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# Access to markets for small actors in the roots and tubers sector

Tailored financial services and climate risk  
management tools to link small farmers to markets





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## Preface

The roots and tubers (R&T) sector is one of the most important food subsectors across all of the African, Caribbean and Pacific Group of States (ACP) where, under the aegis of the ACP Agricultural Commodities programme (2008–2011), its commercialization as a strategy for poverty reduction was demonstrated by reinforcing linkages between smallholders and semi-formal and formal markets.

In many parts of sub-Saharan Africa (Africa), where R&T is a major source of sustenance, accounting for 20 percent of calories consumed in the region, crops such as cassava, yam and potatoes are not only important for food security but also increasingly for income – particularly for women.

The main driver of growth for crops such as cassava, yam and potatoes in Africa is increasing national and regional urbanization. According to the World Bank’s report on the potential of agribusiness in Africa (World Bank, 2013), urban food markets are set to quadruple over the next two decades, meaning that domestic and regional markets will offer significant opportunities for African producers.

Against this background, by collaborating with the European Union and the ACP, FAO is supporting the cassava and potato value chains in seven African countries – Benin, Cameroon, Côte d’Ivoire, Ghana, Malawi, Rwanda and Uganda – under the “African Roots and Tubers project”. To implement this project, FAO has followed a comprehensive approach aiming to increase production and improve quality.

From 2015, the project has built the capacity of smallholder farmers, processors and traders to meet increasing market demand and developed inclusive business models that strengthen value chain links and increase access to markets.

However, despite positive results in market linkages and in sustainable production intensification for R&T produced and commercialized by small actors, the project realized that building capacity and facilitating relationships might not be enough to enable farmers to move beyond subsistence farming. It recognized the need to unlock access to credit, savings and insurance, as well as customized climate risk management tools to cope with climate variability affecting R&T production and prices.

To address these issues, the project explored the financial needs and climate risks for cassava and potato value chains actors affecting the above-mentioned African countries at national and district levels. These needs assessments served to develop ad hoc activities according to the specific needs of each country. Interventions included business-to-business meetings, technical training sessions with agricultural and financial and information service providers, government officials, insurance companies, farmers’ representatives and small and medium enterprises engaged in R&T.

This publication was developed to summarize the findings, lessons learned and recommendations to improve access to finance and climate risk management for actors engaged in the R&T value chain following the experience of the African Roots and Tubers project.

The present study has also served as a reference to develop two policy briefs targeting the main areas of work included in this document (climate risk management and finance in agriculture).

This study has been made possible thanks to the development of a qualitative and quantitative exercise at country level, which has been nurtured and promoted through in-country capacity development activities, joint analytical work, as well as results dissemination and peer-review events. Long-standing country-level partnerships with government, research institutions and other stakeholders are recognized as an essential component of this technical study.



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# Acronyms

<b>ACP</b>	African, Caribbean and Pacific Group of States
<b>ART</b>	African Roots and Tubers project
<b>BRAC</b>	Bangladesh Rural Advancement Committee
<b>CAADP</b>	The Comprehensive Africa Agriculture Development Programme
<b>CCA</b>	Climate change adaptation
<b>CCKP</b>	The World Bank's Climate Change Knowledge Portal
<b>CRM</b>	Climate risk management
<b>CRMS</b>	Climate risk management strategies
<b>DRRM</b>	Disaster risk reduction management
<b>ESA</b>	Agricultural Development Economics Division (FAO)
<b>FAFCI</b>	Women's Support Fund of Côte d'Ivoire
<b>FAO</b>	Food and Agriculture Organization of the United Nations
<b>FI</b>	Financial institution
<b>FFS</b>	Farmer Field Schools
<b>GMET</b>	Ghana Meteorological Agency
<b>ID</b>	Identity documents
<b>MOA</b>	Ministry of Agriculture
<b>MSMEs</b>	Micro, small- and medium-scale enterprises
<b>NMA</b>	National meteorological agency
<b>PCC</b>	Potato collection centres
<b>R&amp;T</b>	Roots and tubers
<b>SMEs</b>	Small and medium enterprises
<b>UB</b>	Unguka Bank
<b>USD</b>	United States Dollar
<b>WFP</b>	World Food Programme
<b>WMO</b>	World Meteorological Organization

## Executive summary

The present study aims to provide a summary of the most important lessons learned on how to facilitate access to financial services and climate risk management tools, for small actors in the cassava and potato value chains in Africa. The findings of the study are the result of a series of analyses, diagnostics and evaluations conducted between 2017 and 2018 under the project “Strengthening linkages between small actors and buyers in the roots and tubers sector in Africa”. This project – more commonly known as the African Roots and Tubers (ART) Project – is funded by the European Union through the African Caribbean and Pacific Group of States and was implemented by FAO between 2015 and 2019.

The objective of the project was to improve the livelihoods of small value chain actors (mainly producers and processors) engaged in the roots and tubers (R&T) value chains in selected African countries: Benin, Cameroon, Côte d’Ivoire, Ghana, Malawi, Rwanda and Uganda. This objective was meant to be achieved through increased commercialization of the potato, cassava and yam value chains, by establishing and strengthening linkages with domestic and regional buyers. The project was designed with a multi-disciplinary approach, to work simultaneously on different technical areas which affected the performance of the actors in these value chains. Two of the main areas of project support related to the facilitation of access to information services, finance and climatic risk management instruments, for small producers and processors in the cassava and potato value chains.

The R&T industry in sub-Saharan Africa has been growing steadily in recent years, in terms of overall production and trade. Nevertheless, to date a series of challenges has prevented the majority of actors in these value chains from taking advantage of such growth. One of these challenges relates to the scarce provision of, and access to, investment and working capital for producers and processors. Strictly related to this challenge is the exposure of R&T crops to climate variability on both an inter-annual and intra-seasonal scale, which may reduce productivity and production.

In order to properly assess these challenges, the ART project conducted a series of assessments and analyses which focused on: (i) the demand and supply of financial services within specific R&T value chains, in order to identify relevant gaps, constraints and opportunities; and (ii) climate impacts on R&T, to identify to what extent climate variables cause inter-annual production variability. Building on the findings of these studies, the project has been providing technical assistance to producers and processors on one side, and different services providers, including financial institutions – to reduce the existing information gaps, improve the value of the financial services and risk management tools provided, and increase the access to such services.

This technical study presents the main lessons learned from the assessment and analyses, building on specific examples and cases related to both the cassava and potato industries, and provides recommendations for policy-makers.



# 1 Introduction

The present technical study aims to provide a summary of the most important lessons learned on how to facilitate access to financial services and climate risk management tools, for small actors in the cassava and the potato value chains in Africa. The findings of the study are the result of a series of analyses, diagnostics and evaluations conducted between 2017 and 2018 under the project “Strengthening linkages between small actors and buyers in the roots and tubers sector in Africa”. This project – more commonly known as the African Roots and Tubers (ART) project – is funded by the European Union through the African Caribbean and Pacific Group of States (ACP) and was implemented by FAO between 2015 and 2019.

The roots and tubers (R&T) industry in sub-Saharan Africa has been growing steadily in recent years, in terms of overall production and trade. Nevertheless, to date a series of challenges has prevented the majority of actors in these value chains from taking advantage of such growth. One of these challenges relates to the scarce provision of, and access to, investment and working capital for producers and processors. Strictly related to this challenge is the exposure of R&T crops to climate variability on both an inter-annual and intra-seasonal scale, which may reduce productivity and production.

The first chapter of the document focuses on the challenges that R&T value chain actors face in accessing financial services, and possible ways to facilitate the provision of and access to these services. R&T value chains in the region are loose, fragmented and informal. Smallholders (both producers and processors) have a relatively weak collective bargaining power, while the margins on the added value are often not paid. Access to information on good agricultural practices and improved varieties, as well as on suitable financing solutions, is not yet widespread. These factors point to untapped investment potential for all value chain actors, from smallholder farmers to processors, to wholesale buyers and exporters. The actors in these value chains tend to rely mainly on informal financial service providers to compensate for the absence of commercial banks and other formal financial institutions (FIs).

In addition to the traditional challenges faced by FIs in extending financing to agriculture (lack of collateral, high costs, high risk exposure), and the fragmentation of staple food value chains like cassava and potato, there is a deep lack of knowledge about this specific agricultural sector on the part of FIs, which prevents them from identifying potential business opportunities.

The ART project has identified specific good practices that can dramatically facilitate the provision of profitable and sustainable financial services for the small producers and processors of the R&T value chains. Among them, the most effective ones have appeared to be the establishment of regular dialogue and information exchange between value chain actors and FIs, along with specific technical assistance for FIs and financial literacy training for farmers. The study therefore recommends: favouring capacity-building of formal FIs instead of subsidizing their operation costs; creating tailored State funds for R&T financing, complementing the offer of financial services for R&T value chain actors by formal FIs;<sup>1</sup> facilitating the use of alternative forms of guarantees and developing a financial regulatory framework that has provisions to accept unconventional forms of guarantees such as sale contracts, movable assets, livestock, and agricultural inventories. In order to properly

<sup>1</sup> The term “formal” financial institution indicates an organization that has been legally authorized and regulated by a State to provide financial services to the masses. This includes banks, microfinance institutions and credit unions, among others.

support farmers and processors to become reliable clients for FIs, the study also recommends strengthening the structure and organization levels of R&T actors' groups and cooperatives to ensure the sustainability and recognition of these entities; and most of all, fostering regular interactions between value chain representative groups and formal FIs in order to exchange information on the respective business models and ensure better mutual understanding of constraints to making investments, managing risks and influencing the design of tailored financial products. Over time, such meetings can be upgraded to stable fora and innovation platforms (physical and digital) for information exchange.

The second chapter focuses on the impact of climate variability on R&T products, and the climate risk management strategies and instruments that can help mitigate such risks and reduce their effects. R&T crops, such as cassava, are increasingly been studied for their higher tolerance to poor soils and drought against other crops in Africa. However, R&T production is still not immune to the negative effects of climate variability and change, as well as natural hazard-induced disasters. By analysing the impact of climate variability on R&T production, particularly cassava, in selected African countries, the present technical study aims to study possible climate risk management (CRM) strategies which could alleviate the scale of climate-related losses on the livelihoods of these smallholder farmers. Designing new or strengthening existing CRM measures for these sectors – whose crops in some cases are more resilient than other crops of other sectors – could have positive catalytic effects in the efforts to fight food security in vulnerable African countries.

The elaboration of climatic data in these African countries showed that temperatures increased from 0.5 to 0.8 °C between 1991 and 2015. Different models indicate that warming is already slowing yield gains in a majority of wheat-growing countries, including in Africa. By contrast, root-crop yields, such as cassava, are in some cases positively correlated with increasing temperatures affecting several African countries. In many districts of Benin and Ghana, the study found that from the last two seasons onwards, cassava yields per hectare improved dramatically. Although this increase is taking place along with Government policies supporting this sector, these data represent some important findings in term so f developing food security and livelihoods strategies – such as promoting alternative crops – to adapt to climate variability and change, natural hazard-induced disasters, unpredictable rains, erosion, and an increase in livestock and crop disease in vulnerable countries.

Small R&T producers in these agro-ecological zones are still not exempt from risks of severe climate-related production losses. In some countries, cassava yields were found to be negatively correlated with temperatures, meaning that increasing temperatures would considerably decrease cassava yields (-40 percent). In these areas, small actors engaged in R&T sectors need to take prompt actions to reduce the impact of climate variability on their production.

In this respect, the study provides a series of recommendations for policy-makers, which include: integrating CRM into agricultural development policies and planning to anticipate, prevent or more effectively manage production crises; developing an inclusive strategy for climate services which combines investments to improve climate information systems at central and local levels; building the capacity of agricultural units at all levels on climate modeling, risk assessment and management tools; encouraging the role of the private sector in CRM; and organizing regular spaces of dialogue between key R&T value chain leaders, national meteorological agencies (NMAs), formal and informal FIs, and insurers to develop insurance schemes tailored to the specific needs of small farmers and processors of the R&T value chains.

## 2 Provision of and access to financial services for small farmers and processors in the roots and tubers value chains

### KEY MESSAGES

- ◆ The increased growth of the economic value of the roots and tubers products in the past twenty years show that there are great opportunities to invest in the sector, especially for smallholders, who represent the majority of these value chains in Africa, and who may access larger markets.
- ◆ However, there is an untapped investment potential for all value chain actors, due to the loose, fragmented and informal structure of these value chains, whose actors (both producers and processors) have relatively weak collective bargaining power, while the margins on the added value are often not paid
- ◆ Information exchange, financial literacy, and business advisory services are key to increase access to financial services in the sector.

### 2.1 Increasing opportunities and limited investments in African agribusiness: the regional context of a sub-optimal scenario

The agriculture and agribusiness sector in sub-Saharan Africa has been undergoing significant transformations over the past few years, and even more important changes are expected to occur in the next decades. The transformation of food value chains has mainly been driven by population growth (the region's population is expected to rise fourfold, up to 4 billion people, by 2050) and the dramatic expansion of urban areas (projected to double by 2030) (The World Bank, 2013).

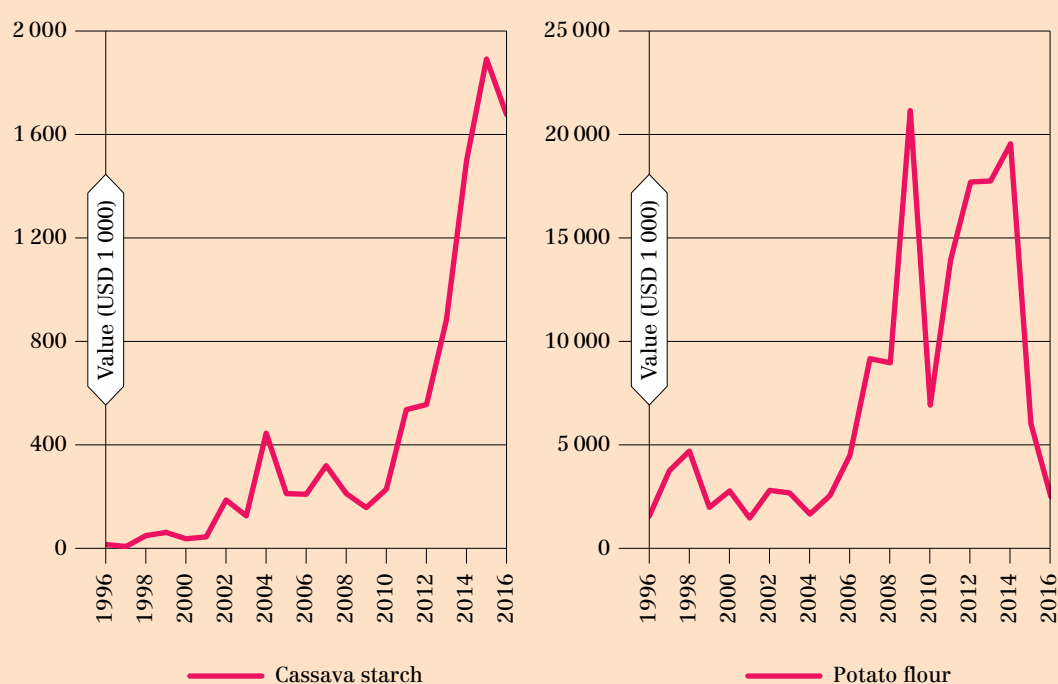
These factors – combined with a per capita increase of 4 percent per year – have translated into an increased demand for food and has opened up considerable opportunities for agribusinesses to serve a larger number and variety of markets with a greater range of food products. For instance, the demand for meat and cereals has increased by 50 percent over the past 15 to 20 years, and it is expected to continue growing alongside the urbanization process (The World Bank, 2013). This shift clearly implies a scenario of new business opportunities in farming and processing. Agribusinesses, and especially micro, small- and medium-scale enterprises (MSMEs), which represent the largest share of the industry on the continent, need to adapt to these structural changes. In order for this to happen, there is a need for short-, medium- and long-term investments in the MSME sector.

However, the growth of the African agribusiness industry and the related business opportunities are not reflected in increased investments on the part of formal FIs, especially regarding the provision of financial services to MSMEs, which is in general very limited. It is estimated that less than 2 percent of the demand for global financing by smallholder farmers is met by formal FIs (Dalberg, 2012). This situation appears to indicate a sub-optimal scenario in which profitable business opportunities exist, but the FIs are not able to assess them and exploit them through adequate provision of appropriate financial services.

## 2.2 Focus on the roots and tubers value chains: global trends

For what specifically concerns the R&T industry, according to recent data there has been an evident increase in demand for these kinds of products, on a global scale. Figure 1 below shows the growth in export value for cassava and potato in Africa (used as a proxy for the overall R&T market) from 1996 to 2016.<sup>2</sup> Figure 2 shows the parallel rise in cassava and potato production in Africa from 1997 to 2017. As of 2015, Africa produced 58 percent of the overall cassava in the world (153 million tonnes), with Nigeria being the largest cassava-producing country (58 million tonnes). Per capita food consumption of cassava in sub-Saharan Africa was estimated at 109 kg/year per capita in 2015, underlining its status as a core subsistence crop in the region (FAO, 2016).

