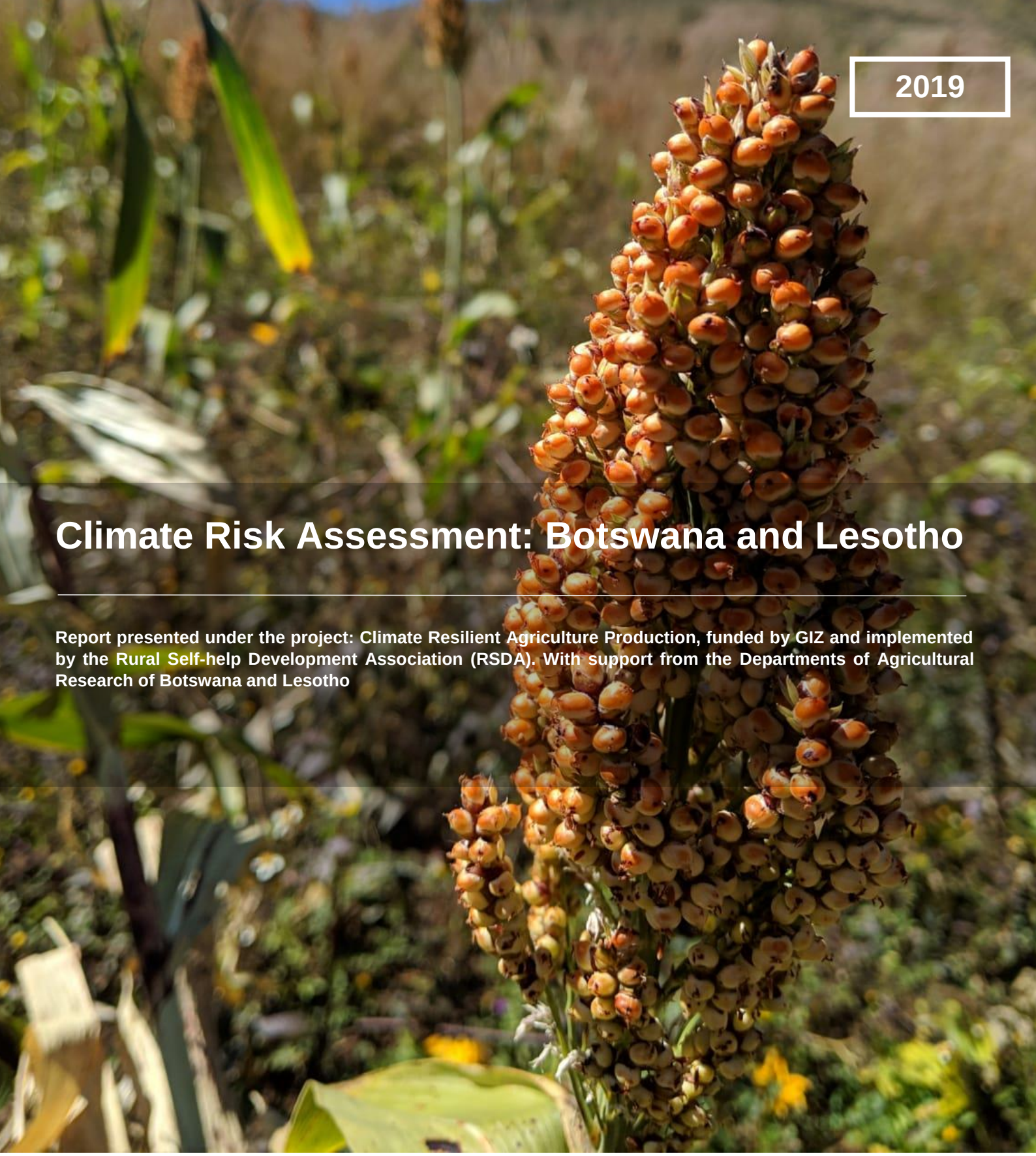

2019

Climate Risk Assessment: Botswana and Lesotho

Report presented under the project: Climate Resilient Agriculture Production, funded by GIZ and implemented by the Rural Self-help Development Association (RSDA). With support from the Departments of Agricultural Research of Botswana and Lesotho

REPUBLIC OF BOTSWANA

CCARDESA
Centre for Coordination of Agricultural Research and Development for Southern Africa

Rural Self-Help Development Association

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This publication is the result of collaboration between the Departments of Agricultural Research (DAR) of the Governments of Botswana and Lesotho, under the project: Climate Resilient Agriculture Production, funded by GIZ and implemented by the Rural Self-help Development Association (RSDA) from 2018 - 2019.

Acknowledgements:

GIZ

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Botswana Ministry of Agriculture, Department of Agricultural Research, particularly, Director Dr Pharoah Mosupi, Dr Lekgari Lekgari and the Botswana working group.

Cover photo credit:

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Disclaimer:

Our work is complemented by a synthesis of background documents that are already available in the public domain.

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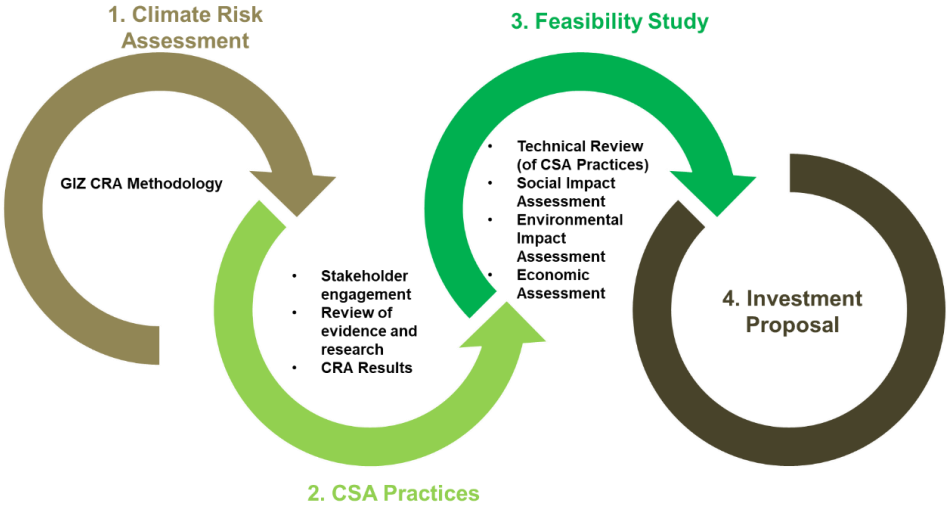
Acronyms and Abbreviations

AF	Adaptation Fund
AGOA	African Growth and Opportunity Act
BUR1	First Biennial Updated Report
CA	Conservation Agriculture
CAADP	Comprehensive Africa Agriculture Development Plan
CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security
CCARDESA	Centre for Coordination of Agricultural Research and Development for Southern Africa
CIAT	International Centre for Tropical Agriculture
CMA	Common Monetary Area
CRA	Climate Risk Assessment
CSA	Climate-smart agriculture
DAR	Department of Agricultural Research
EAC	East African Community
EFTA	European Free Trade Agreement
GCF	Green Climate Fund
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIZ	German Corporation for International Cooperation
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
LDC	Least Developed Country
NAIP	National Agriculture Investment Plan
NAP	National Adaptation Plan
NAPA	National Adaptation Programme of Action
NCCP	National Climate Change Policy
NDC	Nationally Determined Contribution
NEPAD	New Partnership for Africa's Development
NSDP	National Strategic Development Plan
NSFP	National School Feeding Policy
RSDA	Rural Self-help Development Association
RSA	Republic of South Africa
SACU	Southern African Customs Union
SADC	Southern African Development Community
SDG	Sustainable Development Goal
TNC	Third National Communication
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
WFP	World Food Programme

Executive Summary

Programme context and objectives

The Climate Resilient Agriculture Production Programme is a collaboration between the Departments of Agricultural Research in Lesotho and Botswana to undertake a climate risk assessment of sustainable agriculture and climate-smart agriculture (CSA) best practices in both countries, using the sorghum value chain as a reference case where necessary. The Programme is funded by GIZ and its implementation led by the Lesotho-based Rural Self-help Development Association (RSDA). Following the development of 1) a Climate Risk Assessment and the identification of 2) CSA practices suited to the contexts of the countries, the programme will conduct 3) a study of the feasibility of scaling up CSA-based production in both programme countries to inform 4) the development of a scaled investment proposal. A graphic representation of the programme's objectives can be seen below:



The outcomes of this report are 1) the Climate Risk Assessment and 2) identification of CSA Practices, both of which have been developed using existing conceptual frameworks (IPCC AR5, GIZ Vulnerability Sourcebook (2014) and Risk Supplement to the Vulnerability sourcebook (2017)). These sources underpin the work during collaborative workshops with the technical experts in the Departments of Agricultural Research of Botswana and Lesotho.

Country contexts

In Botswana and Lesotho, agriculture is either the primary source of income or contributes supplementary income to rural households. While the agriculture sector accounts for less than 50% of employment in both countries, it remains an important sector of the economy as the majority of the population resides in rural areas and rely on subsistence agriculture for their livelihoods. As an important sector in both countries, it is vital to recognise that the agriculture sector faces considerable challenges, chief among which is the overreliance on rain-fed production, soil erosion and land degradation, overcultivation / overgrazing and the accompanying challenges in rangeland management, and the increasing occurrence of drought, pests, vector and water-borne diseases in both livestock and crop subsectors. In both countries, climate change impacts are already being experienced and Global Circulation Models (GCM) from the AR5 of the Intergovernmental Panel on Climate Change (IPCC) indicate that higher temperatures and more erratic rainfall patterns are to be expected in future, exacerbating the existing challenges to this sector.

With recurrent climate hazards in Lesotho, agriculture and food security are greatly affected: delayed planting (or farmers not planting at all), reduced seed germination, crop failures, deterioration of rangelands livestock emaciation and increased food prices (World Bank & CIAT, 2018). At household level, these effects are felt the most. According to a socio-economic household survey conducted by IFAD in Lesotho, Basotho households are "highly exposed to shocks, resulting from erratic climate variability over the last decade, and the results [from the survey] show that their ability to recover from such shocks is very low" (IFAD, 2014).

In Botswana, drought is a frequent occurrence. According to a FANRPAN study in 2017 of CSA practices in Southern Africa, Botswana's crop production is mainly rain-fed, making it most vulnerable to climate change. The study adds that "relatively poor soil quality, coupled with an overreliance on rain for production, has resulted in low productivity of crops in Botswana" (FANRPAN, 2017). Countries in Southern Africa, including Botswana, are also affected by El Niño (warm) and La Niña (cool) events in the tropical Pacific. According to Botswana's Second National Communication (SNC) to the UNFCCC, rainfall has been highly variable, and droughts are projected to increase in frequency and severity.

Considerations of agricultural production extend beyond the economy. As net food import countries, Botswana and Lesotho rely on food imports from other countries to address food shortages and help people affected by food insecurity. According to the Vulnerability Assessment Committees of both countries, the number of food insecure people has increased and cereal production generally experienced downward turns. Both countries are only able to meet a percentage of total food needs (Botswana meeting only 10% of its required cereal needs through local production, and Lesotho generally produces only 30% of the country's annual food need requirements). By strengthening local production of farmers, both countries can reduce food insecurity and decrease reliance on food imports.

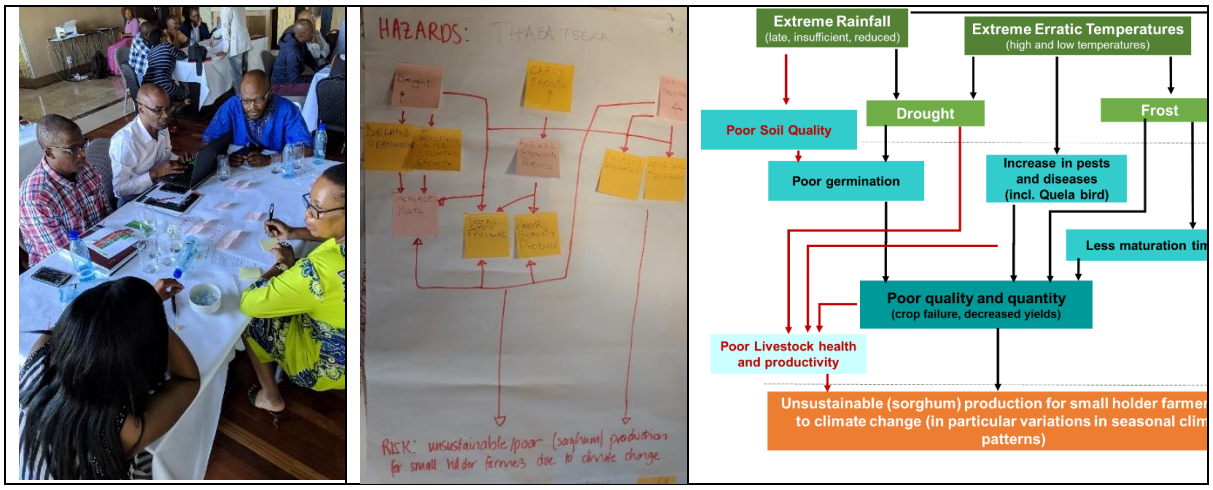
While both countries are taking strides to introduce or mainstream CSA into agricultural policies and frameworks, climate change impacts persist and have bearing on the national economy, livelihoods (especially in the case of rural smallholder farmers) and food security. To advance agricultural development goals, achieve food security and improve the contribution which various farming subsectors are already making to the GDP of the respective countries, CSA is necessary to support farmers to operate in the face of climate change impacts.

Climate Risk Assessment

The Climate Risk Assessment was based on and consistent with assessment frameworks from the GIZ Vulnerability Sourcebook (2014) and the Risk Supplement to the Vulnerability Sourcebook (2017), both aligned with IPCC AR5 methods for conceptualising and analysing climate change impacts, as well as the SADC Climate Proofing Tool (GIZ 2016).

Using the framework as identified, technical experts (agronomists, planning and policy experts within the Departments of Agricultural Research of both countries) collaborated and identified key climatic risks, impacts and adaptations specific to their country contexts. Through sensitisation workshops and briefings with the DAR, the programme Team Leader worked in close consultation with DAR counterparts in developing the working approach. This was followed by two national workshops and one regional workshop.

Stakeholder engagement for mapping country-specific climate risk and impact chains



Changing extremities in weather patterns were the primary climate hazards identified for smallholder farming systems. The primary climate hazards related to this risk of unsustainable production as:

- Extreme Rainfall (late, insufficient, reduced);
- Extreme Erratic Temperatures (more extreme highs and lows),

These hazards led to a number of core critical impacts which significant threaten the success of small holder farmers;

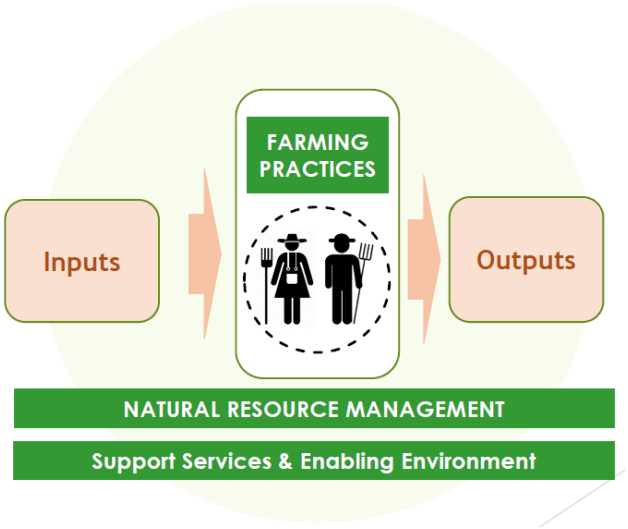
- Poor germination
- Increase in pests and diseases
- Less maturation time
- Poor quality and quantity of output (failure, decreased yield)
- Poor soil quality
- Poor livestock health and productivity

The CRA concluded that;

- The risk categorisation for all of these biophysical elements under the projected climate change will be high.
- These risks are exacerbated by the sensitivities of the farming systems, namely the high reliance on rain fed agriculture and the use of crop types which are highly vulnerable to changes in water, pest and weather.
- The characteristics of the farming system limit the capacity of farmers to cope with the hazard impacts when they do occur;
    - there is low uptake of irrigation systems that manage moisture deficit, limited targeting of agriculture practices to seasonal climate challenges,
    - low utilisation of information services and lack of models to de-risk agriculture for small holder farmers.
- Adaptation measures that target these gaps and build these capacities will be those that best mitigate the risk from the climate hazards.

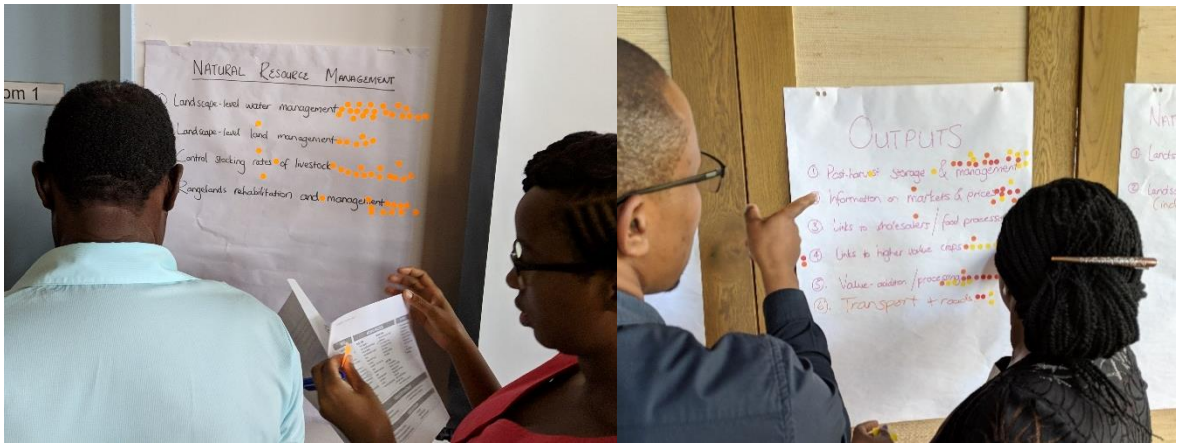
Climate-Smart Agriculture Practices

To analyse and prioritise contextual CSA practices which would serve as adaptation options for smallholder farmers in both countries, a conceptual Farming Systems Framework as shown below.



Using this framework, which outlined 49 practices, the results of the CRA were combined with the results of a CSA literature review and government prioritisation exercises to develop a technically validated CSA practice list of 20 practices to take forward into the prioritisation exercise using the SADC Climate Proofing Tool (GIZ, 2016).

Stakeholder engagement for prioritisation activities



From the list of approximately 20 relevant climate smart practices, eight highest priority practices for adaptation were identified for each country, five of which overlap. These practices scored highest when assessed for effectiveness, cost, feasibility and speed of result.

Climate smart practice priorities (in order of score, common practices bold)

Lesotho	Botswana
Sustainable Fodder Production	Use of local adaptive livestock breeds
Mixed farming (Crops and Livestock)	**Sustainable Fodder Production**
Provision and utilisation of climate Information services (weather, crop information etc)	**Mixed farming (Crops and Livestock)**
Implementation of Rainwater Harvesting	Supply (quantity and location) of improved seeds and breeds available.
Improvements in post-harvest storage and management	**Implementation of Rainwater Harvesting**
Systems which make access to inputs easy (seeds, fertiliser)	**Improvements in post-harvest storage and management**
Systems which link farmers to higher value crops	National Policy and Strategy providing guidance for sector
Phytosanitary legal framework	**Legal and phytosanitary frameworks**

Concluding Recommendations

Based on the results of the analysis undertaken of country context, climate projections, CRA and CSA practice prioritisation the following recommendations are made;

- That the staff of DAR Lesotho and Botswana utilise the CRA framework (giving consideration to hazard, risk, vulnerability and exposure) for considering Climate Risk in future work and replicate the methodology where relevant.
- The impact mapping tool (using post it notes to fill the steps between hazard & risk and identifying causality) can be used at any time to better understand the components and risks of the agricultural model that is being considered.
- The farming systems framework is used as a reference to understand and communicate with other stakeholders the scope and breadth of the components within the farmers operations which can be considered to relate to 'climate smart agriculture' as well as those outside of their operations which can impact on their success.
- That DAR and broader Ministries internalise the fact that changing extremities in weather patterns are the primary climate hazards for smallholder farming systems; particularly late onset and/or reduced rainfall and extreme lows and highs in temperature.
- That consideration is given to the key system risks (poor germination, increase in pests and diseases, less maturation time, poor quality and quantity of output, poor soil quality, poor livestock health and productivity) when programming across DAR and the broader Ministries is set so that adaptations can align to addressing these most critical impacts.
- That DAR drive the research agenda to align to these critical impacts so that the results of their work can feed into and shape the work of the broader Ministry and provide guidance to other stakeholders in the sector.
- That this report and its executive summary be shared via official channels and published on relevant web sites.
- That the work of this report feeds into the upcoming Feasibility Study and Investment Proposal

1 Introduction

1.1 Climate Resilient Agriculture Production Programme Context

The Climate Resilient Agriculture Production Programme is a collaboration between the Departments of Agricultural Research in Lesotho and Botswana to undertake a climate risk assessment (previously vulnerability assessment) of sustainable agriculture and climate-smart agriculture (CSA) best practice production in the countries, using the sorghum value chain as a reference case where necessary. The Programme is funded by GIZ and its implementation led by the Rural Self-help Development Association (RSDA) in Lesotho. Based on available desktop information, a study of the feasibility of scaling up CSA-based production in Lesotho and Botswana will be undertaken to inform the development of a scaled investment proposal.

In rural Lesotho, agriculture is either the primary source of income or contributes supplementary income for more than 50% of the population (Agricultural Sector Strategy, 2003; Lesotho Bureau of Statistics, 2014). Although the agricultural sector accounts for 41% of employment, it is estimated that about 80% of the country is reliant on agriculture either directly or indirectly for a livelihood (World Bank & CIAT 2018). Climate change impacts are already being felt and climate change models indicate that Lesotho will experience higher temperatures and more erratic rainfall patterns in future. Current dependence on rain-fed agriculture makes the country highly vulnerable to such changes, which will exacerbate existing issues of environmental degradation, increase the risk of vector and water-borne diseases and have the potential to slow economic performance and threaten achievements in social development (National Strategic Development Plan - NSDPI). Climate change impacts compound existing economic, social and health challenges faced particularly by the rural population and limit the country's ability to establish and maintain sustainable livelihoods for vulnerable populations.

In Botswana, agriculture is an important sector in the economy because it provides food, income and employment for the majority of the rural populace (Statistics Botswana, 2013). The sector has a potential for growth and to alleviate poverty and hunger and develop a food secure Botswana. Although the agriculture sector accounts for only 1.9% of the national income, over 70% of Botswana's population resides in the rural areas, and the majority (70%) relies on traditional/subsistence agriculture for their livelihoods (UNDP, 2012). However, the performance of the sector has been unsatisfactory due to recurring droughts, pests, diseases and land degradation.

To achieve food security and agricultural development goals, CSA is necessary to support farmers to operate in the face of climate change impacts. Currently, Lesotho and Botswana are net importers of food and climate change is likely to exacerbate this. Agricultural production in Botswana is on a downward trend in terms of cereal production; maize and sorghum are estimated to have declined on a yearly basis to 64 000 tonnes, down 32% from the high output of 2017 (FAO, 2018). Rainfall variability is one important factor that limits production and in many African countries, farmers may seek to replace maize with a drought-resistant crop in areas where rainfall declines due to climate change. As in many African countries, Lesotho is reliant on maize production which, though highly productive when rainfall is abundant, is very sensitive to drought. It is anticipated that the landrace varieties and more nutritious sorghum may do better under erratic rainfall regimes. The work undertaken in this project will assist each country to quantify the climate risks and the components which, currently and under future projections, will have the most impact on sustainable production. Working with technical experts, best practice adaptation measures will be selected and documented to form a model of climate resilient production which can be scaled up.

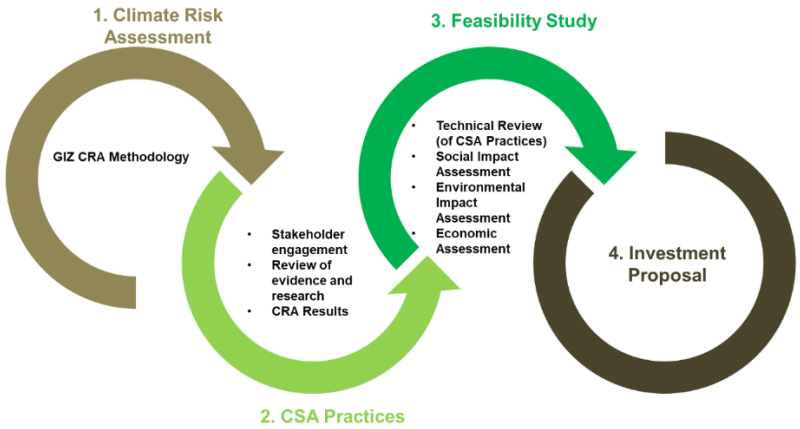
1.2 Programme Description and Methodology

The scope of this work complements sorghum pilot activities undertaken by DAR Lesotho and DAR Botswana. This project aims to better understand climate resilience agriculture (using sorghum as a reference where necessary) and the risk which climate change poses. It also aims to specify the feasibility and scope of scaling up climate resilient production in Lesotho and Botswana for the objective of improving the climate resilience of smallholder farmers.

The objectives of this project are;

- **Climate change risk assessment for agriculture production -** Undertake a climate change risk assessment of agriculture production for smallholder farmers and develop a climate risk profile to identify the opportunities for climate adaptation in Botswana and Lesotho.
- **Identification of CSA best practices for sustainable production -** Based on the climate change risk assessment, identify and propose proven CSA best practices which will be applied to enhance the resilience of smallholder farmers to climate change and help to minimize climate risks and stabilise production and yields, to climate proof agricultural production.
- **Feasibility study for climate resilient production -** Undertake a feasibility study detailing the technical design and implementation of the proposed CSA technologies and best practice for sustainable production, documenting the benefits, including socio-economic benefit, economic analysis, return on investment, environmental impacts, impact on and benefits for women and youth.
- **Investment proposal for the scale-up of climate resilient agriculture production in Lesotho and Botswana –** Develop an investment proposal for upscaling and disseminating the proposed CSA technologies and practices with national partners and/or government, including measures to benefit women and youth.
- **Collaboration -** Delivery of above activities in a collaborative way to ensure technical inputs from specialist staff are leveraged and to build awareness and skills with government counterparts.

The four core components of this project feed into each other as per the representation below. This project is implemented in a collaborative manner working closely with key government counterparts. In addition, through the implementation there are key points of stakeholder engagement which feed into the outcomes. At these points broader groups of key stakeholders are convened to provide technical input into or validate the outcomes of each step.



This report covers the outcomes of the Climate Risk Assessment (CRA) and referencing work that was done by stakeholders towards the CSA Best Practices identification and assessment.

2 Lesotho Country Analysis

2.1 Lesotho Context

Figure 1 Map of Lesotho illustrating 10 districts

Source: (FAO, 2016b).

Lesotho (officially, The Kingdom of Lesotho) is a landlocked country in southern Africa, surrounded by the Republic of South Africa (RSA), with a total area of 30 355 km^2 and an estimated population of 2 007 201 people in 2016 (Lesotho Review, 2019, p.3; Government of Lesotho, 2018; United Nations, 2019). The country has ten districts and four geographic zones, mostly highland (65% of Lesotho's land area), foothills, lowlands and the Senqu Valley (Lesotho Review, 2019, p.3). Despite the fact that approximately only 10% of the total land is suitable for agriculture – due to the mostly mountainous terrain – an estimated 70-80% of the population lives in rural areas and three-quarters of these people are engaged in farming (IFAD, n.d.). Lesotho's mountainous topology poses some challenges: farming often takes place on the slopes with fragile soil formation; this, coupled with climate change impacts, makes soil erosion an ever-present reality. Over-cultivation, overgrazing, urbanization and deforestation contribute to soil loss and land degradation. An estimated 40 million tonnes of soil per year is lost through erosion, and only 1% of the land is indigenous forest (Lesotho Review, 2019, p.36; World Bank & CIAT, 2018). Lesotho experiences a continental climate, where temperature deviations can be extreme and can differ greatly between the highlands and lowlands.

2.1.1 Population

The population of Lesotho was approximately 2 million people in 2016. Data from the last census - Lesotho National Census of 2016 - shows that 982 133 of the population is male (48.9%), 1025 068 female (51.1%) and youth (by Lesotho government definition of individuals aged 15-35) accounted for 39.6% of the total population (Lesotho Review, 2019: p.6). In terms of urbanisation, by 2017 more than a quarter of the population were living in urban areas (28.4%) with 71.6% located in rural areas (FAO, 2019). Lesotho's population density (people per sq. km of land area) is 73.6 (World Bank, 2019c).

