area (AfCFTA)	Energy, Infrastructure and ICT Connectivity	Infrastructure and ICT connectivity, are critical economic and social cohesion enablers for any society.	SDG 9: Industry, Innovation and infrastructure	**Major challenges remain.** Stagnating
			SDG 7: Affordable and Clean Energy	**Major challenges remain.** Stagnating
			SDG 8: Decent work and economic growth	**Major challenges remain.** Moderately improving
			SDG 10: Reduced inequality	Significant challenge remain *Note: limited data*

ANNEX 4: ALIGNMENT BETWEEN THE PRIORITIES OF THE NATIONAL SCIENCE TECHNOLOGY AND INNOVATION POLICY (NSTIP) AND THE PILLARS OF THE NATIONAL DEVELOPMENT PLAN (NDP)

National Development Plan pillar	NSTIP sector priorities	Note
Community Resilience		Very little STI mentions in NDP
Governance reform		Mostly ICT-related in NDP, which is covered in a dedicated ICT chapter in the STIP
Macroeconomic Stability and inclusive Growth	The Economy; Trade and Industry, Innovation and Entrepreneurship; Tourism and Hospitality	
Human Capital Development	Education and Training (Human Capital Development of the Citizenry); Medical and Public Health	
Agriculture, Fisheries, Natural Resources and Climate Change	Agriculture, the Environment and Natural Resources	
Empowerment, inclusion and Leaving No One Behind	Sports and Recreation; Youth and Innovation	
Energy, Infrastructure and Connectivity	Energy; Transportation; National Security	

ANNEX 5: RELEVANT STI INNOVATION FOR THE FOOD SYSTEM IN THE NATIONAL DEVELOPMENT PLAN (NDP)

National Development Plan Pillar	Outcome	Objective	Description	Type of innovation	Type of instrument
Building Community Resilience to Shocks and Crises	1.1 Community level resilience to shocks and crisis enhanced	Improve access to water	Technology transfer: Portable water	Product and service innovation	
		Improve access to energy	Technology transfer Energy (off-grid)	Product and service innovation	
		Improve productivity	Technology access: Labour saving devices	Product and service innovation	
		Improve food provision	Innovation: Year-round integrated food production schemes	Process innovation	
Governance Reform	2.3: Climate and Climate Change Governance enhanced.	Enable enhanced climate change responses and shifts in development pathways	General Innovation		
		Re-directing existing financial flows from high- to low-emissions technologies and systems and to provide additional resources to overcome current financial barriers	Financial innovation	Product and service innovation	
		Understand scientific responses to climate change	Science	n/a	
		Identify technologies and capacities needed at the local level to implement climate change integrated Local Development Plans.	Technology	Product and service innovation	
		Improving Land Governance, Property Valuation, Physical Planning and Development Control.	ICT infrastructure and technology: Development of National Geospatial Data Infrastructure including Geographical Information Systems (GIS) for all LGA	Product and service innovation	Policy intelligence (e.g. evaluations, reviews and forecasts)

National Development Plan Pillar	Outcome	Objective	Description	Type of innovation	Type of instrument
		Form multi-disciplinary facilitation Teams (MDFTs) as bridge between research institutions and the population, leading to a more direct dialogue; giving voice to the most vulnerable groups where the MDFTs must ensure acknowledgment of the high vulnerability of these groups in public policy, through advocacy processes.	Social innovation	Grassroots innovation / Marketing innovation	Horizontal STI coordination bodies
	2.8: An efficient, motivated, accountable and results-oriented public service	Strengthening public service delivery; and enabling the coherence of existing and future digital policies and strategies at national levels and mobilizing effective cooperation between institutions.	ICT infrastructure for social innovation: e-governance system (survey instruments, etc.)	Product and service innovation / Social innovation	Policy intelligence (e.g. evaluations, reviews and forecasts)
Macroeconomic Stability and Inclusive Growth	3.1: Enhanced fiscal and monetary policies, public financial management, inclusive growth, and poverty reduction. Enhance Public Financial Management – for macro-fiscal stability.	Reduce borrowing pressures through public investment programmes	Financial innovation: Public-Private Partnerships (PPPs)	Product and service innovation	
		Greening of all value chains	Financial innovation: fiscal incentive for green R&D	Product and service innovation	Tax or social contributions relief for firms investing in R&D and innovation / Tax relief for individuals supporting R&D and innovation