◆ **FIGURE 1** Export value of cassava starch and potato flour in Africa, 1996–2016

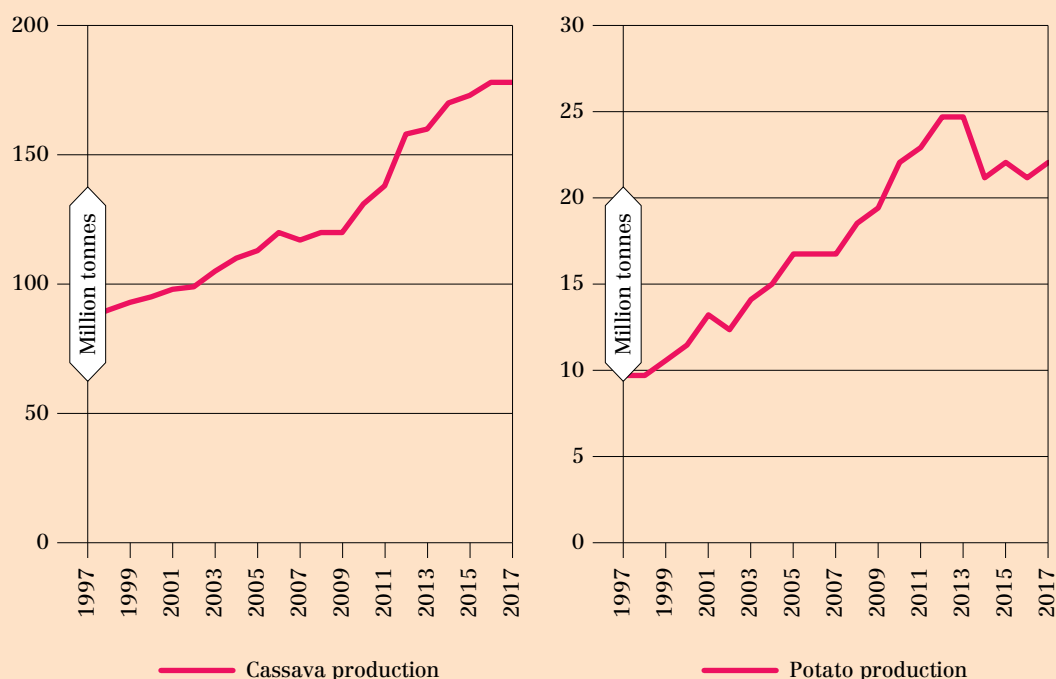


Source: FAOSTAT, 2019.

<sup>2</sup> The graph shows a sharp drop in the exportation value of potato flour between 2015–2016, which is misleading as it mainly reflects the situation of Tanzania and Zambia, where, according to official data, the export value decreased from USD 14.8 million and USD 2.3 million respectively, to almost zero.



◆ **FIGURE 2** Value of production for cassava and potatoes in Africa, 1997–2017



Source: FAOSTAT, 2019.

The demand for R&T products is expected to grow over the next two decades, with the main driver of growth being rising national and regional urbanization. Urban food markets are set to quadruple over the next two decades, meaning that domestic and regional markets will offer significant opportunities to African producers due to the increased demand for refined processed food (The World Bank, 2013). Furthermore, in an effort to support smallholders to transition out of subsistence farming, governments in Africa are placing the commercialization of food staples at the centre of national agricultural development strategies. These national efforts are supported at the regional level by the Comprehensive Africa Agriculture Development Programme.<sup>3</sup>

These data provide evidence of the rising importance of the R&T sector for sub-Saharan Africa. However, R&T value chains in the region are loose, fragmented and informal. Smallholders (both producers and processors) have relatively weak collective bargaining power, while the margins on the added value are often not paid. Access to information on good agricultural practices and improved varieties, as well as on suitable financing solutions, is not yet widespread.

These factors point to untapped investment potential for all value chain actors, from smallholder farmers to processors, to wholesale buyers and exporters. The actors in these value chains tend to rely mainly on informal financial service providers<sup>4</sup> (such as informal moneylenders, friends and family, village loans and savings associations) to compensate for

<sup>3</sup> The Comprehensive Africa Agriculture Development Programme (CAADP) is Africa's policy framework for agricultural transformation, wealth creation, food security and nutrition. Specifically, CAADP aims to stimulate and facilitate increased agricultural performance through improvements in policy and institutional environments, access to improved technologies and information, and increased investment financing.

<sup>4</sup> An "informal" provider refers to any actor that provides financial services, such as credit or savings, without legal authorization and regulation, usually to compensate for the absence of formal providers in his/her context.

the absence of commercial banks and other formal FIs. The next section provides an outline of the features of a prototypical R&T value chain and describes what the main advantages for formal FIs to invest in these environments.

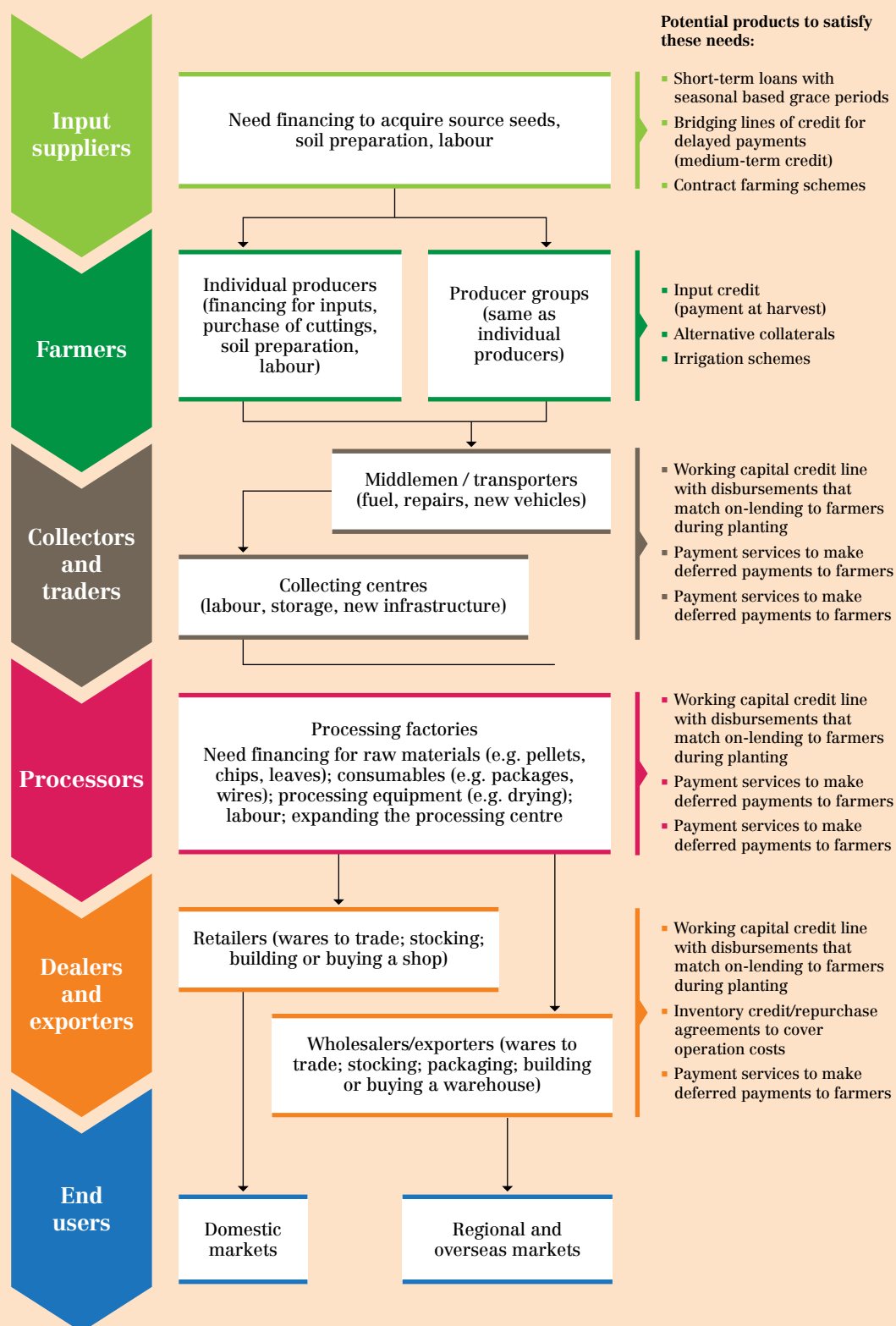
## 2.3 Features and investment opportunities of roots and tubers value chains

Although the features of an R&T value chain can vary considerably depending on the project country under analysis, the evidence collected by the different studies allows us to identify a series of commonalities that characterize these chains, as well as shared investment opportunities that could be unlocked for each value chain segment. Figure 3 provides a diagram of a prototypical cassava value chain, which draws on the main findings gathered from the ART project. Next to each segment, the most common cash deficits for which R&T value chain actors would need financing are identified, as well as specific financial services that could be used to satisfy these financing needs.

Overall, R&T value chains hold considerable investment potential for formal FIs willing to venture into these industries, mainly due to the following factors:

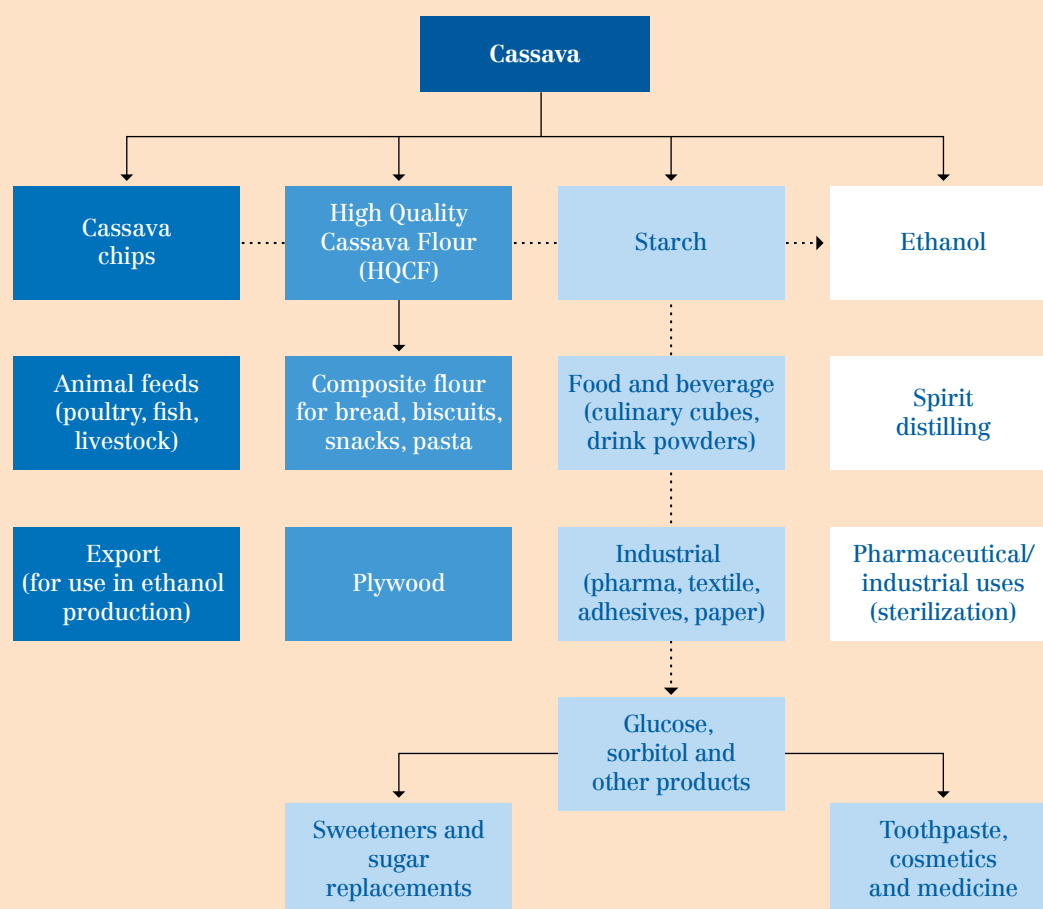
- ◆ **Diverse end-uses:** As can be seen in Figure 4, processed cassava products (chips, flour, starch, ethanol) are used in a variety of industries and sectors: food & beverage; animal feeds (poultry, fish, livestock); industrial (pharmaceutical, textile, food sweeteners, flavouring); spirit-distilling (from ethanol); and more. Similarly, processed potato products (starch, flour flakes) are also used for animal feed, fuel-grade ethanol, spirit-distilling, textile, plywood, glue, and many others. Furthermore, given the relevance of both cassava and potatoes at national level, there are huge opportunities for institutional procurement of raw and processed products for schools, hospitals, public offices, prisons, among others. In some countries where tourism is rising (e.g. Uganda, Rwanda), hotels are demanding increasing volumes of Irish potato and its derived products.
- ◆ **Huge untapped market opportunities:** As illustrated in the previous section, demand for R&T products is expected to rise in the next two decades, both regionally and globally. In the case of cassava, notably, there is a slow but gradual shift in the perception that formal FIs have of its nature, from a complementary subsistence crop to a profitable and export-friendly product that holds considerable investment potential. FIs that plan ahead and invest in strengthening their expertise on financial provision to R&T value chains will be able to gradually seize this rising market segment as the demand for its products grows.
- ◆ **Lack of competition in terms of formal financial provision:** As will be further detailed in the next section, formal FIs in the analysed countries are extremely reluctant to lend to R&T value chains, due to a multiplicity of concrete constraints as well as a substantial institutional bias against engaging with the agriculture sector. Those FIs that set out to devote their resources to overcoming these constraints can be first-comers in a rising market segment that holds considerable potential, consolidating their positions as reference points for R&T financial provision.

♦ **FIGURE 3** Example of a cassava value chain and related financial needs for each segment



Source: Adapted from FAO (2017e) and SNV (2015).

◆ **FIGURE 4** Cassava derivatives and their uses



Source: Dalberg Global Development Advisors, 2015.

## 2.4 Main challenges and constraints to formal financial provision in the cassava and potato value chains

As shown by our analyses, investments in the cassava and potato value chains in the project countries remain very limited (with the exception of Uganda, see Box 1), despite the potential for increased commercialization. Based on the main lessons learned from our evaluations, it is possible to synthesize a series of broad categories of constraints that impede financial provision on the part of formal FIs to producers and processors in R&T value chains.

The following table provides a recap of the main challenges faced by relevant actors in cassava and Irish potato value chains. These are drawn from our studies in Benin, Cameroon and Côte d'Ivoire (for cassava), and Rwanda and Uganda (for Irish potato). A brief description of each constraint is provided afterwards, with different challenges paired together as they represent aspects of the same issue faced by both sides of the spectrum (value chain actors and FIs).

♦ **TABLE 1** Typical constraints in cassava and Irish potato value chains

Actors	Challenges to financial provision
<b>Producers and processors</b>	Lack of organized value chain structures (e.g. producers' associations, cooperatives)
	Lack of access to conventional forms of guarantees and IDs
	High geographical dispersion in rural areas
	Irregular income patterns and high risk exposure
	Low levels of financial literacy and weak credit culture
	Low access to quality seeds and seed multiplication systems
	Limited access to different market channels
<b>Formal financial institutions</b>	Minimal experience in agricultural financing (and R&T value chain financing in particular)
	Bias against lending for a traditional subsistence crop
	Weak banking infrastructure in rural areas

Source: Authors' elaboration.

**Lack of an organized structure and FIs' bias:** Although R&T industries have been gaining considerable importance due to increased demand for starch from the food and textile industries, in the countries under analysis the production of cassava still appears to be viewed as a complementary or secondary agricultural activity. Production is usually carried out in small, family-managed farms, while the farmers' cooperatives that are supposed to stimulate dynamism in the industry remain rather weak in terms of organization levels and financial capacity. This lack of organization has strong repercussions on the capacity of processors and producers to access long-term financing from FIs that they would need to upgrade their business.

A telling example from our studies is that of cassava farmers and processors in Côte d'Ivoire, who spent on average only one day per week working for their informal groups – which often lack defined rules, structure and a clear added value for producers or processors – and who mainly relied on their individual gains to make a living (Positive Planet, 2017).

Faced with this scenario, formal FIs prefer to direct their lending towards safer, more organized and profitable sectors (such as coffee, cocoa, rubber and cashew nuts). In Cameroon, several commercial banks interviewed by the project stated that they would reconsider lending to cassava farmers, provided that these farmers could grow into more structured producers' organizations (FAO, 2017e).

#### ♦ **BOX 1** The exception of Uganda

In Uganda, formal FIs did recognize the notable potential of investing in the potato value chain, but they still eschewed lending to smallholders and SMEs, focusing exclusively on providing credit to large agribusinesses and buyers. These actors have an easier time complying with the requirements set by FIs to access credit, and they can benefit from more regular income flows than producers and processors (FAO, 2017b).

In Rwanda, the Government has been coordinating and providing guidelines and regulations for the establishment of solid and efficient Irish potato value chains. This has led to the establishment of potato collection centres (PCCs) as intermediate actors for marketing potatoes in bulk. In addition, price and quantity ceilings were set by the Government. Nevertheless, PCCs are still at an early stage of development, showing weaknesses in their collecting, weighing and marketing activities. As a result, processors still prefer to buy from individual members of PCCs, who side-sell their products. This overall scenario discourages FIs from investing in these value chains (FAO, 2017a).