2.1.2 Economic overview

Lesotho is a small economy and relatively undiversified, which leaves it vulnerable to regional and international shocks (Lesotho Review, 2019: p.3). With a gross domestic product (GDP) per capita of USD 1,154 in 2017, Lesotho is classified as a lower middle-income country (World Bank, 2019b). The country places a premium on regional economic integration and trade as can be seen through its membership of strategic regional organisations and participation in continental initiatives.

Lesotho is a partner in continental initiatives such as NEPAD (New Partnership for Africa's Development) and enjoys membership of the Southern African Customs Union (SACU), an economic grouping of South Africa, Botswana, Lesotho, Namibia and Swaziland into an economic zone with duty-free trade and a common external tariff on imports from outside the zone (FAO, 2016b). It is also a member of the Southern African Development Community (SADC), an inter-governmental organisation aiming to promote sustainable and equitable economic growth and socio-economic development, deeper co-operation and integration, good governance and durable peace and security among 15 Southern African Member States; and the Common Monetary Area (CMA), linking South Africa, Namibia, Lesotho and Swaziland and allied to the SACU (SADC, 2012). One of the major agreements in the CMA is the currency agreement between the countries and that all national currencies are pegged to the South African rand which is also legal tender in all CMA countries.

In terms of trade, Lesotho maintains a significant import and export relationship with South Africa; its main export partners are primarily South Africa which accounts for 56.4% of exports and the USA which accounts for 35.4%. South Africa accounts for 84.1% of Lesotho imports. The country also maintains trade agreements within the region and continent and owing to its status as a Least Developed Country (LDC), it enjoys various trade agreements.

In addition to being a member of SACU, CMA and SADC, Lesotho is part of a Free Trade Agreement with Europe (EFTA), a Preferential Trade Agreement with MERCOSUR which is the Common Market of the Southern Cone including Argentina, Brazil, Uruguay and Paraguay, trade with the USA under the African Growth and Opportunity Act (AGOA) which accounts for thousands of direct employment to Basotho people, the Tripartite Free Trade Area which connects SADC, EAC and COMESA and will potentially be an agreement that is ratified in 2019 (Lesotho Review, 2019: p.3).

The country's major sectors are agriculture and textile manufacturing, with mining increasingly contributing to the country's economy. The textiles and apparel industry is the principal source of foreign revenue and jobs, and diamond mining has increased its contribution to the country's GDP. Through the National Strategic Development Plan (NSDP II), the government prioritises public sector collaboration with the private sector, which is made up primarily of micro, small and medium enterprises. This is hoped to grow over the next 6 years of the NSDP II (Lesotho Review, 2019; p.3, p36-37).

2.2 Lesotho Agriculture analysis

The contribution of agriculture to the country's GDP has declined in recent years, where today it accounts for only 5% of GDP. The arable agriculture sub-sector focuses on rain-fed cereal production. Livestock farming involves animal grazing, wool and mohair production and the aquaculture industry (Lesotho Review, 2019: p.40-41). Government concurs with IFAD calculations that only 10% of Lesotho's total land is arable; despite this, agriculture (which includes more sub-sectors than arable farming) still accounts for 80% of the livelihoods of Lesotho's population (IFAD, n.d.; World Bank & CIAT, 2018).

Lesotho experiences many constraints related to domestic agricultural production: this includes its overreliance on rain-fed agriculture and limited use of irrigation and technology, weak extension systems, poor marketing infrastructure, limited access to markets for smallholders, insecure land tenure and land degradation (including soil erosion). Additionally, impacts of climate change are notable and unpredictable weather conditions (inconsistent rains and persistent droughts) exacerbate the existing constraints and challenges. According to the Lesotho National Development Corporation, approximately two thirds of the cereal utilised in the country is imported which makes the country vulnerable to external shocks and food price fluctuations (Lesotho Review, 2019: p.39).

2.2.1 Agro-ecological zones

Table 1 Lesotho Agro-ecological zones

Lowlands	Foothills	Senqu River Valley	Mountain range
West of country. Relatively high rainfall. Allows cultivation of maize, sorghum, beans, winter wheat, vegetables. Soil susceptible to erosion (especially by wind / flowing water); cause of concern given high population density. 1 of 2 distinct fish farming zones (due to high temperatures)	Centre of country, lower rainfall compared to the lowland zone. Loose sandy topsoil easily eroded by wind and rainwater due to over-grazing. Maize, sorghum and summer peas grow in this zone. Main pastureland for sheep and goats (wool and mohair production). Small stock well-adapted to area	Steep valley along Senqu River (from east to west of country). Low rainfall, especially in the south-western parts and has rich soils along the banks of the river. Winter wheat and maize grow in this area.	Characterized by very cold winters. Largest portion of the country, covering about 59% of the total land. Wheat and peas grow in this area. Communication facilities are very poor in the mountain areas. 1 of 2 distinct fish farming zones (extreme cold weather suitable for producing trout)

Source: (FEWS NET, 2014).

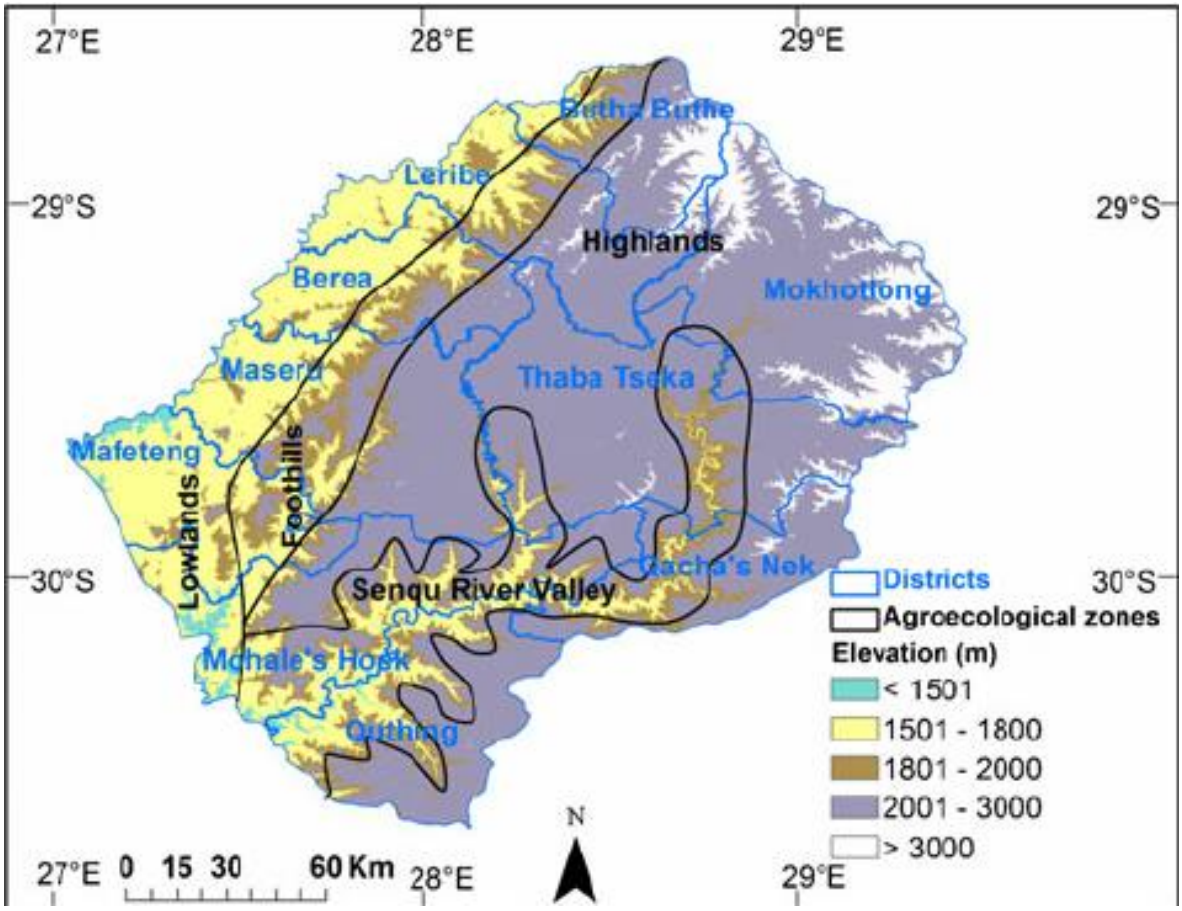


Figure 2 Map of agro-ecological zones: Lesotho

Source: (Moeletsi and Walker, 2013).

2.2.2 Agricultural production

Table 2 Agricultural production in Lesotho

Agricultural produce / activity	Production Information	Trend
Maize	• Maize dominates local cereal cultivation with 70-80 percent of total national cereal production. Low levels of local maize production and yields (on average 0.5 MT/hectare) are primarily due to Lesotho's high cereal production (and input) costs and other factors such as climate change and land degradation. • Maize production in the country also suffers significant post-harvest losses (for example, in Maseru losses were recorded at 2509 tonnes in 2004 compared to 2589 in 2015). But there are underlying constraints in measuring losses and waste of food globally: lack of consensus in definitions and underdeveloped methodologies (Office of the Prime Minister, Kingdom of Lesotho, 2018: p.26).	Maize, Sorghum and Wheat are the top three cereals produced in the country. Based on the Lesotho Vulnerability Assessment Committee (LVAC) 2018, cereal production in the country has decreased considerably since the 2012/2013 season, with a bumper harvest in the 2016/2017 season resulting in increasing stock levels and reduced imports in the next year: 2017/2018 (FAO, 2017). However, yields of the three cereals were significantly less in the year 2017/2018 than the year before.
Sorghum (Lesotho Vulnerability Assessment Committee, 2016)	• Occupies 20% of available arable land of Lesotho • Lesotho has averaged an annual production of 9,600 tonnes of sorghum. • The crop ranks third in terms of preference, after maize and wheat (NB: it is not clear if its preference of farming, import or consumption) (Sekoli & Morojele, 2016).	
Wheat (winter) (Lesotho Vulnerability Assessment Committee, 2016)	• Occupies 10% of available arable land of Lesotho, mainly grown in the mountainous area of the country. • Lesotho has averaged an annual production of about 12,000 tonnes of wheat. • Lesotho imports on average 80% of its annual wheat requirements from South Africa.	
Livestock (cattle) (Lesotho Review, 2019; p40-41)	• Raised primarily for subsistence, draught power, milk, fuel (dung) and meat • Lesotho is self-sufficient in terms of beef production (13500 metric tonnes per year) • No known beef imports or exports take place (with exception of isolated instances)	The livestock subsector accounts for 62% of the country's agricultural GDP. Wool and mohair are considered the country's most important value chains, and emphasis is placed on initiatives that build poultry and piggery abattoirs to increase these agricultural activities.
Livestock (pigs) (Lesotho Review, 2019; p40-41)	• Raised primarily for food (on small scale) • Pig production still in infancy, output of pork production: 3698 tonnes • Majority of pork supplied to outlets in Lesotho are from South Africa.	
Livestock (wool and mohair) (Lesotho Review, 2019; p40-41)	• One of country's most important value chains; industry uses combined 4million sheep and goats. Sheep are raised for meat, wool and skin; goats raised for meat, mohair and hide • Both wool and mohair are used locally (tapestries and knitwear), but large percentage sent to South Africa for processing and packaging before being sold in Asia and Europe • Industry worth M300 million	

Agricultural produce / activity	Production Information	Trend
	• Regulated strictly: trade in wool and mohair requires license (issued in 1 of 6 categories). Export license does not permit the holder to export wool and mohair unless it is prepared, brokered, traded and auctioned in Lesotho	
Livestock (poultry) (Lesotho Review, 2019; p40-41)	• Regulated by BAPOFA (Basotho Poultry Farmers' Association) • Value chain comprises 3 sub-channels: formal live bird markets (higher income consumers), informal city (lower-income consumers); informal rural markets (rural consumers). Only 20% is marketed through formal sector. • High cost of inputs remains a challenge since most inputs are sourced from outside the country	
Livestock (dairy) (Lesotho Review, 2019; p40-41)	• Government is working to stimulate local dairy production • Majority of locally consumed dairy products imported from SA • Local farmers are producing only 1.3million litres but the country spent M210 million on 18.9 million litres of dairy products in 2017/2018	
Fisheries (Lesotho Review, 2019; p40-41)	• Lesotho's 2 distinct fish farming regions (lowlands, highlands) good potential for increasing production. Trout is produced for local consumption and export to Japan and SA. • Opportunities exist for Tilapia farming, extraction of Omega oils and other derivative / by-products / fish-food production.	

The country's agriculture sector is dominated by cereal (maize and wheat) production and the rearing of goats and sheep for Lesotho's mohair and wool industry. Key challenges for the sector, as indicated in Section 2.3.3, are low soil fertility, land degradation and a high vulnerability to droughts. These factors are compounded by "high food price fluctuations and reliance on imports to meet local food needs" (World Bank & CIAT, 2018).

According to the Lesotho Vulnerability Assessment Committee (LVAC), Lesotho is a net food importing country as the small percentage of arable land (estimated at 10% of total land area in Lesotho) generally produces only 30% of the country's annual food need requirements:

> *"Since 2007 Lesotho has been averaging an annual cereal production of 97,600 tonnes, disaggregated by cereal: around 76,000 tonnes of maize, 9,600 tonnes of sorghum and 12,000 tonnes of wheat. However, even in good harvest years, Lesotho is only able to meet roughly 30 per cent (110,000 tonnes) of its annual cereal requirements (approximately 360,000 tonnes). Lesotho is therefore highly dependent on food imports to meet its food needs. On average the country imports around 70 per cent of its food need requirements per year, which a vast majority, if not all, are imported from neighbouring South Africa" (Lesotho Vulnerability Assessment Committee, 2016: p.8).*

2.2.3 Food Security

According to the 2018 Lesotho Zero Hunger Strategic Review, Lesotho is generally a food deficient country having a large percentage of the population exposed to situations of chronic food insecurity – especially in rural areas where the population depend on subsistence farming and other rural non-farm activities (Office of the Prime Minister, Kingdom of Lesotho, 2018: p.1). The increasing number of food insecure population in rural areas has remained under 500 000 since 2009, but in 2016/2017 it rose to 679 437 people. Additionally, the country experiences the triple burden of malnutrition - under and over nutrition and micronutrient deficiency across all age groups.

2.3 Lesotho Climate Change Response and CSA

2.3.1 Key Climate Change Policies and Frameworks

Lesotho was one of the countries that signed the UNFCCC at the Earth Summit in Rio de Janeiro in 1992 and ratified the Convention in 1995. Consequently, a number of policies and measures in various sectors, which are closely aligned with the objectives of the UNFCCC and the country, have become increasingly aware of the obligations under the Convention (Ministry of Energy and Meteorology, Kingdom of Lesotho, 2017). Lesotho submitted the Initial (2000) and Second National Communication (2013). It developed and published a National Adaptation Programme of Action (NAPA) in 2007 highlighting 11 priority areas for immediate adaptation needs and subsequently submitted her Intended Nationally Determined Contribution (INDC) in 2015. The country is currently preparing the Third National Communication (TNC), First Biennial Updated Report (BUR1) and National Adaptation Plan (NAP).

In 2017 Lesotho released the National Climate Change Policy the policy vision is to build climate change resilience and low-carbon pathways including a prosperous sustainable economy and environment in Lesotho. The overarching objective of the policy is to ensure that all stakeholders address climate change impacts and their causes through the identification, mainstreaming and implementation of appropriate adaptation and mitigation measures, while promoting sustainable development. Specifically, the policy fosters development of processes, plans, strategies and approaches that:

1. Promote climate-resilient, social, economic and environmental development that is compatible with, and mainstreamed into, national development planning and national budget-setting processes;
2. Explore low-carbon development opportunities, nationally and internationally, in order to promote the sustainable use of resources and
3. Strengthen a framework that promotes efficient climate change governance, strong international cooperation, capacity building, research and systematic observations, clean technology development, transfer and use, education, training and public awareness and financing in a way that also benefits the most vulnerable through the implementation arrangements to be defined in the strategy.

To achieve the Vision and Objectives, the National Climate Change Policy (NCCP) calls for prioritisation and implementation of the following core pillars: adaptation and climate risk reduction, mitigation and low-carbon development pathways, governance and institutional arrangements, climate finance and investment framework, as well as cross-cutting issues

The other most relevant policy frameworks in the sector are summarised below.

Table 3 Summary of relevant policies and frameworks in Lesotho

Policy / Framework	Regionality	Years	Key objectives
United Nations Framework Convention on Climate Change (UNFCCC)	International	1992 (opened for signature); 1994 (enforced following ratification by several countries) 2015 (submission of INDCs) 2017 (submission of NDCs)	The framework sets non-binding limits on greenhouse gas (GHG) emissions for individual countries and contains no enforcement mechanisms. Lesotho has signed and agreed to submit reports on GHG emissions, climate mitigation and adaptation activities, vulnerability analyses and policy recommendations, although the country is a non-Annex 1 party to the Paris Agreement (having no obligations to reduce GHG emissions although it should report on anthropogenic sources and sinks of GHGs). Lesotho submitted its report on its Intended Nationally Determined Contributions (INDCs) towards achieving the stabilisation of GHG in the atmosphere, to the UN in 2015. This was followed by its Nationally Determined Contributions report (submitted in 2017), which is a follow-on to the INDCs after the Paris Agreement was signed and ratified by countries.
Forestry Act	National	1998	Protection and preservation of forests and calls for land to be made available for forestry activities (incl. fuel wood production) to preserve indigenous shrubs and trees that guard against soil erosion.
National Agricultural Sector Strategy	National	2003 (unclear if still in effect)	
National Action Plan for Food Security	National	2007-2017 (unclear if still in effect)	
National Adaptation Programme of Action (NAPA)	National	2007 (developed; unclear if still in effect or if joined with National Climate Change Policy)	In the absence of a national adaptation plan, NAPA remained best indication of Lesotho's intentions for adaptations to climate change.
Environment Act	National	2008	Protection and management of the land base against negative impacts of infrastructure development. The Act introduced Environmental Impact Assessments, audits and project monitoring
National Forestry Policy	National	2008	Increase Lesotho's tree cover to 5% by 2020 and to promote the preservation of natural heritage of trees and shrubs by rural people
Comprehensive Africa Agriculture Development Plan (CAADP) Framework	Regional	2010 (launch) 2013 (Lesotho signed its compact)	Emphasises sustainable land and water management for improved agricultural productivity through research, technology adoption and dissemination and agricultural GHG emission reduction.
National Strategic	National	2012/13 – 2016/17	NSDP include many sectors, of which agriculture and environmental conservation are key. Focus in these sectors is to reverse environmental

Policy / Framework	Regionality	Years	Key objectives
Development Plan (NSDP)		(NSDP II under renewal)	degradation and adapt to climate change. Fundamental issues in the NSDP related to agriculture and the environment include protecting water sources, boosting the environment's natural resilience to climate change, conserving biodiversity, rehabilitation of areas affected by soil erosion.
School Feeding Policy	National	2014	The Government of Lesotho with technical support from the World Food Programme (WFP) formulated the National School Feeding Policy (NSFP), approved by the Cabinet of the GoL in July 2015. The NSFP sets the framework for implementation of the national school feeding programme; including both Early Childhood Care and Development (ECCD) component and the primary schools. The School Feeding Programme (SFP) is fully supported financially and operationally by the government and is providing school meals to learners from 1,425 public primary schools across the country, out of which, WFP assists 920 public primary schools. The NSFP advocates for Home Grown School Feeding (HGSF) where food commodities for the programme are sourced within the schools' localities. As a step to achieving this HGSF initiative, there are efforts to link smallholder farmers to schools thus creating markets for their produce—the product of which would be increased incomes for farming households and increased agricultural productivity. However, this component remains weak due to lack of capacity for monitoring and evaluation systems.
National Range Resources Management Policy	National	2014	Guidance for development of strategies to combat land and vegetation degradation, with the end goal of attaining sustainable development and management of rangeland resources for enhanced biodiversity. The Policy also provides a basis for stabilizing livestock-based livelihoods especially in wool and mohair industries. The management and protection of this ecosystem is critical for food and nutrition security hence the need to refine and sharpen policy initiatives for protection and conservation of the rangelands. The current grazing management laws and regulations last amended in the 1980s are dated and must be revised and enforced.
Draft National Agriculture Investment Plan (NAIP)	National	2015 (incomplete)	Technical support to develop the NAIP was received after Lesotho signed CAADP compact. The NAIP provides prioritised investment areas crucial for Lesotho to accelerate growth in the agriculture sector, and achieve the sector growth and development targets.
Energy Policy	National	2015	Aim to reduce fuel wood usage and other fossil fuels and promotes renewable energy and resource efficiency, focusing on increasing energy access in remote areas.

Policy / Framework	Regionality	Years	Key objectives
Food and Nutrition Security Policy	National	2017	Provides the institutional and implementation framework for food security and nutrition in Lesotho.
Climate Change Policy	National	2017	Based on UNFCCC guidance, UN SDGs, African Union Agenda 2063, Paris Agreement and NSDP. Provides strategic direction and coordination and creates links between climate change and sustainable development and it identifies major vulnerable areas and risks for the country. The Policy aims to ensure that different stakeholders address climate change impacts and their causes through identification, mainstreaming and implementation of appropriate adaptation and mitigation measures while promoting sustainable development.

Lesotho is currently in the processes of revising the NAIP which suffered from challenges in finalisation and implementation. This new National Agriculture Investment Plan (Lesotho Investment Plan for Agriculture Development) is under development during 2019 and will become the guiding document for the Agricultural sector.

2.3.2 Climate Smart Agriculture in Lesotho

In 2018, the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) and the International Centre for Tropical Agriculture (CIAT) conducted and published a CSA Profile on Lesotho (funded by the World Bank), which showed that, to a large extent, Conservation agriculture (CA) is the most widely promoted CSA practice in Lesotho. The study also indicated that other practices such as keyhole gardens, small-scale irrigation, organic manure application and the use of tunnels (greenhouses) are common in Lesotho, as well as traditional farming practices such as Likoti and Machobane. These practices have the potential to be integrated into modern CSA practices which could improve acceptability of CSA among rural households (World Bank & CIAT, 2018).

The CSA Profile also indicated that, for livestock production, the main CSA practices include those concerned with fodder production and rangeland rehabilitation management. The adoption of improved breeds of cattle, goats and sheep (due to the county's important wool and mohair sub-sector), will be key to improving the resilience and productivity of meat, milk, mohair and wool (World Bank & CIAT, 2018). Since the country is a net importer of foods, a more productive and resilient local meat industry in Lesotho would address the heavy reliance on food imports.

The study added that although CA and other CSA practices have been promoted in Lesotho, the term "climate-smart agriculture" is fairly new and has not been integrated into Lesotho's policies and programmes. This is expected to change with the National Climate Change Policy of 2017 and the new National Agriculture Investment Plan in development in 2019. In addition to mainstreaming CSA into policy, the country has also not successfully been able to access some of the major climate finance instruments, i.e. the Green Climate Fund (GCF) and the Adaptation Fund (AF).

2.3.3 Key constraints and challenges for agriculture and CSA in Lesotho

A number of key constraints and challenges can be identified which impact the sustainable implementation of agriculture and particularly CSA in Lesotho.

Table 4 Constraints and challenges to agriculture in Lesotho

Constraint	Summary
Climate change	With recurrent climate hazards, agriculture and food security are greatly affected: "delayed planting (or farmers not planting at all); reduced seed germination due to hardened soils and lack of water; crop failures; deterioration of rangelands and pasture; water scarcity for livestock; livestock emaciation and sometimes death; and increased food prices particularly of staple grains such as maize" (World Bank & CIAT, 2018). At household level, these effects are felt the most. According to a socio-economic household survey conducted by IFAD in Lesotho, Basotho households are "highly exposed to shocks, resulting from erratic climate variability over the last decade, and the results [from the survey] show that their ability to recover from such shocks is very low" (IFAD, 2014).
Land degradation	Lesotho suffers considerable land degradation, brought on by a number of factors: - Natural soil characteristics: The underlying sandstone from which Lesotho soils are derived are highly erodible (Ministry of Forestry, Range and Soil Conservation, Kingdom of Lesotho, 2015). - Seasonal impacts: the rainy season often sees heavy downpours and hailstorms that cause considerable soil movement whilst dry winters with no vegetation growth can also lead to erosion (Ministry of Forestry, Range and Soil Conservation, Kingdom of Lesotho, 2015). - Unregulated extraction of firewood (World Bank & CIAT, 2018) - Poor land management practices such as mismanagement of rangelands due to overgrazing. Degraded lands make, especially, arable farming even more difficult; the quality of soil is compromised, productivity is hampered, and yields are reduced.
Deforestation	Deforestation – largely caused by the harvesting of wood for fuel and building materials – is an ever-present reality in Lesotho. Lesotho is heavily deforested with forests now covering just 1.5% of the country's land area. There is a need to scale up agroforestry in meeting the country's goals related to improving forest cover, while at the same time enhancing the food security, nutrition and resilience of households. The integration of stone fruits (peaches and nectarines) and other fruit trees into existing cropping systems could be an option
Overreliance on rain-fed agriculture	Arable agriculture in Lesotho is characterized by largely rain-fed cereal production systems: maize, wheat and sorghum. In their socioeconomic survey on households in Lesotho in 2018, researchers at IFAD found that most households postponed planting if the rains arrive unseasonably late, indicating that they do not have irrigation measures to adapt. Because of the reliance on rain, great risk is present for sustainable food production and this impacts on the country's food security and reliance on imports from other countries (primarily South Africa).
Food production and access	As has been expanded on earlier, climate change in Lesotho is likely to cause significant impacts on agriculture and general livelihoods. This, coupled with additional challenges such as land degradation and overreliance on rain-fed agriculture, compound the problems of adequate local food production. With the exception of the bumper-harvest year (2016/2017), Lesotho is only able to meet approximately 30% of its annual cereal requirements; the country remains a net importer of food to meet the needs of its people. Domestic food production has concentrated on three main cereal crops: maize, wheat and sorghum and their productivity has been on a decline.
Nutrition and dietary diversity	The main source of food for the majority of Lesotho's population is own crop production; livestock products; remittances through economic migration, labour exchange and direct market purchases supplemented with the Government social

	protection interventions (Office of the Prime Minister, Kingdom of Lesotho, 2018: p.12). Heavy reliance on food imports makes Lesotho susceptible to high food prices which increases pressure on vulnerable households' food and nutrition security. Low-income earners and the poor especially the rural population struggle to meet their minimum daily requirements for food intake as they can only access poor quality foods with low micronutrient content. According to the Lesotho Vulnerability Assessment Committee (LVAC), for children under 5 years the national prevalence of stunting is 35% while the prevalence of wasting is 5%
Information, Sensitisation and Awareness	Limited information exists on the costs of adaptation and mitigation initiatives in the agricultural sector, as well as limited capacity to implement these initiatives. An assessment to determine these needs is required to improve long-term planning of CSA finance in Lesotho. There is a need for raising awareness and to build capacity for CSA. Partnerships need to be concluded between government, private sector, international research institutes, development partners and farmers to improve research into CSA in Lesotho (World Bank & CIAT, 2018).