National Development Plan Pillar	Outcome	Objective	Description	Type of innovation	Type of instrument
	3.2: A Private Sector-Led Growth with enhanced Trade and Services, Inclusive and Sustainable Industrialization, and increased Employment	De-risk these investments for private sector capital in general (e.g. performance guarantees to help internalize the social benefits of climate investment, and to avoid or minimize the moral hazard and potentially large contingent liabilities)	Financial innovation: Blending public and private sector finance	Product and service innovation	
		Enhance Financial inclusion	Financial community-based innovation: Strengthen grass-root and community-based financial institutions	Product and service innovation / Grassroots innovation	
		Enhance Financial inclusion	ICT infrastructure / Technology: Create a geospatial mapping of access points to inform expansion by financial service providers.	Product and service innovation	
		Enhance Financial inclusion	Financial innovation: Develop inclusive Islamic Micro-Takaful to cater for the large unbanked population. Financial products and services using Human Centred Design (HCD) approach. Agricultural value chain financing and agriculture-centred financial products. Mobile banking/ Digital Financial Services (DFS)	Product and service innovation	
		Strengthen the National Quality Infrastructure for the Country.	Technology transfer: labs to test and certify products	Marketing innovation	Standards and certification for technology development and adoption
		Promote inclusive and sustainable industrialization	Technology transfer: Facilitate agricultural technology transfer	Product and service innovation	

National Development Plan Pillar	Outcome	Objective	Description	Type of innovation	Type of instrument
		(Improve trade)	ICT infrastructure: connectivity platform to the regional and continental markets	Product and service innovation	Networking and collaborative platforms
		Promotion of Employment and Decent Work.	Technology transfer: technology dissemination and adaptation in employment-generating sectors	Product and service innovation	
	3.3: A competitive and diversified tourism sector contributing to overall inclusive growth, job creation and poverty reduction	Protect the rights of the creative industry.	Innovation (intellectual property): Collecting Society of The Gambia (CSG)	Organizational (institutional) innovation	Intellectual property regulation and incentives
Human Capital Development	4.1: Equitable Access to Quality and Relevant Education for all	Improve access to quality education	ICT infrastructure / social innovation: new teaching initiatives such as remote learning/distance learning. Set up joint e-learning and digital/virtual learning platform for institutions of Tertiary and Higher Education in the country.	Product and service innovation	Technology extension and business advisory services
		Improve the quality of education, which among others may create opportunities for innovation and knowledge production;	STI enablers: Design and develop curriculum using the panel system which entails the following: research, comparative studies and contextualization		(Technology extension and business advisory services)
			Innovation infrastructure: Establish pre-vocational structures with equipped labs with ICT facilities	Product and service innovation	Dedicated support to research and technology infrastructures
			Science and Innovation enablers: Establish incubation centres, and science and technology parks.	Social innovation	Dedicated support to research and technology infrastructures

National Development Plan Pillar	Outcome	Objective	Description	Type of innovation	Type of instrument
			STI enablers: Mainstream STEM and TVET into the programmes and priorities of Government. Undertake outreach and sensitization programmes in the form of seminars and workshops including promotional videos/ radio talk shows and documentaries on the importance of TVET/ STEM.	Marketing innovation	/ Public awareness campaigns and other outreach activities
	4.6: Socio-economic benefits of migration to national development enhanced and adverse consequence mitigated	Leverage financial resources	Innovative finance: Issuance of Diaspora bonds	Product and service innovation / Social innovation	
Agriculture, Fisheries, Natural Resources, Environment and Climate Change	5.1: A modern, productive and sustainable agriculture for food and nutrition security, economic growth and poverty reduction	Increase productivity and food security	Technology transfer: new rice irrigation schemes; introduction and promotion of hybrids; Promoting water - labour efficient technologies	Product and service innovation / Marketing innovation	
		Support the hospitality industry, reduce the import bill and enhance nutritional status	Social innovation (?): supporting social and behavioural change communication to promote the production and consumption of micronutrient-rich vegetables;	Marketing innovation / Pro-poor and inclusive innovation	Public awareness campaigns and other outreach activities
		Promote quality for industry and export	Social innovation: Facilitate and organize producers into groups or cooperatives	Social innovation	