**The lack of expertise in agricultural finance on the part of FI:** In all the case studies analysed, the majority of formal FIs suffered from a diffused lack of expertise and long-term experience in agricultural lending in general, and lending to R&T value chains in particular. This is both a cause and a consequence of the diffused bias among formal FIs towards lending to agri-value chains. When it comes to commercial banks, only a few have specialized departments dedicated to agricultural finance, and these usually engage with more export-friendly cash crops and better organized value chains.

The lack of capacity to assess business opportunities within R&T markets, and the consequent lack of interest in developing specialized financial products and services tailored to the needs of these chains' actors, result in a very limited supply of financial products. The available products show basic features that are similar to non-agricultural ones (short terms, fixed repayment terms, no grace period), with higher costs reflecting the transaction costs that are inherent to agricultural activities. Such financial products have no added-value proposition and are usually completely inadequate to the needs of producers and processors. What R&T actors need, in fact, is a wide range of different financial services that can cover both their short- and long-term business needs (see Figure 3, as an example).

**Rigid requirements to access financial services:** This is closely related to the previous point. Rural actors in R&T value chains are usually not able to satisfy the requirements to access credit and savings services that are normally set by formal FIs. Often, these requirements imply having: conventional forms of guarantees (e.g. titled land, fixed assets); various forms of official identity documents (IDs); a high rate of compulsory savings; a guarantor willing to vouch for the loan applicant; and more. Rural producers and processors rarely meet even one of these criteria. Furthermore, this lack of access is compounded by the loose organization of many R&T value chains (such as cassava); producers and processors do not usually band together to pool their resources and try to comply with these requirements.

**Client dispersion and the weakness of rural banking infrastructure:** The geographical fragmentation of R&T value chain actors in rural areas increases the costs and challenges for FIs to reach them with their financial offer, as well as to manage their agricultural portfolios and the associated risks. This is compounded by the weakness of most FIs' banking infrastructure in rural areas, which forces rural actors to undertake long and potentially unsafe travels to reach the nearest FI's branch to access financial services.

**Irregular income patterns:** As shown by the Côte D'Ivoire case study, producers and processors in the cassava value chain face very irregular income flows deriving from their agricultural activities, which lowers their creditworthiness in the eyes of formal FIs and strongly discourages these actors from applying for a loan. Producers and processors of cassava face an agricultural cycle of 12 to 14 months, which is a complete mismatch with the usual credit conditions imposed by formal FIs.

When these actors do manage to access loans, it is often due to a complementary income-generating activity (not necessarily agricultural) that helps them smooth their income flows. Overall, even those formal FIs which do decide to provide credit to the cassava value chain prefer to focus on the downstream segments (e.g. wholesalers, retailers), given the more regular income flows that characterize these agents (Positive Planet, 2017).

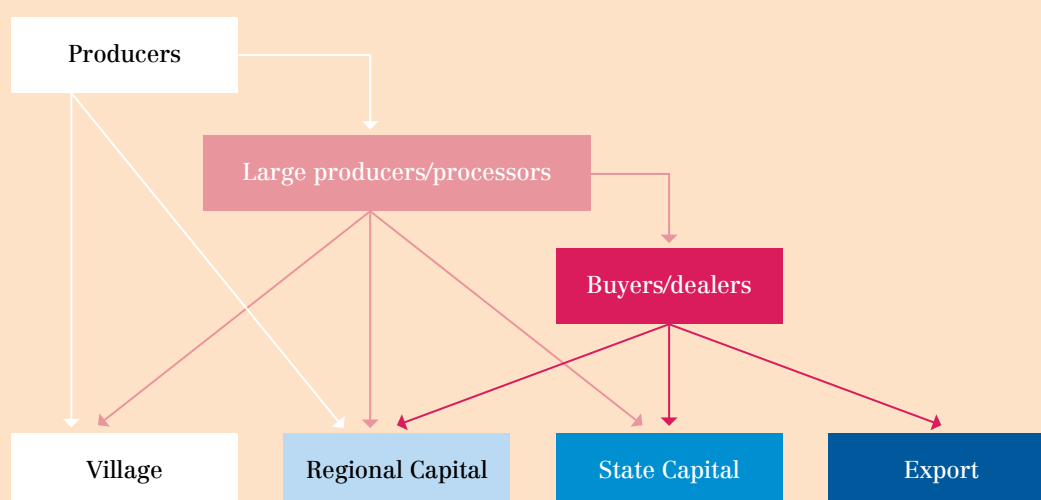
**Low literacy (and financial literacy) levels:** In all the case studies analysed, the majority of the cassava farmers were prevalently elderly and illiterate. This brings about a series of issues, including: difficulties in understanding the complexities of offered financial instruments; a skewed perception of agricultural and business-related risks; challenges in elaborating solid business plans; a weak credit culture; a loss of creditworthiness in the eyes of formal FIs; vulnerability to malfeasance on the part of formal and informal financial providers; and so forth.

**High risk exposure:** R&T producers and processors are exposed to a variety of production, marketing and environmental risks in their agricultural activities. These include: market price fluctuations (for their products as well as their inputs); natural hazards (e.g. droughts); pests and disease-related risk; changes in the financial regulatory framework; and many more. This scenario is compounded by the almost non-existent offer of insurance products for SMEs in R&T value chains, on the part of formal FIs. All these elements negatively affect the appeal that R&T farmers have as potential clients of FIs, while they also contribute to the farmers' lack of confidence in being able to repay loans.

**Low uptake of high-quality seeds:** This challenge has two dimensions – one is the inadequacy of good-quality seed and the other is the scarce accessibility of such seed by R&T farmers. Notwithstanding the introduction of improved varieties and practices (for example, through farmer field schools - FFS) that have shown how productivity can be improved, the uptake of improved seedlings by farmers is low, mainly due to the significant cost of high-quality seeds. As a result, farmers who are unable to afford quality seeds continue to purchase and recycle poor-quality seeds for household consumption (FAO, 2017d).

**Lack of market outlets for different value chain segments:** R&T value chains are often extremely limited in their choice of channels to commercialize their products on the markets, with the upstream segments (producers and processors) being the most affected. In the case of cassava, for example, its low export value and its widespread perception as a food, non-cash crop results in very limited commercialization choices for producers and processors, and a consequent loss of contracting power with the other value chain segments. Figure 5, taken from our study in Cote d'Ivoire, shows the typical market outlets for the main segments of a cassava value chain (Positive Planet, 2017).

♦ **FIGURE 5** Main market channels for each cassava value segment



Source: Positive Planet, 2017.



**Exposure to risks:** Cassava and potatoes have the potential to perform better than other staple crops, when it comes to the increased climate variability and climate change in sub-Saharan Africa. However, a number of vulnerability assessments indicate that their yields could also decrease if the effects of climate change continue unchecked. In addition, when other crops fail, rural households will consume more cassava, leaving fewer surpluses for processing industries and urban markets, which would increase prices. Furthermore, production and market risks are also relevant for R&T markets. All of these risks represent additional factors limiting investments in R&T value chains. The lack of insurance products available for producers and processors is an additional determinant of the lack of provision of credit and savings services to these segments of the chain.

## 2.5 Approaches and good practices to foster investment in roots and tubers value chains

Despite the constraints that determine the lack of adapted financial products for small producers and processors in R&T value chains, some encouraging new initiatives and approaches have been documented whose implementation can overcome these constraints, based on the experiences drawn from the ART project.

Such approaches are described below, categorized according to whether they are meant to address the constraints on the side of the demand for financial services (i.e. producers, processors, and other value chain actors), making them more reliable clients for the FIs; or those on the supply side (formal FIs), with the objective of developing products and services with a high-value proposition.

### On the demand side

**Strengthen the financial education of R&T value chain actors:** Increasing the capacity of smallholder producers and processors to properly understand the functioning of the offered financial products – as well as the responsibilities, implications and risks associated with adoption – can strongly increase their creditworthiness and their perception as appealing clients in the eyes of formal FIs. This kind of capacity-building should not be reserved only for producers and processors but should be extended to all segments of the value chains. Doing so would ensure, for example, the sustainability of contract farming arrangements involving different R&T value chain segments.

The case study of Benin shows how fostering financial literacy also has a strong effect on establishing a correct credit culture among smallholders, as it teaches clients that using part of the credit from a tailored loan to finance other agricultural activities (that have different production cycles and weren't originally intended to be financed by the loan) can lead to missed repayments and the accumulation of debt (FAO, 2017d).

**Provide value chain actors with business advisory and other extension services:** R&T producers and processors often lack essential business-planning and management skills, as well as basic knowledge of FIs' procedures. This strongly impairs their appeal as potential clients, while also increasing their distrust towards formal FIs. To overcome this constraint, formal FIs – with eventual support from development agencies – can develop and offer various complementary extension services to R&T producers and processors. For example, they could complement their financial offer with a loan application follow-up service that helps the applicant to navigate the requirements and steps expected to obtain the loan. It is also possible to link farmers and processors with professional agribusiness service providers, to increase their capacity in recordkeeping, financial management, and so forth.



## On the supply side

**Provide technical support, information and capacity-building to formal FIs:** All case studies analysed show that FIs lack the expertise to design flexible financial products that can hold considerable added value for R&T value chain actors. Providing FIs with technical support on designing and implementing such products can considerably enhance their uptake, profitability and sustainability among R&T value chain actors. Tailored financial credit products for cassava and potatoes, for example, should have longer repayment periods, flexible loan instalments that are tailored to specific agricultural cycles, more affordable interest rates, and longer-term loan durations with a particular focus (e.g. purchase of technology and equipment, infrastructure). For instance, the analysis in Uganda underlined how Irish potato producers could benefit greatly from farm infrastructure loans of at least three years' duration, used to permanently upgrade their businesses with new technologies and structures (FAO, 2017b).

As a more long-term endeavour, formal FIs can be assisted in building their capacity on methodologies and techniques to properly analyse agricultural business models, assess agri-loan proposals, and evaluate/manage agricultural risk. The case of Côte D'Ivoire shows how, in recent years, more and more commercial banks in the country have begun integrating specific divisions within their structures that focus exclusively on agricultural financing, to consolidate their expertise and overcome their information gap. Hence, formal FIs can be supported in developing dedicated agri-financing divisions in-house, which can build and maintain the institution's expertise in this domain (Positive Planet, 2017).

**Facilitate dialogue and information exchange:** Within the framework of the ART project, there have been some very promising experiences of organizing targeted fora to foster dialogue and the exchange of information between FIs and value chain actors. This initiative has strongly helped to overcome the existing information gap, while also raising the interest of microfinance institutions and commercial banks to invest in the sector. A relevant example in this sense is the one that the ART project had in Malawi with a number of formal FIs (see Box 2).

### ♦ BOX 2 The importance of fostering dialogue between FIs and value chain actors to unlock investment: the case of Malawi

In Malawi, the offer of financial products for small-scale cassava producers and processors is almost non-existent. This is due to some of the factors illustrated so far in this document, such as high risk exposure and consequent strict conditions imposed on value chain actors to become eligible for a loan. As a result, only very costly and inadequate short-term credit products are offered to smallholder farmers, with interest rates that can reach up to 40 percent or more.

Another determining factor is that this crop has never been perceived by FIs as a profitable business to invest in, compared to other crops like maize and tobacco. This is mainly due to a misled perception of the non-profitability of the sector, whereas it has been proven, through more in-depth studies, that cassava industries do present high growth rates and margins for considerable profits. This is why, through the facilitation of the ART project, a series of meetings and fora were organized to facilitate the dialogue between FIs and producers/processors in the country.



On such occasions, profitable business plans for financing processing units of cassava wet cakes and high-quality cassava flour were presented, including a number of reliable financial projections that prefigured significant internal rates of return on the investment.

Faced with these prominent business opportunities, some FIs – including a successful commercial bank called Financial Holdings Limited – agreed to review their lending conditions (eligibility requirements, loan duration and interest rates), in case they received proposals for solid and profitable investment plans for cassava production and processing. The fact that an FAO project was providing technical assistance to these producers and processors represented for the bank an additional form of indirect guarantee (the processor's capacity to develop a business plan was part of the project's assistance).

**Facilitate tripartite agreements and value chain financing schemes:** By financing less risky agribusinesses, most often those near the end of the chain, the costs associated with risk protection are reduced. In this way, a financial institution can lend to an established business such as a renowned input provider (in some cases public agencies or private-public partnerships), and let it make internal value chain lending decisions based on its first-hand knowledge of producers or traders. An interesting case of a tripartite agreement is the one of the Unguka Bank in Rwanda (see Box 3).

**Encourage the use of alternative forms of collateral:** Access to conventional collateral, as seen in the previous section, is one of the most pressing constraints for smallholders and SMEs active in R&T value chains who wish to access a loan. This situation is worsened by the low levels of organization in many R&T value chains, which implies that producers are not able to combine their resources to meet the FIs' requirements (e.g. with group guarantees).

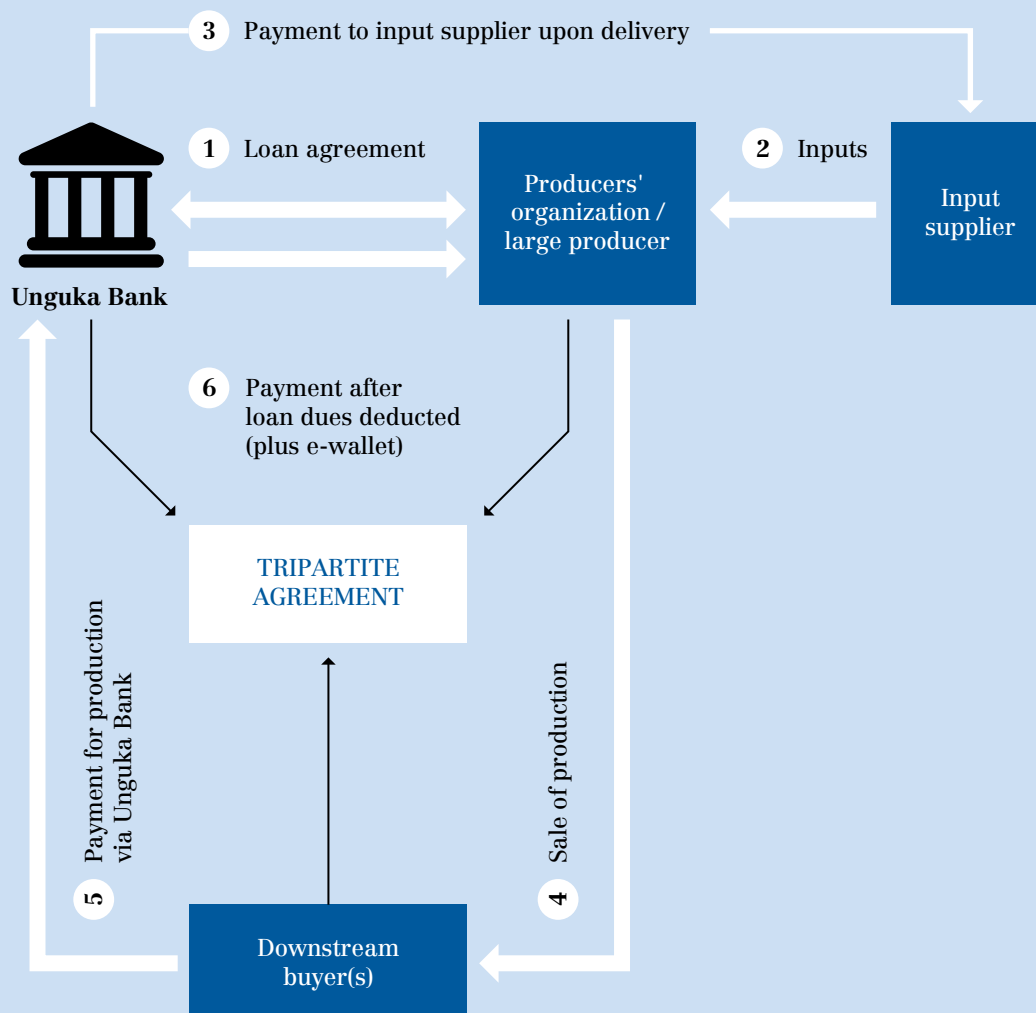
Several formal FIs have tried to overcome this constraint by developing systems that allow alternative forms of collateral to be accepted as guarantee for credit (e.g. moveable assets, group guarantees). The case of BRAC in Bangladesh provides a good example of how to use potatoes as a form of collateral (see Box 5). As can be seen in the next section, these solutions only become possible when there is a regulatory financial framework in place that specifically enables them. The technical assistance provided to value chain actors by public national and international institutions (such as extension services, agribusiness and SME governance and management) represents an additional form of guarantee for FIs. The presence of programmes that back the repayment capacities of smallholders can make FIs keen to consider alternatives to requests for collateral-based guarantees. This is what enabled the disbursement of credit in Malawi, Rwanda and Uganda.

**Encourage the adoption of digital technologies to make more information and data available for FIs:** The increasing availability of data and information on agricultural prices, trends and dynamics, along with new technologies that can be used to reduce the costs of market analysis, can help FIs to tap into informational advantages that are typically held by value chain actors. An example in this sense is the development of the FARMIS online database in Uganda (see Box 4).