3 Botswana Country Analysis

3.1 Botswana Context

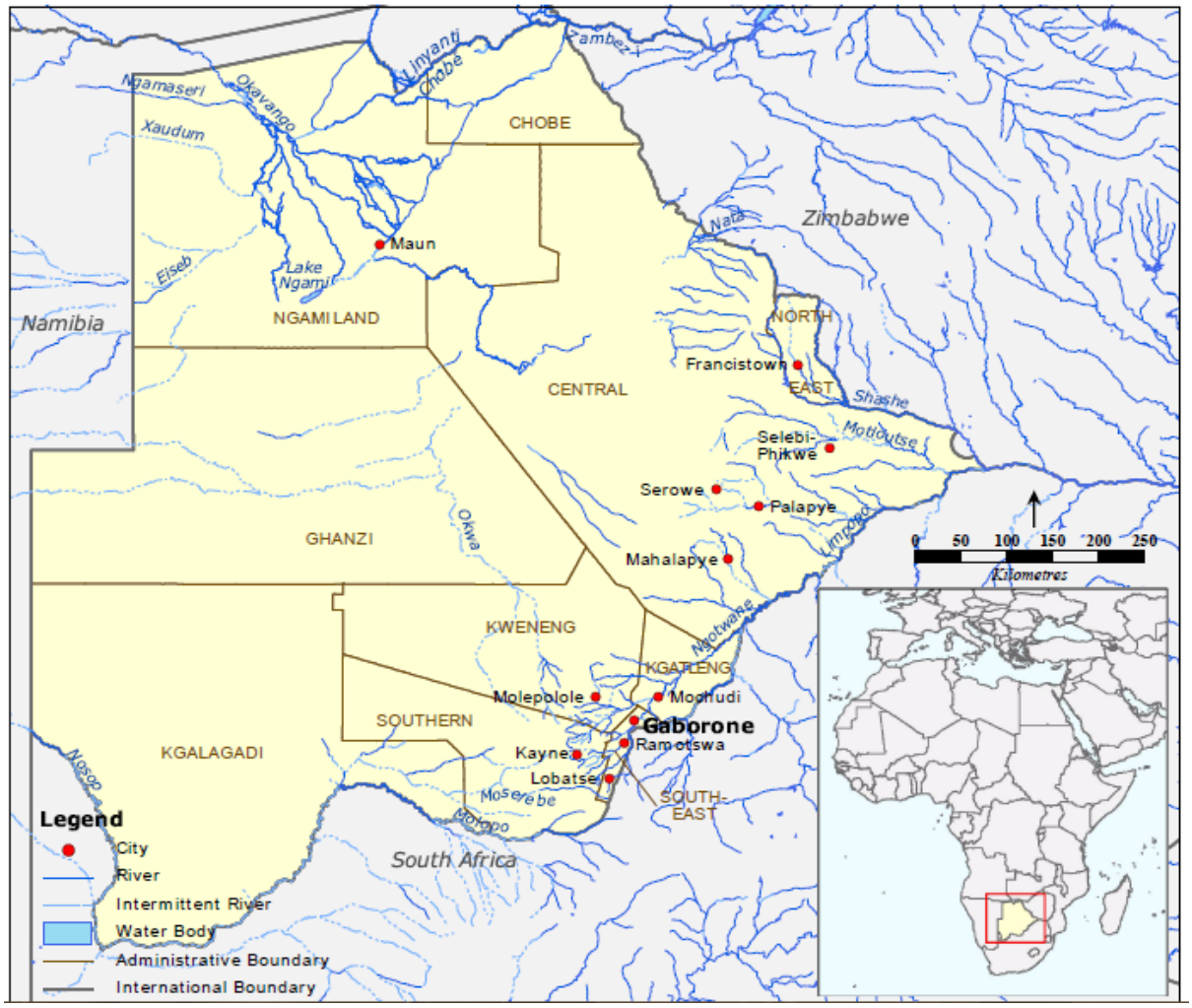


Figure 3 Map of Botswana illustrating districts

Source: (FAO, 2016a)

The Republic of Botswana is located at the centre of Southern Africa, bordering South Africa, Namibia, Zambia, and Zimbabwe. It was one of the world's lowest-income countries at independence in 1966, but rapidly achieved upper middle-income country status. The country has considerable mineral (diamond) wealth, economic management and a relatively small population of 2.2 million people in 2017 (World Bank, 2019a).

The climate is arid and semi-arid, with low rainfall and high rates of evapotranspiration. Rainfall occurs in the form of localised showers and thunderstorms and generally falls between October and March, with a highly irregular pattern. Drought is a recurring problem in the country although a record rainfall in 200 caused flooding (World Bank, 2019a).

The country covers an area of 582,000 km² and is relatively flat, at 900 metres above sea level. The Kalahari Desert occupies more than 70% of the country, with valleys and pans across the landscape. The eastern part of Botswana has the highest (1,500m) and the lowest (500m) points of elevation, with hills and deep valleys, whereas the western portion of the country is semi-arid with rocky outcrops (CCARDESA, n.d.).

Surface water is the main source of water supply for urban areas, but there is little surface water, except in the far north and some 66% of the country depends entirely on groundwater. Population increases and urbanisation aggravate water threats. More than 60% of Botswana is savannah woodland and scrub and the country's forests provide a range of economic, social, and environmental benefits and services. However, human activities, particularly burning wood for fuel, put pressure on forest resources (South South North, 2017).

3.1.1 Population

The 2017 Botswana Demographic survey estimated a total population of 2,154,863, of which 1,034,578 are males and 1,120,285 females. This is a 6.4% increase compared to the 2011 population and housing census. However, there is a decline in the number of non-Batswana residing in the country. The figure has dropped from 111,846 in 2011 to 85,414 during the survey year (2017) (Statistics Botswana, 2018). The Demographic survey is an inter-censal survey in order to update figures between official census years (the last one being 2011). Based on the same demographic survey of 2017, 63,9% of Botswana's population reside in urban areas and the country has a population density of 3.7 people per square km.

3.1.2 Economic Overview

Botswana is reliant on diamonds and the public sector, making it vulnerable to short term shocks and structural changes. Although poverty has been declining, it remains high in rural areas, and low job creation means inequality levels are still some of the world's highest (South South North, 2017).

Since independence in 1966, Botswana has been one of the world's fastest growing economies – according to the World Bank, averaging 5% per annum over the last 10 years. But reliance on commodities (in particular diamonds) makes the country vulnerable to international market fluctuations. Economic growth is expected to be led by mining, construction, the services sector and intensified public investments (World Bank, 2019a).

The contribution of the agricultural sector to the country's GDP decreased from 40% in 1966 to 2.5% in 2003. This is attributed in part to the expansion of mining but also to the stagnation of the agriculture sector itself and the impact of recurrent droughts. Despite this, the agricultural sector remains fundamental as a source of food and income for nearly 50 percent of the total population. The contribution of agriculture to total exports and imports in 2001 was 5% and 17% respectively. Most of the exported agricultural production comes from the livestock sub-sector. A significant percentage of the annual cereal requirements in the country is imported from South Africa (FAO, 2016a).

3.2 Botswana Agriculture Analysis

Botswana's agriculture sector includes crop and livestock production, and as is the case in Lesotho, traditional farming remains the dominant farming system. The main crops grown are sorghum, maize and millet while cattle rearing is one of the main livestock sub-sectors in Botswana (FANRPAN, 2017).

The agricultural sector is composed of two farming systems on which both crop and livestock production are done: the commercial and the traditional systems. The difference between commercial and traditional farming is based on land tenure, use of technology and marketing as opposed to consumption of production; FAO explanation below (FAO, 2016a):

- Commercial farms focus primarily on cattle production. They cover 8% of the total land area and account for less than 1% of all farms.;

- Two-thirds of traditional farmers practise mixed farming, with cropping on individually managed areas and livestock grazing on communal land. As the incidence of drought is high, small farmers are highly vulnerable to crop failure because they are totally reliant on rain-fed crop production and do not use drought-resistant varieties.

The average yield of cereal crops on commercial farms is 500 kg/ha, compared with 200 kg/ha on traditional farms. Commercial farms also have higher annual calving rates and lower animal mortality (FAO, 2016a).

According to South South North “agriculture meets only a small portion of total food needs and contributes to GDP mostly through beef exports”. Less than 1% of total land area is arable, and this challenge is compounded by “poor soils, inadequate economic infrastructure, scarce water resources, and recurrent drought” (South South North, 2017).

3.2.1 Agro-ecological zones

Botswana has three agro-ecological zones:

Table 5 Botswana Agro-ecological zones

Kalahari Desert (centre, west)	Savannah grasslands, woodlands (east)	Okavango Delta (northwest)
The Kalahari Desert is located in the centre and west of Botswana and accounts for 66% of total land area. It has low rainfall and savannah grasslands with woodland. The area mainly supports cattle, goats and other livestock and wildlife although it is not suitable for cultivation.	The east of the country has more fertile soils than the Kalahari and experiences good rainfall annually. The landscape is primarily savannah grasslands and woodlands with some forest.	The Okavango has areas of open water and green wetlands, primarily hosting wildlife. The area experiences difference in terms of seasons and rainfall.

Source: (FAO, 2016a)

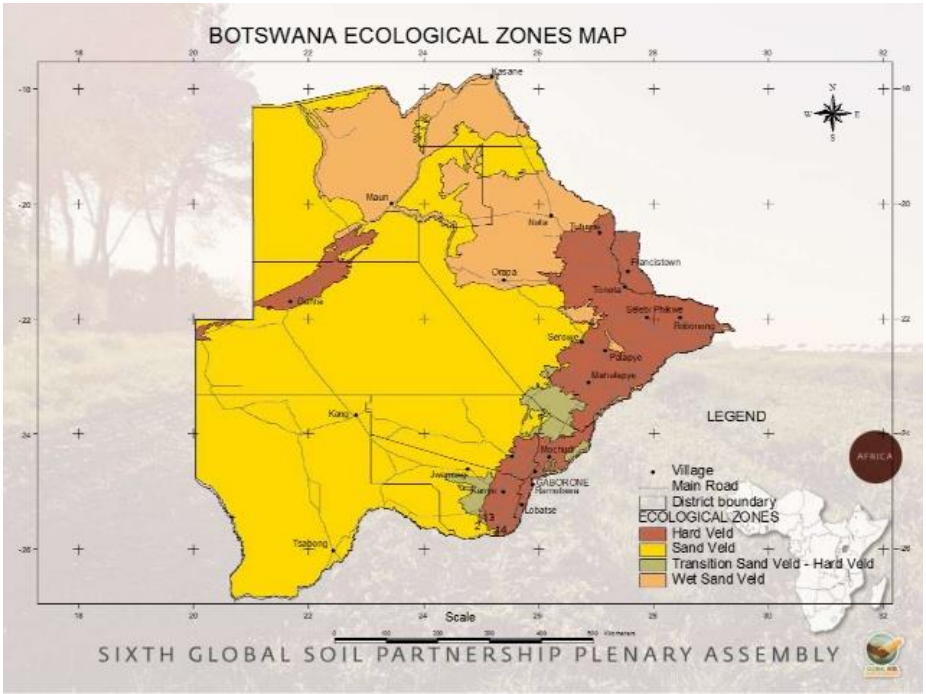


Figure 4 Map of agro-ecological zones: Botswana

Source: (Fanani, 2018).

3.2.2 Agricultural production

Table 6 Agricultural production in Botswana

Agricultural produce / activity	Production Information
Dairy farming	Information from the Ministry of Agriculture, Botswana (2011a): Botswana is a net importer of dairy products from neighbouring countries. Modernization of the dairy industry along the lines of large-scale enterprises found in developed countries is the best strategy for assuring increased milk and dairy products. The Ministry of Agriculture has conducted extensive studies on the subject and has prepared a comprehensive dairy handbook that tries to identify some of the fundamental issues in a profitable dairy enterprise. The key findings are that a minimum of 50 dairy cows is the recommended ideal herd size to give farmers a reasonable return to continue production and reduce milk imports. Proper feeding strategies and a regular supply of fresh water would also assist in boosting output. The term dairy breed is used to differentiate those cattle that are bred primarily to produce milk against those that are used for meat production. Dairy cattle may be defined as a particular group of animals developed in a certain area for a definite purpose and having the same general characteristics such as colour, conformation and quality of product i.e. milk. A purebred dairy cow is one whose ancestry traces back to the same breed. A registered dairy cow is a purebred that has been registered by a particular breed association. There are six (6) major dairy breeds of which 4 are widely found in Botswana: Friesians/Holsteins, Jerseys, Guernseys and Dairy Swiss (Braunveih). Dairy cattle not common in Botswana are Aryshires and Dairy Shorthorn.
Poultry farming	Information from the Ministry of Agriculture, Botswana (2011b): Although commercial turkey production does not occur in Botswana, the consumption of turkey meat has increased over time in the past six years as epitomized by increased imports from overseas via the Republic of South Africa (RSA). The interest in turkey rearing has increased substantially in Botswana, hence the need to prepare a manuscript for use by poultry extension agents to guide turkey hobbyists, as well as, prospective farmers on turkey management. All turkey meat consumed in Botswana is imported from overseas through RSA. The consumption of turkey meat has generally increased over time. These significant increases in consumption could be sending strong signals to prospective investors that turkey industry is probably ready for exploitation.
Ostrich farming	Information from the Ministry of Agriculture, Botswana (2011c): In 1994, the Department of Wildlife and National Parks's aerial surveys estimated Botswana's wild ostrich population to be about 60 000 with the largest population being in north-western Kgalagadi and south-west Ngamiland. Commercial ostrich farming started in Botswana in the late 1980s. Currently, breeding birds reared commercially in Botswana are estimated to be slightly over 1000. Ostrich products for export include leather, meat, eggs, egg shells, feathers and carcass. Ostriches are slaughtered and processed at an export abattoir and thereafter exported to European Union. However, it should be noted that the first offsprings (F1 generation) of birds produced from parents captured from the wild are not slaughtered for export. There is a great need to increase the supply of ostriches to the abattoir. the ostrich abattoir is operating below capacity.

Beef Cattle	According to an agricultural census released by Statistics Botswana in 2017, the country's estimated cattle population has fallen from 2.5 million in 2011 to 1.7 million in 2015 (Tshipa, 2019). Despite this, livestock (cattle) for beef production remains the largest sub-sector in Botswana's agricultural activities. Livestock production, especially cattle, contributes an estimated 80% to the agricultural GDP. Livestock and cattle raising and grazing is by far Botswana's primary agricultural product and export. The cattle population is currently estimated at 2.1 million. Livestock production exceeds domestic needs and the country has exported range-fed beef to the European Union. The development of a modern cattle farming and slaughter industry (and the corresponding development of a market for U.S. feed stocks, ingredients and technology) is limited by the government's monopoly on meat processing plants, exports, livestock prices, as well as outbreaks of Foot and Mouth Disease especially in the north-eastern part of the country (Export.gov, 2019).
Range Management and Fodder production	Information from the Ministry of Agriculture, Botswana (2011d): The Range Management Section encourages farmers to grow pasture and fodder crops to supplement livestock feeds from rangeland pastures, promote controlled grazing, and encourage better management of both the range and livestock to ensure increased productivity and sustainability through fencing. The Section is responsible for extension management of range and beef production systems. Beef cattle (and small stock) production entirely depends on rangeland pastures. About 80% of cattle are produced in extensive communal/traditional grazing systems, and the reminder in commercial freehold and leasehold farms. Ranchers have exclusive rights over the use of rangeland resources and are able to practice improved and better management of both livestock and range resources
Maize **Sorghum** **Millet** **Wheat**	The crop sub-sector is dominated by the growth of cereals, but is limited by constrained productivity in the sector, unreliable water supply, and the fact that desert and poor soils cover 70% of the country. In 2015/2016, national cereal production totaled 54,374 metric tons (MT), supplying only 18% of domestic demand. Sorghum comprises 72% of national cereal production, followed by maize (17%) and millet (6%). Botswana also produced 14,000 MT of beans, 2,000 MT of groundnuts and 1,800 MT of sunflowers in 2015. Horticulture production is focused in the southeast, with a small annual production valued at $14 million in 2013, primarily consisting of potatoes, tomatoes, cabbage and oranges (Export.gov, 2019).

3.2.3 Food Security

According to the Botswana Vulnerability Assessment Committee (BVAC), the number of people affected by food insecurity in 2018 is estimated to have increased to approximately 35 000 people, up from 12 000 in 2017. The increase is mostly reflective of the reduced cereal output in 2018, which mainly affected the food security situation of subsistence farmers (FAO, 2018; Botswana Vulnerability Assessment Committee, 2018).

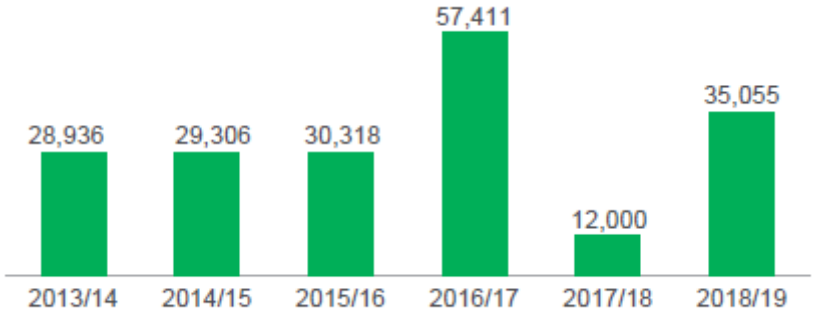


Figure 5 Food insecurity trend (number of people) in Botswana from 2013/14 - 2018/19

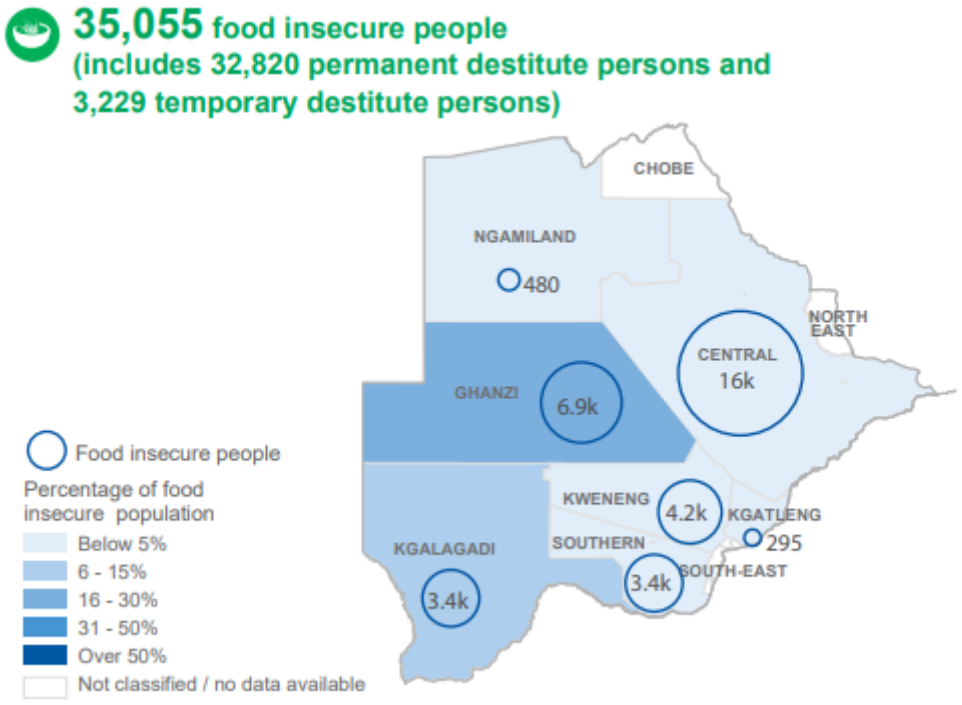


Figure 6 Food Security Situation in Botswana in 2018

Source: (Botswana Vulnerability assessment Committee, 2018).

Cereal production, mainly maize and sorghum, is estimated to have declined, on a yearly basis, to 64 000 tonnes, down 32% from the high output of 2017, but it remains above average. The decrease was mainly caused by unfavourable weather conditions during the start of the year, a critical period for crop development, when reduced rains and higher-than-normal temperatures stunted crop growth. Improvements in weather conditions from late February

helped crops recover and also led to an improvement of pasture conditions. However, the mid-season dryness meant that estimated yields remained below the exceptional levels of 2017.

The country is a net importer of cereals as it can only meet 10% of cereal demand, through local production (more than 90% of the domestic cereal requirements are met by imports). Total cereal imports are expected to rise in 2018/19 and remain below average, as larger opening cereal stocks, on account of the bumper 2017 output, curbed further increases in import requirements (FAO, 2018).

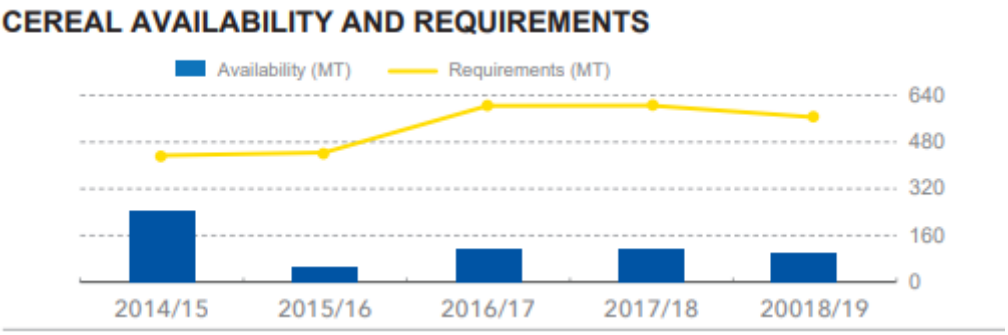


Figure 7 Trend of cereal availability and requirements in Botswana: 2014/15 – 2018/19

Source: (Botswana Vulnerability Assessment Committee, 2018).

3.3 Botswana Climate Change Response and CSA

3.3.1 Key Climate Change Policies and Frameworks

In 2016 Botswana launched the national CSA Program for the period 2015 to 2025. Both the Ministry of Agricultural Development and Food Security and the Ministry of Environment, Natural Resources Conservation and Tourism Development jointly implemented the program.

A total of six strategic priorities were identified as sources of Botswana's agricultural development and growth in a changing climate. These are:

- Improved productivity and incomes;
- Building resilience and associated mitigation co-benefits;
- Value chain integration;
- Research for Development and innovations;
- Improving and sustaining advisory services, and;
- Improved institutional coordination.

The Food Agriculture and Natural Resources Policy Analysis Network (FANRPAN) commissioned a study in 2017 on Policies and Practices for Climate-Smart Agriculture in Sub-Saharan Africa. The results from this assessment highlight a set of areas for action in terms of both policy and practice and identify key barriers to the successful integration of climate smart practices at the regional and national levels. The key findings of the assessment revealed that the eastern and southern African countries have policies on agriculture and climate, and do recognize the impacts of the latter on the former" (FANRPAN, 2017).

Botswana, like most of the African countries have examples of both traditional and research-based agricultural practices that can be considered to be climate-smart. The challenge is, they are not mainstreamed and still receive limited support. Such practices include both agro-

ecological techniques (e.g. mulching, intercropping, agroforestry, mixed farming) and agricultural biotechnology, such as high-yield and/ or drought-tolerant crop varieties and livestock breeds (FANRPAN, 2017).

The FANRPAN study identified four key areas of action in order to promote CSA:

1. Increased investment in material and human resources,
2. The design of coherent, integrated policies,
3. A focus on evidence-based, context-specific plans, that include the promotion of strategies to ensure equitable participation in governance,
4. Capitalising on innovation as a pathway to promote CSA.

With regards to Climate-smart agriculture policy, Botswana has formulated and implemented the following: CSA Framework Programme, National Master Plan for Arable Agriculture and Dairy Development, Integrated Support Programme for Arable Agriculture Development, and Livestock Management and Infrastructure Development programme (Statistics Botswana, 2017).

Table 7 Summary of relevant policies and frameworks in Botswana

Policy / Framework	Regionality	Years	Key objectives
United Nations Framework Convention on Climate Change (UNFCCC)	International	1992 (opened for signature); 1994 (enforced following ratification by several countries) 2015 (submission of INDCs) 2017 (submission of NDCs)	The framework sets non-binding limits on greenhouse gas (GHG) emissions for individual countries and contains no enforcement mechanisms. As a non-Annex I party to the Paris agreement, Botswana has no obligations to reduce greenhouse gas emissions, but has obligations under the UNFCCC Paris Agreement to report on the anthropogenic sources and sinks of greenhouse gases, and to identify measures to minimize the impacts of global warming and climate change. Botswana submitted its Nationally Determined Contribution (NDC) to the convention in 2016, and this was ratified in November 2016. The NDC states the intention to achieve an overall emissions reduction of 15% by 2030. Botswana is fully committed to the implementation of global initiatives outlined in the UNFCCC, hence the establishment of the national focal point at the Department of Meteorological Services (DMS), under the Ministry of Environment Wildlife and Tourism, to coordinate and implement climate-change initiatives.
Comprehensive Africa Agriculture Development Plan (CAADP) Framework	Regional	2010	Botswana is implementing the CAADP Framework (2010), which emphasizes sustainable land and water management for improved agricultural productivity through research, technology adoption and dissemination, and agricultural GHG emissions reduction. Botswana launched its CAADP implementation process in December 2015 and is working towards finalising its compact.
National Policy on Agricultural Development	National		Botswana has several agricultural policies all nested in the National Policy on Agricultural Development. Goal is to improve food security at both household and national levels, as well as to conserve scarce agricultural and land resources for the future.
National Adaptation Plan	National		The country is also developing a National Adaptation Plan (NAP) and Action Plan which will highlight all the priority areas, including Climate-Smart Agriculture. The National Adaptation Plan development is coordinated by the Ministry of

			Environment, Wildlife, and Tourism, with support from the National Committee on Climate Change. Botswana set up a multi-sectoral National Committee on Climate Change (NCCC) in 1995 to provide, amongst other things, guidance on development areas; to facilitate national research programmes concerning global warming and climate change; and to advise government.
National Development Plan	National		Developing a response to climate change is an objective in several policy documents, including the National Development Plan (NDP).
Climate Change Policy and National Action Plan	National		Pending development and approval, with the purpose to operationalize the climate change policy. Will include a focus on CSA as a priority
National Master Plan for Arable Agriculture and Dairy Development (NAMPAADD)	National		Focuses on dairy, horticulture and rainfed farming, through production and Training Farms (PTFs). And establishing Agricultural Service Centres (ASCs) at each PTF. These will be operated on a commercial basis and will provide the necessary inputs for the different sectors that the PTFs cover with extension services provided by Ministry of Agriculture staff.

NEPAD, in collaboration with the Botswana government, have established a country CSA framework, aligned with the National Vision, the National Development Plan and the agriculture sector policies and strategies. The Framework espouses integrated CSA approaches on climate change, gender and youth. Subsequent to the advent of the programme, a regional platform for learning and sharing of experiences was established. Furthermore, a multi-sectoral and multidisciplinary national expert coordination team from environment and agriculture was established to prepare Botswana's CSA Programmes (NEPAD, 2019).

Botswana has also been supported by NEPAD in mainstreaming nutrition into National Agriculture and Food Security Investment Plans (NAIPS), to ensure that agricultural and economic development policies and initiatives are nutrition-sensitive and have a clear approach, stronger capacities and clear road maps for implementation (NEPAD, 2019). Botswana is currently revising the NAIP and the process is ongoing in 2019.

3.3.2 Key constraints and challenges for agriculture and CSA in Botswana

In Botswana, drought is a frequent occurrence. According to a FANRPAN study in 2017 of CSA practices in Southern Africa, Botswana's crop production is mainly rain-fed, making it most vulnerable to climate change. The study adds that "relatively poor soil quality, coupled with an overreliance on rain for production, has resulted in low productivity of crops in Botswana" (FANRPAN, 2017).

Countries in Southern Africa, including Botswana, are also affected by El Niño (warm) and La Niña (cool) events in the tropical Pacific and these have impacted on agriculture in the region. These environmental factors are further complicated by lack of infrastructure, inadequate markets, lack of support services, and limited access to water systems. A comparative assessment reveals that the impacts of climate change are already being perceived both by formal experts and by rural populations across Eastern and Southern Africa, including Botswana (FANRPAN, 2017).

According to Botswana's Second National Communication (SNC) to the UNFCCC, rainfall has been highly variable, and droughts are projected to increase in frequency and severity. These are the variations in precipitation experienced in different regions:

- North suffers droughts in terms of rainfall deficits;
- South-west suffers extreme droughts based on low rainfall and soil conditions; and
- Northeast suffers high rainfall events and risks of floods.
- Botswana is already suffering constrained agricultural production, increasing food insecurity, and increasing water stress. These effects are expected to increase with climate change (South South North, 2017).

FANRPAN's assessment of CSA policies and practices in 15 Southern African countries also highlight other challenges to these countries' development. These challenges include inadequate material such as human resource capacity, insufficient smallholder participation in governance, and gender imbalances which exacerbate the already existing challenge of lack of women empowerment. The other hindering factor that affects not only Botswana but the rest of the sub-Saharan African countries in the assessment is that of lack of funds, which is often coupled with limited access to technology to upscale CSA practices (FANRPAN, 2017).

FANRPAN recommends that there is need for South-South and North-South cooperation that promotes the endogenous technological development of Africa. There is also a need for smallholder farmers, women and the youth, in particular, to actively participate in policy formulation and implementation, and decision-making processes (FANRPAN, 2017).

4 Conceptual Frameworks

Two core conceptual frameworks underlie the analysis that is undertaken in this report: Climate Risk Framework and a Farming Systems Framework. These frameworks provided the theoretical and technical basis around which the analysis and the interactive work and training session were framed. These frameworks provide structure to the analysis process, reflect the latest developments and research in the sector and facilitate the application of this process or other similar activities by the partners involved.

4.1 Climate Risk Framework

The work undertaken in this analysis is consistent with the assessment frameworks outlined in the GIZ Vulnerability Sourcebook (2014) and the Risk Supplement to the Vulnerability Sourcebook (2017). These are aligned with the IPCC methodologies for conceptualising and analysing the impacts of climate change and align to the conceptual model specified in the Fifth Assessment Report of the IPPC (AR5). These materials were developed to provide a standardised approach to climate change assessments. These assessments were initially called Vulnerability Assessments; however, the terminology has now changed to Climate Risk Assessment to reflect the conceptual advancements in AR5.

The conceptual framework for Climate Risk in AR5 is shown in Figure 8 below. It shows that the risk of climate-related impacts results from the interaction of climate related hazards with the vulnerability and exposure of human and natural systems.

