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Integrating Climate Smart Agriculture in Pigeon Pea Production: Insights from Export Trading Group in Mozambique

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Preface

This paper forms part of a set of five Climate Smart Agriculture (CSA) innovation model papers that are premised on the adoption and integration of various climate smart agricultural approaches to smallholder farming in East and Southern Africa (ESA). Funded by the United Kingdom's Department for International Development (DFID), the cases draw on pilot initiatives within the Agricultural Development portfolio of the Vuna programme. The pilot projects are country-specific with different project components that are based on CSA. The papers explore the experience of different models designed to strengthen the delivery and uptake of climate smart agricultural practices, inputs and partnerships among smallholder farmers. Notably, the implementation period of the Vuna innovation models was short, ranging between 9 and 12 months. Consequently, the findings contained herein are based on emerging insights and the potential of the innovation models supporting farmer resilience in a scalable and sustainable manner. The innovation model series of papers sought to assess and identify early lessons emerging from the innovation model's adoption, uptake and ownership by implementing partners.

The series of the *innovation model papers* include:

- Building Climate Resilience for Dairy Farmers, through Climate Smart Solutions: Insights from the Malawi Smallholder Dairy Sector;
- Integrating Climate Smart Agriculture in Pigeon Pea Production: Insights from Export Trading Group in Mozambique (this paper);
- Integrating Climate Smart Agriculture Capacity Development in Out-grower Schemes: Insights from Musoma Food Company Ltd and G2L Ltd in Tanzania;
- Integrating Climate Smart Agriculture into E-Voucher Farmer Input Subsidy Programme: Insights from Zambia; and,
- Building Inclusive Seed Systems for Semi-Arid Areas: Insights from Zimbabwe Super Seeds.

The research was conducted between October 2017 and February 2018, in three phases. First, available literature on CSA, climate change and agriculture in the focus country and within the region was reviewed. Second, desktop research of Vuna project documents (baseline reports, quarterly reports, grant application(s), and the Vuna project plan) was done. Third, field research was conducted to assess the extent to which the innovation model has been adopted and whether it's being adapted to enhance desirable outcomes for key value chain actors. Field research results were analysed to determine the potential for the sustainability of the interventions.

Acronyms

CLUSA	Cooperative League of the United States of America
CSA	Climate Smart Agriculture
DAI	Development Alternatives Incorporated
DFID	The United Kingdom's Department for International Development
DNAE	National Directorate of Extension
EFF	Export Trading Group Farmers Foundation
EMCL	Export Marketing Company Limitada
ESA	East and Southern Africa
ETG	Export Trading Group
ETGL	ETG Logistics Limitada
FAO	Food and Agriculture Organization of the United Nations
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IIAM	Mozambique Institute of Agricultural Research
IITA	International Institute of Tropical Agriculture
InovAgro	Innovation for Agribusiness
MoU	Memorandum of Understanding
NCEA	Netherlands Commission for Environmental Assessment
NGO	Nongovernmental Organisation
TA	Technical Assistance
TNS	Technoserve
USAID	United States Agency for International Development
USAID FTF	United States Agency for International Development Feed the Future
	World Food Programme

Executive summary

More than one million smallholder farmers cultivate pigeon pea across Mozambique. As a drought tolerant and export-oriented crop, improving pigeon pea productivity is central to smallholder livelihood and resilience building strategies. To increase productivity and incomes while enabling smallholder farmers to adapt to changing climatic conditions, the Export Trading Group (ETG) in collaboration with Solidaridad Southern Africa designed the "*Development of Climate Smart Agricultural (CSA) Capacity in Pigeon Pea*" innovation model. Founded in 1967, the ETG is one of Africa's largest agricultural trading groups- moving more than 5 million metric tonnes of agricultural commodities globally. Solidaridad Southern Africa, an international civil society organisation specialising in sustainable value chain development, is responsible for the provision of CSA aligned extension services to farmers.

The ETG-led innovation model has two objectives: increasing farmer's resilience by improving crop productivity and income and improving ETG's security of supply through productivity enhancing investments and market linkages. To achieve these objectives, ETG co-invested in the provision of CSA aligned extension services by Solidaridad to farmers. Solidaridad extension agents selected and trained lead farmers to establish demonstration plots where farmer groups were taught CSA production practices and business management skills. The intended impact of farmer training was increased productivity and when translated to sales, incomes. At the onset of the marketing campaign, ETG was responsible for marketing and/or purchasing produced pigeon pea on a non-contractual basis. The impact of which was increased produce for sale by ETG into their largest export market-India. Through these activities, the model sought to build the resilience and economic viability of participating farmers and ETG.

This study sought to analyse the extent to which the innovation model contributed to resilience building in the pigeon pea value chain, with a particular focus on smallholder farmers and the extent to which the model is potentially sustainable and scalable. It explores the emerging lessons with regards to model adoption and ownership by pilot partners, with a view to understand prospects for model sustainability and scalability. The paper is divided into four sections. Section 1 is an overview of the pigeon pea sub-sector. Section 2 details the innovation model, its key actors and their functions. An assessment of the innovation model's adoption by pilot partners is outlined in section 3. Section 4 is an assessment of the extent to which pilot partners adapted the model and its implications for potential sustainability. In the last section, the paper presents the key findings and recommendations that emerge from the analysis.

Innovation model implementation began in January 2017 and activities have occurred over less than one agricultural season. During this pilot phase, the model was effective in delivering climate smart agricultural extension services that led to increased farmer awareness and adoption of select CSA practices, including: minimum tillage, mulching, intercropping and improved threshing and storage. However, the extent to which the model contributed to improved resilience through income increases was limited by broader market dynamics. A fall in demand from the Indian market led to ETG's inability to market or directly purchase pigeon pea at a price point agreeable to farmers. As such, market dynamics hindered effective market linkages between smallholder farmers and ETG. Thus, perceptions of model pilot success are mixed. Productivity enhancing services were viewed as beneficial to resilience building and the lack of purchasing as detrimental.

Importantly, there was evidence of model adaptation in response to implementation experiences and emerging market realities. Solidaridad's training content and delivery proved responsive to field experiences and market dynamics. For example, in response to the fall in pigeon pea price Solidaridad encouraged farmers to store rather than sell produce; training farmers on improved storage techniques to limit pest damage. Farmer's engagement in the model resulted in the adoption of select CSA practices on a trial basis and requests for locally suitable adaptations to the model. At a firm level, ETG's implementation experiences triggered two adaptations. At a model level, ETG intends to establish the ETG Farmers Foundation (EFF) in Mozambique, as the institutional vehicle for delivering ETG aligned farmer support programmes. Critical for ETG, the foundation is able to leverage external funding for extension provision. At a sector

level, ETG is looking to strengthen the pigeon pea value chain by stimulating domestic demand with the support of development partners.

The implications of model adoption and adaption on future sustainability are nascent. The model was designed to be a buyer-led extension model with ETG integrating extension services into business operations post-project funding. ETG's intention to establish EFF highlights that for the business an external (albeit aligned) entity is the ideal institutional vehicle for delivering farmer support services in the long-term. The provision of CSA aligned extension, may also find other vehicles for replication and expansion. In particular, Solidaridad works in close collaboration with public extension officers, transferring CSA production knowledge to public officers who will share it with other farmers. While at the farm level, lead farmers are committed to continue providing CSA technical advice to neighbouring farmers, supported by Solidaridad's Pigeon Pea Conservation Agriculture Production handbook. Thus, there are emerging markers of model sustainability, particularly as it relates to the provision of CSA extension services.

Innovation model implementation experiences offer some lessons on how to improve similar interventions as well as broader insights on how to contribute to building resilient smallholder farming systems, sustainably:

- **Selecting the right partners:** Selecting private sector partners with the right incentives and capacities (financial and operational) is critical to model sustainability. Only when a business has the commercial incentive to invest in farmer development activities are they likely to sustain these services beyond the lifetime of the programme. A rigorous analysis of the market system, focusing on what drives market player behaviour strengthens implementing partners understanding of the incentives and capacities of any stakeholder to invest in productivity enhancing extension services post-programme completion.
- **Establishing a realistic vision of sustainability:** The model's vision for sustainability rested on ETG integrating extension services into their operating model post-2020. ETG's intention to establish EFF suggests that the integration of extension services into their core business is unfeasible. Rather, the establishment of an external (albeit aligned) entity that can leverage external funding is the ideal institutional vehicle for delivering farmer support services in the long-run.
- **Partnership negotiation and management:** The pilot demonstrates the importance of effective partnership negotiation and management. The model envisaged resilience building as a function of crop diversification and included the promotion of both pigeon pea and sesame. Similar to pigeon pea, sesame is a drought tolerant crop with a growing market, yet support to both crops was not detailed in the project's management plan. As a result, partners did not invest in sesame CSA extension services and farmers' risks were not diversified. Consequently, ensuring that key model elements are clearly outlined in the management plan assists in realising their implementation.

"There is a need to look beyond production focused adaptation measures and explore, understand, and intergrate into intervention design mitigation measures for potential economic and commercial shocks.

- **Planning for system-wide shocks:** The shock induced by plunging demand in the Indian end-market highlights that climate smart projects for agriculture should consider both climate and market risks. There is a need to look beyond production focused adaptation measures and explore, understand, and integrate into intervention design mitigation measures for potential economic and commercial shocks. Cognisant of these dynamics, ETG is exploring mechanisms for stimulating domestic pigeon pea demand to reduce their reliance on the Indian export market.
- **Building the business case for model scale-up**: Scalability relates to model replication by other market actors and invariably requires active promotion and intervention. Implementing partners have to go beyond farm level demonstrations to actively build the business case through the collection and dissemination of key data points,

particularly with respect to buyer return on investment in extension services. Harnessing such information would allow programmes to make the business case for large trading-based businesses to shift from an extensive to an intensive sourcing strategy proximate to their warehousing facilities.

- **Provision of market information:** Farmers' expectations that ETG would purchase produced pigeon pea at a favourable price were raised during project sensitisation efforts. ETG was unable to purchase pigeon pea from project participants at a favourable price point, leaving some demoralised and frustrated. Farmers' frustrations were heightened by the lack of information on why ETG's purchases were limited and the market dynamics that dictated the low price being offered. The incidence highlights the importance of clear and timely market information flow to maintain farmer engagement.
- **A step-wise approach to building resilient production systems:** ETG introduced a number of technologies in their demonstration activities, including: biocatalysts, certified seed, and organic pesticides, amongst others. However, farmers participating in the demonstration activities tended to adopt technologies that were low-cost and less labour intensive. This mirrors regional dynamics where resource-poor farmers tend to favour low-cost and low labour production and post-production techniques that enhance yields and income. Thus, the next phase of model implementation should consider the farmers' relative commercialisation levels, proposing a stepwise approach that aligns with the farmers' ability to invest in productivity enhancing measures.

1 Introduction

Climate change is changing rainfall patterns, and inducing more severe and frequent extreme weather events such as droughts and flooding in many parts of East and Southern Africa (ESA). These changes threaten to deepen the challenges already being faced by millions of farming households. The situation is even more alarming in regions that are already semi-arid where climate risk is endemic. Unless decisive adaptation action is taken to build resilience of the agricultural sector, food insecurity and poverty are set to worsen. Effective response measures are urgently required to sustainably increase productivity, stabilize yields and diversify production systems while building the adaptive capacity and resilience of farming communities.

Climate Smart Agriculture (CSA) is the most promising adaptation approach for the agricultural sector that has gained traction amongst governments, non-governmental organisations (NGOs), private sector and donors. CSA has been formally defined by the Food and Agriculture Organisation of the United Nations (FAO) as consisting of three components: (i) sustainably increasing agricultural productivity and incomes; (ii) adapting and building resilience to climate change; (iii) reducing and/or removing greenhouse gas emissions. The concept of CSA has now been widely adopted at various levels. Significant levels of national and international funding are correspondingly being allocated to the development and promotion of CSA.

This paper considers the delivery of climate smart practices implemented under the "Integration of Climate Smart Agriculture Practices into Pigeon Pea Production in Mozambique" project (hereinafter innovation model), exploring how the innovation model contributed to resilience building in the pigeon pea value chain, and emerging lessons with regards to model adoption by pilot partners, with a view to understand prospects for model sustainability and scalability.

The innovation model aimed to promote climate smart agricultural practices in pigeon pea production in Zambézia Province, Mozambique. Pigeon pea production is well suited to the semi-arid climatic conditions of the country's north and central regions. Producers in Zambézia further benefit from decent road infrastructure, proximity to Nacala Port, private sector trading posts, and various development efforts focused on pigeon pea production. The innovation model

is being implemented by ETG Logistics Limitada[1] (ETGL) in partnership with Solidaridad Southern Africa in Magige, Lioma, and Tetete villages in Gurué district of Zambézia Province.

ETG Logistics Limitada is an integral part of Export Trading Group (ETG Group), a 50-year-old business conglomerate and one of Africa's largest end to end agricultural commodity trading companies. Founded in 1967, ETG holds a decisive first mover advantage in procurement, production, logistics, processing, import/export and distribution of agricultural commodities.

The Group's supply chain penetrates deep into remote agricultural regions procuring commodities from smallholder farmers through extensive sourcing networks. Annually, ETG moves approximately 5 million metric tonnes of agricultural commodities around the world and directly employs more than 20,000 people globally. Over the years, ETG has established long withstanding relationships with thousands of smallholder farmers, regional authorities, and governments in all countries where it operates.

These relationships enable ETG's extensive supply chain to link remote agricultural regions to major industrial hubs. Export Trading Group's supply chains extend across sub-Saharan Africa, North America, Europe, the Middle East and South East Asia. In Mozambique, one key ETG differentiation factor is its deep roots in the country, more than 80% of its products are directly procured at the farm gate from smallholder farmers.

Solidaridad Southern Africa is an international civil society organisation operating in Southern Africa since 2009. It has vast experience in facilitating development of socially responsible, ecologically sound, and profitable supply chains across the region, including: Malawi, Zambia, South Africa, Namibia, and Mozambique. The Mozambique office was established in 2014 and is a subsidiary of Solidaridad Southern Africa with its head office in Johannesburg, South Africa. Since 2009 Solidaridad Southern Africa has impacted more than 35,000 farmers in Mozambique through various projects funded by a number of donor agencies.

Box 1:. ETG and Solidaridad Profiles

1.1 Local livelihood system

Gurué district spans an area of 5,606km^2 with a population of approximately 380,000 that depend primarily on agriculture-based livelihoods. The district is divided by the Namuli Ridge into two agricultural production zones, with the small town of Gurué as its economic centre[2]. Gurué district's Northern zone is characterised by commercial tea production which dates back to the colonial period. Since independence in 1975, commercial operations relating to macadamia nuts, horticulture, maize, sugar beans, and soyabean production and processing have also emerged. However, the emergence of commercial scale production has had a limited impact on the small-scale farming systems of Gurué district's Southern zone. In line with Mozambican smallholder production dynamics, the Southern zone is characterised by the low input/low output small-scale farming of pigeon pea, cassava, common beans, mung beans, sorghum, and soyabean. Other economic activities include small-scale fishing, hunting, trading, and the processing and sale of maize flour.

Pigeon pea in particular is an important export-oriented crop for Gurué smallholders. Pigeon pea cultivation is difficult to mechanise, as such, local smallholders benefit from producing a cash crop which is largely protected from competition

1. Registered entity for ETG in Mozambique
2. ETG Logistics Limitada/ Solidaridad, 2017

by large-scale commercial farmers. This is in contrast to soyabean, another popular legume, where Mozambican farmers are facing significant competition from commercial South American exporters. In addition, from a food security perspective, pigeon pea's high protein content (21-25%) complements cereals for a balanced diet which is critical in a region where protein deficiency is endemic.

1.2 Climate risks and impacts

The key climate risks identified by **Gurué** farmers are associated with shifting rainfall patterns, increasing temperature, and increasing frequency of extreme events, specifically droughts and floods. Farmers noted that historically, rains commenced in October, continuing until January in a "*well distributed*" manner. In recent times, steady rains only begin in December or January. For farmers that plant at the official start of the season (mid-October), the delayed rainfall affects crop germination, early establishment, and ultimately yields. Shifting rainfall patterns have been accompanied by higher temperatures. In the words of one farmer: "*Gurué used to be fresh; but now it gets hotter, earlier*". The impact of which has been increased evapotranspiration and accompanying reduced moisture for crops.

Farmers' perceptions of climatic changes are supported by historical weather data trend analysis (Annex 1). The district has been characterised by above average incidences of drought ranging between 8 to 10 incidents between 1980 and 2000 (Figure 1). A climate trends analysis from 1960 to 2005 highlights increasing temperatures across most of the country, specifically, a decreasing number of cold nights and cold days, and a later start to the rainy season by up to 45 days in some locations. Historical changes in temperature indicate a steady increase in temperature over the 18-year period, with increases in Gurué district ranging from 0.58 to 0.67 degrees[3]. While these changes might appear to be subtle, the impacts on water availability, increased evapotranspiration and reduction in soil moisture should not be underestimated.

Although flooding was also identified by farmers among the climate risks, the extent of the flooding in Gurué district is not a significant threat, given the number of incidents recorded. Examining historical flood data (1985-2003), shows that there is low flood prevalence in Gurué as only 2 extreme weather events led to flooding during this period (Figure 1[4]).

Climate projections suggest that variable rainfall patterns and increasing temperatures will be the new norm. Countrywide climate projections indicate a significant average temperature rise (ranging from a minimum increase of 1.0°C for 2010-2100 to a maximum increase of 4.6°C for 2010-2090). Highest increases are expected for inland and southern regions, especially the Limpopo and Zambezi valleys with increases from 2,5°C up to 3.0°C increase between 2046 and 2065.[5] In addition to average temperature increases, the number of hot days and nights (above 35°C) are likely to increase further, occurring on 20-53% of all days and 26-76% of all nights by 2090 (compared to 10% as a reference value).[6] The main increase in number of hot days/nights is projected for the hot season, between December and February.[7]

Projected climatic changes will affect water availability and food security in a number of ways. These include yield decreases due to more hot days during the harvest cycle for major grain crops, while a less predictable onset of the rainy season increases the risk of crop failure - particularly for farmers who plant prematurely. At the same time, higher evapotranspiration will increase demand for water; this increase will likely be greater than potential rainfall increases projected in some areas. As such, farmers will experience the climate as hotter and drier.[8]

3. Tadross, M., 2009
4. CHRR, 2005
5. Tadross, 2009
6. Tadross, 2009
7. Ibid
8. Ibid

Pigeon pea is a drought resistant crop. Its deep (3-4metres) root system ensures that it can thrive in the low moisture conditions of Zambézia, improving the resilience of farmers in case of prolonged dry spells or severe drought. In addition, pigeon pea has nitrogen fixing qualities and improves overall soil fertility for both pigeon pea and the crops it is typically grown alongside - maize, sesame, and sorghum. Pigeon pea production can thus help farmers adapt to Zambézia's changing climatic conditions, and if linked to an appropriate off-taker ensure more stable incomes.

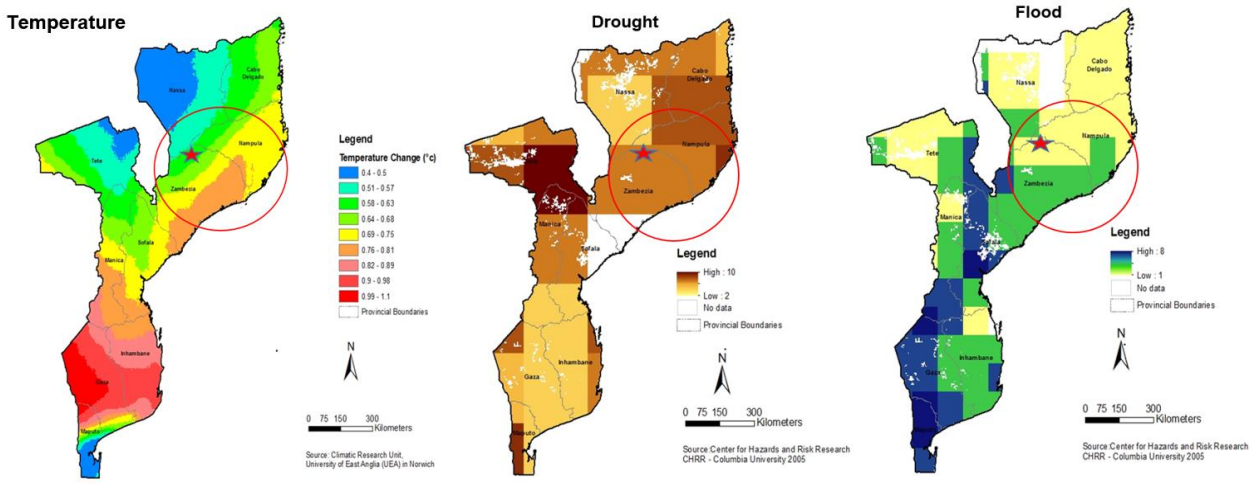

Figure 1:. Climate Risks in Mozambique. Temperature Change (left) Drought (middle), Floods (right). The approximate location of Gurué town is marked with a star. Gurué District, Zambézia provinces is highlighted with the red circle.

1.3 Structure of the pigeon pea market system

Pigeon pea was first introduced to Mozambique in the 19th century by Indian immigrants working on the East African railway network.[9] A crop historically produced for household consumption, production steadily increased in the late 1990s, stimulated by demand from the Indian market, the presence of trading companies such as ETG, and the support of development partners such as Technoserve (TNS), Cooperative League of the United States of America (CLUSA), and Innovation for Agribusiness (InovAgro). As a result, an estimated one million rural households now produce pigeon pea on approximately 290,000 hectares. Zambézia and Nampula provinces are the dominant production regions with the former being the largest producer, contributing more than 70% of total production and 55% of the one million households farming pigeon peas. It is estimated that by 2025, pigeon pea will become the third most important field crop within the small -to- medium sized sector in Mozambique.[10]

Currently, pigeon pea is largely cultivated by resource constrained smallholder farmers in a rain-fed intercropping system alongside crops including maize, soyabean, sesame, common bean, and sorghum. As a result, the land used for pigeon pea cultivation is small, ranging from 0.25 to 2 hectares.[11] Average yields are low at 446 kilograms per hectare as compared to that of regional competitors like Malawi, Kenya, and Tanzania whose average yields are 1,459 kilograms per hectare, 994 kilograms per hectare, and 897 kilograms per hectare respectively.[12] