Deliverable 2.1

BOTSWANA

TECHNOLOGY NEEDS ASSESSMENT REPORT

CLIMATE CHANGE ADAPTATION

AGRICULTURE SECTOR

September 2022

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LIST OF ACRONYMS

ASWG	Agriculture Sector Working Group
ATO	Adaptation Technology Option
BAEF	Barrier Analysis and Enabling Framework
BCCP	Botswana Climate Change Plan
BCCP	Botswana Climate Change Policy
BCCS	Botswana Climate Change Strategy
BITRI	Botswana Institute of Technology, Research and Innovation
BNBPU	Botswana National Beef Producers Union
BNDP	Botswana National Drought Plan
BOCONGO	Botswana Council of Non Governmental Organizations
BoFA	Botswana Farmers' Association
BoHoC	Botswana Horticulture Council
COP	Conference of Parties
CSA	Climate Smart Agriculture
DAP	Department of Animal Production
DCP	Department of Crop Production
DMS	Department of Meteorological Services
EWS	Early Warning System
GCF	Green Climate Fund
GCM	Global Climate Model
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GHG	Greenhouse Gas
GoB	Government of Botswana
ICT	Information and Communications Technology
INDC	Independent Nationally Determined Contribution
KP	Kyoto Protocol
MEWT	Ministry of Environment, Wildlife and Tourism
MoA	Ministry of Agriculture
NARDI	National Agricultural Research and Development Institute

NC	National Communication
NCCSAP	(Botswana) National Climate Change Strategy and Action Plan
NDA	Nationally Designated Authority
NDC	Nationally Determined Contribution
NDE	Nationally Designated Entity
NDP	National Development Plan
PCFA	Pandamatenga Commercial Farmers Association
RCM	Regional Climate Model
RCP	Representative Concentration Pathway
SDG	Sustainable Development Goal
TAP	Technology Action Plan
TNA	Technology Needs Assessment
UCCC	UNEP Copenhagen Climate Centre
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCC	United Nations Framework on Climate Change

Executive Summary

Botswana through GCF funding is updating its technology needs assessment to develop a technology road map for prioritized adaptation technologies to address climate change challenges in the agriculture and water sectors and mitigation technologies in the energy sector. The CTCN is responsible for the execution of the TNA project through UNEP Copenhagen Climate Centre team of international and sector specific national experts.

This agriculture sector Deliverable 2.1 report has been prepared as part of the process of updating the 2004 TNA which has three reporting stages: Technology Needs Assessment (TNA), Barrier Analysis and Enabling Framework (BAEF) and Technology Action Plan (TAP). This report is the first part of the TNA adaption report and will be followed by Deliverable 2.2 after prioritization and ranking of adaption technology options (ATO).

The agriculture sector was prioritized at the project formulation by the Nationally Determined Agency (NDA) and approved by the National TNA Committee. Stakeholder participation and gender mainstreaming in the assessment and prioritization of ATOs was achieved through the constitution of the Agriculture Sector Working Group (ASWG) with 10 stakeholder institutions and 36% female members. The stakeholder institutions were Department of Crop Production, (DCP) Department of animal Production (DAP), Department of Meteorological Services (DMS), National Agricultural Research and Development Institute (NARDI), Botswana Institute of Technology, Research and Innovation (BITRI), Botswana Horticulture Council (BoHoC), Botswana Farmers Association (BoFA), Pandamatenga Commercial Farmers Association (PCFA), Botswana University of Agriculture and Natural Resources BUAN), Botswana International University of Science and Technology (BIUST) and National Beef Producers Union (BNBPU). The heads of the institutions appointed one member each except BoFA who presented two resulting, BUAN who did not nominate and BIUST whose nominee did not participate. The ASWG had six males (60%) and 4 females (40%).

The contracted national agricultural expert reviewed various national, regional and international relevant policies/strategies/plans and technology sources to prepare a potential list of technologies that could eventually be prioritized for the TNA Report. The expert conducted training for members on the TNA process and facilitated the final selection, prioritization and multi criteria analysis (MCA), the results of which, will constitute Deliverable 2.2.

CHAPTER 1. INTRODUCTION

1.1 About the TNA project

The Technology Needs Assessment (TNA) is crucial for an emerging economy like Botswana. The purpose of the current TNA project in Botswana is to assist it with updating the country's TNA process which was first undertaken in 2004 and develop a technology roadmap for prioritized technologies to address climate change challenges in the most critical sectors of the economy. The work is conducted taking into consideration the broader context of the TNA conducted by many countries and recognized by the COP as a key element for technology identification and planning to address climate change challenges. This is to be achieved through the following three outcomes:

- Outcome 1. Institutional capacity and coordination mechanisms in place to govern and coordinate climate action and finance
- Outcome 2: Country Programming process that will contribute to the development of short- and long-term solutions that aid climate change resilience and build the necessary capacity in terms of environmental systems
- Outcome 3: Climate finance strategies strengthened, private sector mobilized, and project pipeline enhanced

These outcomes serve as a guide for the implementation approach in the project as well as the TNA methodology (as laid out in the TNA Step-by-Step Guidance).