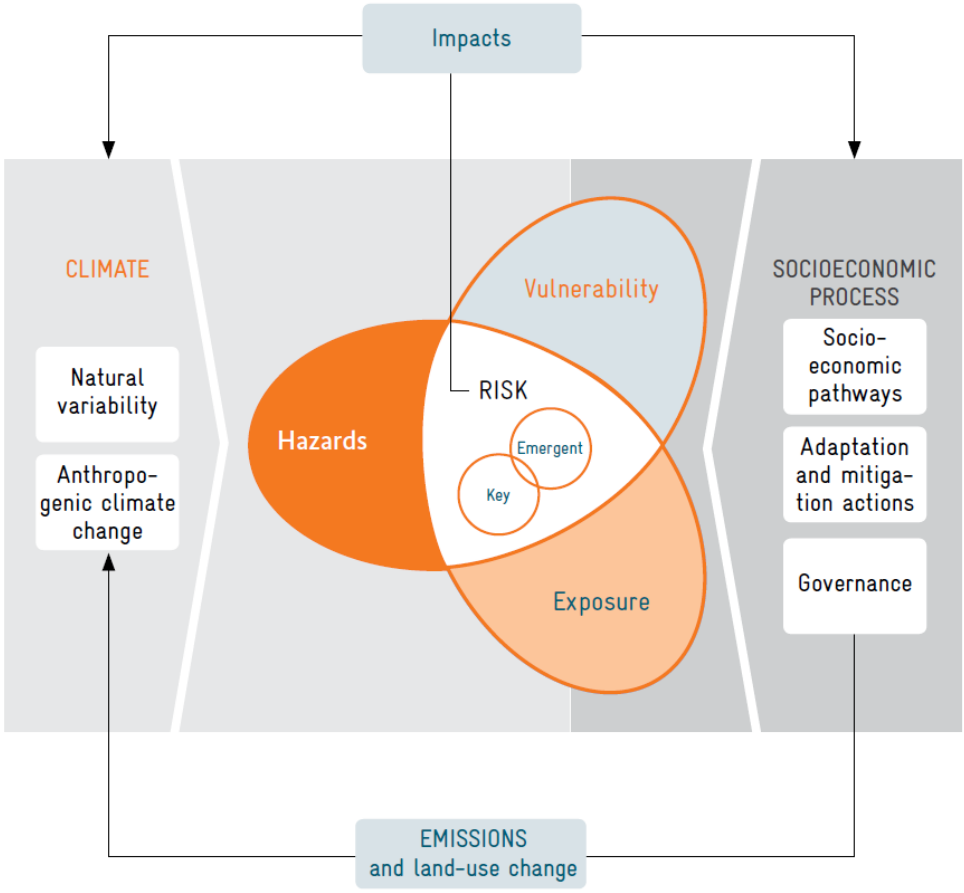


Figure 8 The Broad Climate Risk Framework of AR5

Source: (GIZ & EURAC, 2017).

Within this framework, at the core, Climatic Risk is a function of the interactions of Hazard, Vulnerability and Exposure. For the Climate Risk Analysis, we focus on the core (Climatic Risk) of this framework and consider each of the three subcomponents. The Hazard is a direct incident (i.e. flood, landslide) or a trend (i.e. later onset rain) which drives the risk of impact to something of value. The impact of this Hazard will depend on both the exposure to it (i.e. number of people affected) and the Vulnerability to it (i.e. how vulnerable are the people affected). The Vulnerability is determined by considering the sensitivity to harm (attributes of a system which mean the hazard can cause harm), and the capacity to prevent or respond to harm (either with short/medium term coping or by longer term adaptations).

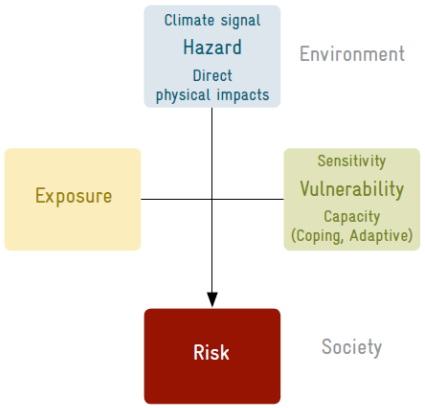


Figure 9 Climate Risk Assessment Conceptual Framework

Source: (GIZ & EURAC, 2017).

Analysing the risk in this way allows us to identify the magnitude of the contribution from each factor to the overall risk, therefore targeting and tailoring adaptation to this risk profile. Figure 10 shows the way that adaptations that reduce sensitivity (to harm from the hazard) and increase capacity (to handle or avoid the harm from the hazard) can also reduce the exposure (number of people effected) to the hazard and are therefore extremely effective at minimising the overall risk.

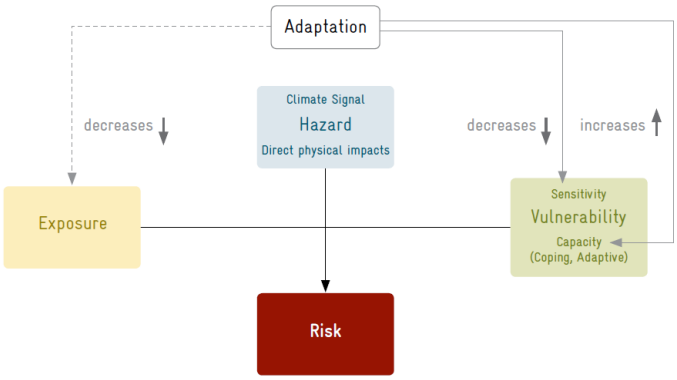


Figure 10 Climate Risk Assessment Conceptual Framework + Adaptation

Source: (GIZ & EURAC, 2017).

This CRA framework provides the overarching approach for the technical analysis in this report. It is combined with other methodologies as relevant to deliver practical and useable conclusions which can be adapted by policy makers and development partners as well as feeding into the following phases of this work. The detailed methodologies utilised in the report are detailed in Section 5.

Definitions

Risk: The potential for consequences (impacts) where something of value is at stake and where the outcome is uncertain.

Hazard: The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources. (In the IPCC report the term usually refers to climate-related physical events or trends or their physical impacts).

Exposure: The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure or economic, social or cultural assets in places and settings that could be adversely affected.

Vulnerability: The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including *sensitivity* to harm and lack of *capacity* to cope and adapt.

- Sensitivity is determined by those factors that directly affect the consequences of a hazard. Sensitivity may include physical attributes of a system, social, economic and cultural attributes.
- Capacity in this context refers to the ability of societies and communities to prepare for and respond to current and future climate impacts. It comprises;
    - Coping capacity - the ability of people, institutions, organisations and systems, using available skills, values, beliefs, resources and opportunities, to address manage, and overcome adverse conditions in the short to medium term. (i.e. early warning system in place)
    - Adaptive capacity - the ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities or to respond to consequences (i.e. knowledge to introduce new farming systems)

Adaptation: the process of adjustment to actual or expected climate and its effects. In human

4.2 Farming Systems Framework

The concept of CSA has gained prominence over the past decade and the most frequently cited definition of CSA is that set out by FAO. This presents three integrated objectives, frequently referred to as the three pillars of CSA and states that the objectives of CSA are to (FAO, 2010):

- Sustainably increase agricultural productivity, to support equitable increases in farm incomes, food security and development;
- Adapt and build resilience of agricultural and food security systems to climate change at multiple levels; and
- Reduce greenhouse gas emissions from agriculture (including crops, livestock and fisheries).

CSA proponents identify practices that can deliver all three objectives simultaneously. These technologies are then used to demonstrate the potential of CSA to generate 'triple wins', i.e. agricultural practices that can simultaneously raise agricultural productivity while also mitigating climate change and building farmers' resilience to climate changes. Early interpretations of CSA focused heavily on the notion of the 'triple win'. Whilst, the African Union acknowledged in 2010 that adaptation was a higher priority than mitigation for SSA countries, it still demonstrated its support for idea that both could be delivered simultaneously (Place, Bwalya & Phiri, 2010). In implementing this CSA framework, 'CSA practices' have been extensively documented and defined by academic institutions, research bodies, policy makers, regional bodies and implementers. It can now reflect an extremely broad range of practices which relate to farming – evidenced by the CSA Profiles developed by CIAT and CCAFS with World Bank funding – which, in the case of Lesotho assesses a list of 28 practices tailored to the country context. For decision makers and those involved in strategic policy decision making it is helpful to first consider the framework within which a farmer operates to both redirect the focus back to the farmer, as well as to capture the breadth and complexity of the systems which impact on their operations. For the purpose of this analysis the framework outlined below was used to conceptualise the comprehensive farming system. This framework is sufficiently comprehensive to capture a high level of detail in potential factors, practices and systems, whilst avoiding the common pitfall of focussing on on-farm practices at the risk of neglecting other system components with high adaptive potential (such as policy, market sector, etc).

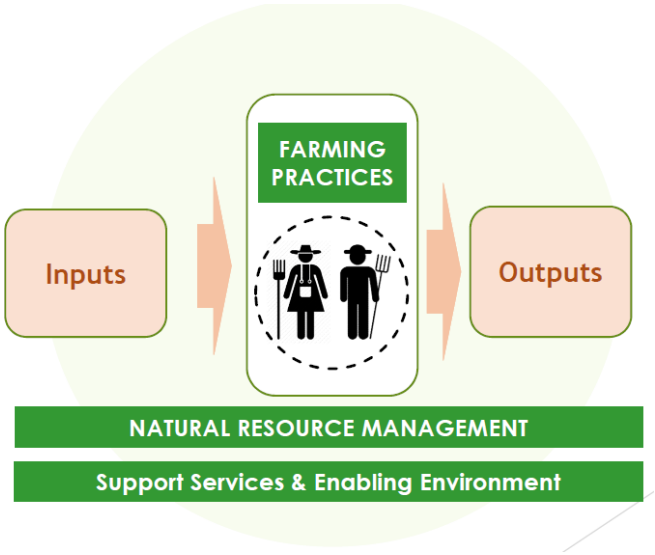


Figure 11 Farming Systems Framework

This framework starts with the farmer and their on-farm **Farming Practices** at the centre of the system. Next, it acknowledges the critical **Input** and **Output** considerations which input into the farm and process the outputs of the farm. Additionally, it considers the **Natural Resource Management** processes which impact on the farm operations, but which are often beyond the sphere of control of an individual farmer. Similarly, the **Support Services** and **Enabling Environment** (government policy, extension, subsidies) are added as these can significantly impact farmers' operations. To understand the system within which the farmer operates and to understand their climate resilience, all these elements must be considered in the analysis and response mechanisms.

The partner governments in Lesotho and Botswana expanded on this simplified framework to develop the below representation of the farming systems framework which applies to farmers in Lesotho and Botswana.

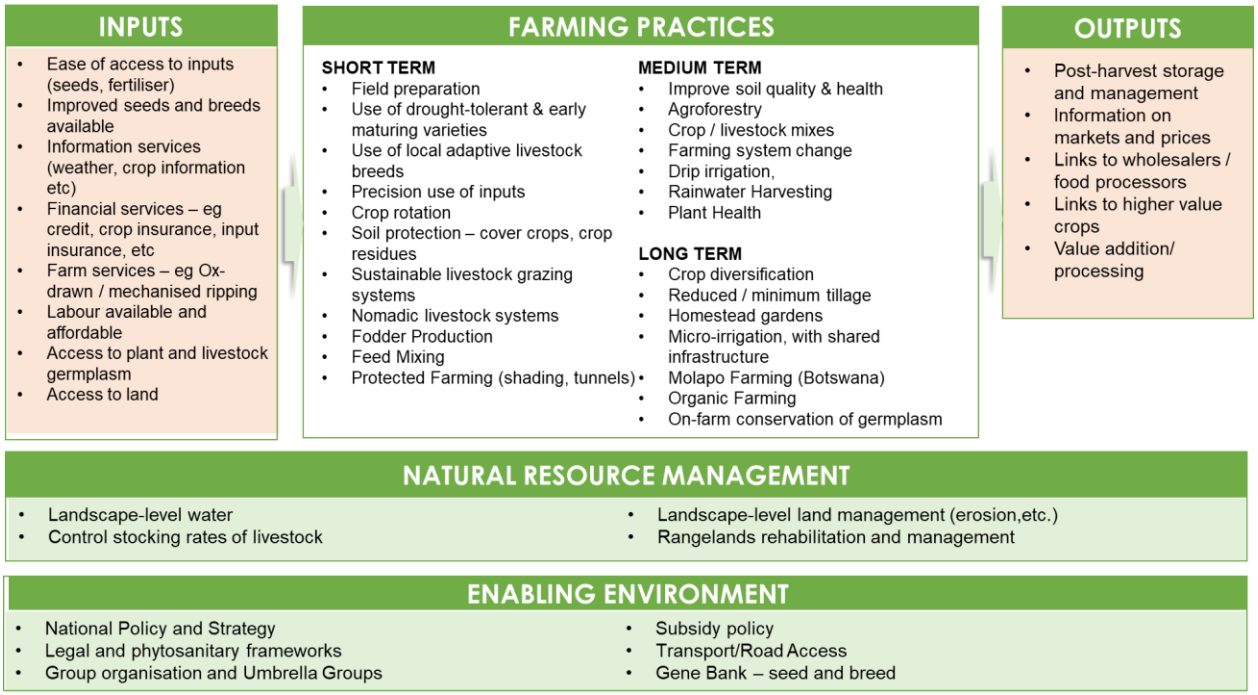


Figure 12 Detailed Farming System Framework relevant to Lesotho and Botswana

As a conceptual framework this diagram is not intended to reflect every possible activity or element within the system, but rather to prompt a comprehensive consideration of the farmers operations (beyond only on-farm considerations).

Within this analysis, the Farming System Framework is used to provide context for working discussions and sessions relating to the CRA analysis as well as framing and capturing information and prioritisation relating to climate smart farming practices, as outlined in the following section.

5 Methodology

This analysis adopted some specific methodologies to ensure that a rigorous and technically sound approach was combined with an interactive and collaborative learning process that ensured that all stakeholders built new skills and knowledge.

5.1 Capacity Building and Active Learning

This project is delivered in partnership with the DAR's of Lesotho and Botswana. Their technical and strategic guidance and country-specific knowledge is critical to the CRA methodology that has been adopted. The activities of the CRA analysis were undertaken in a collaborative way that involved briefing sessions, working sessions and concluded with a regional workshop. The processes and events that were undertaken for engaging with the DAR's and other key stakeholders is outlined below. This approach allowed for sensitisation and subsequently practical application of the technical methodologies by stakeholders as well as the collection and feedback of critical knowledge from stakeholders into the analysis process. Key components of the technical approach (i.e. CRA) were implemented jointly with the relevant stakeholders. This approach was found to be extremely successful in ensuring the knowledge transfer extended beyond theory to a strong understanding of the practical application of the CRA components. 94% of participant feedback on the regional workshop indicated that the methodologies and information included in the workshop were both relevant and applicable to stakeholders' work. Further information about the events and attendance lists are provided in Annex 1.

Table 8 Collaborative engagements with Botswana and Lesotho Government

Engagement	Purpose
Collaboration	Team Leader worked in close consultation with DAR counterparts in developing the working approach. DAR counterparts took the lead on all internal activities and engagement.
Lesotho National CRA Methodology Briefing	Briefing to core DAR staff on the CRA methodology for purposes of sensitisation ahead of National Workshop. Q&A on CRA.
Lesotho National Workshop	Working session with core national stakeholders to develop CRA impact chains for Lesotho with core stakeholders and to prioritise Climate Smart Practices.
Botswana Stakeholder Briefing	Sensitisation on CRA methodology to very broad stakeholder base and early prioritisation exercise undertaken.
Botswana National Workshop	Subset of regional workshop where CRA impact chains for Botswana context were developed.
Regional Workshop	Participants from Lesotho and Botswana convened jointly for briefing on CRA initial results and to assess and input into their implications for adaptation, as well as prioritisation of potential adaptation actions.
National Prioritisation Working Teams	Working Teams were convened in each country to progress follow up activities from the National workshop with information and results fed into the CRA.

5.2 CRA Methodology

Adopting the conceptual framework for CRA outlined previously, this assessment applied elements from two methodologies to deliver a profile of climate risk which provided an understanding of the risk components and enabled decision-making regarding adaptation measures. The methodology outlined in the Risk Supplement (GIZ & EURAC, 2017) was followed (Phase 1) to map out Impact Chains which analyse and breakdown each component of the Risk. Then the Climate Proofing Tool (CCARDESA 2016) was used (Phase 2) to quantify risk and take forward the preparation and assessment (Phase 3) of the Adaptation Measures. The following key steps where undertaken in this analysis

- Risk/Hazard Identification
- Impact Chain mapping to identify key Hazards and intermediate impacts
- Sensitivity and Capacity mapping
- Exposure analysis
- Risk Classification
- Adaptation measures prioritised and assessed

5.3 CSA Practice Selection Methodology

Prioritisation of some CSA practices is a key activity of this programme and, along with the results of the CRA, feeds into the Feasibility Assessment and Investment Proposal. The collaborative implementation of the CRA provides a unique opportunity to link the outcomes of the analysis with this best practice exercise. To identify a set of CSA practices to take forward, the farming systems framework was adopted, and three different sources were utilised as shown in Figure 13 below.

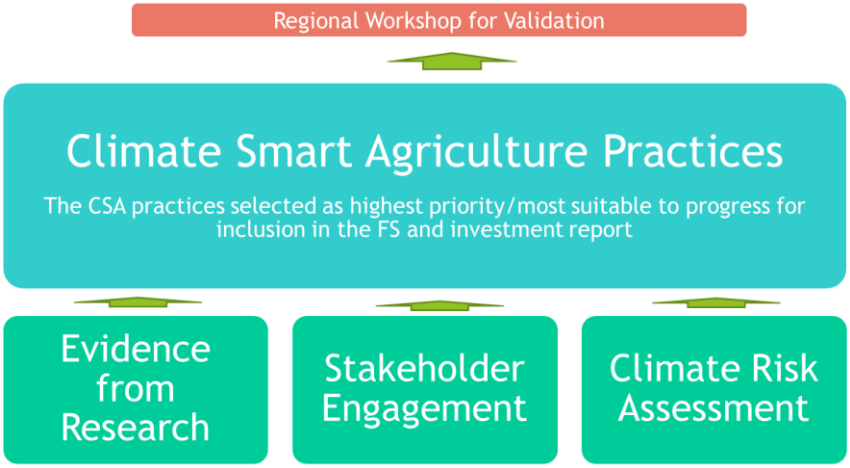


Figure 13 Climate Smart Agriculture Practice Selection

Evidence from Research - national, regional and global research and evidence were analysed and key conclusions and learnings were captured.

Stakeholder Engagement - in a working session structured around the farming systems framework national stakeholders assessed the practices and conducted an initial prioritisation.

Climate Risk Assessment - with respect to the CRA conceptual framework, climate smart agriculture practices are considered to be adaptation measures applied to reduce climate risk. This allowed the identification of practices needed to specifically address the climate risk.

Outcomes from these three sources were presented to the regional stakeholder workshop for further analysis and prioritisation and follow up technical consultation.

6 Climate Risks and Projections

This section outlines the current and projected future climate trends in Lesotho and Botswana based on climate modelling undertaken by CGIAR research institutions and the World Bank.

6.1 Lesotho Climate Projections

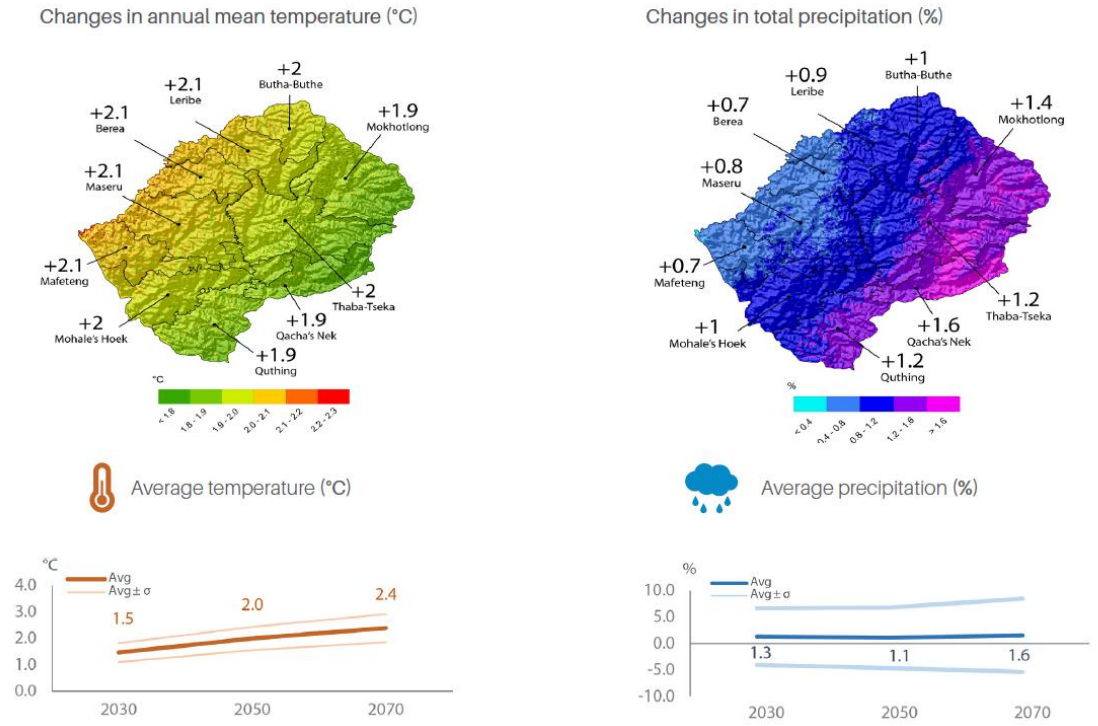


Figure 14 Projected change in annual mean temperature (°C) and total precipitation (%) in Lesotho by 2050

Source: (World Bank & CIAT, 2018).

Figure 14 appears in the CSA Profile: Lesotho, developed by CCAFS, CIAT and funded by the World Bank, and has been assembled from research by CIAT and the IPCC AR5. Global Circulation Models (GCMs) used to show climate projections for the country suggest that temperatures are likely to increase by an average of 2°C by 2050 and up to 2.4°C by 2070. According to the CSA Profile: Lesotho:

> *The largest increase is expected to occur along the northwestern border of the country, which largely comprises the country's lowlands. The eastern and central parts of the country, including the mountain livelihood zone and part of Senqu River valley, are expected to experience a slightly lower increase in ambient temperatures than the northeastern parts of the country. (World Bank & CIAT, 2018).*

Changes in rainfall are expected to pose challenge to the country's food security and production since agriculture is largely rain-fed, and irrigation systems are not used at a large scale. The CSA Profile: Lesotho also indicate that flooding may become more frequent and severe, which will challenge agricultural production, marketing infrastructure and rural livelihoods. Increased rainfall variability across the country can be expected to have impacts on water availability for crop and livestock production.

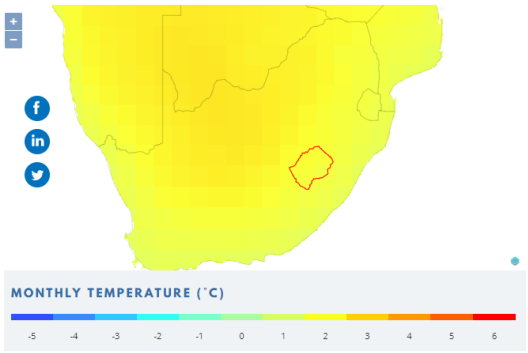


Figure 15 Projected Change in Monthly Temperature of Lesotho for 2040-2059 (Compared to 1986-2005)

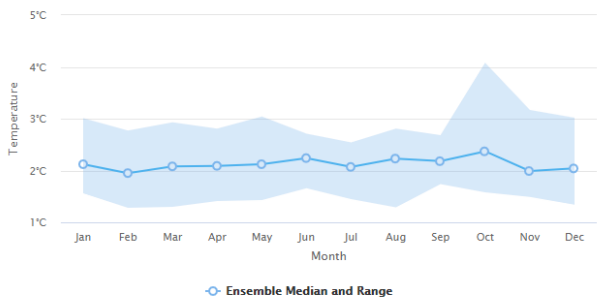


Figure 16 Projected Change in Monthly Temperature of Lesotho for 2040-2059

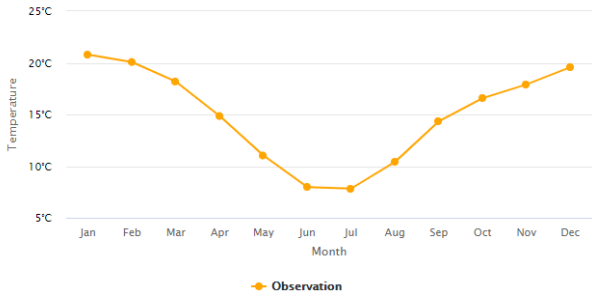


Figure 17 Historical Observed Monthly Change in Temperature for Lesotho for 1986-2005

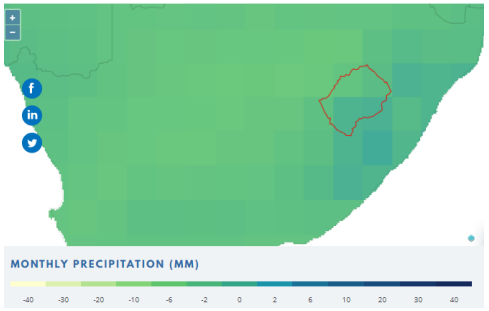


Figure 18 Projected Change in Monthly Precipitation of Lesotho for 2040-2059 (Compared to 1986-2005)

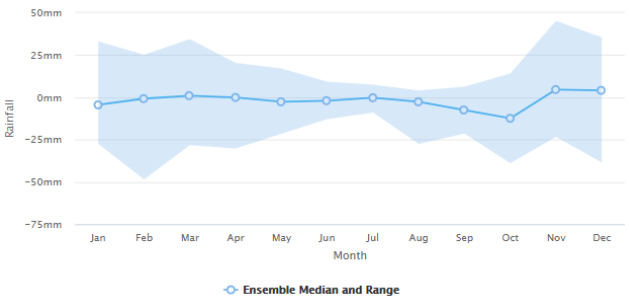


Figure 19 Projected Change in Monthly Precipitation for Lesotho for 2040-2059

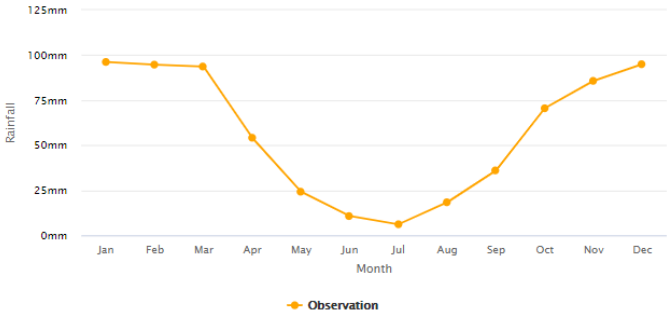


Figure 20 Historical Observed Monthly Precipitation for Lesotho for 1986 - 2005

Figure 15 and Figure 16 are derived from the World Bank Climate Knowledge Portal and show the projected changes in Lesotho's monthly temperature for 2040-2059, under the scenario RCP 8.5 which is the high emissions scenario, compared to the historical observation of monthly temperature in Lesotho for the period 1986 – 2005 (Figure 17) (World Bank, 2019e).

Figure 18 and Figure 19, also derived from the World Bank Climate Knowledge Portal show the projected changes in Lesotho's precipitation for 2040-2059, under the scenario RCP 8.5 which is the high emissions scenario, compared to the historical observation of monthly precipitation in Lesotho for the period 1986 – 2005 (Figure 20) (World Bank, 2019e).

It can be concluded that Lesotho is likely to experience higher temperatures, increased climate variability, and an increased frequency and intensity of extreme weather events all with impacts on crop and livestock production, water security, and rural infrastructure.

6.2 Botswana Climate Projections

Temperatures in Sub-Saharan Africa are already close to or beyond thresholds at which already low yields and low farming productivity are encumbered. Like much of the Southern African region, Botswana is expected to experience a considerable increase in temperature and decrease in precipitation. The country's Communication to the United Nations Framework Convention on Climate Change (UNFCCC) notes that the country is expected to be 1-3°C warmer by 2050 (FANRPAN, 2017).

These projections are corroborated by the World Bank Climate Knowledge Portal, which projects temperature and precipitation changes (amongst other indicators) globally. Future climate information is derived from 35 available global circulation models (GCMs) used by the Intergovernmental Panel on Climate Change (IPCC) 5th Assessment Report and illustrate mean or change in monthly temperature compared to the reference period (1986-2005). In general, the value of monthly temperature change varies between 0 and 4 degrees. Zero value indicates there is no change in projected monthly temperature compared to historical mean (World Bank, 2019d). According to the metadata explanation of the World Bank Climate Knowledge Portal, each 20-year time window can be compared to the standard "present day" reference period of 1986-2005 (World Bank, 2019d). For the purposes of this CRA report, scenario RPC 8.5 (high emissions scenario) is used for Lesotho as well as Botswana.