### ♦ BOX 3 The case of Unguka Bank in Rwanda

Unguka Bank (UB) is a microfinance bank actively engaged in financing the Irish potato value chain in Rwanda. As part of its value chain financing strategy, it has developed a model to ensure a sustainable provision of financing aimed at all segments of the potato value chain. Figure 6 shows the aspect of the model specifically dedicated to financing potato producers. As part of a tripartite agreement between UB, the producers' organizations and the downstream buyers, UB provides input credit services by directly paying the input providers at planting season, addressing the liquidity constraints of farmers. Based on agreements previously made with buyers, including setting the prices and the quantity to be purchased, the bank is paid back with the sales made by farmers who procure to the buyers at harvesting time, so that the payment for production is paid directly by buyers to UB, and UB in turn pays the farmers after loan dues are deducted.

♦ FIGURE 6 Diagram of a financial solution for potato producers



Source: SNV and FAO, 2017.

#### ◆ **BOX 4**     **An example of a digital service for R&T smallholders in Uganda**

The Farmer Record Management System (FARMIS) is an online application for R&T farmers and formal FIs, developed in Uganda by Infotrade. It collects relevant data on R&T farmers' activities to assist in business planning and management, as well as to connect them with the markets and FIs. Its features include: an internal accounting system; recordkeeping for all farm activities throughout the agricultural cycle; updated market information; weather updates via mobile; and a farmers' performance registry and assessment tool that FIs can use to connect with smallholders and make better credit decision.

#### ◆ **BOX 5**     **How investments in storage infrastructures can be profitable, even in non-traditionally potato-producing countries: the case of BRAC in Bangladesh**

The Bangladesh Rural Advancement Committee (BRAC) is an example of the efforts of a large financial services development organization to provide integrated financial and value chain services to the potato sector. BRAC is providing multiple financial and non-financial services across Bangladesh. In particular, two key interventions are in place: a large cold-storage centre and the development of complementary financing and services; and the development of seed production to promote improved quality and yields.

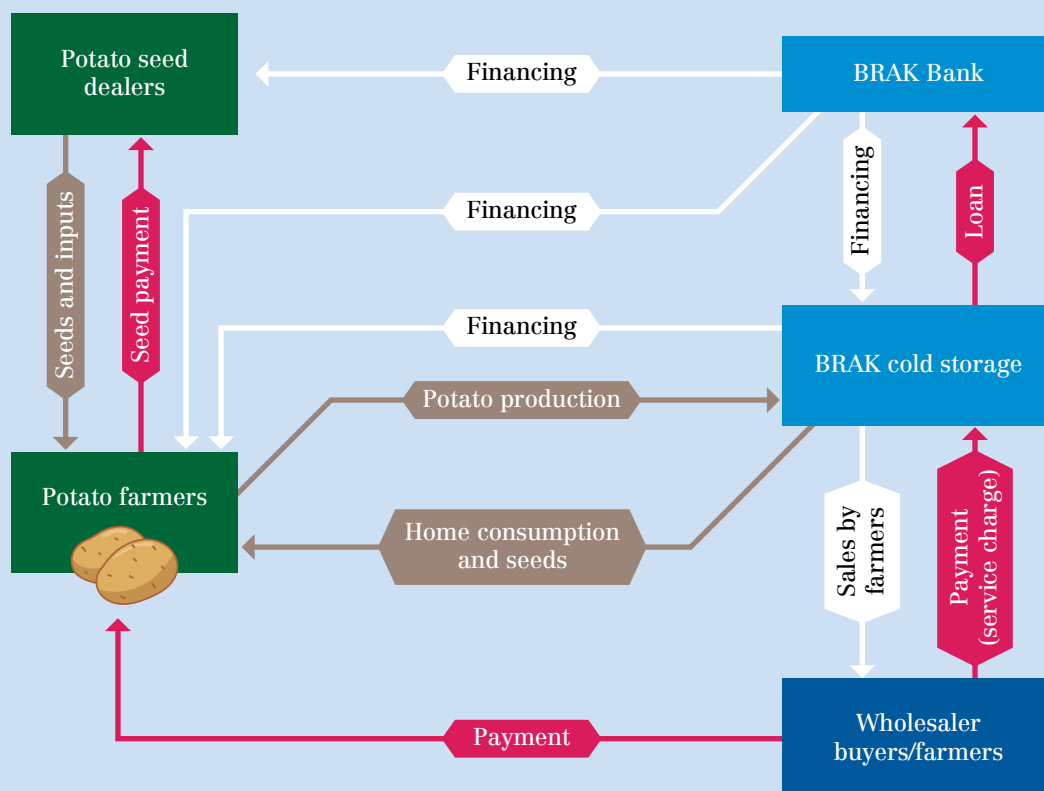
BRAC has banking services in place which can provide financing for the entire production and marketing cycle, either in the form of forward financing for production or as concessional loans, by partnering with the Government. Moreover, warehouse receipt financing is provided at the time of storage, thanks to funding on the part of BRAC Bank.

As shown by Figure 7, in BRAC's model, potato production, cold storage and eventual sale to traders or wholesalers follows a logical path, with financing coming from BRAC's FIs to various actors in the chain. By using the potatoes as collateral and ensuring repayment through direct discount at the time of sale, the risks and costs of financing are reduced. The cold storage has insurance coverage for the stock of stored potatoes.

While BRAC is involved in seed production for rice and other crops, it has only developed a storage and marketing programme for potatoes. To do so with other crops would involve both heavy investment and high competition. In cold storage BRAC was an early mover; although there is now considerable competition, it has an established clientele and a recognized service. Through its vertical integration, it is able to address financing needs more readily than many of its competitors. At the same time, the programme faced many challenges, despite BRAC's experience and resources.



♦ **FIGURE 7** Potato production, cold storage, finance and marketing



Source: Miller, 2017.

Several features of BRAC's value chain finance approach have the potential to be replicated and adapted to African context.

## 2.6 Fostering an enabling policy environment for investment in roots and tubers value chains: recommendations for policy-makers

The following section focuses on the role that the public sector can have in fostering an enabling environment for investment in R&T value chains. It also proposes a series of policy recommendations, drawn from the findings of the ART project, which have proven effective in achieving this goal.

Effective policies that can foster an enabling environment need to take into consideration all inputs from the private sector to ensure proper understanding of its needs and constraints, as well to build the broadest consensus possible (i.e. "buy-in") for their adoption. Policies must address the root causes of specific issues, rather than try to address them in a superficial and short-lived manner. In order to achieve this, it is necessary to take into consideration both supply- and demand-side challenges in accessing financial services, as well as the manner by which these challenges feed into each other.

Once the policies have been established and implemented, it is paramount to ensure the stability of any regulatory enabling environment, in order to guarantee that the policies remain predictable for market actors from both the demand and supply sides – from smallholders to FIs. Unpredictable changes in rules and regulations (e.g. on imports and exports) or other

macroeconomic shocks (e.g. sudden domestic currency appreciation) negatively affect the engagement of market actors, as they become unable to predict what real benefits can come out of their efforts. In the worst-case scenario, the effects of their work might be completely negated by external factors (e.g. fixing prices of commodities).

### Supply-side policy recommendations

#### **Favour capacity-building of formal FIs instead of subsidizing their operation costs:**

In order to achieve the sustainability of formal FIs' engagement with the R&T sector, it is necessary to direct policy-making towards the fostering of FIs' capacity to develop a broad portfolio of financial products, tailored to the needs of each value chain segment. From a policy perspective, this is considerably more useful and sustainable in the long term than subsidizing FIs' operation costs (including interest rates) to engage in the agriculture sector. This policy focus on capacity-building should also aim at transforming FIs' internal processes to make them more capable of managing risk in their agricultural portfolio.

**Create tailored State funds for R&T financing:** Instituting a State fund dedicated to enhancing and complementing the offer of financial services for R&T value chain actors – on the part of formal FIs – can go a long way in ensuring that vital segments of R&T value chains are not financially excluded. A notable example is the Women's Support Fund of Côte d'Ivoire (see Box 6). These funds usually offer complementary extension services aimed at strengthening individual farmers or cooperatives in a range of relevant skills such as business management, risk mitigation and financial literacy.

#### **BOX 6     The example of FAFCI in Côte d'Ivoire**

The Women's Support Fund of Côte d'Ivoire (FAFCI) is a State fund instituted in 2012 to complement the credit offer from banks and microfinance institutions engaged in rural areas. FAFCI exclusively targets rural women in agricultural value chains, either individually or in cooperatives, with the aim of enhancing their access to credit and strengthening their skills in managing their income-generating activities.

FAFCI finances women-led micro-business projects with flexible credit conditions and facilitated requirements in terms of collateral and bureaucracy. It also requires clients to take part in two sessions devoted to understanding the implications of purchasing a credit product, and sensitizing them on the importance of using the loan for its intended purpose and on reimbursing the loan.

From 2012 to 2017, FAFCI provided USD 20 million in credit to more than 110 000 women-led business projects. In our study, 24 percent of the surveyed R&T farmers' cooperatives in Côte d'Ivoire had obtained credit thanks to FAFCI.

*Source:* Positive Planet, 2017.

**Facilitate the use of alternative forms of guarantees:** Policies can make or break all the best intentions that formal FIs might have in introducing alternative forms of guarantees for their products. Enlightened policy-making will aim to develop a financial regulatory framework that has provisions to accept unconventional forms of guarantees such as sale contracts, movable assets, livestock, and agricultural inventories. Investments in macro-level financial infrastructure, such as a national credit bureau, can also strongly increase FI's willingness to accept and allow alternative forms of collateral for their services. In Uganda, for example, encouraging the inclination of banks through enabling policy-making to accept

group guarantees as collateral instead of land has been highlighted as a major potential breakthrough in extending financial services to Irish potato farmers, given the relatively higher level of organization in the upstream segments of that value chain (FAO, 2017b).

### Demand-side policy recommendations

#### **Strengthen the structure and organization levels of R&T actors' groups and cooperatives:**

Inadequate levels of organization (in groups or cooperatives) has been underlined as a major obstacle towards the financial inclusion of R&T producers and processors. An enabling policy environment is fundamental to ensure the sustainability and recognition of these entities. In fact, enlightened policy-making can target different aspects of a cooperative model to ensure its replication and sustainability, such as: facilitating the cooperative's transition from an informal grouping to a formal, legally recognized entity; enhancing the cooperative's linkages with dedicated public funds for increased access to credit; easing the collateral requirements for cooperatives applying for loans (e.g. group collateral); and carrying out mass awareness campaigns for R&T value chain actors to sensitize them on the benefits of pooling their strengths and resources.

#### **Foster regular convening between value chain representative groups and formal**

**FIs:** The lack of detailed information on R&T value chains (for FIs) and FIs' procedures and products (for R&T value chain actors) has been highlighted as a major reason for mistrust and lack of involvement between these two counterparts. A way to overcome this gap would be to foster regular meeting events between R&T producers/processors' groups and local FIs, aimed at exchanging information on the respective business models, ensuring better mutual understanding of constraints to make investments, managing risks, and influencing the design of tailored financial products. Over time, such meetings can be upgraded to stable fora and innovation platforms (physical and digital) for information exchange.



### 3 Strengthening climate risk management along the roots and tubers value chains in Africa

#### KEY MESSAGES

- ◆ Roots and tubers crops, particularly cassava, are increasingly been studied for their tolerance to increasing temperature and water stresses.
- ◆ However, increasing frequency and severity of climate anomalies in Africa is threatening also these crops, leading to food insecurity and income losses for small R&T farmers and processors, as well as market shocks.
- ◆ Developing climate information services and increasing access to climate risk management strategies is crucial to enable appropriate choice of practices and strategies to match the current and future climate risks.

The R&T sectors are some of the most important food sub-sectors in Africa. For many parts of sub-Saharan Africa, these commodities account for 20 percent of calories consumed, and their importance is growing not only in terms of reduce food insecurity and external food assistance and increasing the income of smallholder farmers, but also to fight against unfavorable climatic conditions. In Malawi, dry conditions in 2018 are causing a below-average cereal harvest for the 2019 season, which is estimated to increase the number of people considered to be food-insecure to 3.3 million from October 2018 to March 2019, doubling the levels of the previous biennium (FAO, 2018). This implies that in Malawi, investing in alternative crops such as R&T crops may help increase food security and reduce rural poverty, as well as decrease the dependence on crops such as cereals, whose yields are more sensitive to climate. R&T are drought-tolerant crops, capable of growing in marginal lands. In a context of extreme changes of weather conditions, resilient cassava, potato and yam may become even more important to mitigate the impact of climate on agriculture. However, R&T productivity and production could still be affected by climate variability on inter-annual and intra-seasonal timescales.

Reducing climate risks requires robust and innovative tools that can help producers and relevant institutions to make pro-active decisions and adjustments to their activities. In order to support climate risk management in the R&T sectors, the analyses undertaken by the ART project provide an overview of the status of climate variability and natural hazards in the seven countries supported by the project, and the impact of climate variables on R&T crops, focusing on cassava. Floods, droughts, delayed rainfalls and increased temperatures were recorded in all of the studied areas, with Eastern African countries showing some of the largest inter-annual rainfall variations in the world. In some countries, like Benin and Ghana, increased temperatures were positively correlated with cassava yield and productivity levels,



reinforcing the view of this crop as “an insurance for farmers” in vulnerable African countries. However, in other countries cassava seems vulnerable to variations in temperatures.

Potential CRM strategies and tools at different levels are proposed and recommended to increase climate resilience of the cassava and potato value chains. Some examples include strategies for farmers as well as for governments, and private and financial sectors. The effectiveness of these strategies will depend on their responding to the needs of R&T sectors and their simultaneous support by different stakeholders.

### 3.1 Climate trends in Africa

According to the Intergovernmental Panel on Climate Change, near-surface temperatures have increased by 0.5 °C or more during the last 50 to 100 years over most parts of Africa, with minimum temperatures warming more rapidly than maximum temperatures. Near-surface air temperature anomalies in Africa were significantly higher for the period 1995–2010 compared to the period 1979–1994 (Essel *et al.*, 2014). Outcomes of an increase in global temperatures may include increased risk of drought and increased intensity of storms, including tropical cyclones with higher wind speeds, and, possibly, more intense mid-latitude storms (NASA, 2005). The same study released by NASA explained that the combination of increased temperatures over land and higher humidity could result in cycles of droughts and floods.

The most influential climate variables affecting yields on a global scale are temperature and precipitation (Matiu *et al.*, 2017). Therefore, to understand the impacts of climate variability and change on different crops and the role that R&T could play, it may be necessary to first analyse and assert the temperature variations, as well as provide evidence of selected natural hazard-induced disasters – floods and droughts – hitting the projects countries over different timeframes.

Negative climatic variations combined with increasing recurrence of floods and droughts over the region, the generally low incomes, and the dependence on water resources, all of which account for a high vulnerability, have dramatic effects on the economy and the living of local communities.

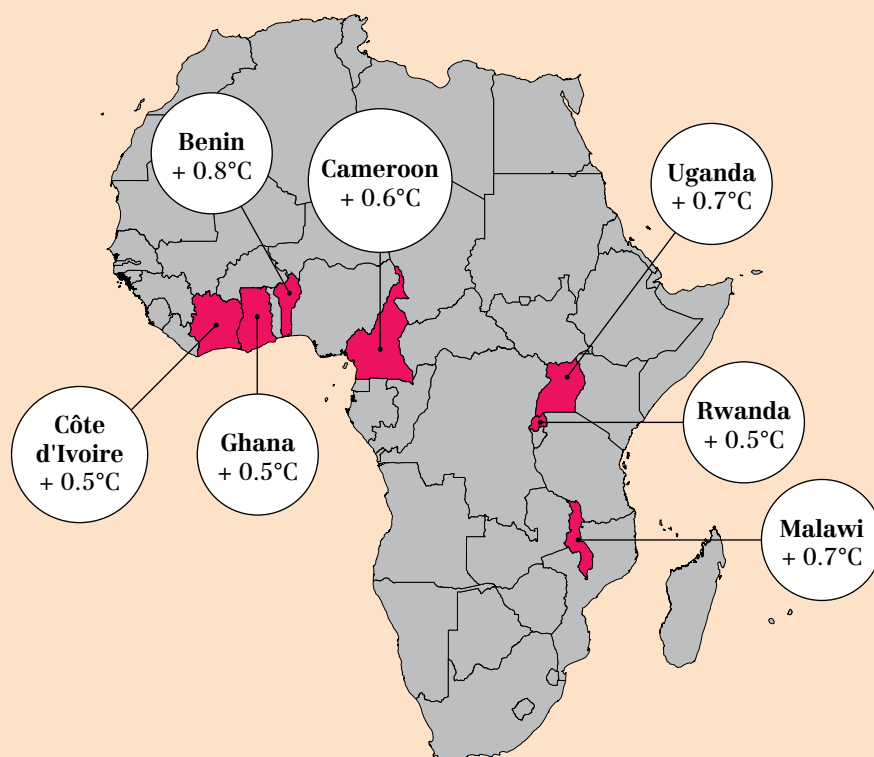
### 3.2 Trends in the project countries

As mentioned above, specificities on the climatic trends and targeted natural hazard-induced disasters related to the ART project’s countries have been elaborated from Google Earth Engine - Earth Map, the World Bank and The Oxford Research for Climate Science 2018. These data showed that all the countries analysed between 1991 and 2015 experienced a consistent increase in mean annual temperature coupled with reduced frequency but increased intensity of cumulative rainfall volumes (see Figure 8).