National Development Plan Pillar	Outcome	Objective	Description	Type of innovation	Type of instrument
	5.2: A vibrant fisheries and aquaculture sector contributing to economic growth and employment creation.	Improve management and ensuring the sustainability of fisheries resources of The Gambia.	Technology	Product and service innovation	
	5.3: Sustainable environmental and natural resources management, enhanced climate action and disaster risk reduction	Encourage organic waste recovery by composting at the household level, including a national awareness campaign to encourage composting of organic household waste; encourage household waste recycling through a national awareness campaign; and introduce waste separation at landfills.	Social innovation: promote the concept of circular economy	Social innovation	Public awareness campaigns and other outreach activities
		Greening of energy and transport sectors	Research and technology adoption: invest in research and adoption of renewable energy from carbon-free sources	Product and service innovation	Institutional funding for public research /
Empowerment, Social Inclusion – Leaving No One Behind	6.1: Empowered Gambian women economically, socially and politically	Economic empowerment of women	Technology adoption: digitalization of women-owned businesses through supporting e-commerce platforms and use of mobile money	Product and service innovation	
	6.3: Enhanced economic opportunities and all-round social and cultural development for youth empowerment.	Enhance and advance youth entrepreneurship and employment in the productive sectors	Technology and innovation: promotion of the sector to youth (e.g. encourage youth participation in e-commerce and other digital platforms, etc.)	Product and service innovation	Public awareness campaigns and other outreach activities

National Development Plan Pillar	Outcome	Objective	Description	Type of innovation	Type of instrument
		Facilitate access to information to enhance productivity on the farm; enabling agricultural innovation; and providing access to financial services and markets	ICT infrastructure: mobile phones and improved internet availability	Product and service innovation	
		Promote innovation	Innovation: Establishment of innovative hubs	Product and service innovation	Horizontal STI coordination bodies
	6.4: Inclusiveness and care for persons with disabilities and older persons improved	E.g. improve the inclusion in the development of e-learning or other learning platforms	Research: data collection and support research on Persons With Disabilities (PWD) and related services		

ANNEX 6: OBJECTIVES OF THE 2015 – 2024 STI POLICY

Short-term Objectives	Long-term Objectives	Long-term Objectives
1.5.4.1.1 Train personnel in the management, dissemination and implementation of the policy;	1.5.4.2.1 Enhance collaboration nationally and internationally to foster STI knowledge transfer, adaption and diffusion;	1.5.4.3.1 further strengthen scientific research as a means to spur innovation and entrepreneurship especially among the youth and women to enhance employability, among others;
1.5.4.1.2 strengthen scientific research capacity to develop STI;	1.5.4.2.2 Develop and strengthen capacity for STI by producing a trained and skilled population competent to transform the nation into a knowledge -based economy;	1.5.4.3.2 strengthen the incorporation of indigenous technology and traditional medicine in the application of STI in the day-to-day living of the citizens;
1.5.4.1.3 set up a comprehensive central database on STI to serve all sectors of the economy;	1.5.4.2.3 Further develop and strengthen research capacity and dissemination of scientific findings;	1.5.4.3.3 transfer, adapt and assimilate appropriate technologies;
1.5.4.1.4 provide modern and appropriate ICT infrastructure;	1.5.4.2.4 develop technological and indigenous knowledge through innovative links with industries, to add value to the country's products and services;	1.5.4.3.4 create and sustain a knowledge-based economy in which the citizens can effectively apply scientific and technological knowledge and skills in resolving socio-economic problems;
1.5.4.1.5 strengthen data collection and analytical capacity;	1.5.4.2.5 Establish the legal and regulatory framework that ensures effective use of STI for national development with adherence to set standards.	1.5.4.3.5 modernize agriculture and other national industries through STI to create quality products and services for sustained economic growth;
1.5.4.1.6 set up a data bank with appropriate data management facilities and resources;		1.5.4.3.6 Use STI to modernize agriculture and create quality products and services for sustained economic growth.
1.5.4.1.7 promote awareness and participation in STI to increase the number of students offering STI-related areas at all levels (both formal and non-formal) of the education system;		
1.3.4.1.8 Set adequate standards to strengthen the delivery of quality STI.		

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