Compared to a 20-year interval (1986-2005), Botswana is expected to average temperature increases of between 2-3°C by 2059. The projected changes of monthly temperatures for the period 2040-2059 (Figure 21 andFigure 22) can be compared to the historical observation of monthly temperatures for the period 1986-2005 (Figure 23) (World Bank, 2019d). In terms of monthly precipitation, the Climate Knowledge Portal shows a notable decrease in rainfall by 2059 (Figure 24 and Figure 25) which can be compared to the historical observed precipitation for the period 1985-2005 (Figure 26) (World Bank, 2019d):

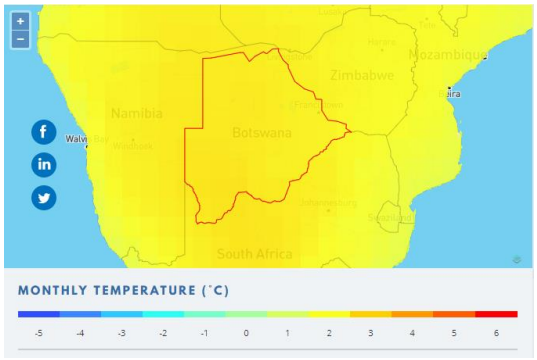


Figure 21 Visual representation of projected change in monthly temperature of Botswana for 2040-2059 (Compared to 1986-2005)

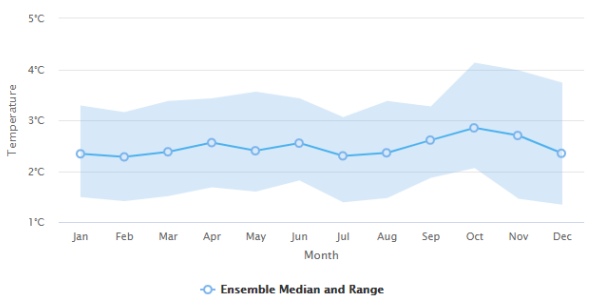


Figure 22 Projected change in monthly temperature for Botswana for 2040 - 2059

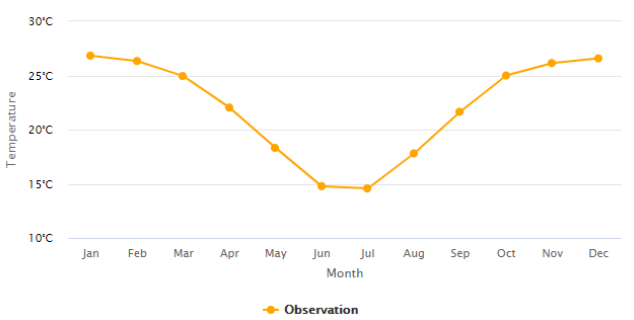


Figure 23 Historical observed monthly temperature for Botswana for 1986 - 2005

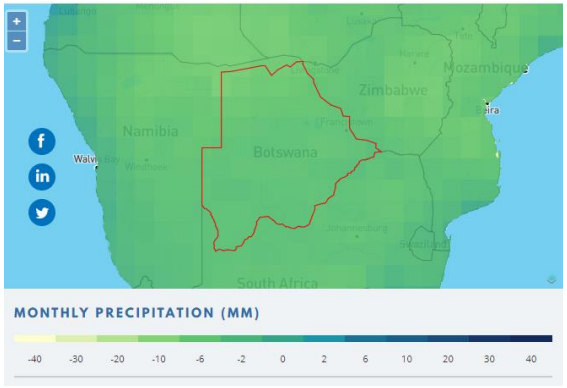


Figure 24 Projected Change in Monthly Precipitation of Botswana for 2040-2059 (Compared to 1986-2005)

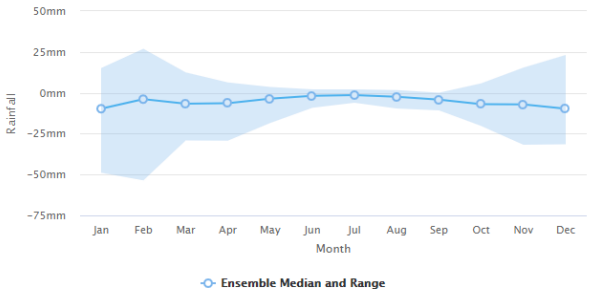


Figure 25 Projected change in monthly precipitation for Botswana for 2040 – 2059

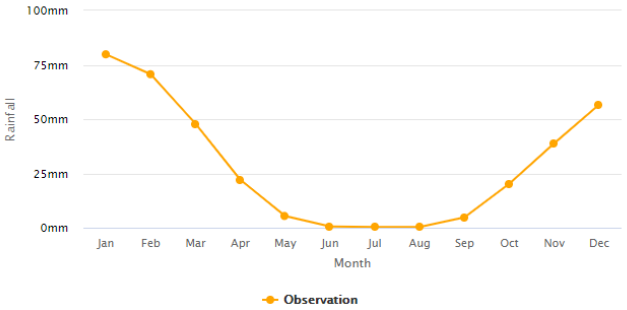


Figure 26 Historical observed monthly precipitation for Botswana for 1986 - 2005

7 CRA Results

The methodology outlined in Section 5.2 was implemented for both countries through a series of interactive workshops and technical analyses. A summary of the development of the CRA is provided in Annex 4 and selected excerpts are provided below.

7.1 Phase 1: Climate Risk Assessment Mapping

The framework shown in Figure 9 Climate Risk Assessment Conceptual Framework) and Figure 10 Climate Risk Assessment Conceptual Framework + Adaptation) was applied and each component mapped so that linkages were identified and adaptation measures could be defined.

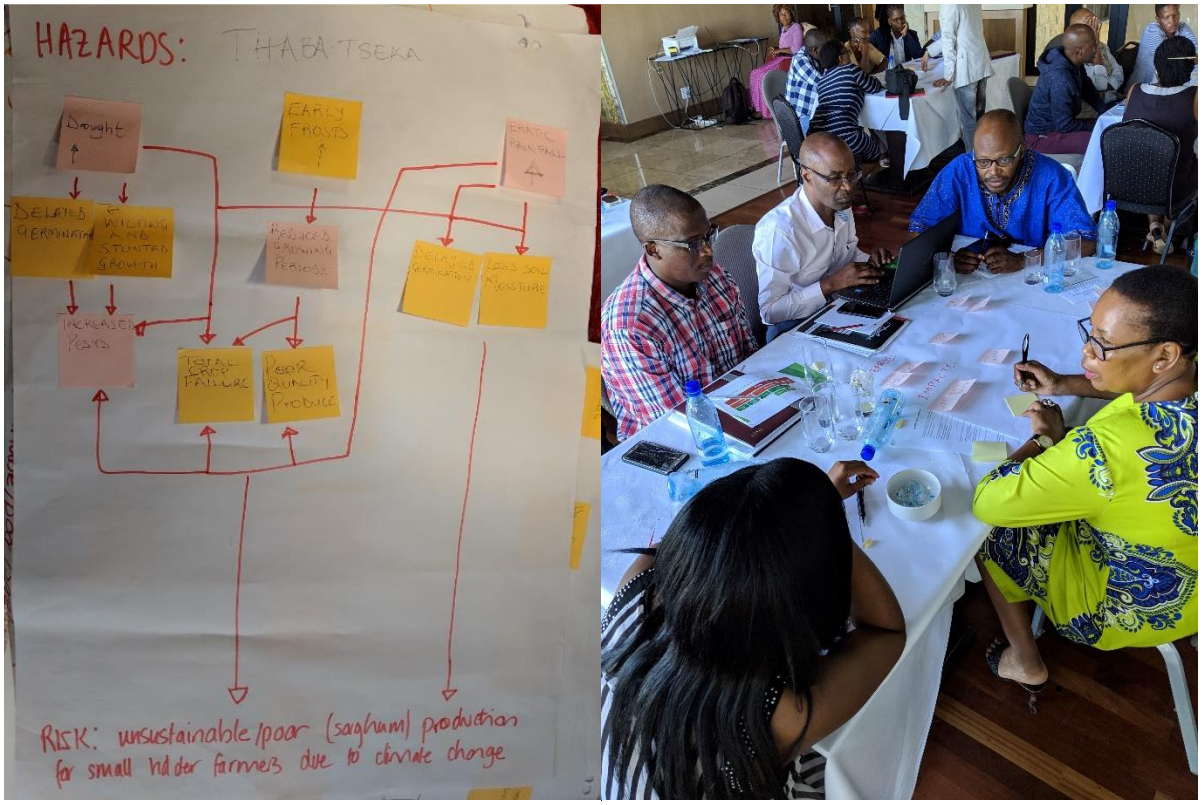
7.1.1 Impact Chains linking Hazards and Risk

Workshop participants worked in groups to design impact chains. The risk analysed was that of **unsustainable (sorghum) production for smallholder farmers due to climate change.** Based on the research and observed climate trends, the primary climate hazards were identified by participants as being;

- **Extreme Rainfall** (late, insufficient, reduced)
- **Extreme Erratic Temperatures** (more extreme highs and lows)

The core secondary hazards of Drought and Frost were also highlighted by participants and are considered to be 'subsets' (or characteristics) of the primary hazards.

Participants then mapped interim impacts between the hazard and the risk, and mapped causal links and impact chains.



Photos 1 Impact Chain Mapping Exercise

The consolidation of these impact chains from the Lesotho stakeholders is shown below.

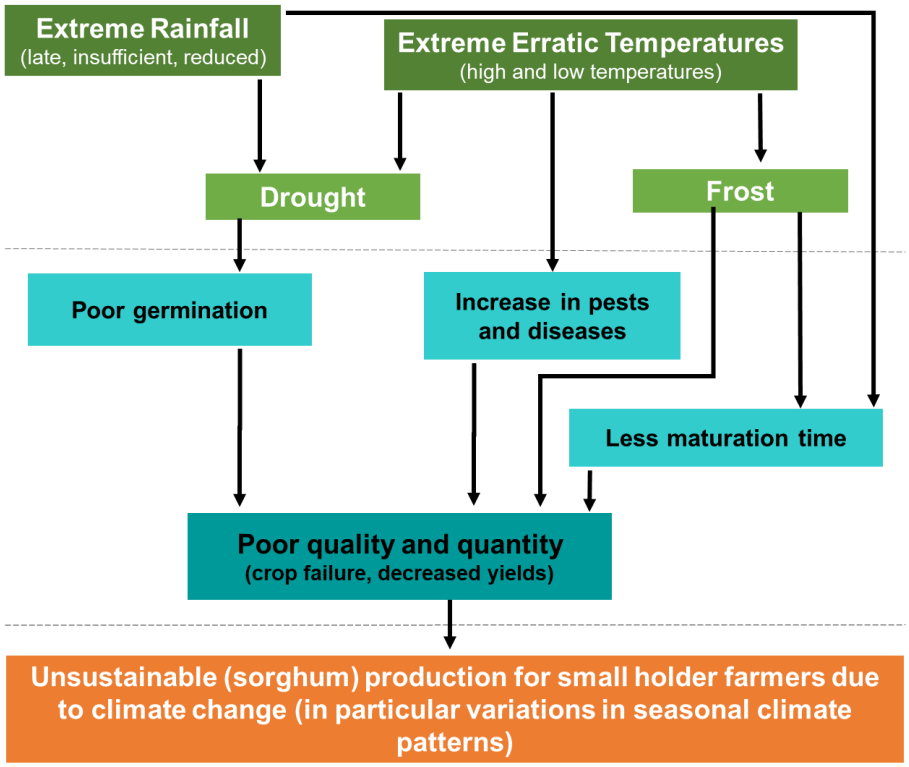


Figure 27 Impact Chain mapping from Lesotho National Workshop

The Botswana National Workshop exercise led to the inclusion of soil quality and livestock components within the framework.

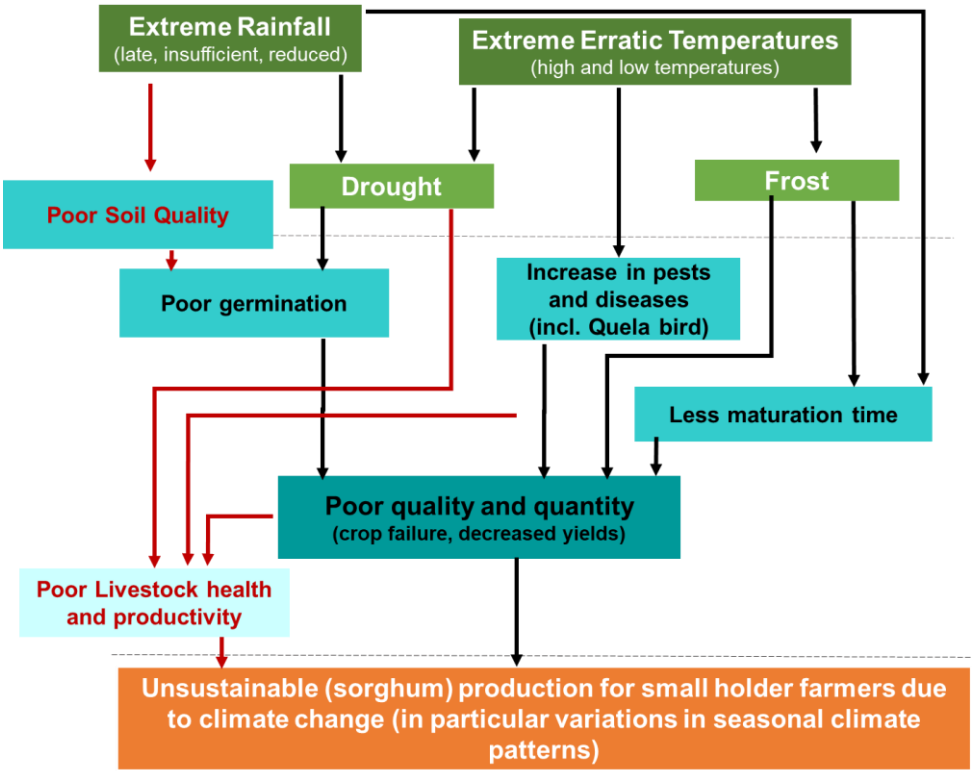


Figure 28 Additions to Impact Mapping from Botswana National Workshop

7.1.2 Vulnerability, Exposure and Adaptation

Adopting the interim impact mapping allows identification of associated Vulnerabilities (both Sensitivity and Capacity) and Exposure. These interim impacts are removed from the final representation as per technical methodology (GIZ & EURAC, 2017); this representation is shown below. The interim working steps for this representation are shown in Annex 4.

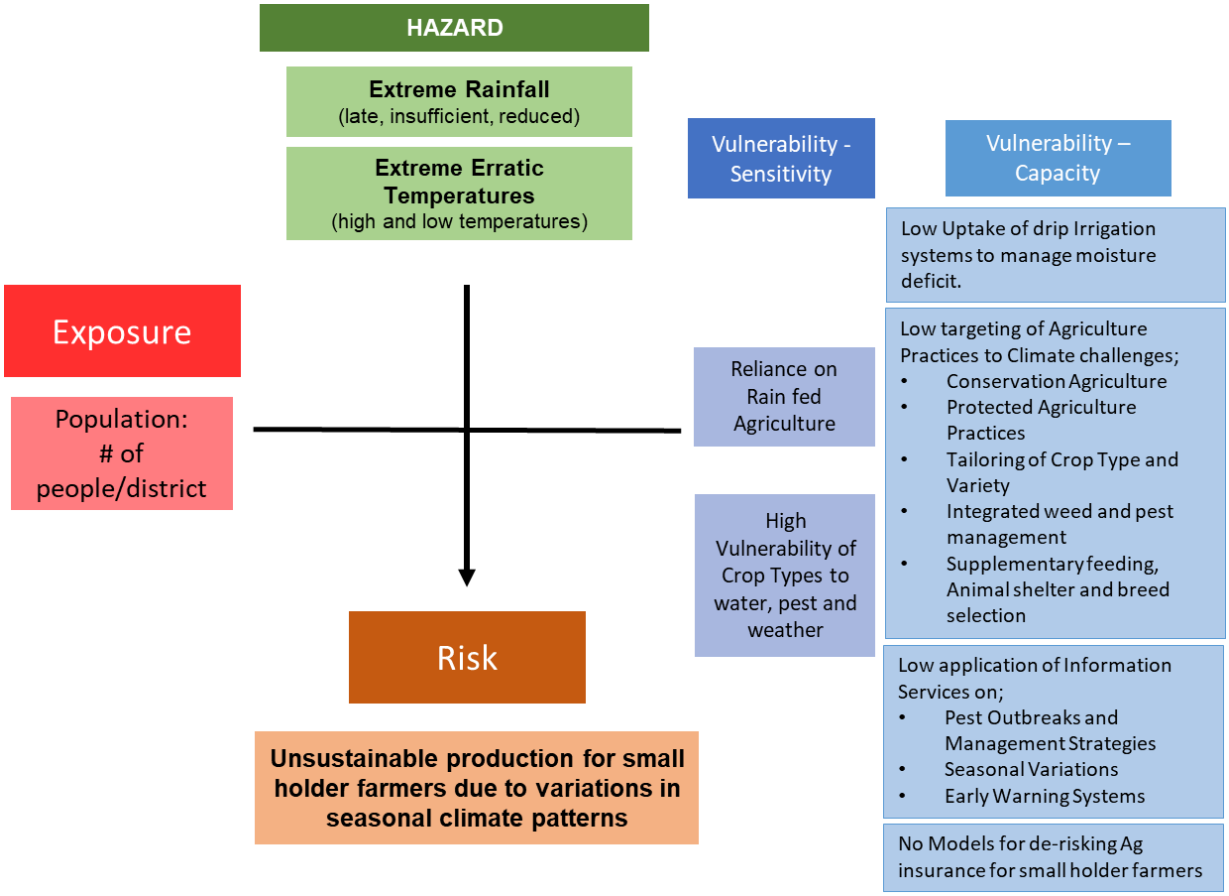


Figure 29 Final Climate Risk Analysis Framework

The mapping also allows the identification of Adaptation measures relevant to the specific system vulnerabilities. These are detailed below and feed into the exercise for prioritisation of CSA practices which is discussed further in Section 7.3.

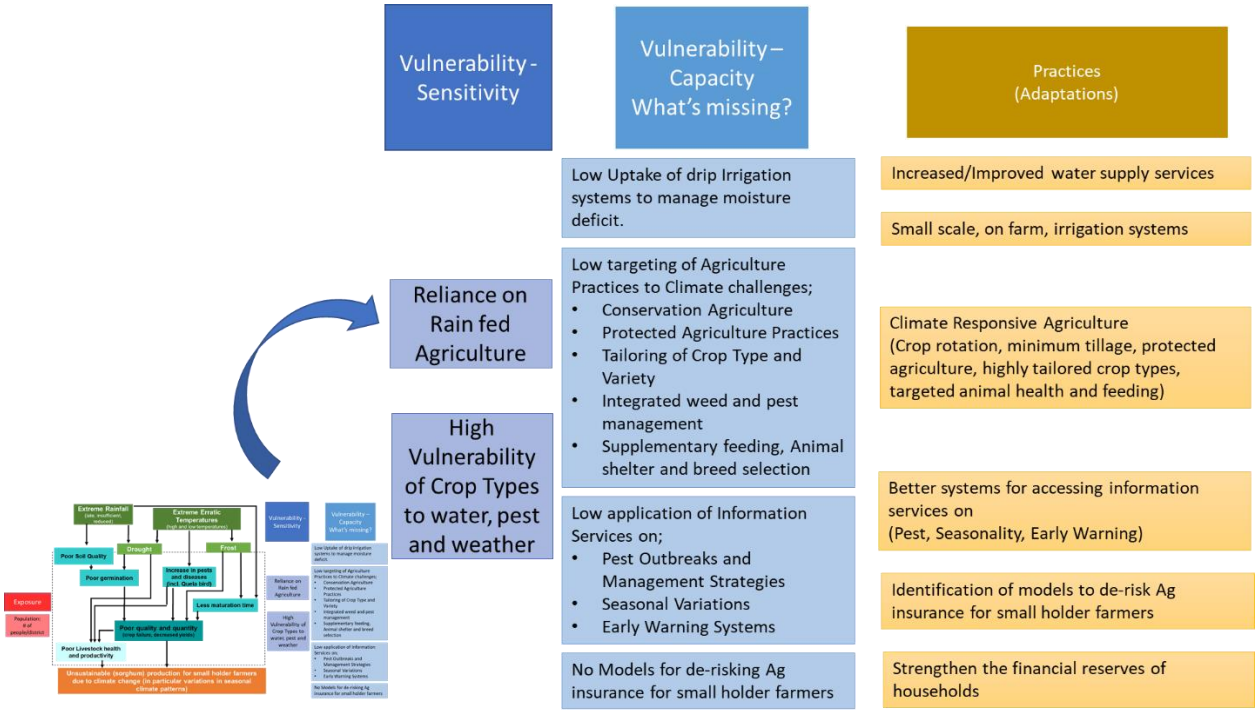


Figure 30 Identification of Adaptation Practices from CRA Framework

7.2 Phase 2: Risk Analysis

By mapping this system within a traditional risk framework, we can broadly classify risks and identify the associated adaptation measures which can target reducing the risk from these specific climate hazards. According to the SADC Climate Proofing Tool (GIZ, 2016) methodology, the work in Phase 1 above represents some of the first columns as well as framing the core biophysical risks. The following series of tables represents the climate proofing analysis and risk classification.

Table 9 Climate Proofing Analysis Part 1: System Elements

A* System of interest and development goal	D Climate hazard the system might be exposed to	E Sensitivity	F adaptive Capacity
Sustainable (sorghum) production for small holder farmers in the face of climate change (in particular variations in seasonal climate patterns)	Extreme Rainfall Extreme Erratic Temperatures (including Drought and Frost)	Reliance on Rain fed Agriculture High Vulnerability of Crop Types to water, pest and weather	• Low Uptake of drip Irrigation systems to manage moisture deficit. • Low targeting of Agriculture Practices to Climate challenges; - Conservation Agriculture - Protected Agriculture Practices - Tailoring of Crop Type and Variety - Integrated weed and pest management - Supplementary feeding, Animal shelter and breed selection • Low application of Information Services on; - Pest Outbreaks - Seasonal Variations - Early Warning Systems • No Models for de-risking Ag insurance for small holder farmers

*column lettering aligns to CCARDESA Climate Proofing Tool categories

Table 10 Climate Proofing Analysis Part 2: Risk Classification

G Biophysical	H Socioeconomic	Current Risk Lesotho	Projected Future Risk Lesotho	Current Risk Botswana	Projected Future Risk Botswana
Poor germination	*Increased Production Costs* *Increased Labour Requirements* *Low Farm Outputs* *Low market price* *Reduced Household Savings*	Medium	High	Medium	High
Increase in pests and diseases		Medium	High	Medium	Medium
Less maturation time		High	High	Medium	High
Poor quality and quantity (crop failure, decreased yields)		Medium High	High	Medium	High
Poor Soil Quality		Medium	Medium	High	High
Poor Livestock health and productivity		Medium	Medium	Medium	High

From this analysis, a list of core adaptation measures was identified. These adaptation measures can also be considered as 'climate smart practices'.

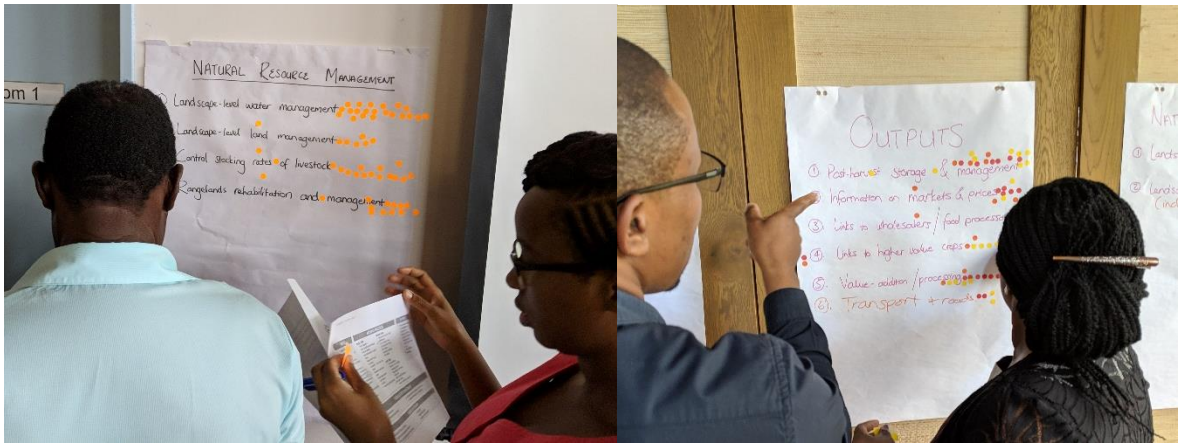
Table 11 Climate Proofing Analysis Part 3: Adaptation options

K Selected impacts of "high" risk	L Adaptation options
Poor germination	*Small scale, on farm, irrigation systems* *Climate Responsive Agriculture (Crop rotation, minimum tillage, protected agriculture, highly tailored crop types, targeted animal health and feeding)* *Better systems for accessing information services on (Pest, Seasonality, Early Warning)* *Identification of models to de-risk Ag insurance for small holder farmers* *Strengthen the financial reserves of households*
Increase in pests and diseases	
Less maturation time	
Poor quality and quantity (crop failure, decreased yields)	
Poor Soil Quality	
Poor Livestock health and productivity	

7.3 Phase 3: CSA Practices and Prioritisation

The list of climate smart practices developed as a result of the CRA above was taken into consideration as one component of a larger review of CSA practices which was undertaken in this analysis. As per the methodology shown in Figure 13 Climate Smart Agriculture Practice Selection) and outlined in Annex 2, the results of the CRA were combined with the results of a literature review and government prioritisation exercises to develop a technically validated CSA practice list to take forward into the prioritisation exercise. This final combined list can be represented as highlights within the farming system framework.

Figure 31 Final Climate Smart Practice List for Prioritisation



Photos 2 CSA Practice Group Prioritisation Exercise

Further prioritisation and consolidation were achieved through applying the prioritisation stages of the Climate Proofing Tool to this list.

The Climate Proofing Tool presents a matrix of criteria that allow policymakers to prioritise adaptation measures by considering:

i. Effectiveness (describes the extent to which the adaptation option reduces vulnerability and provides other benefits)
ii. Costs (describes relative costs of an adaptation option. This includes investment costs as well as costs over time, such as operation and maintenance costs, reconstruction costs, etc. It also includes economic and non-economic costs - costs of avoided damage.)
iii. Feasibility (whether the necessary legal, administrative, financial, technical, etc. resources exist. Adaptations that can be implemented under the current operational framework will usually be favoured)

Additionally, the governments chose to add the additional criteria of:

iv. Speed of result (how quickly would results be seen if adaptation measure is implemented)

Consideration was also given to the mitigation co-benefits; however, this criterion was applied less consistently and was considered secondary analysis to the core scoring exercise. Table 12 shows the summary of the country scores for each practice, the detailed scoring breakdown is provided in Annex 3.

Table 12 Climate Proofing Analysis Part 4: Prioritisation of Practices

Adaptation Options	Lesotho evaluation score	Botswana evaluation score
Systems which make access to inputs easy (seeds, fertiliser)	**17**	16
Supply (quantity and location) of improved seeds and breeds available.	16	**18**
Information services (weather, crop information etc)	**18**	17
Financial services – eg credit, crop insurance, input insurance, etc	15	9
Uptake of drought-tolerant & early maturing varieties on farm	16	15
Use of local adaptive livestock breeds	N/A	**20**
Application of soil protection techniques to improve quality and health (cover crops, crop residues)	12	12
Sustainable Fodder Production	**19**	**19**
Utilisation of protected farming (shading, tunnels)	13	14
Implementation of Agroforestry	13	12
Crop / livestock mixes	**19**	**19**
Implementation of drip irrigation	15	12
Implementation of Rainwater Harvesting	**18**	**18**
Micro-irrigation, with shared infrastructure	12	14
Improvements in post-harvest storage and management	**18**	**18**
Systems which link farmers to higher value crops	**17**	16
National Policy and Strategy providing guidance for sector	16	**18**
Legal and phytosanitary frameworks	**17**	**18**
Early Warning and Information Systems linked to farmers	16	15

N/A indicates practice that was added by one country and was not subject to analysis by the other.

From the list of approximately 20 relevant climate smart practices, eight highest priority practices for adaptation were identified for each country. These practices scored highest when assessed for effectiveness, cost, feasibility and speed of result.

Table 13 Climate smart practice priorities (in order of score, common practices bold)

Lesotho	Botswana
Sustainable Fodder Production	Use of local adaptive livestock breeds
Mixed farming (Crops and Livestock)	**Sustainable Fodder Production**
Provision and utilisation of climate Information services (weather, crop information etc)	**Mixed farming (Crops and Livestock)**
Implementation of Rainwater Harvesting	Supply (quantity and location) of improved seeds and breeds available.
Improvements in post-harvest storage and management	**Implementation of Rainwater Harvesting**
Systems which make access to inputs easy (seeds, fertiliser)	**Improvements in post-harvest storage and management**
Systems which link farmers to higher value crops	National Policy and Strategy providing guidance for sector
Phytosanitary legal framework	**Legal and phytosanitary frameworks**

For the purposes of this project we will be feeding the outcomes of the prioritisation into three follow-on exercises;

- The production of communication materials for a set of highest priority practices for use by stakeholders in communicating key concepts to farmers.
- Stakeholder engagement to better understand and 'ground truth' analysis conclusions with communities and farmers across different zones and farming systems.
- The technical scope of the Feasibility Study that follows on from this CRA.

Climate Smart Practices
What does the research say?

Based on the desktop research, government review and government prioritisation, CSA practices should consider the entire value chain, be specific to the country and contextual in terms of value chain. In their Synthesis Report on Policies and Practices for Climate Smart Agriculture in Sub-Saharan Africa, published in August 2017, FANRPAN underlines the fact there is unfortunately no one-size fits all solution across these (and other) countries, since the extent of climate impacts, extent of policies and enabling environment, the farming systems in use, etc. vary greatly (FANRPAN, 2017).

Researchers from the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) and the International Centre for Tropical Agriculture (CIAT) show that Conservation agriculture (CA) is the most widely promoted climate-smart agriculture (CSA) practice in Lesotho – this is the subset of practices of minimum / reduced tillage, soil protection and crop diversification. They also show that other practices i.e. keyhole gardens, small-scale irrigation, organic manure application and the use of tunnels (greenhouses) do exist in Lesotho, alongside traditional CSA practices such as Likoti and Machobane farming. To this end, they argue that these systems' practices should be integrated into modern CSA practices, thereby improving acceptability of CSA practices among rural households, which account for the largest percentage of farming households in the country (World Bank & CIAT, 2018).

Botswana also has both traditional and research-based agricultural practices that can be considered climate smart, but it requires mainstreaming (FANRPAN, 2017). In both countries it could be argued that combining local / traditional farming systems practices with researched CSA practices, could provide the best entry point for adoption of CSA practices, and that promoting a combination of short-term CSA coping approaches and long-term adaptation strategies could be the most effective to promote uptake. But data on CSA adoption vs. disadoption is lacking, as is the case with many countries and need to be better researched in order to understand which practices have higher likelihood of adoption (or require more investment).

8 Conclusions and Recommendations

This report summarises the results of exercises and analyses undertaken to better understand climate risk for smallholder production systems in Lesotho and Botswana. The objective of the work was to collaboratively undertake the CRA methodology and identify and analyse adaptation options to take forward into the follow-on phases of the work. This work was carried out together with the DAR's of Lesotho and Botswana (and additional stakeholders as relevant) and served as a capacity building and training exercise for the key components of the CRA methodology. The methodologies applied here can now be replicated by DAR staff.

Climate Threat

Lesotho

Global Circulation Models (GCMs) used by CCAFS show climate projections for the country suggest that temperatures are likely to increase by an average of 2°C by 2050 and up to 2.4°C by 2070 (World Bank & CIAT, 2018). Overall, Lesotho is likely to experience higher temperatures, increased climate variability, and an increased frequency and intensity of extreme weather events all with impacts on crop and livestock production, water security, and rural infrastructure. Changes in rainfall are expected to pose challenge to the country's food security and production since agriculture is largely rain-fed, and irrigation systems are not used at a large scale. Flooding may become more frequent and severe, which will challenge agricultural production, marketing infrastructure and rural livelihoods. Increased rainfall variability across the country can be expected to have impacts on water availability for crop and livestock production.

Botswana

World Bank Climate Knowledge Portal indicates that compared to a 20-year interval (1986-2005), Botswana is expected to average temperature increases of between 2-3°C by 2059 and a decrease in monthly precipitation by 2059 in both median and extremes of range. Temperatures in this region are already close to or beyond thresholds at which already low yields and low farming productivity are encountered.

Defining and Assessing Climate Risk

Changing extremities in weather patterns were the primary climate hazards identified for smallholder farming systems; particularly late onset and/or reduced rainfall and extreme lows and highs in temperature. These hazards led to a number of core critical impacts which significant threaten the success of small holder farmers;

- Poor germination
- Increase in pests and diseases
- Less maturation time
- Poor quality and quantity of output (failure, decreased yield)
- Poor soil quality
- Poor livestock health and productivity

The risk categorisation for all of these biophysical elements under the projected climate change will be high. These risks are exacerbated by the sensitivities of the farming systems, namely the high reliance on rain fed agriculture and the use of crop types which are highly vulnerable to changes in water, pest and weather. The characteristics of the farming system limit the capacity of farmers to cope with the hazard impacts when they do occur. There is low uptake of irrigation systems that manage moisture deficit, limited targeting of agriculture

practices to seasonal climate challenges, low utilisation of information services and lack of models to de-risk agriculture for small holder farmers. Adaptation measures that target these gaps and build these capacities will be those that best mitigate the risk from the climate hazards.

Responding to Climate Risk

From a list of 25 relevant climate smart practices, 8 highest priority practices for adaptation were identified for each country. These practices scored highest when assessed for effectiveness, cost, feasibility and speed of result.

Table 14 Climate smart practice priorities (in order of score, common practices bold)

Lesotho	Botswana
Sustainable Fodder Production	Use of local adaptive livestock breeds
Mixed farming (Crops and Livestock)	**Sustainable Fodder Production**
Provision and utilisation of climate Information services (weather, crop information etc)	**Mixed farming (Crops and Livestock)**
Implementation of Rainwater Harvesting	Supply (quantity and location) of improved seeds and breeds available.
Improvements in post-harvest storage and management	**Implementation of Rainwater Harvesting**
Systems which make access to inputs easy (seeds, fertiliser)	**Improvements in post-harvest storage and management**
Systems which link farmers to higher value crops	National Policy and Strategy providing guidance for sector
Phytosanitary legal framework	**Legal and phytosanitary frameworks**

This work was undertaken primarily on a desktop basis using and leveraging existing analysis, research, data and expert advice. Validation was undertaken through engagement with a broad range of government representatives and other stakeholders; however, field engagement is ongoing as part of the Feasibility Study and elements of the results may be updated as a result of information collected in that process.

Recommendations

- That the staff of DAR Lesotho and Botswana utilise the CRA framework (giving consideration to hazard, risk, vulnerability and exposure) for considering Climate Risk in future work and replicate the methodology where relevant.
- The impact mapping tool (using post it notes to fill the steps between hazard & risk and identifying causality) can be used at any time to better understand the components and risks of the agricultural model that is being considered.
- The farming systems framework is used as a reference to understand and communicate with other stakeholders the scope and breadth of the components within the farmers operations which can be considered to relate to ‘climate smart agriculture’ as well as those outside of their operations which can impact on their success.
- That DAR and broader Ministries internalise the fact that changing extremities in weather patterns are the primary climate hazards for smallholder farming systems; particularly late onset and/or reduced rainfall and extreme lows and highs in temperature.
- That consideration is given to the key system risks (poor germination, increase in pests and diseases, less maturation time, poor quality and quantity of output, poor soil quality, poor livestock health and productivity) when programming across DAR and the broader Ministries is set so that adaptations can align to addressing these most critical impacts.

- That DAR drive the research agenda to align to these critical impacts so that the results of their work can feed into and shape the work of the broader Ministry and provide guidance to other stakeholders in the sector.
- That the work of this report and the upcoming FS are aligned to and positioned to feed well into the Lesotho Investment Plan for Agriculture Development providing the research and evidence base for that process.
- That this report and its executive summary be shared via official channels and published on relevant web sites.

9 References

Bureau of Statistics. (2014). *2010/2011 Household Budget Survey: Analytical Report.* Vol. 14, Maseru: Bureau of Statistics.

Botswana Vulnerability Assessment Committee. (2018). *Botswana Vulnerability Assessment Committee Results 2018.* Retrieved from: https://reliefweb.int/sites/reliefweb.int/files/resources/SADC_Botswana_snapshot_19July2018_final.pdf.

Centre for Coordination of Agricultural Research and Development for Southern Africa. (n.d.). *Botswana.* Retrieved from: http://www.ccardesa.org/botswana.

Export.gov. (2019). *Botswana - Agricultural Sectors.* Retrieved from: https://www.export.gov/article?id=Botswana-Agricultural-Sectors.

Famine Early Warning System Network. (2014). *Food Security Brief: Lesotho Desk Review.* Retrieved from: http://fews.net/southern-africa/lesotho/food-security-brief/april-2014.

Fanani, C.M. (2018). *3rd African Soil Partnership (AfSP) Meeting: Country Presentation: Botswana [PowerPoint Slides].* Retrieved from: https://www.slideshare.net/ExternalEvents/the-4th-afsp-workshop-botswana?from_action=save.

Food, Agriculture & Natural Resources Policy Analysis Network. (2017). *Policy Brief: Climate Smart Agriculture in Botswana*. Retrieved from: http://www.statsbots.org.bw/sites/default/files/publications/Botswana%20Demographic%20Survey%20Report%202017.pdf .

Food and Agriculture Organization of the United Nations. (2010). *"Climate-Smart" Agriculture - Policies, Practices and Financing for Food Security, Adaptation and Mitigation.* Retrieved from: http://www.fao.org/3/i1881e/i1881e00.htm.

Food and Agriculture Organization of the United Nations. (2016a). *AQUASTAT: Botswana.* Retrieved from: http://www.fao.org/nr/water/aquastat/countries_regions/BWA/.

Food and Agriculture Organization of the United Nations. (2016b). *AQUASTAT: Lesotho*. Retrieved from: http://www.fao.org/nr/water/aquastat/countries_regions/LSO/.

Food and Agriculture Organization of the United Nations. (2017). *GIEWS Country Brief: Lesotho.* Retrieved from: http://www.fao.org/giews/countrybrief/country.jsp?code=LSO.

Food and Agriculture Organization of the United Nations. (2018). *GIEWS Country Brief: Botswana.* Retrieved from: http://www.fao.org/giews/countrybrief/country.jsp?code=BWA&lang=en.

Food and Agriculture Organization of the United Nations. (2019). FAOSTAT website. Food and Agriculture Organization of the United Nations (FAO). Retrieved from: http://www.fao.org/faostat/en/#country/122.

Food and Agriculture Organization of the United Nations. (n.d.). *Climate-Smart Agriculture*. Retrieved from: http://www.fao.org/climate-smart-agriculture/en/.

GIZ. (2014). *The Vulnerability Sourcebook - Concept and guidelines for standardised vulnerability assessments.* Retrieved from: https://mia.giz.de/esearcha/browse.tt.html.

GIZ. (2016). *Tackling Climate Change in Agriculture - Approaches to Climate Change Adaptation and Climate Smart Agriculture in Southern Africa. Training Manual for the Climate Proofing Tool - A practice-oriented training based on the OECD Policy Guidance, adopted to climate smart agriculture in southern Africa*. Retrieved from: https://mia.giz.de/esearcha/browse.tt.html.

GIZ & EURAC. (2017). *Risk Supplement to the Vulnerability Sourcebook. Guidance on how to apply the Vulnerability Sourcebook's approach with the new IPCC AR5 concept of climate risk*. Retrieved from: https://mia.giz.de/esearcha/browse.tt.html.

Government of Lesotho. (2018). *About Lesotho.* Retrieved from: https://www.gov.ls/about-lesotho/.

International Fund for Agricultural Development. (2014). *Socioeconomic Survey using the Multidimensional Poverty Assessment Tool.* Retrieved from: https://www.ifad.org/en/web/knowledge/publication/asset/39631564.

International Fund for Agricultural Development. (n.d.). *Lesotho.* Retrieved from: https://www.ifad.org/en/web/operations/country/id/lesotho.

Lesotho Review. (2019). Retrieved from: http://www.lesothoreview.com/.

Lesotho Vulnerability Assessment Committee. (2016). *Market Assessment Report.* Retrieved from: https://reliefweb.int/sites/reliefweb.int/files/resources/wfp284541.pdf.

Ministry of Agriculture, Botswana. (2011a). *Dairy Farming.* Retrieved from: http://www.gov.bw/en/Ministries--Authorities/Ministries/MinistryofAgriculture-MOA/Farming/Dairy-Farming/.

Ministry of Agriculture, Botswana. (2011b). *Turkey Production.* Retrieved from: http://www.gov.bw/en/Ministries--Authorities/Ministries/MinistryofAgriculture-MOA/Farming/Turkey-Production/.

Ministry of Agriculture, Botswana. (2011c). *Ostrich Farming.* Retrieved from: http://www.gov.bw/en/Ministries--Authorities/Ministries/MinistryofAgriculture-MOA/Farming/Ostrich-Farming/.

Ministry of Agriculture, Botswana. (2011d). *Range Management and Fodder Production.* Retrieved from: http://www.gov.bw/en/Ministries--Authorities/Ministries/MinistryofAgriculture-MOA/Farming/Range-Management-and-Fodder-Production/.

Ministry of Agriculture and Food Security, Kingdom of Lesotho. (2003). *Agricultural sector strategy: statement of policy and strategy in the agricultural sector.*

Ministry of Energy and Meteorology, Kingdom of Lesotho. (2017). *National Climate Change Policy Implementation Strategy.* Retrieved from: https://europa.eu/capacity4dev/pg/file/79286/download?token=gJqt11UI.

Ministry of Forestry, Range and Soil Conservation, Kingdom of Lesotho. (2015). *Lesotho National Action Programme in Natural Resource Management, Combating desertification and Mitigating the effects of Drought: The National Adaptation*

Programme (for the United Nations Convention to Combat Desertification – UNCCD. Retrieved from: https://knowledge.unccd.int/sites/default/files/naps/Lesotho.pdf.

Moeletsi, M & Walker, S. (2013). *Agroclimatological suitability mapping for dryland maize production in Lesotho. Theoretical and Applied Climatology.* 114(1–2). Theoretical and Applied Climatology. 114. 10.1007/s00704-012-0829-1. Retrieved from: https://www.researchgate.net/publication/257449112_Moeletsi_ME_Walker_S_Agroclimatological_suitability_mapping_for_dryland_maize_production_in_Lesotho_Theoretical_and_Applied_Climatology_1141-2/citation/download.

New Partnership for Africa's Development. (2019). *Botswana.* Retrieved from: https://www.nepad.org/countries/botswana.

Office of the Prime Minister, Kingdom of Lesotho. (2018). *Lesotho Zero Hunger Strategic Review.* Retrieved from: https://reliefweb.int/report/lesotho/lesotho-zero-hunger-strategic-review-2018.

Place, F. Bwalya, M. & Phiri, E. (2010). *The AUC-NEPAD Agriculture Climate Change Adaptation-Mitigation Framework, The New Partnership for Africa's Development (NEPAD) Planning and Coordinating Agency: a technical body of the African Union*. Johannesburg, South Africa

Sekoli, M & Morojele, M. (2016). *Sorghum Productivity Trends and Growth Rate for Lesotho*. Global Journal of Agricultural Research. Vol 4 (1). Retrieved from: www.eajournals.org.

South South North. (2017). *Southern African Climate Finance Partnership: Botswana Country Diagnostic*. Retrieved from: https://southsouthnorth.org/wp-content/uploads/2018/09/Botswana-Country-Diagnostic.pdf.

Southern African Development Community. (2012). *SADC Facts & Figures.* Retrieved from: https://www.sadc.int/about-sadc/overview/sadc-facts-figures/.

Statistics Botswana. (2017). *Botswana Environment Statistics – Natural Disasters Digest 2017.* Retrieved from: http://www.statsbots.org.bw/sites/default/files/Botswana%20Environment%20Natural%20Disaster%20Digest_2017.pdf.

Statistics Botswana. (2013). *2011 Annual Agricultural Survey Report*. Retrieved from: http://www.statsbots.org.bw/sites/default/files/publications/Agricultural%20Survey%202011%20Report%20%20Sept%2020%202013.pdf

Statistics Botswana. (2018). *Botswana Demographic Survey Report 2017.* Retrieved from: http://www.statsbots.org.bw/sites/default/files/publications/Botswana%20Demographic%20Survey%20Report%202017.pdf.

Tshipa, S. (2019). *Where's the beef? Drought-parched Botswana struggles to keep cattle culture alive.* Retrieved from: https://www.reuters.com/article/us-botswana-drought-cattle/wheres-the-beef-drought-parched-botswana-struggles-to-keep-cattle-culture-alive-idUSKCN1RH0D8.

United Nations. (2019). *Population and Vital Statistics Report.* Retrieved from: https://unstats.un.org/unsd/demographic-social/products/vitstats/.

UNDP. (2012). *Botswana study guide, strategic information and developments.* Washington DC: International Business Publications.

World Bank. (2019a). *The World Bank in Botswana.* Retrieved from: https://www.worldbank.org/en/country/botswana/overview

World Bank. (2019b). *The World Bank in Lesotho.* Retrieved from: https://www.worldbank.org/en/country/lesotho/overview.

World Bank. (2019c). *World Development Indicators. Country Profile: Lesotho.* Retrieved from: https://databank.worldbank.org/views/reports/reportwidget.aspx?Report_Name=CountryProfile&Id=b450fd57&tbar=y&dd=y&inf=n&zm=n&country=LSO.

World Bank. (2019d). *Climate Change Knowledge Portal - Climate Data Projections: Botswana.* Retrieved from: https://climateknowledgeportal.worldbank.org/country/botswana/climate-data-projections.

World Bank. (2019e). *Climate Change Knowledge Portal - Climate Data Projections: Lesotho.* Retrieved from: https://climateknowledgeportal.worldbank.org/country/lesotho/climate-data-projections.

World Bank & CIAT. (2018). *Climate-Smart Agriculture in Lesotho. CSA country profiles for Africa, Asia, and Latin America and the Caribbean series*. Retrieved from: https://ccafs.cgiar.org/publications/climate-smart-agriculture-lesotho#.XWFZCegzbb2.

Annex 1 - Workshop Participant Lists

National Workshop: Climate Risk Assessment Methodology (25 - 26 Feb 2019, Maseru, Lesotho)

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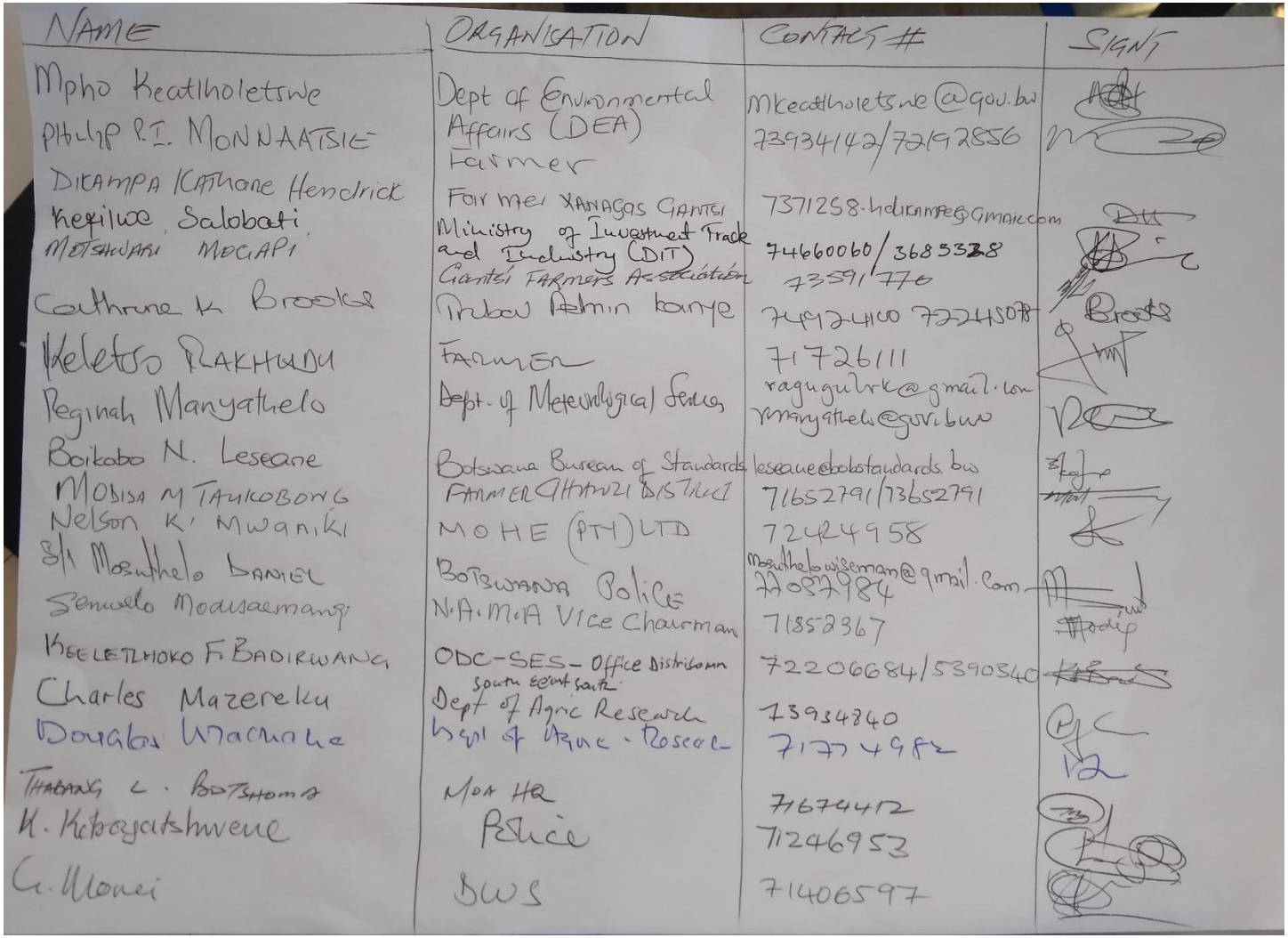
National Workshop: Climate Risk Assessment Methodology (14 March 2019, Gaborone, Botswana)



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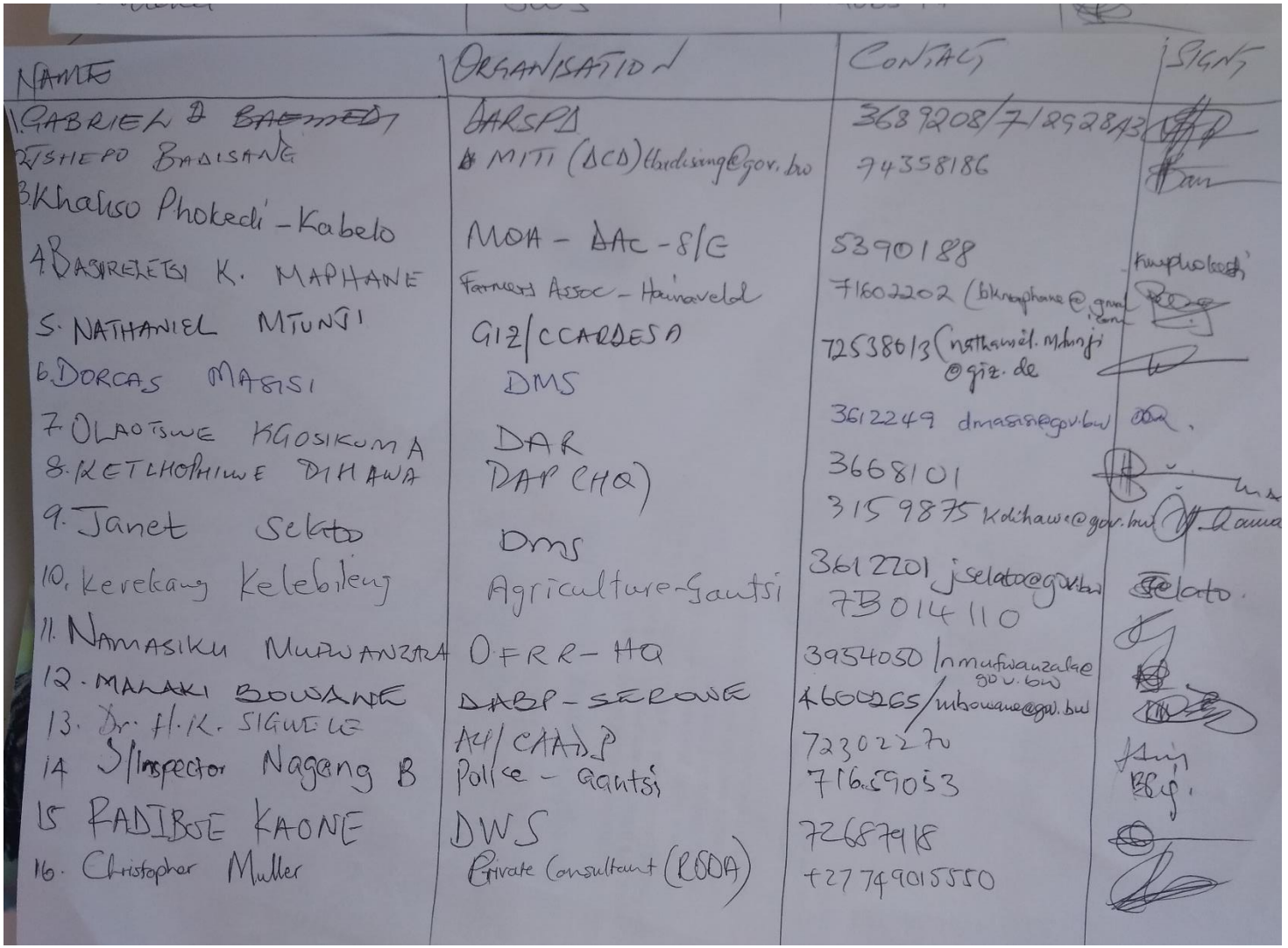

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Regional Workshop: Validating Climate Risk Assessment and Identification of CSA Practices (15 March 2019, Gaborone, Botswana)

CCARDESA
Centre for Coordination of Agricultural Research and Development for Southern Africa

SADC
SOUTHERN AFRICAN DEVELOPMENT COMMUNITY
TOWARDS A COMMON FUTURE

The Sorghum VC National and Regional Workshop
15/03/2019, at Blue Tree hotel, Botswana

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Annex 2 - Prioritisation of CSA Best Practices

Prioritisation of CSA Best Practices

Introduction

Climate Smart Agriculture (CSA) is “an approach that helps to guide actions needed to transform and reorient agricultural systems to effectively support development and ensure food security in a changing climate” (FAO, n.d.).These actions aim to enhance the climate resilience of farmers by 1) sustainably increasing productivity, 2) enhancing adaptation and 3) reducing / removing greenhouse gases (mitigation) where possible. CSA cuts across all aspects of an agricultural value chain as it includes considerations from the input side of farming (i.e. farmer access to adaptive seeds and breeds, access to weather information, etc.) to the output side (postharvest management, linking farmers to markets, etc.).

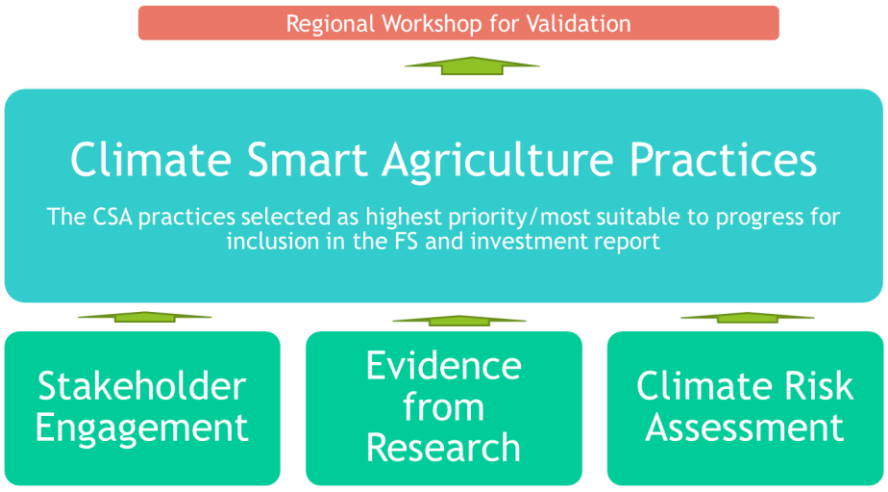
Within the scope of this project CSA practices were identified that would suit the contexts of the project countries (Botswana and Lesotho) to assist in enhancing the climate resilience of farmers in important agricultural sub-sectors in both countries.

Based on a three-pronged approach to identify the CSA practices (outlined below), focus was placed primarily on practices that improve productivity and enhance adaptation. Practices that promote mitigation of climate change impacts will be considered as co-benefit.

Our research largely shows that CSA practices should be contextual, that no one-size-fits-all solution exists and that practices should consider the entirety of the value chain (for example not only on-farm practices, but also aspects related to the inputs required by farmers, the policy environment and the management of natural resources).

Methodology

To identify CSA practices for the two countries, the following three-pronged approach was used.



Analysis

1. **Government-review of identified CSA practices at national workshops in Lesotho and Botswana.**

A farming systems framework was used which showed how the different CSA practices can be placed / considered in a typical agricultural value chain. This framework was presented to agriculture experts: government officials, subject experts and field officers in the Departments of Agricultural Research of the Ministries of Agriculture in Botswana and Lesotho.

During workshops in both countries, these experts were asked to participate in further refining the identified CSA practices and apply their country contexts. This was done through exercises which roughly mapped participant priorities from the list of practices in the farming system framework, based on their country's value chains and contexts. Government officials voted on the most important CSA practices they considered in their countries which would enhance the climate resilience of farmers. In some instances, this exercise was undertaken prior to and after the Climate Risk analysis and reflected a change in the officials' responses once they had spent time working on climate hazards and impacts.

2. **Desktop research of existing literature on agriculture and CSA in Botswana and Lesotho.**

The starting point for the desktop research was broad-based research on CSA and how it is applied in different countries. The primary sources were country-based profiles and assessments by leading research institutions and development organisations (the Food and Agriculture Organization of the United Nations (FAO), the Food, Agriculture & Natural Resources Policy Analysis Network (FANRPAN), the World Bank and the Consultative Group on International Agricultural Research (CGIAR)).

The desktop review of CSA practices in Lesotho and Botswana allowed narrowing down to:

1) viewing CSA practices through a farming "framework" that illustrates processes along the entire value chain (inputs, farming practices, outputs, natural resource management and the enabling environment and support services). This is illustrated in figures adopted for each element of the approach;
2) focusing on the most dominant agriculture sub-sectors in the respective countries and practices that are specific to those value chains;
3) considering practices that promote adaptation and productivity of farmers in those sub-sectors.

3. Results of Climate Risk Assessment Analysis

The climate risk assessment required participants to identify a risk to agricultural production in their countries and to link the key hazards which could lead to that risk. In doing so, they identified relationships between hazards and risks and illustrated a chain of intermediate impacts which highlighted actions that could be introduced to address those impacts (CSA Practices). These impacts were used to identify Vulnerabilities, Exposure and eventually define adaptation measures which would mitigate the risk. This process is detailed further in Section 7 of the Climate Risk Assessment report and in Annex 4.

Summary of results

Based on the desktop research, government review and government prioritisation, CSA practices should consider the entire value chain, be specific to the country and contextual in terms of value chain. In their Synthesis Report on Policies and Practices for Climate Smart Agriculture in Sub-Saharan Africa, published in August 2017, FANRPAN underlines the fact there is unfortunately no one-size fits all solution across these (and other) countries, since the extent of climate impacts, extent of policies and enabling environment, the farming systems in use, etc. vary greatly (FANRPAN, 2017).

Researchers from the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) show that Conservation agriculture (CA) is the most widely promoted climate-smart agriculture (CSA) practice in Lesotho – this is the subset of practices of minimum / reduced tillage, soil protection and crop diversification. They also show that other practices i.e. keyhole gardens, small-scale irrigation, organic manure application and the use of tunnels (greenhouses) do exist in Lesotho, alongside traditional CSA practices such as Likoti and Machobane farming. To this end, they argue that these systems' practices should be integrated into modern CSA practices, thereby improving acceptability of CSA practices among rural households, which account for the largest percentage of farming households in the country (World Bank & CIAT, 2018).

Botswana also has both traditional and research-based agricultural practices that can be considered climate smart, but it requires mainstreaming (FANRPAN, 2017). In both countries it could be argued that combining local / traditional farming systems practices with researched CSA practices, could provide the best entry point for adoption of CSA practices, and that promoting a combination of short-term CSA coping approaches and long-term adaptation strategies could be the most effective to promote uptake. But data on CSA adoption vs. disadoption is lacking, as is the case with many countries and need to be better researched in order to understand which practices have higher likelihood of adoption (or require more investment).

A simplified list of CSA practices drawn from research was presented in the form of a farming framework that considers the entire farming value chain. This was presented to the governments of Lesotho and Botswana to review and to add shortcomings, and to eventually prioritise these practices. The purple text highlights the overlap between practices identified during the desktop research and practices prioritised by government.

Based on this final list of practices, a regional workshop was hosted to further refine the practices of both countries and to select CSA adaptation measures using the GiZ Climate Proofing Tool (based on

OECD Policy Guidance "Integrating Climate Change Adaptation into Development Co-operation", published in May 2009).

The Climate Proofing Tool presents a matrix of criteria that allow policymakers to prioritise adaptation measures by considering:

i. Effectiveness (describes the extent to which the adaptation option reduces vulnerability and provides other benefits)
ii. Costs (describes relative costs of an adaptation option. This includes investment costs as well as costs over time, such as operation and maintenance costs, reconstruction costs, etc. It also includes economic and non-economic costs - costs of avoided damage.)
iii. Feasibility (whether the necessary legal, administrative, financial, technical, etc. resources exist. Adaptations that can be implemented under the current operational framework will usually be favoured)

Additionally, the governments chose to add the additional criteria of:

iv. Speed of result (how quickly would results be seen if adaptation measure is implemented)

Following the prioritisation of adaptation measures, consideration was given to the mitigation co-benefits. However, this consideration was applied less consistently and was considered secondary analysis to the core scoring exercise.

Conclusion

The table below shows the summary of the country scores for each practice; the detailed scoring breakdown is provided in Annex 3.

Adaptation Options	Lesotho evaluation score	Botswana evaluation score
Systems which make access to inputs easy (seeds, fertiliser)	**17**	16
Supply (quantity and location) of improved seeds and breeds available.	16	**18**
Information services (weather, crop information etc)	**18**	17
Financial services – eg credit, crop insurance, input insurance, etc	15	9
Uptake of drought-tolerant & early maturing varieties on farm	16	15
Use of local adaptive livestock breeds	N/A	**20**
Application of soil protection techniques to improve quality and health (cover crops, crop residues)	12	12
Sustainable Fodder Production	**19**	**19**
Utilisation of protected farming (shading, tunnels)	13	14
Implementation of Agroforestry	13	12
Crop / livestock mixes	**19**	**19**
Implementation of drip irrigation	15	12
Implementation of Rainwater Harvesting	**18**	**18**
Micro-irrigation, with shared infrastructure	12	14
Improvements in post-harvest storage and management	**18**	**18**
Systems which link farmers to higher value crops	**17**	16
National Policy and Strategy providing guidance for sector	16	**18**
Legal and phytosanitary frameworks	**17**	**18**
Early Warning and Information Systems linked to farmers	16	15

N/A indicates practice that was added by one country and was not subject to analysis by the other.

From the list of approximately 20 relevant climate smart practices, eight highest priority practices for adaptation were identified for each country. These practices scored highest when assessed for effectiveness, cost, feasibility and speed of result.

Lesotho	Botswana
Sustainable Fodder Production	Use of local adaptive livestock breeds
Mixed farming (Crops and Livestock)	**Sustainable Fodder Production**
Provision and utilisation of climate Information services (weather, crop information etc)	**Mixed farming (Crops and Livestock)**
Implementation of Rainwater Harvesting	Supply (quantity and location) of improved seeds and breeds available.
Improvements in post-harvest storage and management	**Implementation of Rainwater Harvesting**
Systems which make access to inputs easy (seeds, fertiliser)	**Improvements in post-harvest storage and management**
Systems which link farmers to higher value crops	National Policy and Strategy providing guidance for sector
Phytosanitary legal framework	**Legal and phytosanitary frameworks**

For the purposes of this project we will be feeding the outcomes of the prioritisation into three follow-on exercises;

- The production of communication materials for a set of highest priority practices for use by stakeholders in communicating key concepts to farmers
- Stakeholder engagement to better understand and 'ground truth' analysis conclusions with communities and farmers across different zones and farming systems.
- The technical scope of the Feasibility Study that follows on from this CRA.

Annex 3: Detailed breakdown of CSA Best Practices prioritisation

Lesotho Climate Smart Practice Prioritisation Scores

Adaptation Options		Criterion 1: Effectiveness (range: 1 low effective, 5 highly effective)	Criterion 2: Costs (range: 1 high cost, 5 low cost)	Criterion 3: Feasibility (range: 1 hard to implement, 5 highly feasible)	Criterion 4: Speed of Result (range: 1 slow to see results, 5 Quick results)	Overall evaluation (score totals)	Mitigation Co-benefit? (1-5). Low to high.	Comments
1	Systems which make access to inputs easy (seeds, fertiliser)	5	3	4	5	**17**	3	Mitigation co-benefit uncertain (i.e. fertiliser-dependent)
2	Introduction of new varieties (Check Malealea Report)	4	2	4	3	**13**	4	
3	Supply of Improved seeds(quantity, Quality, nutrition and location) available.	5	2	5	4	**16**	3	Mitigation co-benefit uncertain (i.e. fertiliser-dependent)
4	Provision and utilisation of climate Information services (weather, crop information etc)	5	5	4	4	**18**	4	
5	Financial services – eg credit, crop insurance, input insurance, etc	5	4	4	2	**15**	1	
6	Uptake of drought-tolerant & early maturing varieties on farm	5	4	3	4	**16**	5	
7	Implementation of Intergrated Pest and Disease Management	4	4	3	4	**15**	3	
8	Application of soil protection techniques to improve quality and health	4	2	3	3	**12**	5	Uncertainty / debate that benefits to soil quality, health and structure are slow (longer than one season).

Adaptation Options		Criterion 1: Effectiveness (range: 1 low effective, 5 highly effective)	Criterion 2: Costs (range: 1 high cost, 5 low cost)	Criterion 3: Feasibility (range: 1 hard to implement, 5 highly feasible)	Criterion 4: Speed of Result (range: 1 slow to see results, 5 Quick results)	Overall evaluation (score totals)	Mitigation Co-benefit? (1-5). Low to high.	Comments
9	Sustainable Fodder Production	5	4	5	5	**19**	4	
10	Utilisation of protected farming (shading, tunnels)	5	1	2	5	**13**	3	
11	Implementation of Agroforestry	4	4	3	2	**13**	5	
12	Mixed farming (Crops and Livestock)	5	5	5	4	**19**	4	
13	Implementation of drip irrigation	5	2	3	5	**15**	3	Flushing the clogs (due to salty water); desalination process costly
14	Implementation of Rainwater Harvesting	5	4	5	4	**18**	5	
15	Micro-irrigation, with shared infrastructure	4	1	3	4	**12**	4	
16	Improvements in post-harvest storage and management	5	3	5	5	**18**	4	
17	Systems which link farmers to higher value crops	4	4	5	4	**17**	4	
18	National Policy and Strategy providing guidance for sector	5	4	4	3	**16**	N/A	
19	Phytosanitary legal framework	5	4	5	3	**17**	N/A	
20	Early Warning and Information Systems linked to farmers	4	4	4	4	**16**	N/A	

Botswana Climate Smart Practice Prioritisation Scores

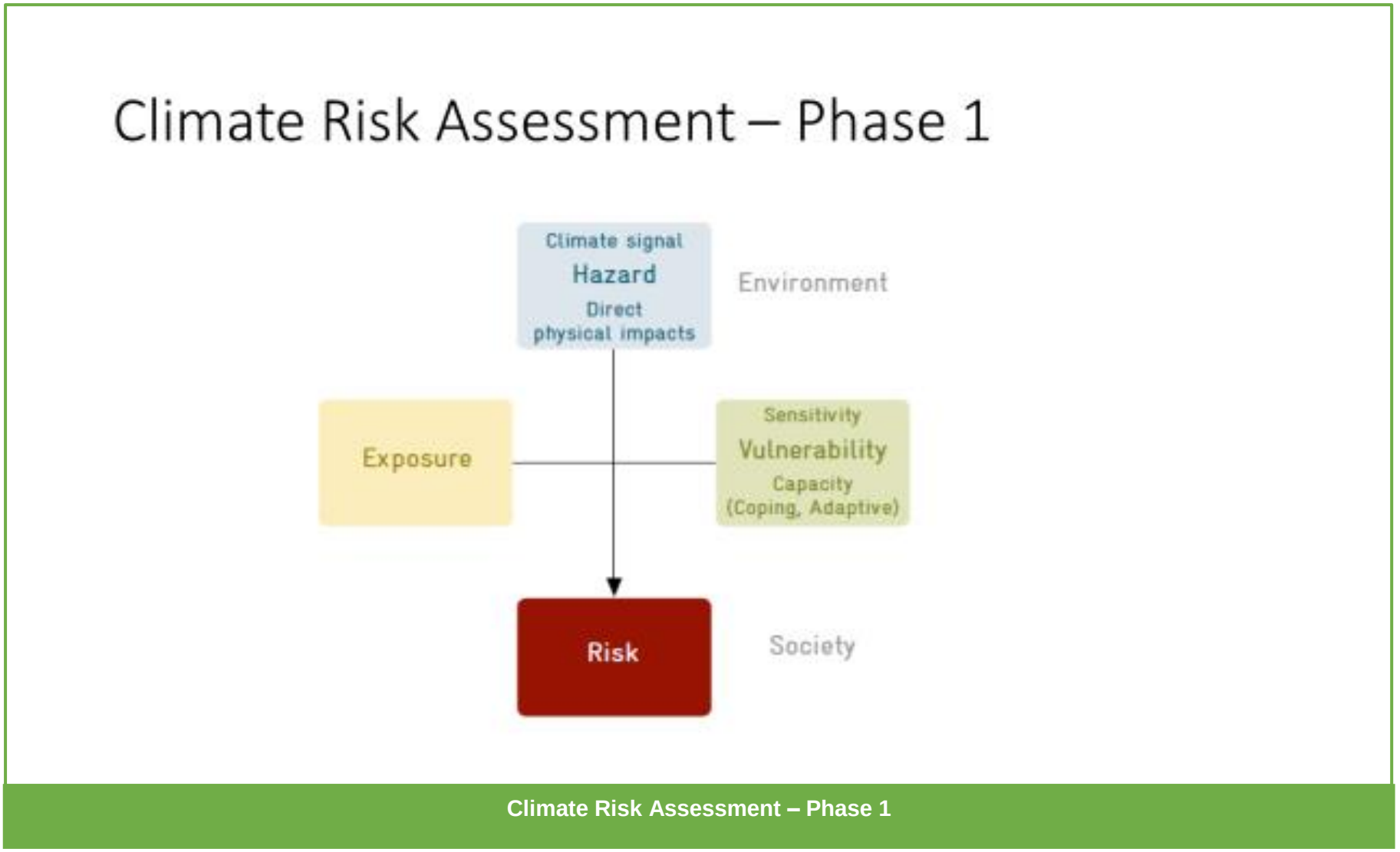
Adaptation Options		Criterion 1: Effectiveness (range: 1 low effective, 5 highly effective)	Criterion 2: Costs (range: 1 high cost, 5 low cost)	Criterion 3: Feasibility (range: 1 hard to implement, 5 highly feasible)	Criterion 4: Speed of Result (range: 1 slow to see results, 5 Quick results)	Overall evaluation (score totals)	Mitigation Co-benefit? (1-5). Low to high.	Comments
1	Systems which make access to inputs easy (seeds, fertiliser)	5	2	5	4	**16**	3	Mitigation co-benefit uncertain (i.e. fertiliser-dependent)
2	Supply (quantity and location) of improved seeds and breeds available.	5	4	5	4	**18**	3	Mitigation co-benefit uncertain (i.e. fertiliser-dependent)
3	Information services (weather, crop information etc)	5	5	5	2	**17**	4	
4	Financial services – eg credit, crop insurance, input insurance, etc	5	1	1	2	**9**	1	
5	Uptake of drought-tolerant & early maturing varieties on farm	5	4	3	3	**15**	5	
6	Use of local adaptive livestock breeds	5	5	5	5	**20**	5	
7	Application of soil protection techniques to improve quality and health (cover crops, crop residues)	4	2	3	3	**12**	4	Uncertainty / debate that benefits to soil quality, health and structure are slow (longer than one season).
8	Implementation of sustainable livestock grazing systems	5	2	3	1	**11**	4	
9	Sustainable Fodder Production	5	4	5	5	**19**	4	
10	Utilisation of protected farming (shading, tunnels)	5	1	4	4	**14**	5	

Adaptation Options		Criterion 1: Effectiveness (range: 1 low effective, 5 highly effective)	Criterion 2: Costs (range: 1 high cost, 5 low cost)	Criterion 3: Feasibility (range: 1 hard to implement, 5 highly feasible)	Criterion 4: Speed of Result (range: 1 slow to see results, 5 Quick results)	Overall evaluation (score totals)	Mitigation Co-benefit? (1-5). Low to high.	Comments
11	Implementation of Agroforestry	3	4	3	2	**12**	3	
12	Crop / livestock mixes	5	5	5	4	**19**	5	
13	Implementation of drip irrigation	3	2	3	4	**12**	4	Flushing the clogs (due to salty water); desalination process costly
14	Implementation of Rainwater Harvesting	5	4	5	4	**18**	4	Overlap with previous group, but different opinions on ratings
15	Using climate information for crop diversification	3	3	4	3	**13**	3	Key uncertainty: use vs. availability of weather info, role of education vs. uptake; assumptions of farmer behaviour presently.
16	Reduced / minimum tillage practices	4	5	2	1	**12**	4	
17	Micro-irrigation, with shared infrastructure	4	3	3	4	**14**	4	(Q: can it be highly effective?) B: in B, govt. setup laterals / water structure. Farmers subsequently apply localised irrigation.
18	Improvements in post-harvest storage and management	5	3	5	5	**18**	3	
19	Systems which link farmers to higher value crops	4	3	5	4	**16**	3	

Adaptation Options		Criterion 1: Effectiveness (range: 1 low effective, 5 highly effective)	Criterion 2: Costs (range: 1 high cost, 5 low cost)	Criterion 3: Feasibility (range: 1 hard to implement, 5 highly feasible)	Criterion 4: Speed of Result (range: 1 slow to see results, 5 Quick results)	Overall evaluation (score totals)	Mitigation Co-benefit? (1-5). Low to high.	Comments
20	Landscape-level land and water management approaches	5	1	2	3	**11**	2	
21	Rangelands rehabilitation and management	5	1	2	2	**10**	4	
22	National Policy and Strategy providing guidance for sector	5	4	5	4	**18**	4	
23	Legal and phytosanitary frameworks	5	4	5	4	**18**	4	
24	Early Warning and Information Systems linked to farmers	4	4	4	3	**15**	3	
25	Practices to control stocking rates of livestock	5	4	5	2	**16**	3	

Annex 4 CRA Workflow

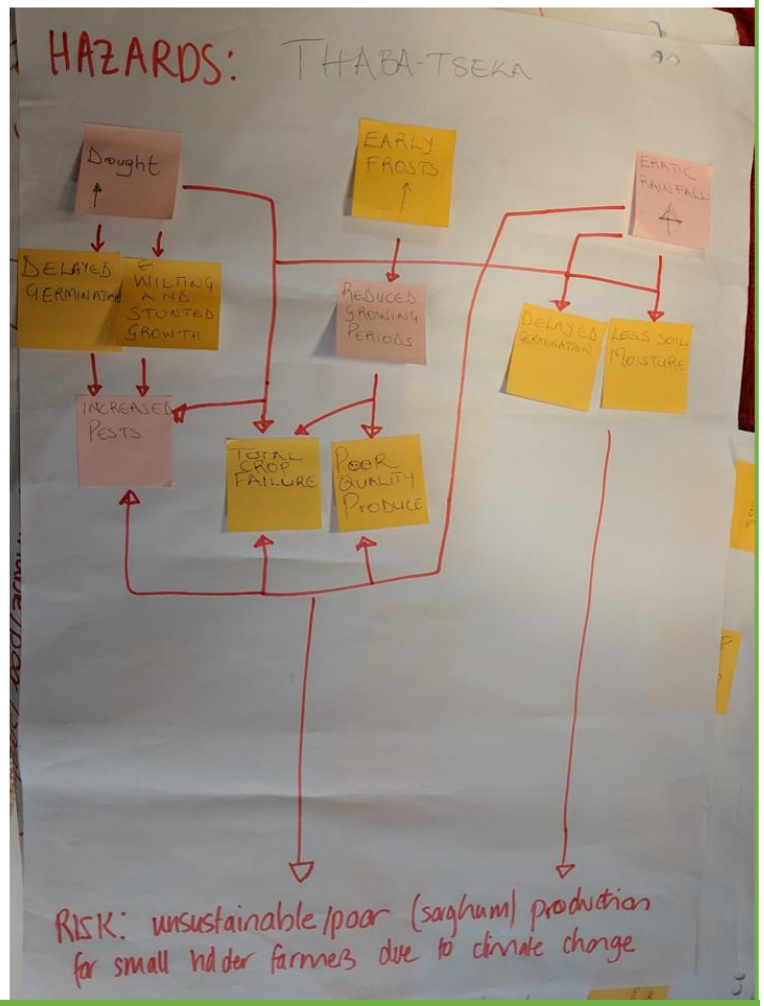
This document is a slide deck of the workflow in the CRA process, reproduced here for convenience.



Climate Risk Assessment – Phase 1

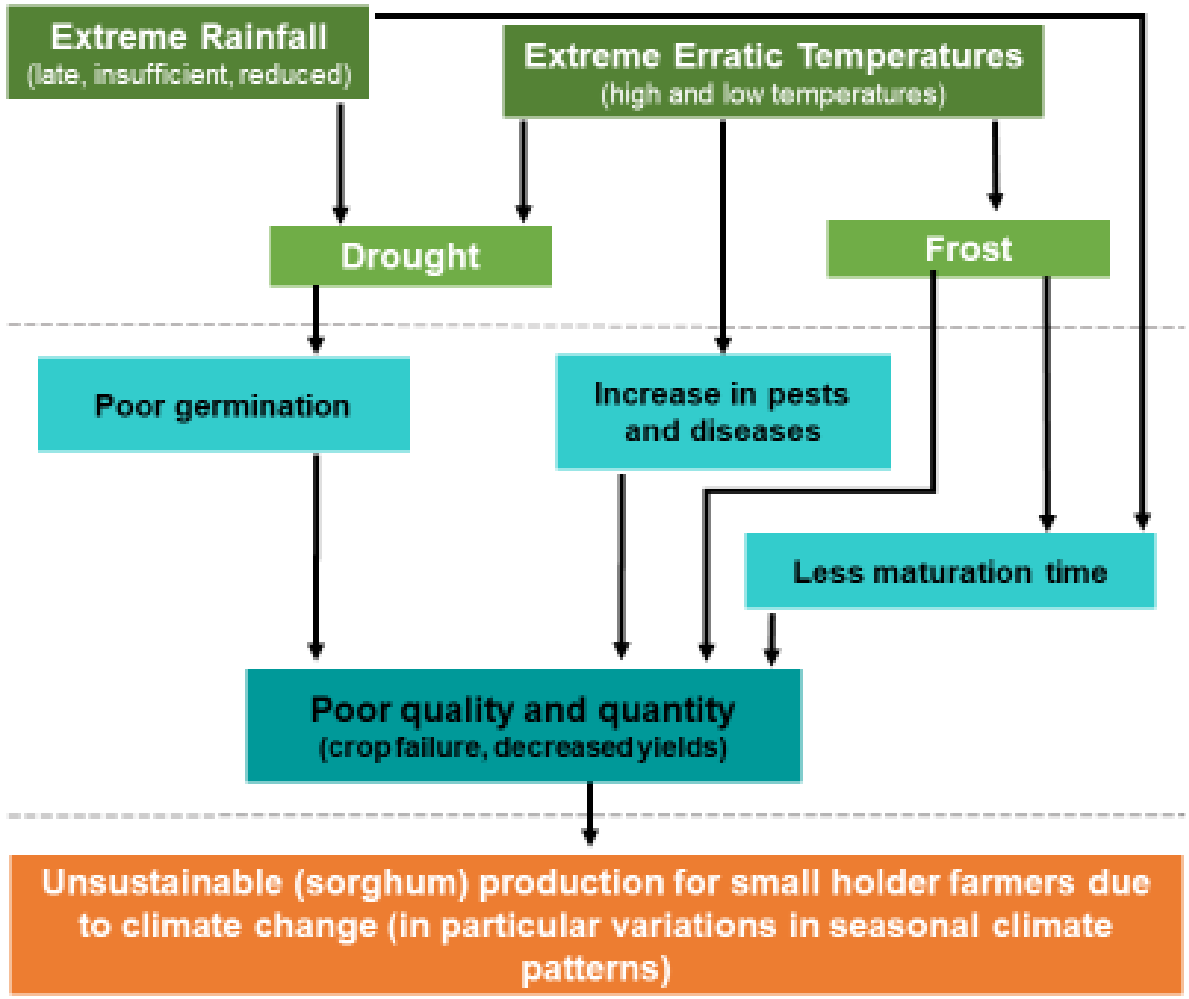
Hazard Impact Mapping

- Impact Chains developed by participants

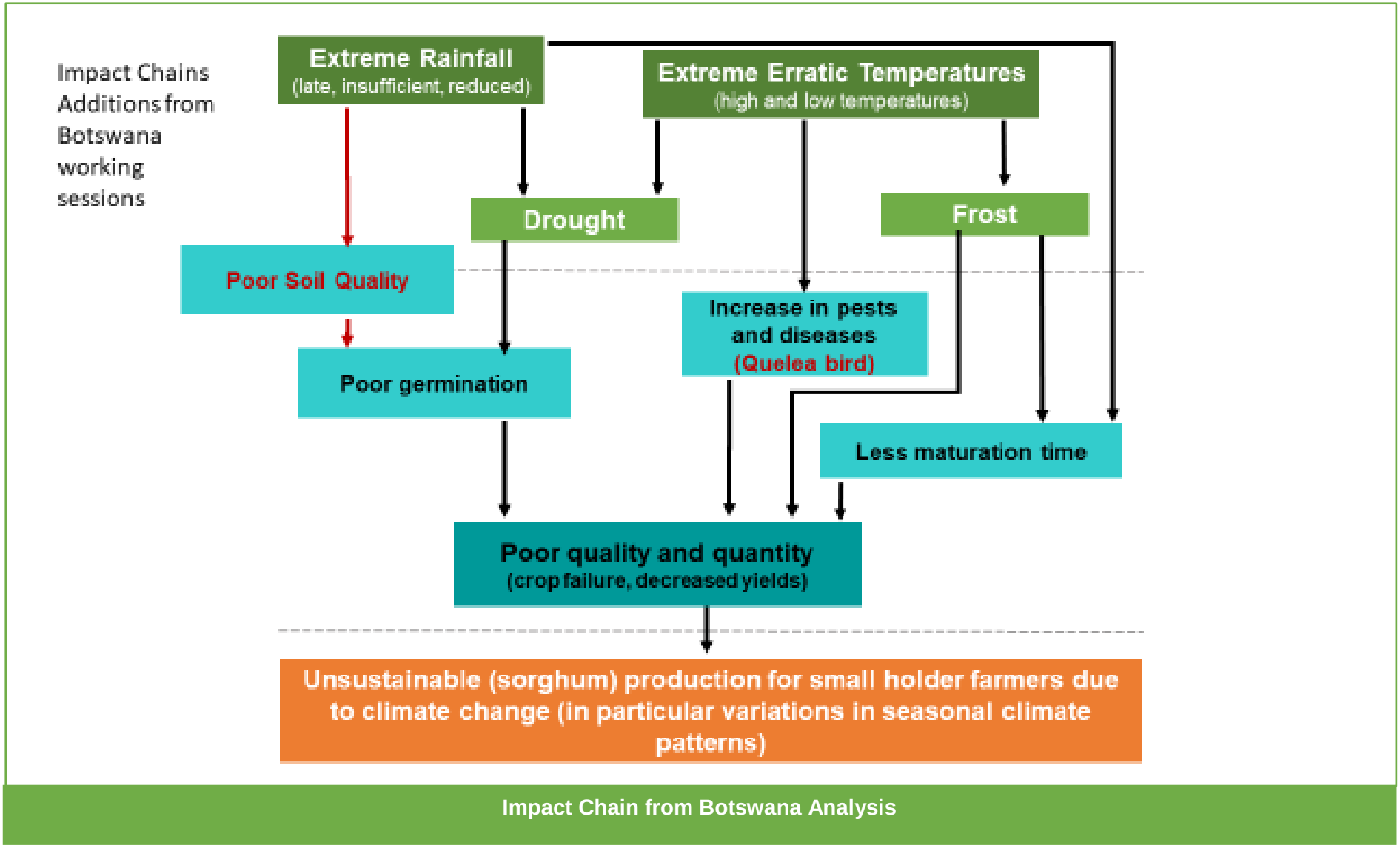


Hazard Impact Mapping: Impact Chains developed by workshop participants

Impact Chain from Lesotho Analysis

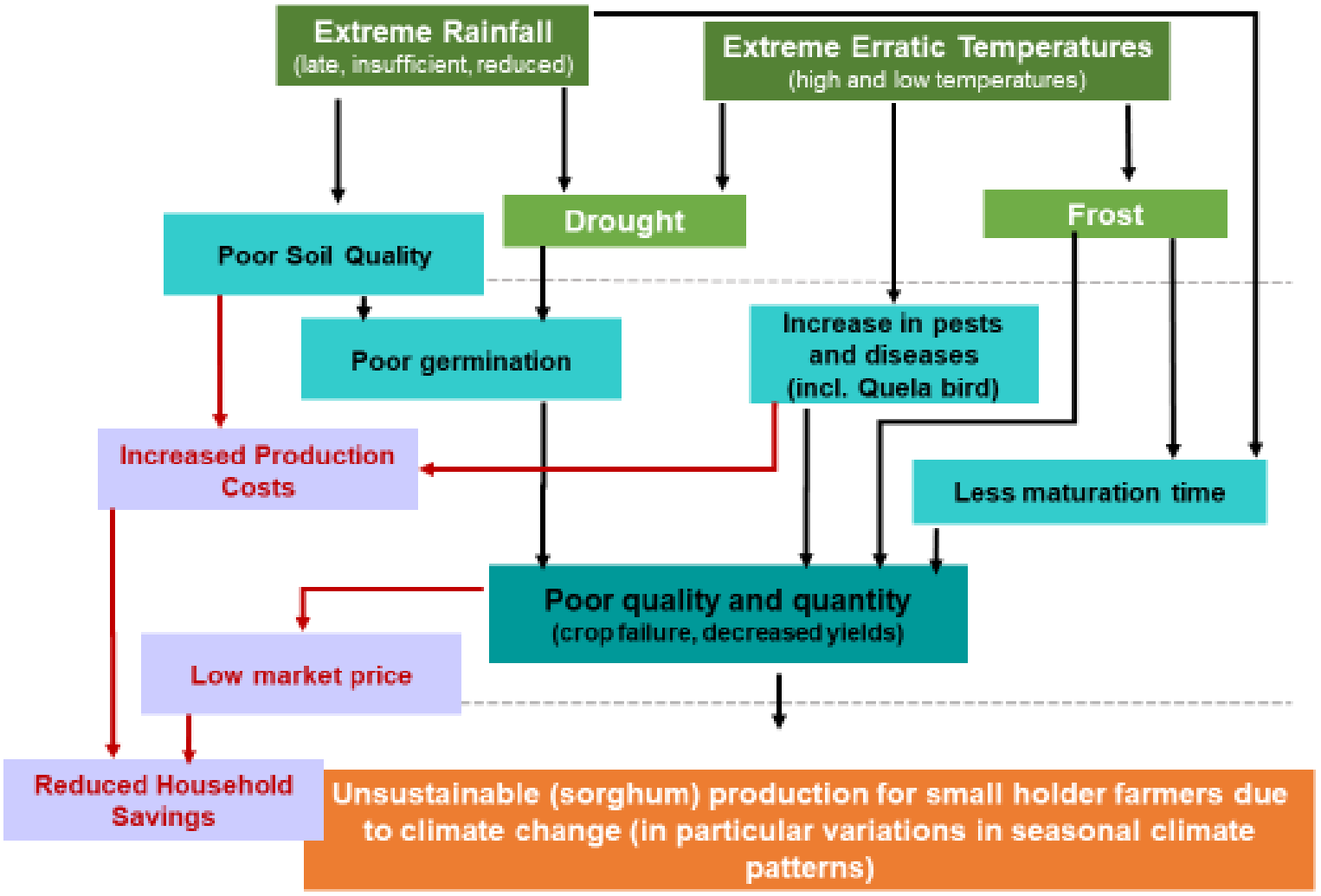


Impact Chain from Lesotho Analysis



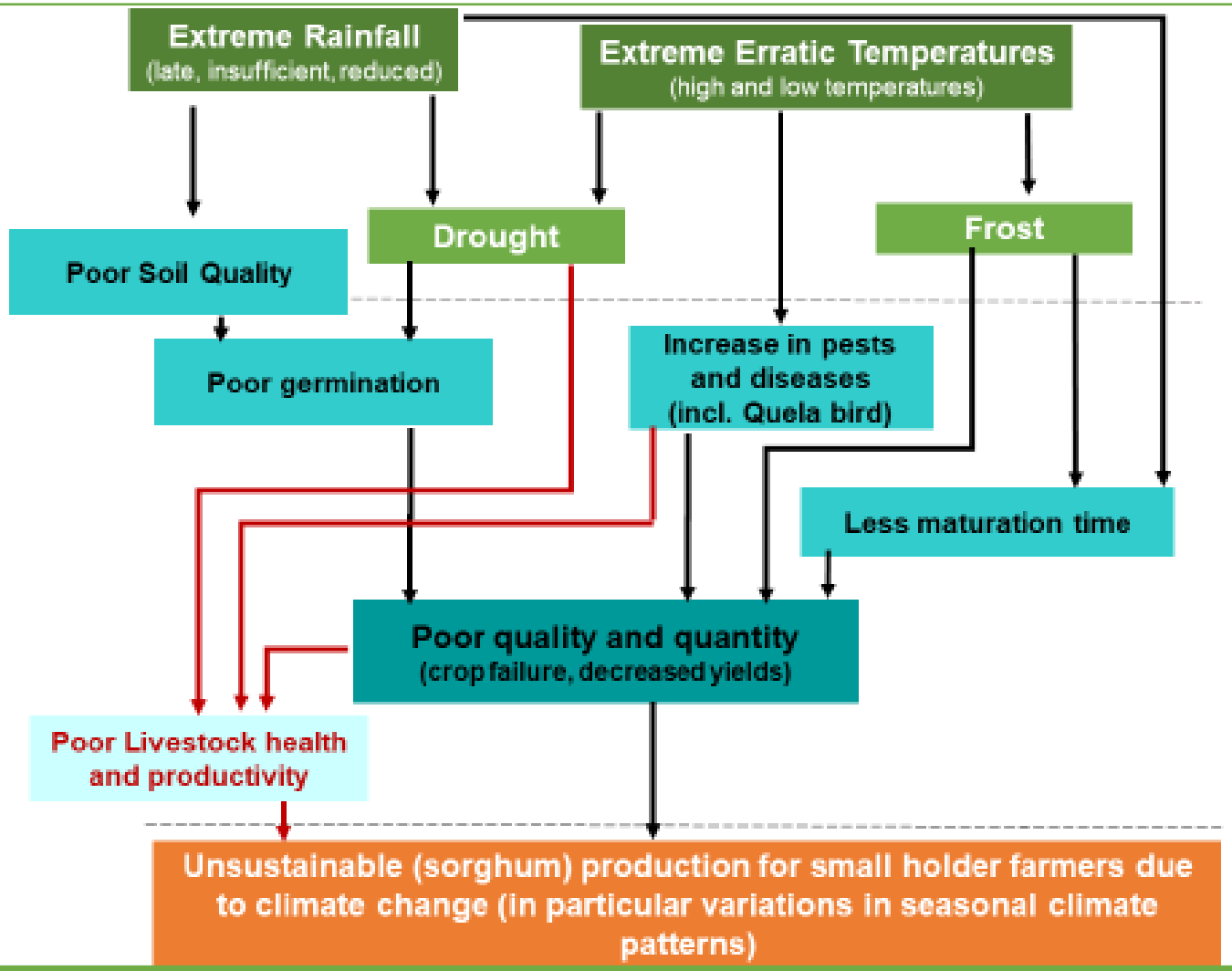
Impact Chain from Botswana Analysis

Social Impacts (identified in both working sessions) can be noted in the impact chain but these socio-economic factors are not incorporated according to the methodology (GIZ 2017)



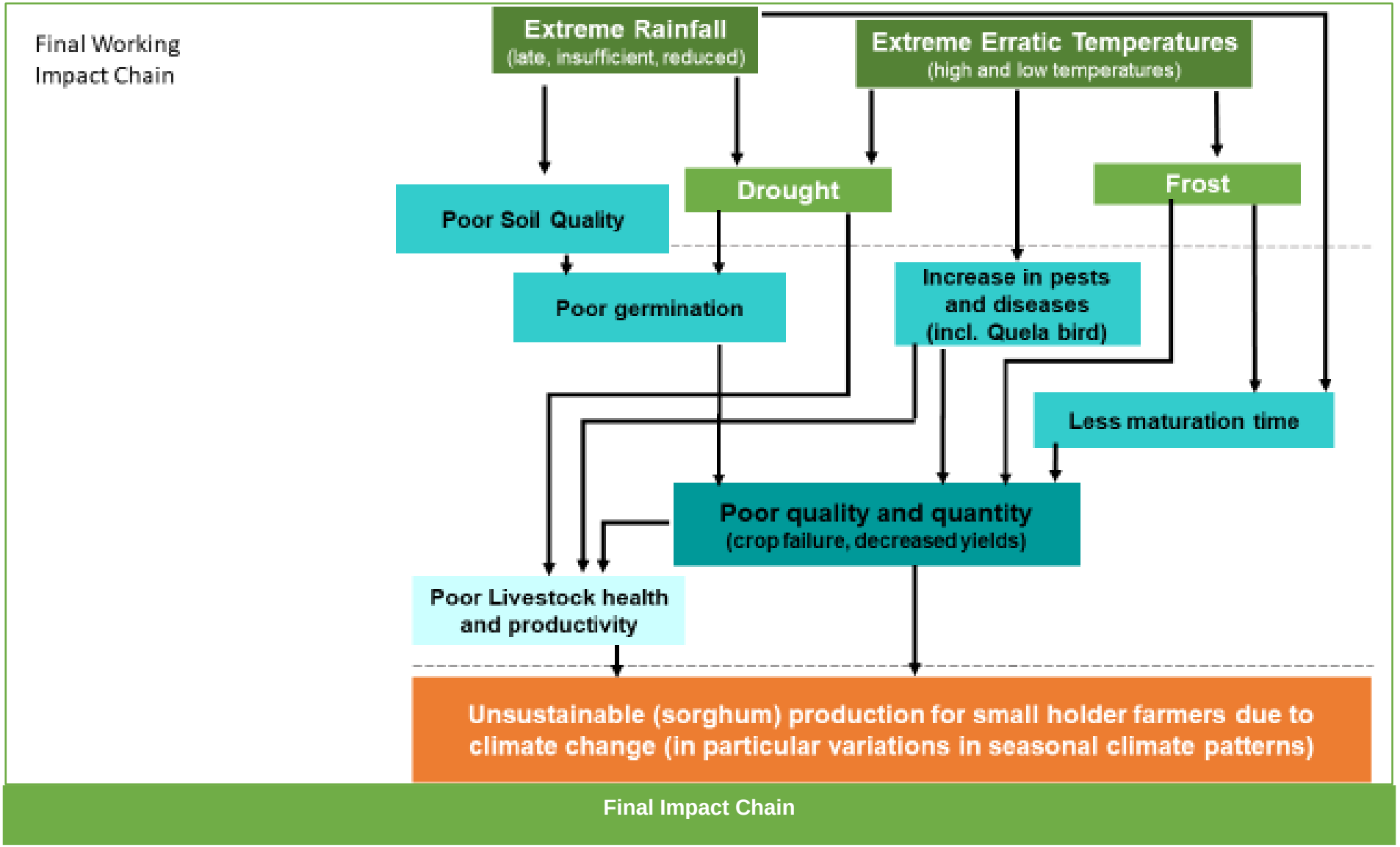
Social Impacts noted in the impact chain

An additional livestock chain can also be reflected. (this was particularly captured in Botswana working session)



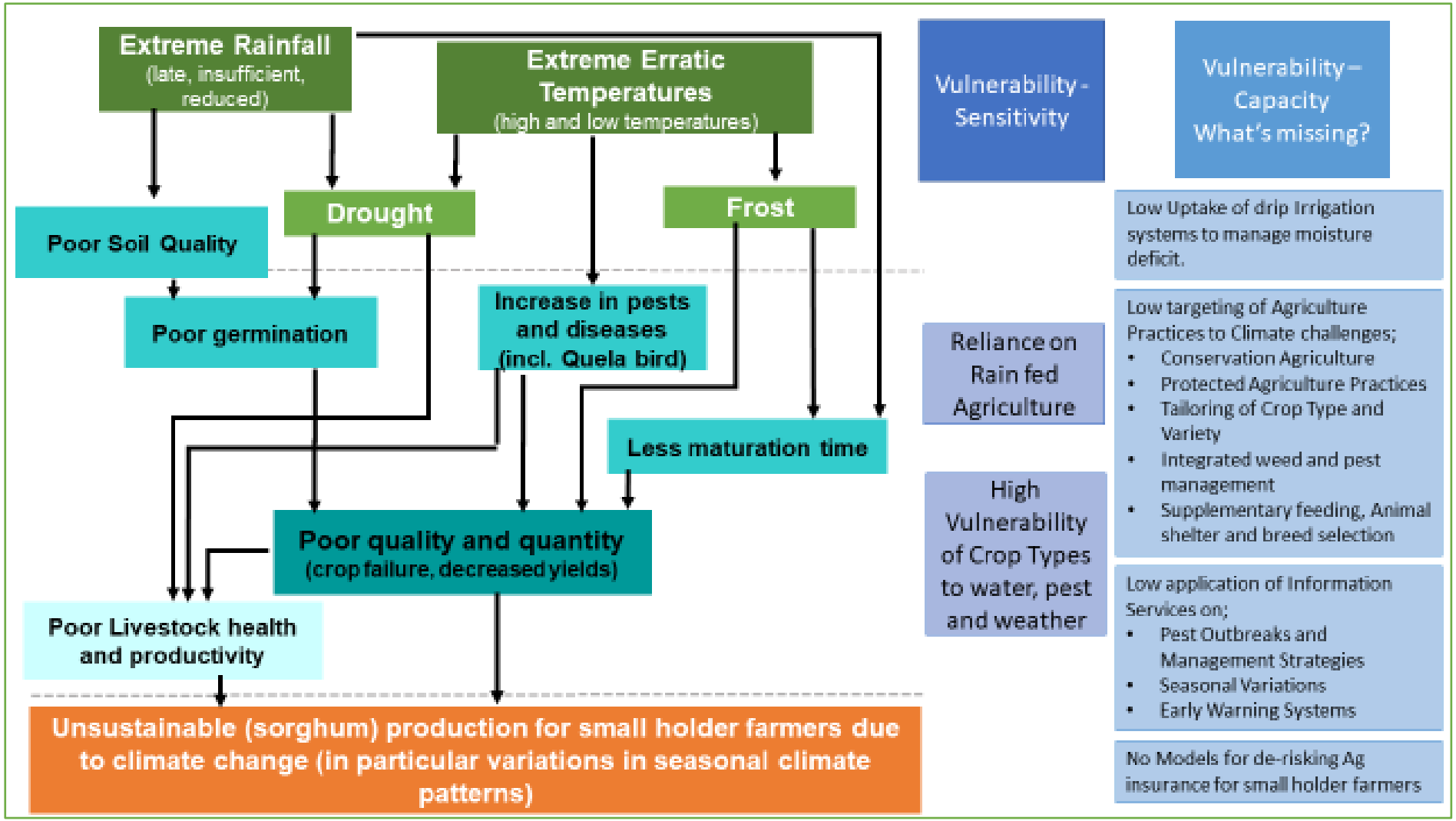
Livestock value chain – Botswana National Workshop

Final Working
Impact Chain



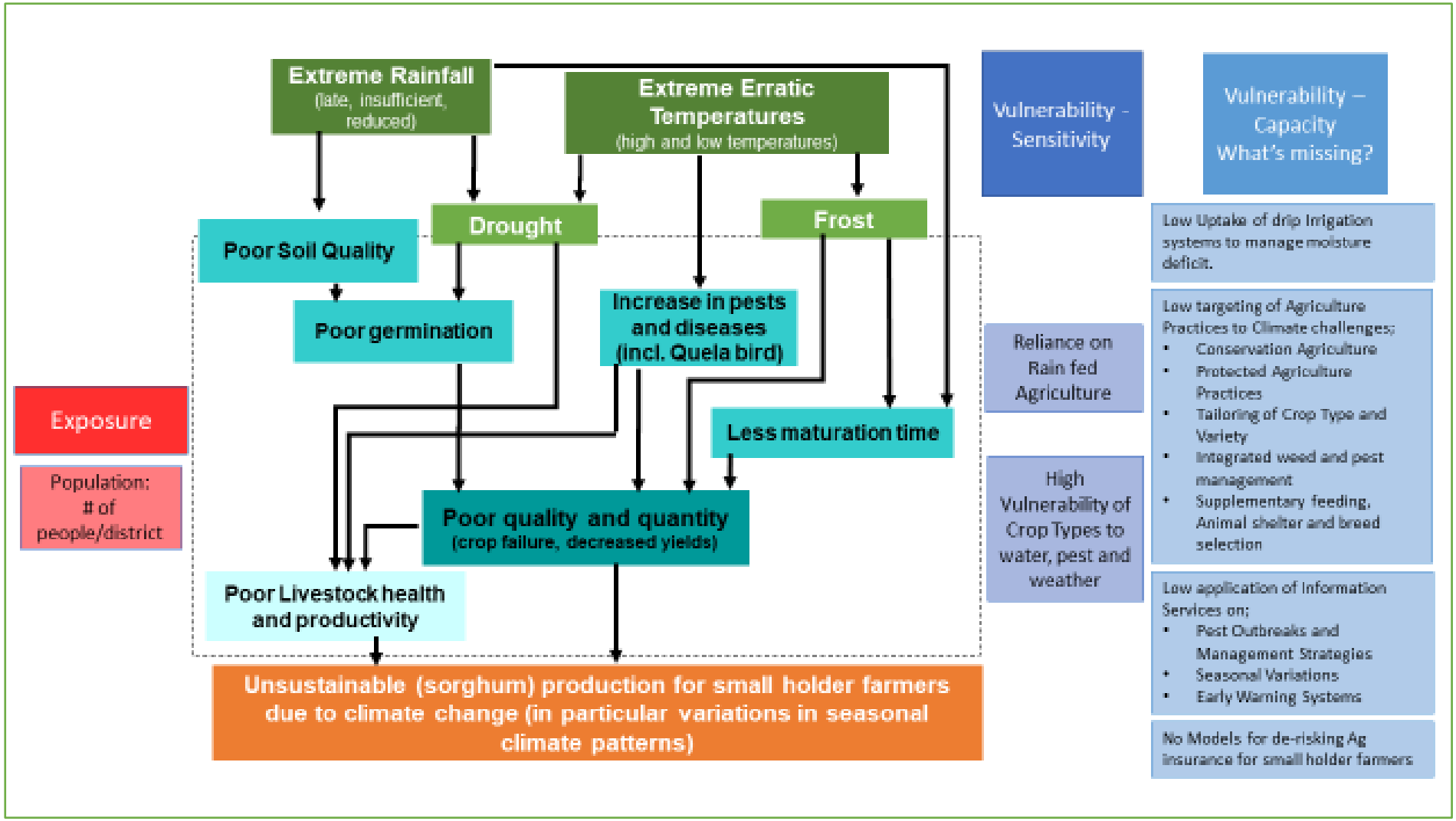
Adding Vulnerability Factors

- What makes the system Vulnerable to these impacts?
- What is missing that would allow farmers to better respond to these impacts?

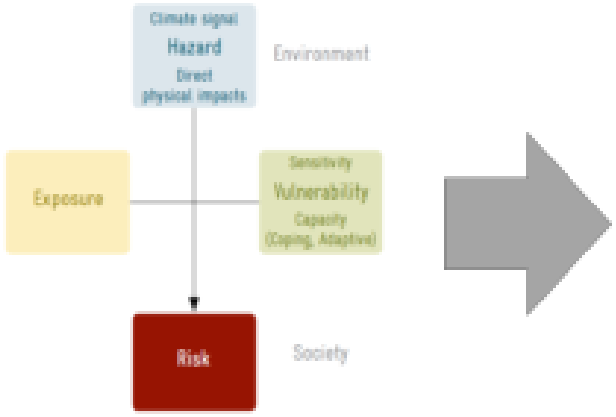

Extreme Rainfall
(late, insufficient, reduced)
Extreme Erratic Temperatures
(high and low temperatures)
Drought
Frost
Poor Soil Quality
Poor germination
Increase in pests and diseases (incl. Quela bird)
Less maturation time
Poor quality and quantity
(crop failure, decreased yields)
Poor Livestock health and productivity
Unsustainable (sorghum) production for small holder farmers due to climate change (in particular variations in seasonal climate patterns)
Vulnerability - Sensitivity
Reliance on Rain fed Agriculture
High Vulnerability of Crop Types to water, pest and weather
Vulnerability – Capacity What's missing?
Low Uptake of drip Irrigation systems to manage moisture deficit.
Low targeting of Agriculture Practices to Climate challenges;
• Conservation Agriculture
• Protected Agriculture Practices
• Tailoring of Crop Type and Variety
• Integrated weed and pest management
• Supplementary feeding, Animal shelter and breed selection
Low application of Information Services on;
• Pest Outbreaks and Management Strategies
• Seasonal Variations
• Early Warning Systems
No Models for de-risking Ag insurance for small holder farmers

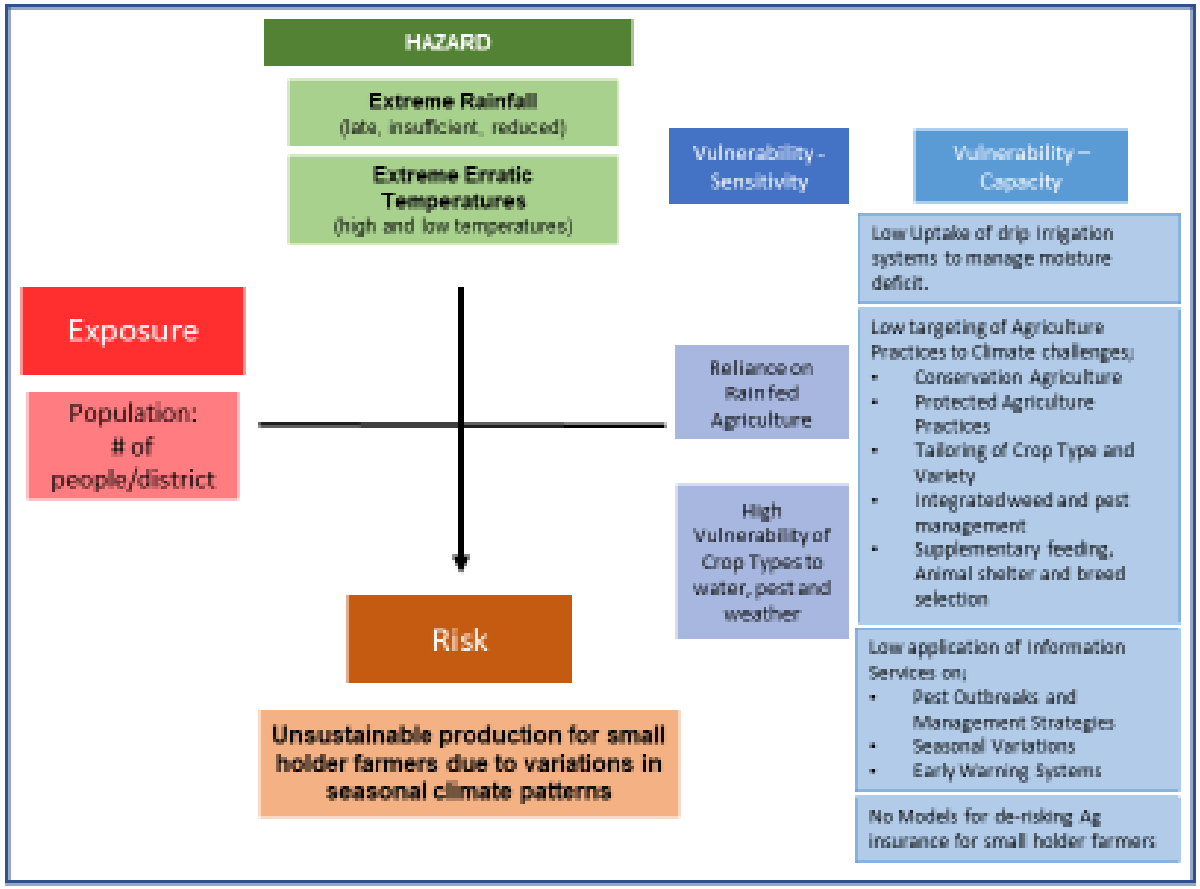
Adding Exposure Factor

- Who is Vulnerable to this impact?


Extreme Rainfall
(late, insufficient, reduced)
Extreme Erratic Temperatures
(high and low temperatures)
Drought
Frost
Poor Soil Quality
Poor germination
Increase in pests and diseases (incl. Quela bird)
Less maturation time
Poor quality and quantity
(crop failure, decreased yields)
Poor Livestock health and productivity
Unsustainable (sorghum) production for small holder farmers due to climate change (in particular variations in seasonal climate patterns)
Exposure
Population: # of people/district
Vulnerability - Sensitivity
Reliance on Rain fed Agriculture
High Vulnerability of Crop Types to water, pest and weather
Vulnerability – Capacity What's missing?
Low Uptake of drip Irrigation systems to manage moisture deficit.
Low targeting of Agriculture Practices to Climate challenges;
• Conservation Agriculture
• Protected Agriculture Practices
• Tailoring of Crop Type and Variety
• Integrated weed and pest management
• Supplementary feeding, Animal shelter and breed selection
Low application of Information Services on;
• Pest Outbreaks and Management Strategies
• Seasonal Variations
• Early Warning Systems
No Models for de-risking Ag insurance for small holder farmers

Project Climate Risk Framework





Project Climate Risk Framework

Using Project Climate Risk Framework

- What adaptation measures (Climate Smart Practices) are needed to respond to the Climate Risk Framework Analysis.

Adaptation (Climate Smart Practices) identified from Project Climate Risk Framework

Vulnerability - Sensitivity	Vulnerability – Capacity What's missing?	Practices (Adaptations)
Reliance on Rain fed Agriculture	Low Uptake of drip Irrigation systems to manage moisture deficit.	Increased/Improved water supply services Small scale, on farm, irrigation systems
	Low targeting of Agriculture Practices to Climate challenges; • Conservation Agriculture • Protected Agriculture Practices • Tailoring of Crop Type and Variety • Integrated weed and pest management • Supplementary feeding, Animal shelter and breed selection	Climate Responsive Agriculture (Crop rotation, minimum tillage, protected agriculture, highly tailored crop types, targeted animal health and feeding)
High Vulnerability of Crop Types to water, pest and weather	Low application of Information Services on; • Pest Outbreaks and Management Strategies • Seasonal Variations • Early Warning Systems	Better systems for accessing information services on (Pest, Seasonality, Early Warning)
	No Models for de-risking Ag insurance for small holder farmers	Identification of models to de-risk Ag insurance for small holder farmers
		Strengthen the financial reserves of households

Adaptation (CSA practices) identified from Project climate Risk Framework


INPUTS
Ease of access to inputs (seeds, fertiliser)
Improved seeds and breeds available
Information services (weather, crop information etc)
Financial services – eg credit, crop insurance, input insurance, etc
Farm services – eg Ox-drawn / mechanised ripping
Labour available and affordable
Access to plant and livestock germplasm
Access to land
FARMING PRACTICES
SHORT TERM
Field preparation
Use of drought-tolerant & early maturing varieties
Use of local adaptive livestock breeds
Precision use of inputs
Crop rotation
Soil protection – cover crops, crop residues
Sustainable livestock grazing systems
Nomadic livestock systems
Fodder Production
Feed Mixing
Protected Farming (shading, tunnels)
MEDIUM TERM
Improve soil quality & health
Agroforestry
Crop / livestock mixes
Farming system change
Drip irrigation,
Rainwater Harvesting
Plant Health
LONG TERM
Crop diversification
Reduced / minimum tillage
Homestead gardens
Micro-irrigation, with shared infrastructure
Molapo Farming (Botswana)
Organic Farming
On-farm conservation of germplasm
OUTPUTS
Post-harvest storage and management
Information on markets and prices
Links to wholesalers / food processors
Links to higher value crops
Value addition/ processing
NATURAL RESOURCE MANAGEMENT
Landscape-level water
Control stocking rates of livestock
Landscape-level land management (erosion
Rangelands rehabilitation and management
ENABLING ENVIRONMENT
National Policy and Strategy
Legal and phytosanitary frameworks
Group organisation and Umbrella Groups
Subsidy policy
Transport/Road Access
Gene Bank – seed and breed
Better systems for accessing information services relating to: Pest, Seasonality, Early Warning
Animal health and fodder production interventions