Among the project countries, **Benin** encountered the highest increase in temperature between 1991 and 2015 (data elaborated from The World Bank, 2018). Rainfall patterns were marked by a high degree of instability, with alternation of deficit and surplus years without apparent periodicity. The inter-annual variability caused fluctuations between wet and dry years. The analysed regions of Adja-Ouèrè, Savalou, Djakotomey, Tchaourou, Nikki and Djougou were affected by a reduction in the number of rainy days per year (128 days of rain per year in 1960 to 80 days of rain in 2008 in the Guinean zone). Furthermore, a decrease in the amount of rain volumes at the start of agricultural seasons was registered. This scenario may induce risks of water stress for crops, also coupled with the impact of increasing temperatures on the evaporative demand of the soils.

**Côte d'Ivoire** exhibited increasing temperatures of over 0.5 °C between 1991 and 2015. According to the World Bank, floods repeatedly hit Côte d'Ivoire during this time period, especially in the southern part of the country, where the highest amount of rainfall occurs.

◆ **FIGURE 8** Mean annual temperature increase in the project countries 1991–2015



Source: African Roots and Tubers project, FAO.

The average annual precipitation over **Cameroon** has decreased by 2.9 mm per decade since 1960. Mean annual temperatures are projected to increase between 1.0–2.9 °C by the 2060s and 1.5–4.7 °C by the 2090s.

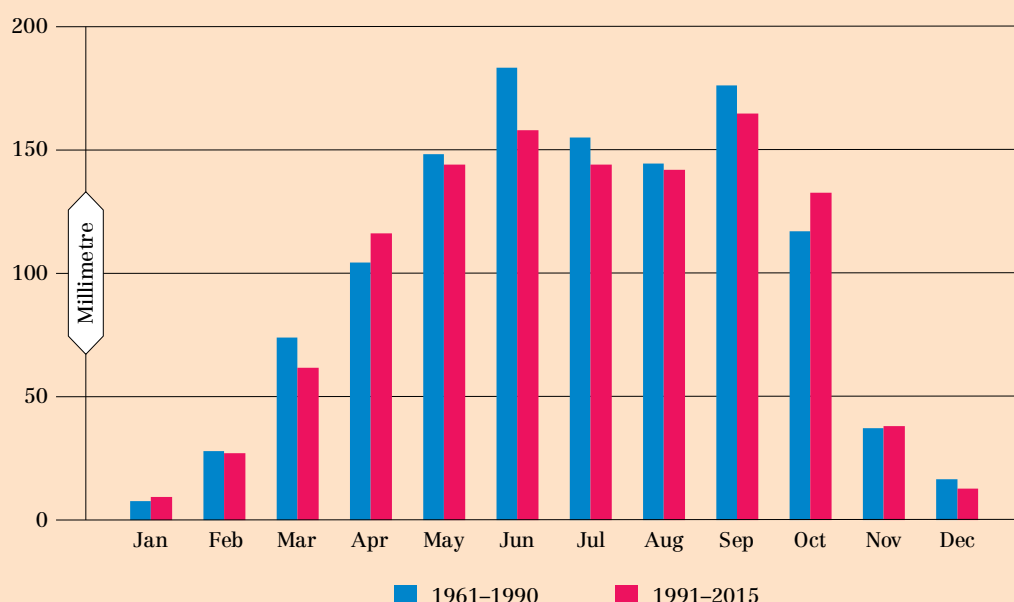
**Ghana** experienced one of the highest reductions in rainfall patterns in Western Africa, with peaks from 237 mm in 1991 to 163 mm in 2015. Generally, rainfall in Ghana decreases from south to north. The northern savannas have recently been affected by a combination of droughts and floods, both accompanied by high temperatures and intense heat. As shown in Figure 9, historical data confirm that the average monthly rainfall in Ghana decreased considerably between 1961–1990 and 1991–2015, with a reduction in cumulative annual rainfall from 1 155.4 mm to 791.7 mm on average.

Eastern Africa shows some of the largest inter-annual rainfall variations in the world, according to research released in 2018 by Oxford Research Encyclopedia of Climate Science.

Unlike the western African countries analysed, **Rwanda** and **Uganda** experienced an increase in rainfall levels, characterized, however, by extreme precipitations. More specifically, Rwanda experienced the highest increase in rainfall volumes during the peak season: 73.8 percent more from 1991 to 2015. Droughts and heavy rainfall events have become more frequent in the northern-western districts of Rwanda, according to the Rwanda's Ministry of

Disaster Management and Refugees; between January and April 2018, more than 115 people died due to these disasters.

◆ **FIGURE 9** Average monthly rainfall in Ghana from 1961–1990 and 1991–2015



Source: African Roots and Tubers project, FAO.

In **Malawi**, the mean annual temperature increased by 0.7 °C between 1991 and 2015. Contrary to Rwanda, Malawi exceeded even Ghana for its level of reduction in mean precipitation per year in the analysed timeframe, with rainfall decreasing from 90 mm to 48 mm (over 53 percent less than the initial period). According to the World Food Programme (WFP) country bulletin released in February 2018, the start of the 2017/18 rainy season saw less-than-average rainfall expected, which is likely to have negative impacts on crop development this season (WFP, 2018). In January 2018, the Ministry of Agriculture declared that 270 000 hectares had been affected by dry spells.

### 3.3 Climate-related agricultural losses

The above-mentioned warmer temperatures, excessive rainfall and recurrent droughts are severely affecting sub-Saharan Africa – particularly in the countries analysed – as they represent drivers of yield shocks (Lobell, 2008). According to FAO, in the region 363 million people were affected by droughts between 1980 and 2014. Absolute production losses in agriculture (crops and livestock production) associated with droughts accounted for about USD 31 billion between 1991 and 2013 in the region. Eastern Africa was the most affected by production losses, reaching over USD 19 billion, followed by southern and western Africa. Losses and dropdowns in yields are particularly perceived after droughts, causing damages in output and revenues (FAO, 2015).

The same analysis carried out by FAO showed that between 1991 and 2013 in sub-Saharan Africa, the production of cereals was reduced by 8 percent, pulses by 22 percent and livestock commodities by 7 percent due to drought. This accounted for 76 million tonnes of cereals, pulses and livestock commodity production losses in physical terms.

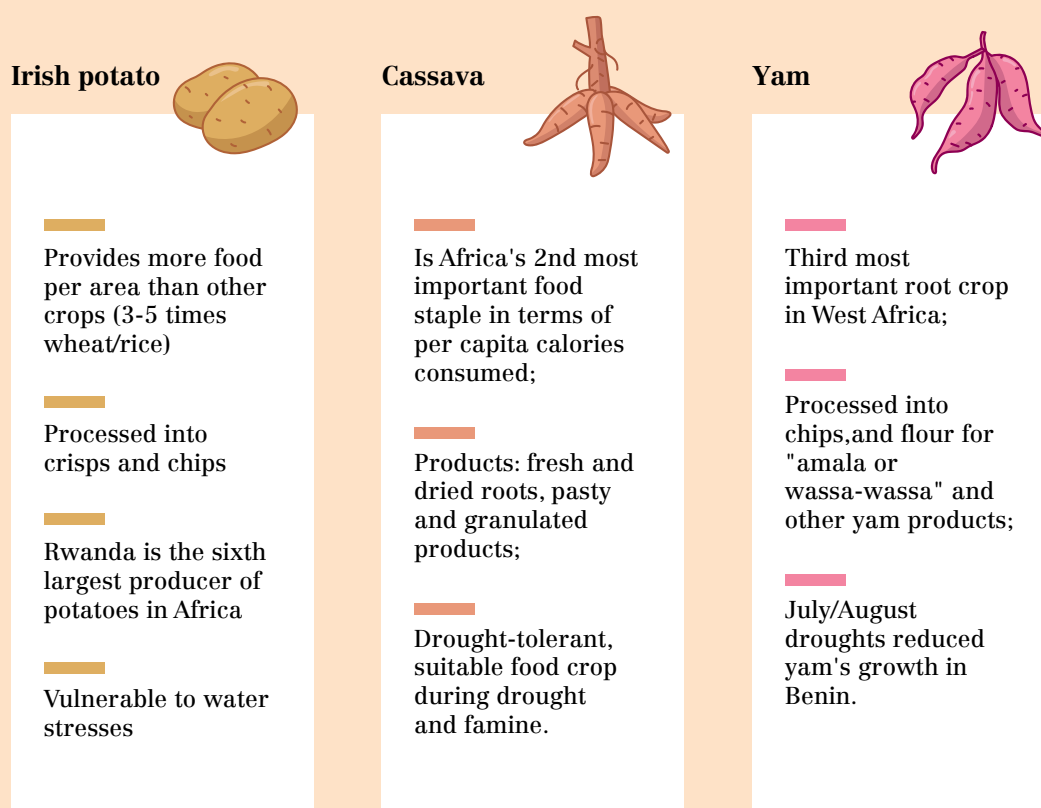
As example at country level, in Malawi dry conditions caused below-average cereal harvest in 2018, which is estimated to increase the number of people considered to be food-insecure to 3.3 million in the period from October 2018 to March 2019, doubling the levels for 2017/18 (FAO, 2018). Given the important contribution of agriculture to food security and income generation in sub-Saharan Africa, these losses represent a serious issue in terms of food availability, farmers' livelihoods and the entire economy of these countries and the region. Measures to reduce the negative impact of climate variability and change, as well as disaster risks, include promoting alternative and more resilient cultivations.

For example, the importance of R&T crops such as cassava – traditionally called the “food of the poor” – is growing as a means to respond the challenges of climate change in several African countries (FAO, 2013). R&T are playing an increasing role in lifting communities out of poverty and reducing food insecurity in many African countries, where cassava is increasingly promoted and produced.

### 3.4 Impact on roots and tubers production

Evidence on the suitability of different staple crops in Africa shows that when compared with maize, sorghum and millet, cassava is the least vulnerable to the climatic conditions predicted in 2030, and that its suitability will rise in most of the 5.5 million square km of African area analysed (Jarvis *et al.*, 2012). Figure 10 describes the main features of the crops supported by the ART project, including their vulnerability to climate related events.

◆ **FIGURE 10** Roots and tubers priority crops supported by the ART project



Source: Authors' elaboration.

The paragraphs that follow describe some features of the impact of climate variability on the production of cassava.

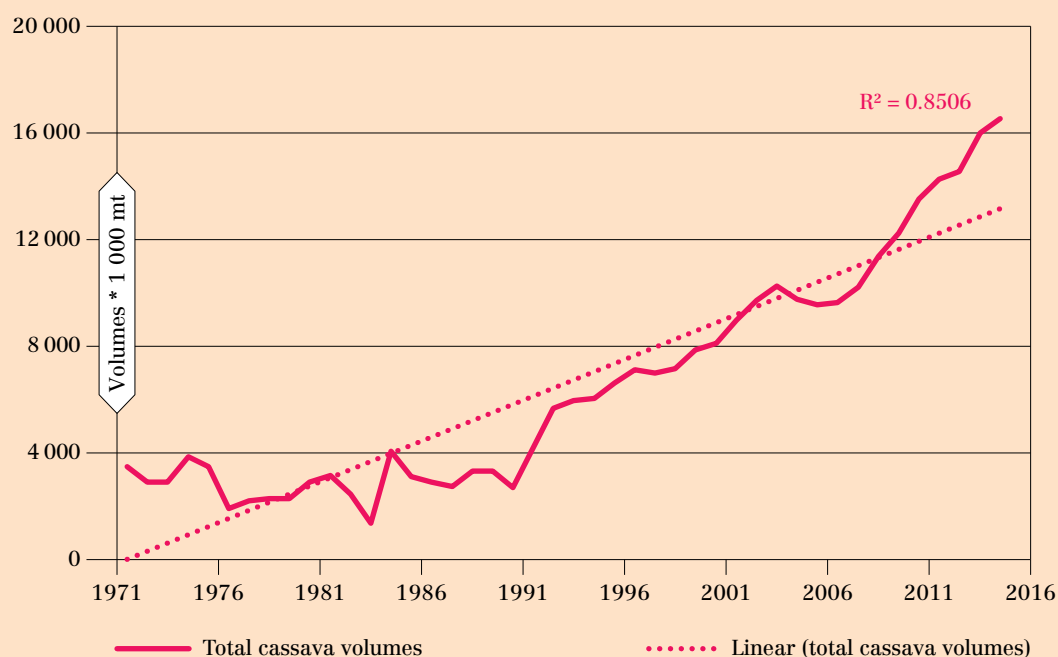
### The case of cassava

According to FAO, cassava performs optimally with mean temperatures between 25 °C and 29 °C, and with soil temperature of about 30 °C, while below 10 °C the plant stops growing (FAO and IFAD, 2001). It could tolerate semi-arid areas with rainfall as low as 500 mm, representing an advantage when comparing with other crops in such conditions. R&T are buried in the soil, making these crops more resistant to temperature variations and rainfall deficits which are affecting several African countries (as discussed in the previous section).

To understand the impact of climate variability on cassava production and yields, various statistical analyses<sup>5</sup> were carried out at district and national levels in R&T production areas.

In Ghana, national climate data have been monitored over the past 40 years, showing significant changes in mean annual daily temperature and total annual rainfall across various ecological zones. The study analysed national cassava production and economic trends using time series and R statistics, which showed fluctuations in cassava volumes, average yields and area cropped between 1971 and 2014 in the country – assumed to be partly associated with the impact of climate variability (Figures 11, 12 and 13).

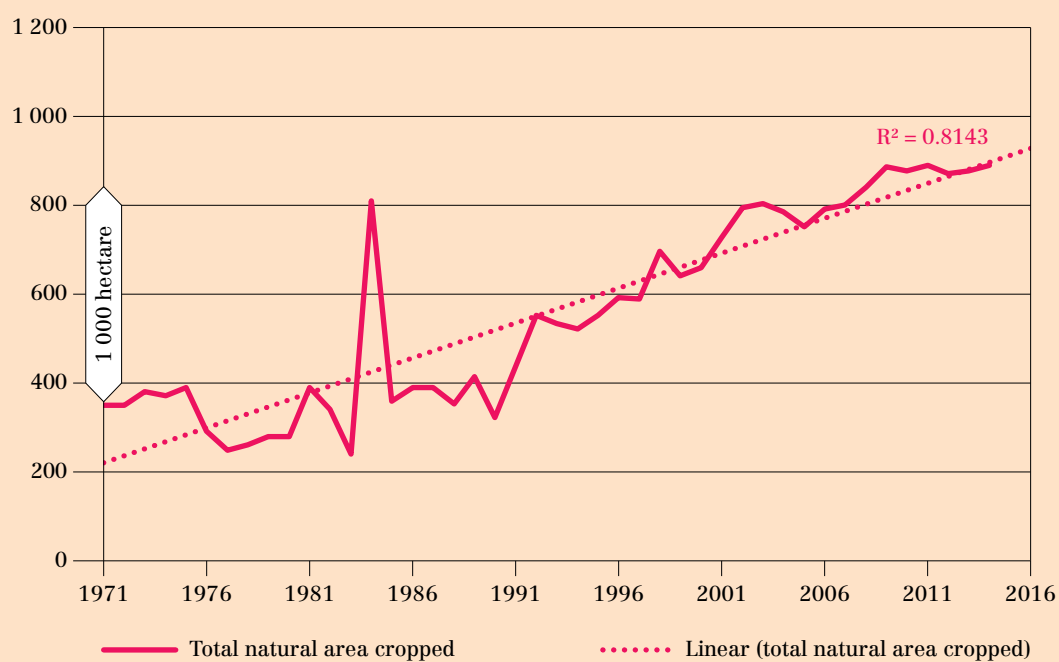
◆ **FIGURE 11** Cassava production in Ghana between 1971 and 2014



Source: African Roots and Tubers project, FAO.

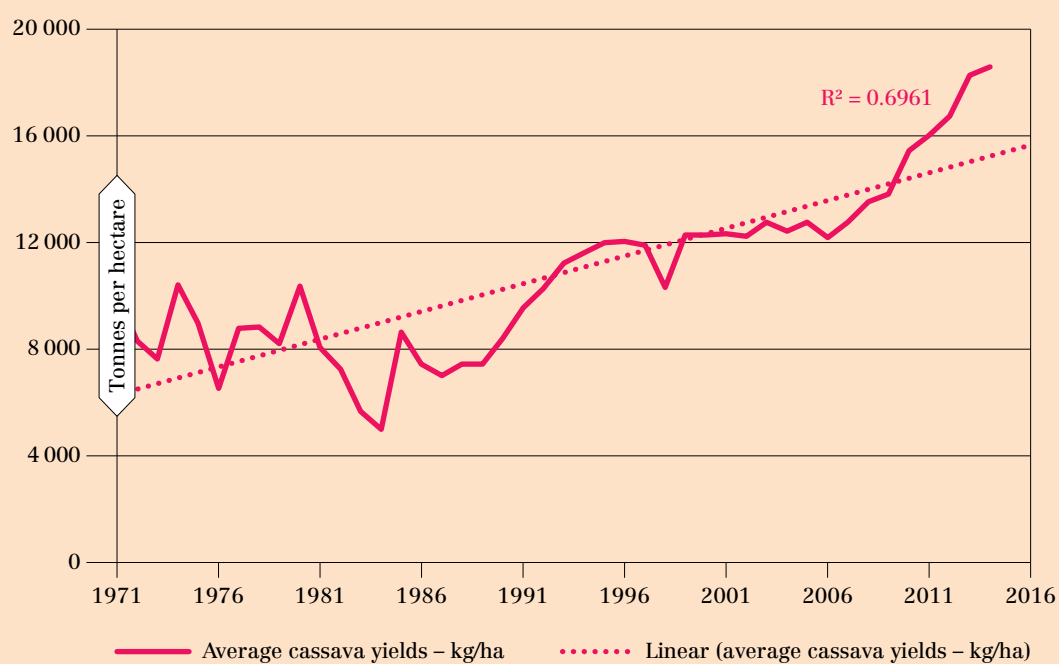
<sup>5</sup> Regression analyses of intra-seasonal, inter-seasonal (annual total) rainfall and intra-seasonal maximum and minimum temperatures, and annual maximum and minimum temperatures as well as Principal Components Analysis using the following variables: cassava yields, area planted for crops, annual rainfall volumes, average annual temperature, and potential evapotranspiration.

◆ **FIGURE 12** Total national cassava area cropped in Ghana between 1971 and 2014



Source: African Roots and Tubers project, FAO.

◆ **FIGURE 13** National average cassava yields per unit area in Ghana between 1971 and 2014



Source: African Roots and Tubers project, FAO.

The correlation analysis presented a significant indication of causal relationship values ( $R^2$ ) for the following: cassava volumes - 0.85; total area cropped - 0.81 and average yields - 0.70. These could be explained with the time (Figures 4, 5 and 6) and could be attributed to the number/ amount of rainfall, temperature changes, soil nutrient levels, varieties cropped, management systems and land available, as well as national policies and schemes supporting the sector.

Further statistical analyses were carried out to establish a causal relationship between average yield and total production volumes with annual rainfalls and temperatures (Tables 2 and 3), gathering data from the five stations of the Ghana Meteorological Agency (GMET) in *Damongo*, *Saltpond*, *Kpando*, *Krachi* and *Apam*. Annual rainfall seems not to significantly influence the causal relationships between average yields and total volumes of cassava production. Except for the case of *Krachi*, annual rains exhibited irrelevant positive relationships.

♦ **TABLE 2** Correlation statistics between average national cassava yields and climate variables in 5 GMET stations in Ghana

GMET stations	Annual rainfall	Temp. minimum	Temp. maximum
<b>Apam</b>	0.08	0.54	0.50
<b>Damongo</b>	0.06	-0.01	-0.38
<b>Kete krachi</b>	-0.16	0.42	0.50
<b>Kpando</b>	0.09	0.72	0.19
<b>Saltpond</b>	0.31	0.72	0.69

Source: African Roots and Tubers project, FAO.

♦ **TABLE 3** Correlation statistics between average national cassava production and climate variables in 5 GMET stations in Ghana

GMET stations	Annual rainfall	Temp. minimum	Temp. maximum
<b>Apam</b>	0.03	0.61	0.57
<b>Damongo</b>	0.005	-0.23	-0.38
<b>Kete krachi</b>	-0.13	0.49	0.63
<b>Kpando</b>	0.10	0.78	0.33
<b>Saltpond</b>	0.03	0.82	0.75

Source: African Roots and Tubers project, FAO.

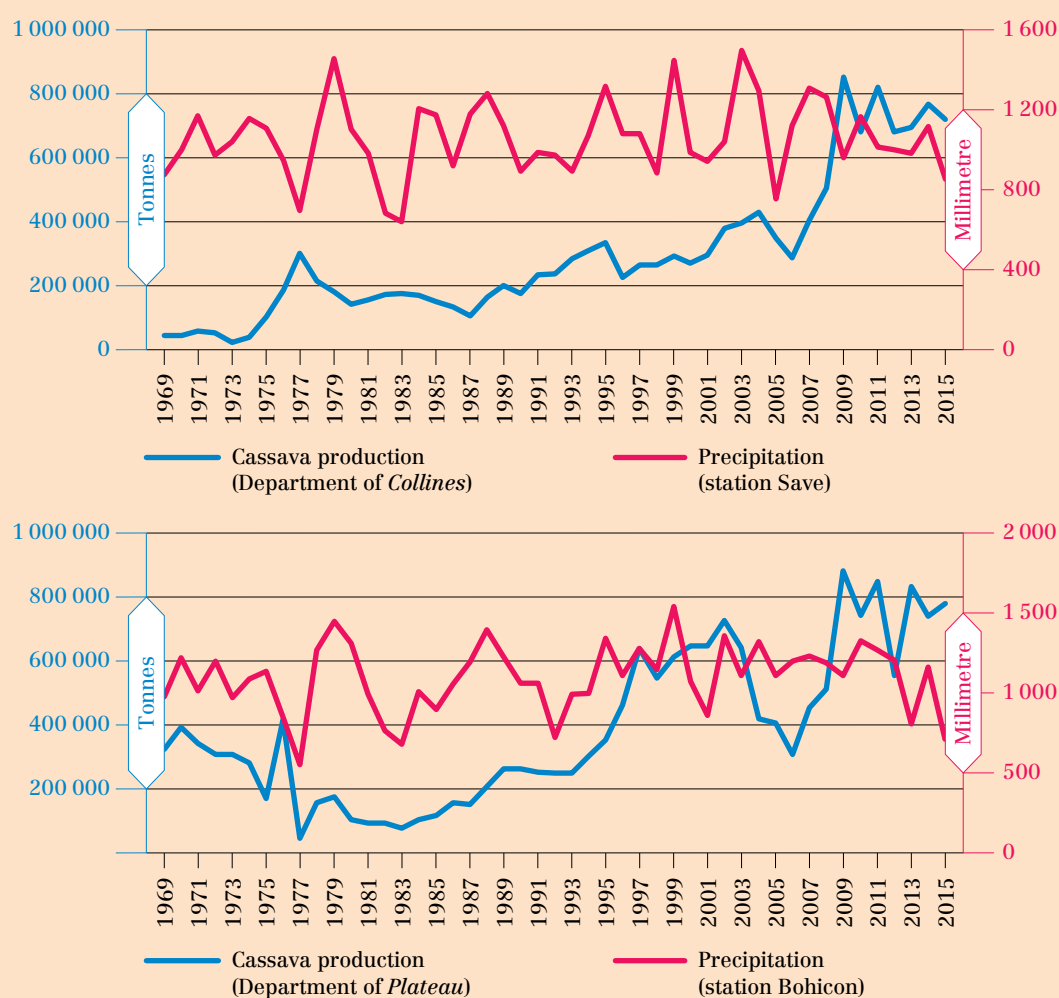
Temperature changes significantly influence cassava average yields (Table 2) and total production volumes (Table 3). Except for *Damongo*, which indicated a negative relationship for both minimum and maximum temperature, all the other areas show positive relationship, an indication that increase in temperature may cause a corresponding increase in cassava yields and total volumes in these locations. Between 42 and 82 percent of the changes

in the average yields and total volumes of cassava production could be explained by the minimum temperature and about 33 to 75 percent by the maximum temperature. Increasing temperatures in *Apam*, *Krachi*, *Kpando* and *Saltpond* would then increase production volumes and average cassava yields (time series analyses of temperature variations – minimum, maximum and average – are included in Annex 2).

According to the national statistics, from the 2000s, in **Benin** cassava yields increased considerably, from less than 10 000 kg to 15 000 kg per hectare.

By comparing the evolution of production with annual rainfall from 1969 to 2015 – assuming a relationship between climate events and crop yields and production – in cassava-cropped areas of Benin,<sup>6</sup> results show that highest production levels, reached in 2009, were associated with above-average rainfall levels but not the converse. In fact, heavy rainfall periods in 1997, 1999 and 2003 did not correspond to particular production levels (Figure 14).

◆ **FIGURE 14** Time series comparing cassava production and annual rainfall between 1969 and 2015 in Benin



Source: African Roots and Tubers project, FAO.

<sup>6</sup> Areas of cassava production studied in the present analysis: *Adja-Ouère* (Department of Plateau), *Savalou* (Department of Collines), *Djakotomey* (Department of Couffo), *Tchaourou* and *Nikki* (Department of Borgou) and *Djougou* (Department of Donga).



The multivariate correlation analysis (Table 4) undertaken under this study confirms that there is low statistical significance between annual precipitations from 1969 to 2016 and cassava yields (8 percent). The low correlations could be explained by the physical characteristics of cassava, which is able to absorb water slowly from the ground and reduce the size of its leaves during water shortages, making it resilient to water shocks.

♦ **TABLE 4** Correlation statistics between average national cassava yields and climate variables in Benin

Variables	Planted area	Yields (kg)	Production	Potential evapotranspiration	Cumulative annual rainfall	Mean annual temperature
<b>Planted area</b>	1.00					
<b>Yields (kg)</b>	0.19	1.00				
<b>Production</b>	0.92	0.45	1.00			
<b>Potential evapotranspiration</b>	-0.32	-0.15	-0.29	1.00		
<b>Cumulative annual rainfall</b>	-0.5	0.08	-0.03	0.00	1.00	
<b>Mean annual temperature</b>	0.56	0.40	0.61	-0.36	-0.11	1.00

Source: African Roots and Tubers project, FAO.

By contrast, cassava production and yields were found to be significantly correlated with mean annual temperature: 61 percent and 40 percent, respectively. As Benin registered the highest temperature increase among the countries analysed from 1991 to 2015 (+ 0.8 °C)<sup>7</sup> as well as increased recurrence of dry spells and floods (2011, 2012, 2013), root crops like cassava could represent an alternative to more vulnerable crops (such as maize).

In 2011, total production of cereals at national level accounted only for 1.5 million tonnes, against the 6.4 million tonnes of R&T (FAOSTAT, 2018). In 2016, R&T production reached 7.4 million tonnes, over 1.8 million tonnes higher than the production of cereals. These figures are not only linked with unfavourable climatic conditions, but also influenced by the Government's interventions<sup>8</sup> in the R&T sector.

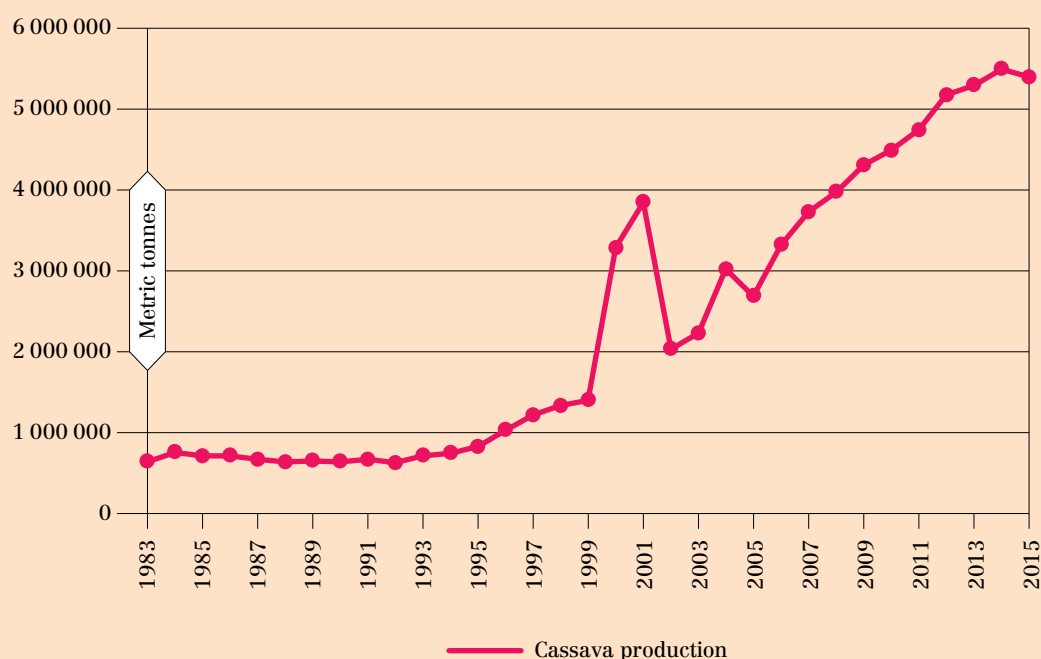
However, degraded areas originally dedicated to maize are increasingly used for cassava production, which has also less soil fertility requirements – comparing with other crops (Oakland Institute, 2018).

<sup>7</sup> Mean annual temperature.

<sup>8</sup> For example the Government's *Projet de développement des racines et tubercules* and *projet d'appui à la croissance économique rurale* (Roots and tubers development project and Support to economic growth in rural areas project).

Increasing levels of cassava production were found also in **Malawi**. As showed in Figure 15, production started to rise dramatically in 1995 after severe droughts associated with El Niño Southern Oscillation occurred the biennia 1991/1992 and 1993/1994.

◆ **FIGURE 15** Cassava production in Malawi 1983–2015



Source: African Roots and Tubers project, FAO.

In the years following these climate shocks in Malawi, cassava became a Government priority crop for the agriculture sector as means to promote food security due to its resistance to drought and water stresses. Switching from maize to cassava – partially or entirely – could raise small farmers' productivity, decrease food insecurity during unfavorable seasons and drought periods, and support rural households with inexpensive in-kind drought insurance. The promotion of cassava between 1994 and 1999 also helped the country to reduce its dependency on cereal aid and imports during droughts (FAO, 2014). This could be attributed to increased dependence on cassava and sweet potatoes as alternative sources of food.

According to FAO, weather forecasts for the period December 2018–March 2019 point to a higher likelihood of below-normal rainfall in Southern Africa, including Malawi. This period coincides with the critical reproductive phase of crops like maize. In these critical seasons, cassava could play an important role for farmers.

Besides the project countries, rural communities of neighboring states such as Tanzania, Zambia and Zimbabwe are moving away from growing traditional crops and switching to cassava not only as a food crop but also as a cash crop. This is happening through increased formal and informal commercialization of the cassava roots, and also through growing rural and urban markets for cassava-processed products: high-quality cassava flour, dry cassava, chips, scones, cakes and biscuits. Small and medium processing units are emerging in rural communities, enabling producers to turn their crops into value-added products to process and sell on for further processing, creating a steady income source and improving household food security.

However, cassava seems not to be entirely immune to the climatic variations occurring in sub-Saharan Africa.

In other countries analysed, climate variability was found to be threatening this resilient crop as well. Mean annual temperatures seem to be significantly associated with lower cassava yields and evapotranspiration in the eastern region of **Cameroon** (as shown in Table 5), an area characterized by a high level of cassava production. Specifically, the negative correlation between cassava yields and temperatures is equal to 40 percent. Considering that the World Bank's data show that mean annual temperatures have increased 0.7 °C since the 1960s and have risen most rapidly during March-May at a rate of 0.19 °C per decade over all of Cameroon (CCKP, 2019), cassava farmers in the eastern region could be severely exposed to increasing temperatures.

♦ **TABLE 5** Correlation statistics between average national cassava yields and climate variables in Cameroon (eastern region)

Variables	Planted area	Yields (kg)	Production	Potential evapotranspiration	Cumulative annual rainfall	Mean annual temperature
<b>Planted area</b>	1.00					
<b>Yields (kg)</b>	-0.68	1.00				
<b>Production</b>	0.8	-0.12	1.00			
<b>Potential evapotranspiration</b>	-0.09	-0.13	-0.26	1.00		
<b>Cumulative annual rainfall</b>	0.28	0.03	0.27	0.25	1.00	
<b>Mean annual temperature</b>	0.17	- 0.40	- 0.13	0.23	0.06	1.00

Source: African Roots and Tubers project, FAO.

These results suggest that R&T farmers need to be prepared to reduce the negative impacts of climate risk through efficient use of water and soil nutrients, as well as by considering the adoption of the recently released cassava varieties that bulk earlier and are therefore highly productive (yields range from 35 to 60 tonnes/ha) to increase productivity per unit area.

### 3.5 Constraints to be addressed along with climatic risks for roots and tubers

In addition to climatic risks, R&T production and commercialization are limited by the following constraints, which add to the impact of climate variability and change, and pose further barriers to the development of these industries:

- ◆ lack of quality/resilient varieties to better resist climate shocks;
- ◆ limited availability of and access to adequate climate information to properly adapt to variable weather patterns;
- ◆ lack of information on market prices, and more specifically on increased prices fluctuations caused by climate variables;
- ◆ limited or poor storage conditions for agricultural commodities and water;
- ◆ absence of or limited access to agricultural risk finance products for R&T (emergency agricultural loans and insurance);
- ◆ climate-related outbreaks of pests and diseases affecting production;
- ◆ increasing farmer-to-market transportation costs during weather extremes (roads, railway or water);
- ◆ reduced performance of agricultural chemicals during heavy rains.

### 3.6 Integrating climate risk management in the roots and tubers sector

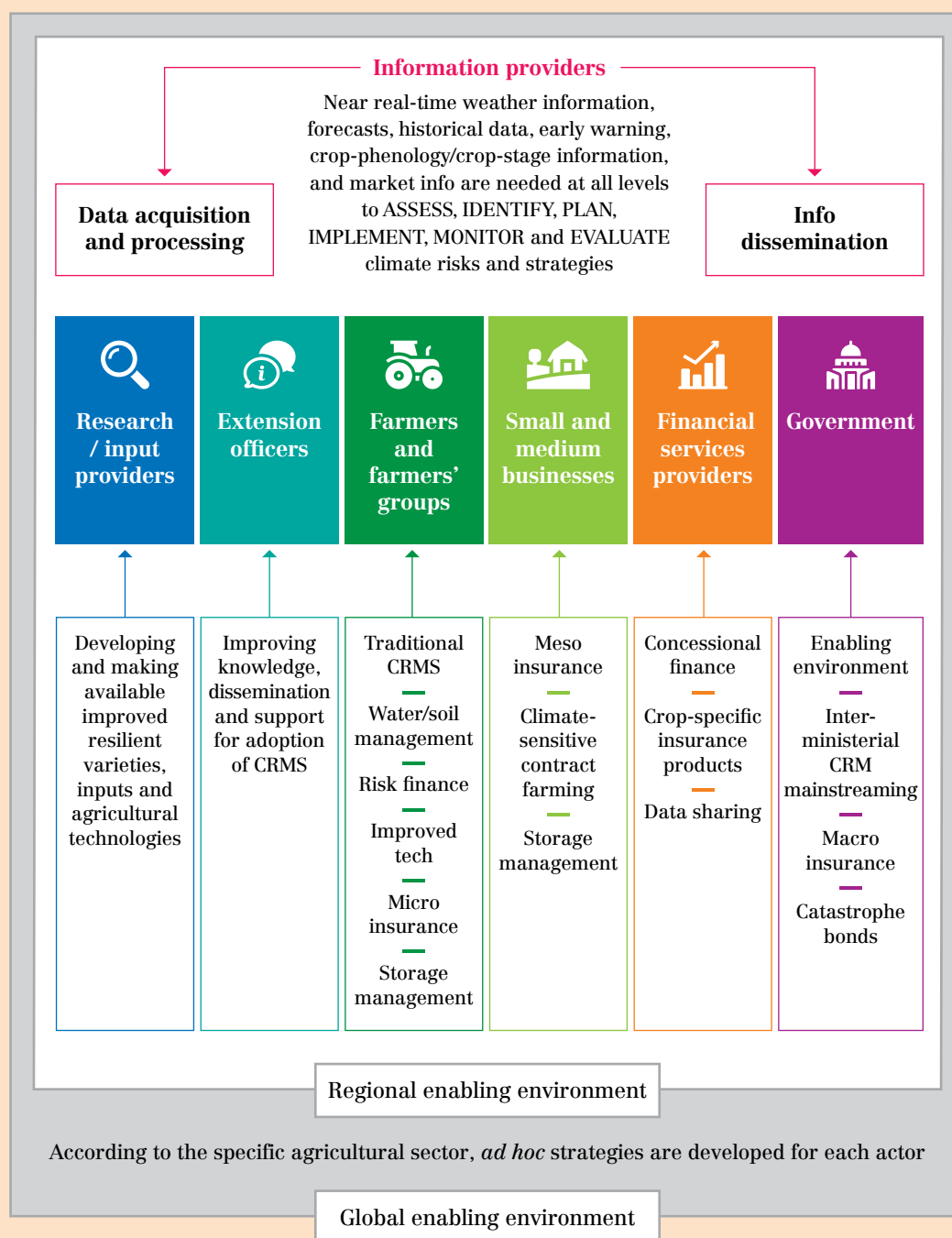
As discussed in the previous section, crops like cassava may be used to reduce the impact of climate variability on food insecurity, due to their higher resistance to drought conditions and water stress. However, as for the case of *Damongo* district of Ghana, and the eastern region of Cameroon, production losses could still be associated directly (e.g. dry spells, floods, temperature fluctuations) or indirectly (e.g. poor seed quality, soil conditions, agricultural practices and storage; credit constraints) with climate-related risks (see also Table A.3 and Figure A.1 of Annex 3).

Farmers cropping cassava in areas with a negative relationship between average yields and minimum and maximum temperatures need to become more aware of the best planting time, in accordance with the variation of the climate. Lower atmospheric temperatures will result in low soil temperatures and therefore poor field establishment, with a subsequent low production.

In order to manage the direct and indirect impacts of changes in short- and long-term weather patterns, as well as natural hazard-induced disasters, it is of utmost importance to develop proper CRM strategies which simultaneously target different actors of the same value chain. The present study proposes a specific framework, as per Figure 16, for mainstreaming climate risk management in the roots and tubers sector.

One of the ART project lessons learned is that CRM strategies (CRMS) for R&T need to target different actors directly and indirectly engaged in the sectors, notably: (i) research and input providers developing and making available new or improved resilient agricultural inputs; (ii) district officers building their capacities and disseminating knowledge on climate services and CRMS at field level; (iii) farmers and farmers' groups implementing climate change adaptation (CCA) and disaster risk reduction management (DRRM) at individual and community levels; (iv) SMEs mainstreaming climate resilience in their businesses; (v) FIs developing and providing credit and risk transfer products targeting the R&T sectors; and (vi) governments designing and implementing policies for food security, CCA and DRRM.

◆ **FIGURE 16** Framework for mainstreaming climate risk management in the R&T sector



Source: African Roots and Tubers project, FAO.

Developing and adopting CRMS for each actor requires functional and adequate information systems to be in place. For example, farmers need information related to onset rains to plan for their planting season; district officers seek information to make decisions for their annual development or emergency budget plans. The paragraphs that follow propose some of the possible CRMS targeting the R&T sectors, including gaps and examples from the countries analysed.

CRM involves a preliminary step that identifies the risk involved, then an assessment process of adaptation options, and lastly the implementation of the selected option(s) for each actor. This section focuses on two aspects of risk treatment, identifying and assessing some adaptation options specific for cassava, yam and Irish potatoes.

### Climate information and services

**Actions required:** Dissemination of regular information on R&T prices, weather and climate, farming advice through SMS, mobile application, television, radio, community leaders (*community level*); or technical information products – Earth or national and local observations (based) – for decision-makers (*institutional level*).

**Constraints:** Lack of regular, clear, context-specific and reliable information on market prices and weather and climate for producers and relevant institutions; lack of farming advice for specific crops and information in local languages; limited number of synoptic stations and alignment with World Meteorological Organization's (WMO) standards; general absence of historical and projected hydro- meteorological data and inappropriate spatial resolution; lack of farmers' as well as government officers' capacity on data interpretation; indigenous knowledge of rainfall calendar and forecasting not integrated with innovative approaches.

**Responsible institutions for implementation:** research/input providers; district officers; governments.

**Role of the government:** Raise awareness and promote the use of technology for dissemination of good practices (e.g. radio, video); strengthen linkages with NMAs and international actors operating in the field of climate information; ensure multi-stakeholder participation in the development and dissemination of climate information (with focus on farmers' inclusion in the design, production and evaluation of climate services).

**Examples:** In Rwanda the ART project is working closely with the NMA (Meteo Rwanda), the WMO and the FAO project "Agricultural services and digital inclusion" to develop a progressive web-app (PWA) which can provide small potato farmers with information on market prices, weather and crop calendars and additional farming advice specifically for the Irish potato sector.

### Multilevel coordination for climate information at the institutional level

**Actions required:** establishment of institutional or technology-based platforms where officials from ministries of agriculture and decentralized offices can exchange information with NMAs and disseminate and interpret weather forecasts in order to plan, implement and monitor climate-sensitive agricultural initiatives.

**Constraints:** Operational units lack of climate data, qualified personnel, proper observation equipment and knowledge at all levels to make projections and develop climate adaptation strategies in agriculture, especially for the recently growing R&T sectors; ministry of agriculture-NMA consultation is weak or restricted to cases of imminent disasters or emergency response.

**Responsible institutions for implementation:** Government officials at national and district levels; NMAs.

**Role of the government:** Strengthen collaboration between NMAs and operational units all levels; increase capacity of ministry of agriculture officers to use climate data for policy-making in agriculture; improve the legislative and regulatory framework for data collection; increase investments and collaborate with the private sector to strengthen infrastructures for climate information and harmonization with WMO standards.

## Improved varieties

**Actions required:** Development and use of improved varieties to overcome yield losses linked with climate variables; combining the use of resilient varieties with improved agronomic practices (proper rotation, use of adequate quality and quantity of fertilizers and pesticides) to increase profitability; establishment of seed/stem banks and seed multiplication activities to reduce prices of seed, while creating business opportunities.

**Constraints:** Informal sector still dominant and price of certified seeds mostly unaffordable for farmers; long certification process.

**Responsible institutions for implementation:** Extension officers, farmers' groups.

**Role of the government:** Commission qualitative and quantitative studies on yield performance as well as econometric analyses; stimulate increased production of commercial, certified resilient varieties, while simultaneously improve quality and control in the informal sector; improve regulatory framework for seed certification; facilitate small farmers' access to agricultural input credits.

**Examples:** In Ghana, the ART project in collaboration with research centres and the Ghana Meteorological Agency developed a study to find the most resilient cassava varieties according to the current weather conditions. Suggestions include the use of *CRI-Bankyehemaa*, *Afisiati*, *Ampong*, *Broni-bankyi*, *Sika-bankyi* and any of the recently released cassava varieties (*CRI-Abrabopa*, *Amansan*, *Duadekpapkpapa*, *Dudzi*, *AGRA-bankyi*, *Lamesese*), which are highly productive (yields range from 35 to 60 tonnes/ha) due to their potential to use soil and water efficiently and can thus increase productivity per unit area. The Rwanda Agriculture Board, an autonomous body established by the Government of Rwanda to bridge the gaps between research and extension, as well as policy linkages, developed and started distributing five new Irish potato varieties to farmers, which are resistant to adverse weather conditions, in order to increase farm yields at the end of November 2018. The innovative varieties are the result of the Board's work over the past five years on 43 potato breeds imported from Peru.

## Improved agricultural products

**Actions required:** Introduction and utilization of new fertilizers that require less rainfall and/or withstand high temperatures or floods; use of manure fertilizers.

**Constraints:** Pest and disease outbreaks that reduce R&T quality and quantity – such as cassava virus mosaic disease, cassava bacterial blight and termites for cassava or *Rhizoctonia*, *sclerotinia*, *black leg*, *powdery mildew*, *powdery scab*, *leaf roll virus* and *late blight* for Irish potatoes – and are exacerbated by absent or extreme rainfall and increased temperature (depending on the agro-ecological zone analysed); certified chemical products unavailable in the markets or unaffordable; excessive precipitation during spraying periods reduce the amount of pesticides on crops, leading to high input costs and losses.

**Responsible institutions for implementation:** Extension officers, farmers' groups.

**Role of the government:** Commission of studies; public-private partnerships to disseminate knowledge and good practices.

**Examples:** In Uganda, potato farmers have learned through FFS how to utilize organic manure. As result in 2017, the Kirundo Growers Potato Cooperative, located in a flood-prone area of the country, reinvested a share of its profits to provide a sheep to each farmer who substituted fertilizers with organic manure.



## Climate change adaptation and disaster risk reduction and management curricula for Farmer Field Schools

**Actions required:** Development and delivery of CCA and DRRM curricula specific to potato, cassava and yam, using group-based learning process (FFS) to improve agricultural production and productivity. The curricula could include: (i) climate-resilient cropping systems management; (ii) soil and water management; (iii) conservation agriculture and agroforestry; (iv) introduction to meteorology and weather analysis; (v) understanding climate information and early warning systems; and (vi) DRRM practices in agriculture.

**Constraints:** Curricula rarely available for specific crops like R&T; whenever good practices exist for Irish potatoes, cassava and yam, they are not translated into local languages.

**Responsible institutions for implementation:** Extension officers, farmers' groups.

**Role of the government:** Commission curricula development including CCA and DRRM for cassava, yam and Irish Potatoes; promote collaboration among NMAs/extension officers/research institutions to integrate crop calendars and climate-sensitive farming practices into FFS curricula.

**Examples:** In Malawi, in collaboration with the World Food Programme (WFP) and the National Department of Climate Change and Meteorological Services, the ART project is strengthening the capacity of extension officers and cassava farmers' leaders on participatory tools to develop and improve cassava and other crops according to the weather conditions, livestock and livelihood options best suited to individual farmers' circumstances. In Uganda, the project developed CCA curricula specific to the Irish potato sector in local languages, including meteorological terminology, with guidelines for simple understanding as well as location-specific CRMS for potato farmers (see Annex 1).

## Climate-sensitive local development plans

**Actions required:** Incorporating climate considerations into district plans, including CCA and DRRM-oriented actions targeting specific sectors (in this case R&T).

**Constraints:** Gaps between community adaptation plans and local government planning process in targeted sectors of agriculture; lack of district officers' capacity (financial and technical) to mainstream CCA and DRRM.

**Responsible institutions for implementation:** District officers and NMAs.

**Role of the government:** Strengthen the capacity of decentralized offices on CCA and DRRM in agriculture as well as on climate adaptation for R&T; develop guiding principles for district officers on climate change mainstreaming into development plans.

**Examples:** In Uganda, the ART project developed a guide to advise the district leadership in potato production areas on how climate change activities can be incorporated into the district development plans in collaboration with the Uganda National Meteorological Agency.

## R&T processing, value addition products and improved storage structures

**Actions required:** Development of climate-sensitive processing strategies, such as improved storing and packaging materials to reduce production losses linked with climate; development of contract farming arrangements, including climate-sensitive farming requirements, to influence farmers in adopting coping and adaptation strategies.

**Constraints:** Lack of small producers' capacity on value addition and processing techniques; lack of investments by the private sector in processing facilities and packaging material to withstand the potential impacts of climate change (e.g. extreme weather events,



pest infestations); lack of knowledge on climate-resilient processing strategies, requirements and standards; inappropriate storage facilities or located in vulnerable areas; lack of proper measures for handling, conditioning, transportation and proper storage.

**Responsible institutions for implementation:** Technical assistance providers, SMEs.

**Role of the government:** Commission studies to develop resilient techniques for processing; promote private sector investments in packaging materials maintaining quality and safety under climate risks, such as extreme heat; improve regulations and raise awareness on smart temperature- controlled packaging; develop market-based instruments such as subsidies/tax exemptions, which may also be considered to encourage the development of the value chain.

### Crop-specific insurance products against climate risks

**Actions required:** Development of specific agricultural insurance products. As a risk management instrument, insurance can be adopted at different levels: (i) at macro level, for governments to improve their capacities to plan, prepare and respond to extreme weather events and natural hazard-induced disasters; (ii) at meso level, financial institutions and different aggregators (e.g. farmers' organizations, cooperatives) could purchase it to reduce their own exposure to risks and create payout rules that directly or indirectly benefit farmers; and (iii) at micro level, farmers, households and SMEs could purchase it to avoid default and restart production, as it would compensate for additional costs, provide income support in lean periods, supplement other sources of household income that may be disrupted, facilitate access to credit, and encourage investment in higher-quality inputs.

**Constraints:** General lack of understanding of the products, contracts and economic returns; absence of minimum quality standards; high costs for individual policies; poor indices design; limited resources for farmers to pay the premium upfront; lack of trust toward insurance companies; absence of hybrid (crop- and peril-specific) products; lack of channels to collect payouts (mobile phones, bank accounts); late payouts when policies are available; limited support from the government or, when available, difficulty to understand funding requirements; limited data on agricultural losses to develop business opportunities; scattered demand by R&T small producers; lack of technology to lower the costs; lack of integration of insurance schemes with customized early warning, information services, and capacity building activities on CCA and DRR farming; lack of coordination with financial service providers, input suppliers or mobile operators for bundled products; weak regulations and link between micro insurance and social protection; lack of coordination between financial actors, government and potential beneficiaries; focus only on farmers and not on enabling the environment for sustainable market development; lack of value proposition analysis (client value as well as value for donors, insurers and/or the public sector) before, during and after implementation of the insurance scheme.

**Responsible institutions for implementation:** Insurance companies and/or FIs partnering with services providers and public agencies which would support all the non-financial costs (see the role of the government below).

**Role of the government:** Raise awareness on insurance products and innovation for climate risks, sharing products at all levels; support insurance as a social protection measure (for micro insurance); establish public-private partnerships for product and market development, as well as for information sharing; commission cost/benefit analyses for agricultural insurance for R&T; invest in weather infrastructures providing accurate information for claim assessments; improve regulations and work together with FIs and insurance companies to support the development of alternative payment methods.

**Examples:** In Uganda, the ART project assisted vulnerable farmers to access tailored agricultural insurance products against climate risks. By partnering with government

officials, Uganda NMA, the Uganda Potato Platform, the Uganda Agribusiness Alliance and the country's Insurance Consortium, the project developed a unique index-based insurance product for Irish potatoes which compensates farmers when drought hits. The cost of the premium will be 5.5 percent of the yield value (partially covered by government subsidies of 30 to 70 percent of the premium, according to farmers' location and farm size). According to the needs of the potato producers' communities, a hybrid product is under development to cover district-specific climate risks.

### 3.7 Recommendations for policy-makers

Even if R&T crops may have the potential to be more tolerant to climate shocks when compared with other primary crops (e.g. maize), production and productivity were still found to be affected by adverse weather conditions emanating from climate change and climate variability in the countries analysed. Increasing temperatures, extreme rainfall, recurrent droughts and floods could result in great losses in terms of R&T yields and production.

In addition to direct climate factors, other indirect climatic elements – such as vulnerable crop varieties, pest and disease outbreaks following climate shocks, or poor farming methods – were found to affect R&T production as well as the livelihoods of small producers. The sustainability of these sectors and their production potential may be linked with the ability of R&T actors to reduce their vulnerability to risks and manage the ones associated with climate events, which could even increase in frequency, intensity and extent in the future. Various strategies can be implemented at different levels to adapt to climate variability and build resilience in the sectors.

The following recommendations have been formulated to strengthen CRM for the R&T sectors. The recommendations are based on four years of implementation of CRM activities under the ART project as well as through regional and national consultations with a broad range of partners to assess CRM needs according to the different R&T crops and geographical locations, in particular with the support of the NMAs in the project countries.

- ◆ **Integrate CRM into agricultural development policies and planning to anticipate, prevent or more effectively manage production crises**, especially when value chain development is targeted. CRM could be addressed as a development and a business opportunity from all the actors of the value chain (through climate-related financial products and small, medium and large investments to build resilient agricultural activities, as well as to enable the transition to a low-carbon agricultural sector).
- ◆ **Develop an inclusive strategy for climate services** which combines investments to improve climate information systems at central and local levels (infrastructures), strengthen collaboration with international climate services organizations, and place greater emphasis on the dissemination of open data from NMAs to other climate information processors (e.g. platforms, UN agencies, research centres), increasing availability as well as accuracy of climate information for end-users. Engaging with local actors (e.g. cooperatives, FFS) is crucial to contribute to the development and dissemination of climate information in local languages, including location-specific production options.
- ◆ **Build the capacity of agricultural units at all levels regarding climate modelling, risk assessment and management tools**, including greater coordination with respective national meteorology agencies and ministries of disaster management to effectively integrate climate considerations into local and national agricultural development plans.
- ◆ **Recognize and encourage the role of the private sector in addressing CRM**, such as integrating specific climate regulations into farmer-agro-industry contract farming contracts or promoting group farming to facilitate the adoption of coping and adaptation

strategies. Market-based instruments such as subsidies/tax exemptions may also be considered to encourage the use of improved production practices to encourage climate-resilient value chains.

- ◆ When the development of climate insurance schemes for agriculture is considered, **start by organizing regular spaces of dialogue between key R&T value chain leaders, NMAs, formal and informal FIs and insurers. Leverage existing local institutions to raise awareness** and to ensure that risk transfer mechanisms are designed to properly address the climate needs of smallholder farmers. Over time, such meetings can be upgraded to stable fora and innovation platforms (physical and digital) for information exchange. Successful cases of insurance schemes based on a one-to-one interaction between insurers and farmers are very limited; rather, insurance schemes should be developed using an inclusive framework which targets various value chain actors (e.g. aggregators, farmers' groups, FIs, regulators, mobile operators, input suppliers). If partially or entirely government-funded, these schemes should have an ex ante plan to move gradually from subsidy-based to investment-based in order to be sustainable. This will require greater collaboration with the private sector.

## 4 Conclusions

In a long-term perspective, the increasing demand for R&T commodities – in sub-Saharan Africa and beyond – is likely to be met, given the recent and prospective trends in the sector. This will be due to a projected increase in production and productivity resulting from larger investments in the sector. The question is whether these results will enable the inclusion of small actors of the related value chains, especially producers and processors, who would become reliable peer partners of larger actors of a robust, deftly conceived institutional framework.

The regional production and commercial trends of the cassava and potato industries, together with the experiences documented in the case studies, appear to indicate the existence of a sub-optimal scenario, where an important part of the demand from small and medium agribusinesses for specialized financial services is largely unmet. Lack of existing specific CRM tools makes it more difficult for investments and financing to take place. Providers of finance observe a range of finance-related bottlenecks and challenges, leading to a perception of the sector as high risk, and discouraging them from providing finance. This results in unexploited agribusiness opportunities for this population segment, also as a result of the technical support provided in the past four years by the ART project implemented by FAO. Therefore, there is a need to intervene at different levels.

On one side, it is of utmost importance to facilitate access to information on market trends and value chain dynamics to FIs, so that they can properly assess business opportunities and overcome their lack of knowledge across value chains and about typical agri-business economics. This can be achieved through ad hoc technical assistance, and effective interaction with value chain actors, and with the support of public agencies and donor organizations to transfer non-financial costs. On the other side, tools need to be developed to manage the progressive effects of climate risks on traditional agronomic risks, which may fundamentally change the potential productivity and locations for cultivation. Among them, climate information services, CCA curricula and insurance will be highly relevant for safeguarding production and strengthening the position of smallholder farmers and processors vis-à-vis the other actors in the value chains.

As can be seen from the evidence presented, the solutions to unlock the full investment potential of R&T value chains in the region lie in a blend of macro and micro interventions that are tailored to each country's constraints and opportunities in the sector. The cases discussed in this technical study are a testimony that, although countries share similar challenges when it comes to financing R&T value chains, only tailored and context-specific policies have a chance to become sustainable.

However, in order to enable further experiences of a sustainable supply of specialized financial services to the small actors of the R&T value chains, a dialogue between financial institutions and different economic actors of the value chains needs to be established to facilitate information exchange, under the coordination of public programmes, and the capacities of such actors and of financial institutions needs to be built, through the technical assistance of specialized national and international supporting agencies.

The present study provides relevant implications for policy-makers who seek to develop solid and integrated R&T value chains, in which the competitiveness of small actors is improved through access to financial and CRM services, thus making it possible for them to establish relevant market linkages with larger actors. The evidence and the examples presented in this technical study can support policy-makers, development agencies and

market stakeholders in establishing a fruitful discussion – revolving around the main opportunities and constraints defined within R&T value chains – that can lead to concerted efforts to unlock the full investment potential of these extremely promising (and often undervalued) commodities.

# References

- Alemaw, B. & Simalenga, T.** 2015. Climate Change Impacts and Adaptation in Rainfed Farming Systems: A Modeling Framework for Scaling-Out Climate Smart Agriculture in Sub-Saharan Africa. *American Journal of Climate Change*, 4(4): 313–329.
- Dalberg Global Development Advisors.** 2012. *Catalysing Smallholder Agricultural Finance*. Washington DC, Dalberg Global Development Advisors.
- Dalberg Global Development Advisors.** 2015. *Market Opportunities for Commercial Cassava in Ghana, Mozambique and Nigeria*. Washington DC, Dalberg Global Development Advisors.
- FAO.** 2013. *Save and Grow: Cassava A guide to sustainable production intensification*. Rome.
- FAO.** 2014. *Corporate Document Repository: Malawi*. Rome.
- FAO.** 2015. *The impact of disasters on agriculture and food security*. Rome.
- FAO.** 2016. *Food Outlook: Biannual Report on Global Food Markets - October 2016*. Rome.
- FAO.** 2017a. *Assessment of Financial Services in the Potato Value Chain in Rwanda*. Study commissioned by the African Roots and Tubers project. Rome.
- FAO.** 2017b. *Assessment of Financial Services in the Potato Value Chain in Uganda*. Study commissioned by the African Roots and Tubers project. Rome.
- FAO.** 2017c. *Climate-Smart Agriculture Sourcebook*. Rome.
- FAO.** 2017d. *Etude pour l'évaluation du marché financier agricole du Bénin*. Study commissioned by the African Roots and Tubers project. Rome.
- FAO.** 2017e. *Evaluation du marché financier agricole au Cameroun: Focus sur la Chaîne de valeur du manioc*. Part of the Roots and Tubers Project Reports. Rome.
- FAO.** 2017f. *The impact of disasters on agriculture and food security*. Rome.
- FAO.** 2018. *Crop Prospects and Food Situation Quarterly Global Report, December 2018*. Rome.
- FAO & International Fund for Agricultural Development (IFAD).** 2001. *The global cassava development strategy and implementation plan – Volume 1*. Proceedings of the Validation Forum on the Global cassava Development Strategy. Rome, 26–28 April 2000. Rome.
- Intergovernmental Panel on Climate Change (IPCC).** 2014. *Climate Change 2014 – Impacts, Adaptation and Vulnerability*. Cambridge, UK, Cambridge University Press.
- Jarvis, A., Ramirez-Villegas, J., Herrera Campo, B.V. & Navarro Racines, C.** 2012. Is Cassava the Answer to African Climate Change Adaptation? *Tropical Plant Biology*, 5(1): 9–29.
- Lobell, D.B.** 2008. Prioritizing climate change adaptation needs for food security in 2030. *Science*, 319(5863): 607–610.
- Matiu, M., Ankerst D.P. & Menzel A.** 2017. Interactions between temperature and drought in global and regional crop yield variability during 1961-2014. *PLoS ONE*, 12(5): e0178339.
- Miglietta, F., Bindi, M., Vaccari, F.P., Schapendonk, A.H.C.M., Wolf, J. & Butterfield, R.E.** 2000. Crop Ecosystem Responses to Climatic Change: Root and Tuberous Crops. In K.R. Reddy & H.F. Hodges. *Climate Change and Global Crop Productivity*, pp. 189–212. CAB International.

- Miller, C.** 2017. *How to Unlock Investments in Agricultural Sectors with Potential for Growth*. Presentation provided during a workshop organized by the Roots and Tubers project in Addis Ababa, Ethiopia, as part of the 2017 African Microfinance Week.
- National Aeronautics and Space Administration (NASA).** 2005. The Impact of Climate Change on Natural Disasters. In: *Earth Observatory* [online]. [https://earthobservatory.nasa.gov/Features/RisingCost/rising\\_cost5.php](https://earthobservatory.nasa.gov/Features/RisingCost/rising_cost5.php)
- Netherlands Development Organizations (SNV).** 2015. *Cassava Value Chain Analysis – Inclusive Business Model for Promoting Sustainable Smallholder Cassava Production*. The Hague, Netherlands.
- Oakland Institute.** 2018. *Drought Prone Malawi and Zambia Turn to Cassava*.
- Positive Planet.** 2017. *Evaluation Du Marche Financier Agricole en Côte D'Ivoire*. Part of the Roots and Tubers Project Reports. Courbevoie, France.
- Ridoutt, B., Sanguansri, P., Bonney, L., Crimp, S., Lewis, G. & Lim-Camacho, L.** 2016. *Climate Change Adaptation Strategy in the Food Industry – Insights from Product Carbon and Water Footprints*.
- SNV & FAO.** 2017. *Participatory Financial Assessment Workshops*. Report produced on two workshops held in June 2017 in Kigali and Mwanze (Rwanda) as part of the African Roots and Tubers project.
- The World Bank.** 2013. *Growing Africa: Unlocking the Potential of Agribusiness*. Washington, DC.
- The World Bank.** 2018. Country contest: Ghana. In: *Climate Change Knowledge Portal for Development Practitioners and Policy Makers* [online]. <https://climateknowledgeportal.worldbank.org/country/ghana>
- World Food Programme (WFP).** 2018. *WFP Malawi*. Country Brief.

## Data

FAOSTAT data can be found at <http://www.fao.org/faostat/en/#home>

The World Bank data can be found at the Climate Change Knowledge Portal (available at <http://sdwebx.worldbank.org/climateportal>).



# Annexes

## Annex 1. Methodology

The approach used for this analysis attempts to directly measure the effect of climate variability and change on crop yields and production using various approaches such as the production function and Ricardian approach,<sup>1</sup> assuming a relationship between climate events and crop yields and production. The variables used are temperature, rainfall, potential evapotranspiration and planted area for cassava, potato and yam in the targeted R&T production areas of Benin, Cameroon, Ghana, Malawi, Uganda and Rwanda. In this context, the main challenge was to measure the sensitivity of production or harvested areas to climate variability and change, since many other variables could play an important role. Yields, on the other hand, was considered more representative to analyse the impact of changes in climate variables.

The information used are time series data. These figures come from the NMAs in Benin, Cameroon, Ghana, Côte d'Ivoire, Malawi, Uganda and Rwanda, as well as Google Earth Engine - Earth Map and the World Bank's Climate Change Knowledge Portal (CCKP) for weather data, and from FAOSTAT and the Directorate of Agricultural Statistics for yields and production data. The document includes descriptive analyses showing the evolution of the variables over the different range of periods according to the countries (between 1969 and 2016 depending on availability of data provided by the NMAs) and a Principal Components Analysis to determine the degree of statistical correlation between the variables.

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<sup>1</sup> The first measures the direct impacts of climate change on the various cultures and on their needs in inputs (e.g. luminosity, pesticides, weed-killers, fertilizer) by means of models of simulation biophysics of plants. The latter tries to measure directly the effect of the climate on agricultural yield and production assuming a relationship between climate events and crop yields and production.



## Annex 2. Climatic parameters at 5 GMET stations in Ghana (1970–2014)

◆ **TABLE A.1** Characteristics of the climatic parameters (temperature)

GMET Stations	Mean maximum temperature (°C)	Mean minimum temperature (°C)	Mean average temperature (°C)
Damongo	34.5	17.3	27.9
Kpando	32.2	21.8	27.0
Saltpond	30.7	23.3	26.9
Apam	30.9	23.0	27.0
Kete Krachi	32.7	23.3	28.0

Source: African Roots and Tubers project, FAO.

◆ **TABLE A.2** Characteristics of the climatic parameters (rainfall patterns)

GMET Stations	Long-term mean LTM)	Below-normal rainfall (mm)	Normal rainfall (mm)	Above-normal rainfall (mm)
Damongo	1 077.3	< 1 000.0	1 000.0 – 1 149.0	> 1 149.0
Kete Krachi	1 327.8	< 1 154.4	1 154.4 – 1 442.8	> 1 442.8
Kpando	1 190.1	< 1 130.7	1 130.7 – 1 261.5	> 1 261.5
Apam	854.3	< 712.1	712.1 – 941.8	> 941.8
Saltpond	961.5	< 888.9	888.9 – 1057.0	> 1 057.0

Source: African Roots and Tubers project, FAO.

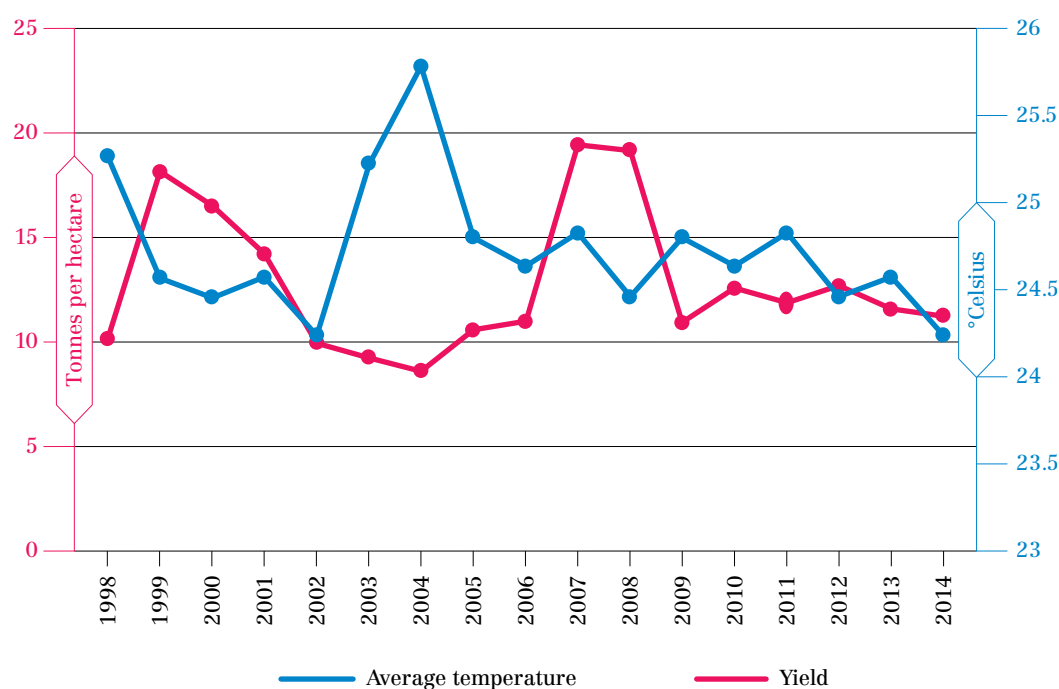
### Annex 3. Agro-climatic parameters and time series in Cameroon (eastern region)

◆ **TABLE A.3** Characteristics of the climatic parameters (temperature)

	N	Minimum	Maximum	Average	Ecart type
Yield	17	8.6	19.4	12.81	3.34
Precipitations	17	1 201	1 925.4	1 565.22	206.74
Number of rainy days	17	94	150	125.94	13.34
Average temperature	17	24.8	25.78	24.72	0.39
Evapotranspiration	17	1 315	1 511	1 349.22	55.43

Source: African Roots and Tubers project, FAO.

◆ **FIGURE A.1** Time series comparing cassava yield and average temperature between 1998 and 2014 in Cameroon (eastern region)



Source: African Roots and Tubers project, FAO.



The roots and tubers industry in sub-Saharan Africa has been growing steadily in recent years. Nevertheless, a series of challenges, including lack of access to finance and climate change related events, has prevented the majority of actors in these value chains, who are mainly small farmers and small processors, from taking advantage of such growth. In order to properly assess such challenges, the project “Strengthening linkages between small actors and buyers in the roots and tubers sector in Africa” conducted a series of studies to identify relevant gaps, constraints and opportunities to develop tailored financial products and risk management strategies for small farmers. The present publication provides a summary of the most important lessons learned, with the related policy recommendations.

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