The objective of 2004 Botswana Technology Needs Assessment on Climate Change (GoB, 2004) was to identify and assess environmentally sound technologies with synergy between reducing impact of climate change and the rate of GHG emissions and national development objectives. This followed the requirements of GEF funding provided to 92 countries between 2000 and 2004 for the first round of TNAs. Since then, it has become more realistic that adaptation and increasing resilience to the impacts of climate should have more emphasis since Botswana's contribution of global GHG emissions is minimal compared to the developed countries. Therefore, the current TNA initiative funded through CTCN using GCF aims to identify both mitigation and adaptation technologies against climate change and its impacts on the prioritized sectors of energy, water and agriculture. The energy sector will deal with mitigation while water and agriculture will deal with adaptation technologies. The Botswana National Designated Authority (NDA) (Ministry of Finance and Development Planning) and the National Designated Entity (NDE) (BITRI) to the UNFCC collaboratively developed and submitted the current TNA proposal to GCF as detailed in GCF Readiness and Preparatory Support (GCF, 2019). The programme title for the TNA is **"Update the technology needs assessment and develop a technology road map for prioritized technologies to address climate change challenges in the most critical sectors of the economy".**

The TNA project will be achieved through the three TNA steps:

1. To identify and prioritize through country-driven participatory processes, technologies that can contribute to mitigation and adaptation goals of the participant countries, while meeting their national sustainable development goals and priorities (TNA).

2. To identify barriers hindering the acquisition, deployment, and diffusion of prioritized technologies.

3. To develop Technology Action Plans (TAP) including policy briefs specifying activities and enabling frameworks to overcome the barriers and facilitate the transfer, adoption, and diffusion of selected /prioritized technologies in Botswana. This section presents the aspects of climate change adaptation for the agriculture sector in Botswana.

1.2 Existing national policies related to technological innovation, adaptation to climate change and development priorities for the agricultural sector

The section reviews the various policy instruments that have been produced after TNA 2004 in relation to climate change adaptation in the agriculture sector. The review will cover national development, agriculture sector and climate change policies These instruments informed the current updating of the Botswana TNA in relation to climate change, and it is hoped the climate adaptation technologies enhance sustainable national development by improving food security and the resilience of the agriculture sector.

1.2.1 National circumstances

Botswana is in the central part of Southern Africa with a land area of 581,730 km^2 of which only 2.58% is water and wetlands and the Kalahari Desert covers 70% of the land. The 2022 population is 2,346,179 compared to 2,024,904 in 2011 a growth rate of about 1.4% (Statistics Botswana 2022). The climate is subtropical, semiarid to arid with unreliable and poorly distributed rainfall with very hot summers and cool winters. The mean annual rainfall is 416mm, ranging from 250mm in the southwest to 650mm in the north of the country while the mean annual evapotranspiration is 2742mm ranging from 2,300 in the east (Mahalapye) to 3200mm in the west (Ghanzi) (GoB 2021b, Andringa 1984). The rain season runs from October to April, however, with climate change the onset of the rains is shifting towards December and the unpredictability, frequency and intensity of droughts and floods are increasing.

Botswana is an upper middle-income aspiring to achieve a high-income country status (GoB, 2016) with its economy mainly dependent on minerals and tourism which contribute about 40% to the GDP. The contribution of agriculture to GDP is only 1.95% but the sector supports more than half of the rural population which is dependent on subsistence crop and livestock farming. Even though Botswana is not technically a poor nation, substantial clusters of poverty remain in its rural areas where the poverty rate is as high as 46% and unemployment for the country is at 17.7% (2022_IndexofEconomicFreedom-Botswana.pdf (heritage.org) Causes of Poverty in Botswana – The Borgen Project viewed on 30 June 2022). The poverty incidence rates in cities, urban villages, and rural areas and nationally based on 2015/2016 survey are 5.34%, 14.05%, 37.48 and 20.84%, respectively (Statistics Botswana 2021.) These figures have increased with the Covid-19 pandemic and the current Russia-Ukraine war which has resulted in increasing prices of fuel, food and other commodities.

The agriculture sector consisting mainly of livestock and arable crop production is dependent on rainfall. The livestock sector is dominated by the traditional livestock farming characterized by low offtakes, high stoking rates and poor herd management resulting in degradation of range resources. During the 2008-2019 period the livestock (cattle, goats and sheep) population decreased from 4.4 million in 2010 to 2.4 million in 2019 with cattle population declining form 2.3 million in 2011 to 935,000 in 2019. The Botswana dairy industry is in its infancy and produces about seven million litres of milk annually, while the country needs about 70 million litres annually. The subsector is limited by availability of heat tolerant breeds and local fodder production. The production of cereals and legumes is characterized by low yields due to drought stress, pests and low soil fertility. As a result, Botswana is a net importer of cereals and grain legumes. During 2008-2019 period, land area planted, and production have declined from 262,000ha and 41,000MT in 2011 to 88,000ha and 3,000MT in 2019 (Statistics Botswana 2019). The horticulture subsector depends on irrigation and the limited water

resources have resulted in the development of horticulture clusters mainly around dams, urban wastewater treatment facilities and areas with readily available ground water. The government on 1st January 2022 banned the importation of most vegetables to encourage retailers to buy from local producers. The agriculture sector is, therefore, vulnerable to the impacts of climate change such as droughts, extreme heat and floods as demonstrated by recent events such as 2019 drought.

1.2.2 National development policies, strategies and action plans related to climate change

1.2.2.1 Vision 2036 - Prosperity for All

Botswana's 20-year development framework for the period 2016 to 2036 is driven by Vision 2036 (GoB 2016b) whose theme is 'Achieving Prosperity for All' and aims to move Botswana from an upper middle-income to a high-income country. The four pillars of Vision 2036 are i) sustainable economic development, ii) human and social development, iii) sustainable environment and iv) governance, peace and security. Under sustainable environment the Vision acknowledges the threat of global warming and climate change on desired economic growth and development and the need for climate resilience and disaster risk reduction strategies.

For the agriculture sector, the Vision states "Our country will have a sustainable, technology driven and commercially viable agricultural sector. We will develop a disease-free agricultural sector that optimizes the use of land (and other resources), utilizing technologies and modern farming methods to improve productivity. We will encourage the development of private sector led value chains in the agricultural sector including the production, processing, marketing, and distribution activities".

1.2.2.2 National Development Plan (NDP) 11 Volume 1April 2017–March 2023.

The NDP11 (GoB 2016) is a development blueprint for the period April 2017 to March 2023 whose theme is *"Inclusive Growth for the Realisation of Sustainable Employment Creation and Poverty Eradication*". Climate change mitigation and adaptation is one of the strategies of NDP 11 under the Sustainable Environment Pillar. During NDP11 the Botswana Government has approved and is implementing the climate change policy, its strategy and action plan.

For the agriculture sector, the thrust of NDP11 is for the adoption of "smart agriculture" which is an approach that will help Botswana to transform her agricultural systems towards more productive, efficient, resilient and sustainable systems. The government allocated funding for "smart agriculture" projects such as Pandamatenga Agricultural Infrastructure Project, Zambezi Integrated Agro-commercial Development Project, Chobe-Zambezi Water Transfer Scheme Phase 1 to increase food security by providing water for irrigation of commercial farms.

Sustainable Development Goals Botswana Domesticated SDG Indicators

1.2.2.3 Sustainable Development Goals Botswana Domesticated SDG Indicators

On 25 September 2015, the 193 countries of the UN General Assembly including Botswana

adopted the 2030 Development Agenda titled "Transforming our world: the 2030 Agenda

for Sustainable Development". The global Agenda has 17 Sustainable Development Goals

(SDGs), 169 associated targets and 232 indicators. Botswana domesticated SDGs indicators are all the global SDGs indicators that are applicable to Botswana. The indicators are also mapped to the relevant pillars of the Botswana Vision 2036 (Statistics Botswana 2018).

The SDGs relevant to the agriculture sector in Botswana are SDG 2 End Hunger whose goal is to end hunger, achieve food security and improved nutrition and promote sustainable agriculture. Some of the targets under this SDG include:

- Target 2.4: By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality
- Target 2.5: By 2020, maintain the genetic diversity of seeds, cultivated plants, and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed

1.2.3.4 Final Action Plan - National Climate Change Action Plan for Botswana

The National Climate Change Action Plan (NCCAP) for Botswana (GoB, 2018) covers 2018 to 2030 timeframe and identified 11 and 7 key sectors for adaptation and mitigation, respectively. The sectors for adaptation are agriculture (livestock and animal husbandry and arable agriculture) Water

human health, human settlements, forest management, land use and land use change, disaster risk management, biodiversity and ecosystems, infrastructure development, industry and manufacturing and tourism.

For agriculture and food security, the NCCAP has proposed five climate change adaptation interventions as follows:

1. Identify key livestock-focused areas of intervention within existing Climate Smart Agriculture (CSA) programmes, and scale-up such programmes with a specific focus on livestock management.

2. Implement a strengthened livestock disease surveillance and response system to manage outbreaks, thereby maintaining resilience in the livestock sector and protecting the value of Botswana's livestock, with a specific focus on climate related threats and impacts.

3. Expand the reach of Botswana's existing Climate Smart Agriculture (CSA) programmes, with a specific focus on increasing resilience in production systems and subsequently production (outcome), during climate change and subsequently improved livelihoods (impact), e.g., job creation and market access,

4. Provide low-cost credit (concessionary loans), rebates, and other financial incentives to farmers and farming clusters for the purchase and use of solar-power water pumps and biogas digesters.

5. Invest in expanded and advanced agricultural early warning systems across all farming regions in Botswana, including the strengthening of watercourse flow gauge network and integration of weather alerts, with integration with ICT and radio-based technologies (e.g., mobile phone alerts) for dissemination of early warnings and climate information services.

1.2.2.5 Botswana National Communications to UNFCCC

Botswana is party to the United Nations Framework Convention on Climate Change (UNFCCC) and its related implementation mechanisms, including the Kyoto Protocol (KP), Paris Agreement and

Conference of Parties (COP). As required by UNFCCC, Botswana has put in place an organization structure for coordination of climate change with the Ministry of Environment, Wildlife and Tourism (MEWT) through the Department of Meteorological Services (DMS) in charge of coordinating all climate change related matters. The government submitted National Communications (NCs) to UNFCCC in 2001 (GoB 2001), 2011 (GoB,2011) and 2019 (GoB, 2019). In these documents, several technologies for climate change mitigation and adaptation were proposed. The implementation of the

proposed adaptation technologies varied from full, partial or no implementation depending on the sectors.

NC 1 of 2001 and NC 2 of 2011 proposed the following adaptation technologies for the agriculture sector: adaptations to changes in growing season length, development of heat tolerant and drought resistant crops, intensify irrigation systems, changes in ploughing methods, develop agricultural infrastructure, adaptations to changes in crop productivity, seed and fertilizer provision, early warning systems, use of greenhouse/nets, drought mitigation, reducing livestock numbers and improving animal productivity. NC3 of 2019 has proposed conservation agriculture, nitrogen fertilizer application and plant population in cowpea, breeding for adapted animals, fodder production, supplementation, destocking, livestock mobility, improved herd health, development of sustainable water sources for livestock, and wildfire control and management. The focus of these technologies is to ensure the resilience of farmers especially the small scale and vulnerable ones and for national food security.

1.2.2.6 Nationally Determined Contributions (NDC) of Botswana to UNFCC

Botswana submitted to UNDP the Botswana INDC (GoB, 2016) and the Updated Nationally Determined Contribution of Botswana (Draft) NDC 2 (GoB, 2022). The Updated NDC covers adaptation, mitigation, as well as cross-cutting measures to increase the resilience of Botswana to climate change and contribute to the global effort to reduce GHG emissions. The sectors for adaptation measures in NDC2 include meteorological services, water, livestock, crop production, biodiversity and ecosystems and human health sectors. In total, there are 35 measures that will be grouped into larger (sectoral and partly even cross-sectoral) programmes to facilitate their implementation. The development of the TNA could play a vital role in identifying appropriate technologies, their required enabling framework conditions and preparing for their implementation plans for their transfer and diffusion.

1.2.2.7 The Botswana Climate Change Policy

The Botswana Climate Change Policy (BCCP) (GoB, 2021) was approved in 2021 and its vision is "Botswana through Vision 2036 strives to be a society that is sustainable, climate resilient, and whose development follows a low carbon development pathway, in pursuit of prosperity for all". The policy aims to mainstream sustainability and Climate Change into development planning and in so doing, enhance Botswana's resilience and capacity to respond to existing and anticipated Climate Change impacts. The policy also promotes low carbon development pathways and approaches that significantly contribute to socio economic development, environmental protection, poverty eradication and global goal for reduction of Green-house-Gases (GHG) from the atmosphere and SDG's. To this effect, the

TNA Project directly contributes to the realization of the objectives of the BCCP by coming up with appropriate adaptation technologies for the water and agriculture sectors.

1.2.2.8 Botswana National Drought Plan (BNDP)

Botswana as signatory to the United Nations Convention to Combat Desertification (UNCCD)

signed and ratified the Convention in 1995 and 1996 respectively following the Rio Convention

of 1992 in Brazil. Since climate change is expected to increase drought frequency and severity, the government has also put in place the Botswana National Drought Plan (BNDP) (GoB, 2021b). A key element of the BNDP is to boost the resilience of people, communities, and ecosystems against

drought by being prepared and acting early. For the agriculture sector the Plan has recommended adaptation measures such as animal and crop insurance, planting early maturing and drought tolerant crop varieties and species and drought tolerant animal breeds and species.

1.3 Vulnerability assessment of the agriculture and other sectors in Botswana

1.3.1 Overview of existing vulnerability assessments

Botswana is one of the most drought prone countries in the world and climate change is worsening the situation by reducing mean annual rainfall, delaying the onset of rains, and raising the temperatures. According to GoB (2021b), Botswana has experienced single-year and multi-year droughts (in bold) since the 1950s as follows:1959/60 **1961-1965**, 1969/70, 1972/73, 1978/79, **1981-87**, 1991/92, **1993-1996**, 2001/02, **2004-2006,** 2007/08, **2011-2013**, 2015/16 and 2018/19. The figures show that the return period between droughts has shortened indicating increased frequency of drought. Botswana's 2050 climate scenarios have been constructed based on representative concentration pathways (RCPs) of 4.5 and 8.5 using global climate models (GCMs) and regional climate models (RCMs) ensemble and seasonal and annual precipitation, mean, maximum, and minimum temperature, drought, and extreme precipitation as inputs. The 2050 climate scenario predicts that Botswana will be hotter (an increase of 1.3 to 2.7ºC) and drier (GoB 2021b GoB, 2021c). This will generally reduce crop yields by decreasing suitable area for growing finger millet, dry beans, and maize while that for sorghum is projected to greatly increase. The increased aridity is expected to reduced livestock productivity due to deterioration and total loss of range resources. The declining rainfall and rising temperatures will also reduce availability of surface and ground water for irrigation of crops and drinking water for animals.

1.3.2 Strategic themes and recommendations coming from these assessments

According to Updated Nationally Determined Contribution of Botswana (GoB 2022), lack of human and institutional capacity and financial resources are major constraints to the implementation of both adaptation and mitigation measures across all sectors. Hence, strengthening of technical and institutional capacity to enable comprehensive assessment of vulnerability and implementation of adaptation actions is critical. The Department of Meteorological Services (DMS) and the Early Warning System (EWS) needs to be strengthened to provide timely weather, climatic information, and a wider range of climate-related threats, on which appropriate adaptation responses depend. It is also important to strengthen the sector-mandated ministries and committees responsible for implementation of climate change related activities namely, Ministry of Minerals and Energy, Ministry of Transport and Public Works and Ministry of Agriculture, the Parliamentary Portfolio Committee on Wildlife, Tourism, Natural Resources and District Development Committees. There is also need for funding of research, systematic observation, training, education, awareness creation and mainstreaming of climate change into all development activities.

1.3.3 Adaptation Priorities Identified

The Botswana Climate Change Policy (GoB 2021a) has identified and prioritized the following sectors for climate change adaptation measures based on their vulnerability:

1. *Agriculture and food security*: The unpredictability of rainfall, frequent droughts and extreme heat events in Botswana are viewed with most concern as most rural communities derive their livelihoods from rainfed small scale crop and livestock production. Most commercial arable farming is also dependent on rainfall because of limited water sources for irrigation.

2. *Water:* Availability of water for domestic and economic purposes determines the economic growth of any country. The varied and low rainfalls have largely affected most sectors of the economy especially major economic drivers such as agriculture, mining, and wildlife. Climate change is

predicted to further reduce the already low water resources in Botswana, hence the need for water efficiency and conservation measures.

3. *Human health*: Climate change will negatively affect human health directly through

increased temperatures, drought, and floods and indirectly through its effect on the spread of water borne, water related, and vector borne diseases and malnutrition, hence the need for measures to reduce vulnerability and increase resilience to such impacts.

4. *Human settlements*: Development of sustainable and resilient human settlements to withstand adverse impacts of climate change with a low carbon footprint without compromising the living conditions of Batswana in rural and urban areas.

5. *Forest Management*: To increase the integrity and sustainability of Botswana forest and ensure that the threats of human and induced interventions are minimized for forests to achieve their dual role of climate change adaptation and mitigation.

6. *Land use and land use allocation*: Sustainable land use and land use allocation to minimize anticipated conflict stemming from climate variability and extreme weather events that result in migration of human settlements, livestock, and wildlife in search for suitable land and environment for socio-economic purposes.

7. *Disaster risk reduction*: Climate change impacts are likely to increase vulnerability to disaster

risk factors such as heatwaves, veldt fires, floods and droughts which will increase pressure on resource allocation towards disaster risk management. Thence the need for comprehensive approaches to disaster risk reduction programmes and plans to enhance societal adaptive capacity and capability

8. *Biodiversity and ecosystems*: Promotion of sustainable use of biodiversity and effective management of ecosystems, as well as promotion of equitable sharing of benefits from natural resources for increased adaptation and resilience to climate change impacts.

9. *Infrastructure Development*: Development of sustainable and climate resilient infrastructure such as buildings, roads, dams, water reticulation systems and electricity connections that can withstand climate change impacts such as floods and extreme heat events

10. *Gender*: Mainstreaming gender into development planning to ensure that climate change response measures are gender sensitive particularly the recognition of youth, women, children, and people living with disability and that such measures reduce their vulnerability to climate change impacts

The Updated Nationally Determined Contribution of Botswana (GoB 2022) climate ambition towards 2030 has prioritized 7 sectors for adaptation namely meteorological services, water, livestock, crop production, biodiversity and ecosystems and human health sectors.

1.4 Sector selection and overview

1.4.1 An Overview of projected climate change and its impacts in agriculture

Botswana has adopted a multi-faceted governance approach to tackle adaptation to the threats of climate change and build resilience to its impacts. The main climate change threats are droughts, floods and extreme temperature events which can further negatively affect the key sectors of the economy such as water, agriculture, and health. Adaptation to climate change and resilience to its impacts have been mainstreamed in NDP 11 (GoB, 2016a), Vision 2036 (GoB, 2016b), Botswana Climate Change Strategy (BCCS) (GoB, 2018a), Botswana Climate Change Policy (GoB 2021a) and NDC3 (GoB, 2022).

Predicted more frequent droughts, delayed onset of the rain season, higher temperatures, floods, and wildfires due to climate change will reduce animal and crop productivity in Botswana. Temperature is expected to increase by 1.3 to 2.7^{o}C while rainfall will decrease in some regions and increase in others. Vulnerability assessment of livestock and rangeland indicated a decline in beef cattle and dairy cattle production by 2050 under RCP 4.5 mainly due to poor rangelands and high temperatures, respectively (GoB, 2019). Crop vulnerability assessment studies showed yield increases or decreases depending on the risk factor, crop species and region. In general, C3 crops like cowpeas will increase in yield with increasing temperature with Maun region having the highest increase of 55%. Among the C4 plants the highest average yield reduction was observed from the maize (-15%) and sorghum (-37%) crop in the Francistown Region under RCP 6.0. while the highest increase in yield (+37%) was from pearl millet after incorporating stover in the soil from the Maun region(GoB, 2019). In general, increasing drought, floods and rising temperature tend to accelerate the rate at which insect pests and pathogens reproduce, the severity of damage they cause to crops and livestock and to expand or alter their range and migration patterns (Maxmen, 2013, Gupta et al., 2017).

1.4.2 Process and results of sector selection

The BCCS (GoB 2018) and Final Action Plan (GoB 2018) identified and prioritized the vulnerable sectors and their strategic adaptation action plans, programmes, and projects to achieve Botswana's vision of being a society that is sustainable, climate-resilient, and whose development follows a low carbon development pathway, in pursuit of prosperity for all. The strategy was cognizant of the fact that climate change will have economy-wide impacts with implications for Botswana's socio-economic growth, and the possibility that the country's objective of prosperity for all as articulated in its Vision 2036 and its achievement of the global Sustainable Development Goals (SDGs) will be jeopardized. Agriculture and food security and water are key to the economic, political, and social stability of any nation and are the most vulnerable to climate impacts especially drought and extreme temperatures. The BCCP (GoB, 2021a) prioritized ten (10) sectors for adaptation and seven (7) for mitigation.

However, the sectors for the current Botswana TNA were pre-selected during the GCF Readiness and Preparatory Support Proposal stage (Green Climate Fund, 2019). For adaptation only the top 2 (Agriculture and Water) out of the 10 sectors were prioritized. For mitigation, three subsectors under energy were prioritized mainly for reduction of GHG emissions. These were: Energy, including renewable electricity, Energy efficiency, the built environment, and Industrial processes. There were no consultations with stakeholders on sector selection for adaptation and mitigation due to limited time for the TNA project.

CHAPTER 2. INSTITUTIONAL ARRANGEMENT FOR THE TNA AND THE STAKEHOLDER INVOLVEMENT

2.1 National and International TNA team

Botswana's TNA project is based at the Ministry of Environment, Wildlife and Tourism (MEWT). The Botswana Department of Meteorological Services (DMS) are the focal point for coordinating the TNA. The main Botswana TNA project team includes a National TNA Focal Point, three national sectoral experts (One mitigation expert, and two adaptation experts), including international technical experts (3 experts). The Botswana TNA project team works with sectoral working groups in the selected sectors. Furthermore, the team consults with relevant stakeholders throughout the process. Figure 1 shows the institutional arrangements of the stakeholder involvement in the TNA process.

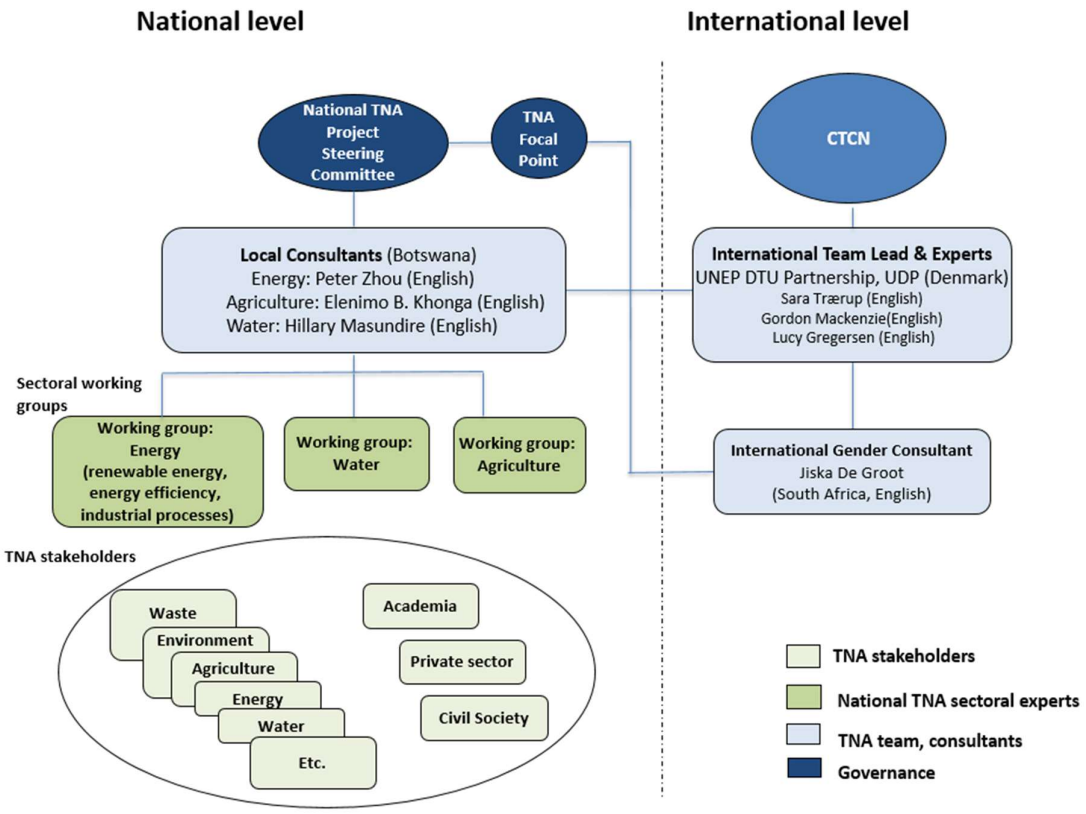

Figure 2. Institutional Structure for the TNA project

National TNA Focal Point

The Botswana DMS designated Mr. Maikutlo Mokakapadi as the TNA Focal Point. He is the focal point for the overall coordination and management of the TNA process nationally and is responsible for facilitating the project, and most importantly, communicate with national stakeholders, and communicate with UNEP Copenhagen Climate Centre (UNEP CCC), Climate Technology Centre & Network (CTCN), Nationally Designated Authority (NDA) to the GCF within the Ministry of Finance and Development Planning, and the Nationally Designated Entity (NDE) to the UNFCCC Technology Mechanism within the Botswana Institute for Technology Research and Innovation (BITRI).

National TNA Committee

The National TNA Committee is the guiding body of the project. The key objectives of the committee are to:

- Provide relevant data and info to the TNA
- Be active in the TNA process
- Oversee implementation
- Ensure validation of the deliverables based on agreed timelines
- Coordinate with the broader stakeholders within priority sectors as necessary

The National TNA Committee comprised of members responsible for policy making from all relevant ministries as well as key stakeholders from the private sector. Special consideration was given to gender balance, vulnerable groups, and appropriate representation throughout the process of the TNA Committee formation. The Committee will be chaired by the Permanent Secretary – Ministry of Environment, Wildlife and Tourism (MEWT). It is suggested that the TNA Focal Point, a representative of the NDE to the UNFCCC Technology Mechanism and representative of the NDA to the GCF are members of the Committee as they will work in close collaboration with the national TNA team and other experts and relevant stakeholders towards the implementation of the TNA project.

The National TNA Committee Consists of representatives from the following organizations presented in Table 1 below.

Table 1 National TNA Committee Members

Organization	Type of Stakeholder
1. Dept. of Energy	Government Institution
2. Dept. of Water and Sanitation	Government Institution
3. Dept. of Project and Infrastructure Planning	Government Institution
4. Dept. of Animal Production	Government Institution
5. Dept. of Agricultural Research Statistics and Policy Development	Government Institution
6. Dept. of Agricultural Research	Government Institution
7. Dept. of Crop Production	Government Institution
8. Ministry of Finance and Development Planning (NDA)	Government Institution
9. Dept. of Waste Management and Pollution Control	Government Institution
10. Ministry of Labour and Home Affairs	Government Institution

11. Ministry of Education and Skills Development	Government Institution
12. Ministry of Local Government	Government Institution
13. Botswana Climate Change Network	Network of Community Based Organizations, Non-Governmental Organizations, Research, and Private Sector
14. Botswana Energy Regulatory Authority	Government Institution
15. Solar Industries Association Botswana	Private Sector
16. BOCONGO	Non-Governmental Organizations

National and International Consultants

The selection of the national and international consultants by the CTCN for implementing the project, was done following competitive international bidding using the UNON procurement process. The team of national and international consultants that were selected, consists of the UNEP Copenhagen Climate Centre (formerly UNEP DTU Partnership) as the international technical experts, Ms. Jiska de Groot as the gender expert, and Mr. Peter Zhou as the national mitigation expert, Mr. Hillary Masundire as the national adaptation expert covering the water sector, and Mr. Elenimo Khonga as national adaptation expert covering the agriculture sector.

The adaptation and mitigation national experts are responsible for consulting relevant stakeholders; identifying and prioritizing technologies for specific sectors; leading the process of analyzing with stakeholders and sector working groups; participating in capacity-building workshops; working in close partnership with the national focal point, sector working groups, and stakeholders; and preparing the TNA and TAP (incl. barrier analysis) reports.

Sectoral Working Groups

To ensure extensive stakeholder participation, a sectoral working group was established for each priority sector. To facilitate strategic decision-making and cross-sectoral co-operation, the sectoral working groups were established under the National TNA Committee. The objective of the working groups was to provide inputs to: Identify prioritized sectors, identify, and prioritize technologies and validating final selection thereof, development of TAP (incl. barriers), and review of TAP for each sector.

Each sectoral working group consisted of representatives from the government ministries, private sector, academia, climate change experts and civil society. Tables 2 presents the composition of the agriculture adaptation sectorial working group.

Table 2 Adaptation sectoral working group for the agriculture sector

Institutions	Name of representative	Gender	Type of Stakeholder
1. Department of Crop Production, Ministry of Agriculture	Ms. Tshepho Matsuokwane replaced by Ms. Evelyn Ramontshanyana	F	Government Institution
2. Department of Animal Production, Ministry of Agriculture	Mr. Thatayaone R. Oageng	M	Government Institution
3. National Agricultural Research and Development Institute (NARDI)	Dr Odireleng Molosiwa	M	Parastatal Organization - Research
4. Botswana Institute for Technology Research and Innovation (BITRI)	Prof Nyaladzi Batisani	M	Parastatal Organization - Research
5. Botswana Horticulture Council	Mr. Mogomotsi Moatswi	M	Private Sector
6. Botswana Farmers Association	Ms. Diane Sibanda	F	Private Sector
	Ms. Botsalano Coyne	F	Private Sector
7. Pandamatenga Commercial Farmers Association (PCFA)	Mr. Ryan Neal	M	Private sector
8. Botswana International University of Science and Technology	Prof G. Mengistu Did not participate	M	Parastatal organization - Academia
9. Botswana University of Agriculture and natural Resources	Not appointed	-	Parastatal organization - Academia
10. Botswana National Beef Producers Union (BNBPU)	Mr. Mpho Molokwe	M	Private sector
11. Department of Meteorological Services	Ms. Pearl Gosiame	F	Government Institution

2.2 Stakeholder Engagement Process followed in the TNA – Overall assessment

After undertaking a stakeholder mapping, the initial stakeholder engagement was done through a Project Kick-Off Meeting held on 27th January 2022. The stakeholders were consulted regarding the rationale for the mitigation and adaptation sector selection, and gain input on the composition of each sectorial working group as well as the National TNA Committee.

The Project Kick-Off Meeting was attended by stakeholders from government, civil society, and the private sector.

Formal communication was sent in the form of official letters to the identified stakeholders to nominate a focal point who will be representing the respective organization in the National TNA Committee. The same was done at the level of the sectorial working groups.

Stakeholder engagement included a mix of bilateral and technical working group meetings and stakeholder workshops to identify and prioritize technologies. Due to the on-going COVID-19 pandemic mostly online meetings were conducted to minimize the risk of infection.

The agriculture sector stakeholder engagement was facilitated by the national consultant through one face to meeting and three virtual meetings. In between meeting stake holders were engaged online as they read documents and provided feedback when required to do so. Table 3 presents the key stakeholder engagement processes for the agriculture sector.

Table 3 Key stakeholder engagement process for the TNA project

Meeting/Workshop	Date and venue	Participants	Main Discussion Points
National TNA Kick-Off Meeting	27th January 2022, Virtual meeting	National TNA Committee and other relevant stakeholders from across the mitigation and adaptation sectors.	• Discussion on the composition of the National TNA Committee and sectorial working groups. • Workplan of the national TNA Committee. • How can gender aspects be mainstreamed into TNA process.
First Agriculture Working Group	22nd February 2022, Aquarian Tide Hotel	Agriculture Working Group members	• Training session for members on the TNA process
Second Agriculture Working Group meeting	7th April 2022, Virtual meeting	Agriculture Working Group members	• Selection of long list of adaptation technologies options (ATOs) • Training on multi-criteria analysis
Third Agriculture Working Group meeting	20th April 2022, Virtual Meeting	Agriculture Working Group members	• Finalization of list of ATOs and criteria for use in MCA

			• Assigning weights to criteria • Scoring of ATOs against criteria using MCA template • Ranking of ATOs
Fourth Working Group Meeting	15th August 2022	Agriculture Working Group members	• Conducted Sensitivity test following agreed adjustments of criteria weight • Final ranking of ATOs

2.3 Consideration of Gender Aspects in the TNA Process

Gender is considered a key aspect of the TNA process and was considered throughout the different stages of preparing the setup of the project and of this report. This was guided by the TNA Guidance for Gender Responsiveness (De Groot, 2018). In terms of the composition of the agriculture sector working group there were 7 males (64%) and 4 females (36%) (Table 2). The nomination of the WG members was done by the organizations after being sensitized about the importance of gender balance. Gender was also considered in the choice of adaptation technologies and their criteria for prioritization in the MCA to ensure that the final list of technologies will be inclusive of women and youth in their implementation.

CHAPTER 3. SUMMARY AND CONCLUSION

The aim of the current GCF funded TNA project is to update the technology needs assessment and develop a technology road map for prioritized technologies to address climate change challenges in the energy, water and agriculture sectors which are critical in the development of Botswana. The report has reviewed the first TNA report of 2004 which emphasized mitigation technologies against climate change in the three sectors. Following vulnerability assessments, the emphasis has now shifted more towards adaptation and increased resilience to climate change impacts of drought, extreme heat, and floods on the various sectors of the economy.

Various policy instruments were reviewed, and they guided the participatory selection and prioritization of the adaption technology options for the agriculture sector. Structures to ensure stakeholder participation in the TNA process were established. These were the National TNA Committee with representation from 16 government and non-government institutions and agriculture sector working group with representation from ten institutions.

LIST OF REFERENCES

Andringa, 1984 The climate of Botswana in histograms. Botswana Notes and Records, 16:117-125 The climate of Botswana in histograms (journals.co.za) accessed 1 July 2022

Clements, R., J. Haggar, A. Quezada, and J. Torres (2011). Technologies for Climate Change Adaptation – Agriculture Sector. X. Zhu (Ed.). UNEP Risø Centre, Roskilde, 2011

Government of Botswana (2001). Botswana Initial National Communication to UNFCCC (NC1) Ministry of Works, Transport and Communications. Gaborone, Botswana. 90.

Government of Botswana (2004). Botswana Technology Needs Assessment on Climate Change Final Report. Gaborone, Botswana. 112p.

Government of Botswana (2011). Second National Communication to the United Nations Framework Convention on Climate Change (UNFCCC) December 2011. Ministry of Environment, Wildlife and Tourism. 124p.

Government of Botswana (2016a). National Development Plan 11 Volume 1 April 2017 – March 2023, Gaborone, Botswana. 292p.

Government of Botswana (2016b). Vision 2036 Achieving Prosperity For All. Gaborone, Botswana. 53p.

Government of Botswana (2018a). Updated National Climate Change Strategy for Botswana, Gaborone, Botswana. 171p

Government of Botswana (2018b). Final Action Plan. A National Climate Change Action Plan for Botswana. Gaborone, Botswana. 68p

Government of Botswana (2019). Botswana's Third National Communication to The United Nations Framework Convention on Climate Change October 2019. Gaborone, Botswana. 240p

Government of Botswana (2021a). The Botswana Climate Change Policy. Ministry of Environment, Natural Resources Conservation and Tourism. April 2021. Gaborone, Botswana. 36p.

Government of Botswana (2021b). Botswana National Drought Plan. Gaborone, Botswana. 86p

Government of Botswana (2022). Updated Nationally Determined Contribution of Botswana. Gaborone, Botswana. 39p

Green Climate Fund, 2019. Readiness and Preparatory Support Proposal Template. GCF. 37p

Gupta, S. Sharma, D Gupta, M. (2017). Climate Change Impact on Plant Diseases. Opinions, Trends and Mitigation Strategies. (**https://doi.org/10.1002/9781119276050.ch3**) accessed 4 July 2022)

Haselip, J. Narkevičiūtė, R. Rogat, J. and Trærup, S. (2015). TNA Step by Step: A guidebook for countries conducting a Technology Needs Assessment and Action Plan. UNEP DTU Partnership Copenhagen, Denmark. 47p.

Maxmen A. (2013). Crop pests: under attack. Nature, 501(7468), S15.

Statistics Botswana 2022. Population and Housing Census Preliminary Results. (2022 Population and Housing Census Preliminary Results.pdf (statsbots.org.bw) accessed 30 June 2022

Statistics Botswana 2019. Annual Agricultural Survey Report 2019 Traditional Sector. Gaborone, Botswana. 106p

Statistics Botswana 2021. Pilot National Multidimensional Poverty Index For Botswana. Gaborone, Botswana.36p.

Statistics Botswana (Updated). Sustainable Development Goals. Botswana Domesticated SDG Indicators. https://www.statsbots.org.bw/sites/default/files/special_documents/Botswana%20Domesticated%20SDG's.pdf Accessed 13 September 2022)

Trærup, S. and Bakkegaard, R.K. (2015). Evaluating and prioritizing technologies for adaptation to climate change - A hands on guidance to multi criteria analysis (MCA) and the identification and assessment of related criteria, UNEP DTU Partnership, Copenhagen, Denmark. 32p

De Groot, J .2018. Guidance for a gender responsive Technology Needs Assessment. UNEP DTU Partnership Copenhagen, Denmark. 36p.

Appendix

List of agriculture sector working group members and their contacts

No.	Name	Gender	Address and contacts
1	Ms. Evelyn Ramontshanyana Replaced Tshepho Matsuokwane in August 2022	F	Department of Crop Production P/Bag 003, Gaborone Tel No 3689396 Cell No.: +267 71474249, 73343438 Email: eramontshonyana@gov.bw
2	Mr. Thatayaone R. Oageng	M	Department of Animal Production P/Bag 003, Gaborone Tel No. 3689181/227/625 Cell No.: +26771636762 troageng@gov.bw
3	Not Nominated	NA	BUAN, P/Bag 0027, Gaborone
4	Dr Odireleng Molosiwa	M	NARDI P/Bag 00177, Gaborone Cell No.: +267 77467426 Email: odireleng@nardi.org.bw
5	Prof Nnyaladzi Batisani	M	BITRI, P/Bag 0082, Gaborone Tel No. 3607627, Cell No: +267 71904463 Email: nbatisani@bitri.co.bw
6	Mr. Mogomotsi Moatswi	M	Botswana Horticulture Council P.O. Box 25324, Gaborone Cell No.: +267 72 913 878 E-mail: mogzer@gmail.com
7	Ms. Diane Sibanda	F	Botswana Farmers Association Cell No: +267 72260091 Email dian.sibanda@gmail.com
8	Ms. Botsalano Coyne	F	Botswana Farmers Association (BOFA) Cell No. +267 71 780 384 Email:botsalano.coyne@gmail.com
9	Mr. Ryan Neal	M	Pandamatenga Commercial Farmers Association Cell No.: +26771404385 Emails: secretary@pcfa.co.bw
10	Prof G. Mengistu (Did not participate)	M	BIUST Cell +26771741922 mengistug@biust.ac.bw
11	Mr Mpho Molokwe	M	Botswana National Beef Producers Union Cell: +26771321000 Email: Kmatswiri@icloud.com Kmatswiri@valuechain.co.bw
12	Ms Pearl Gosiame	F	Department of Meteorological Services Tel No. +267 3612200 pgosiame@gov.bw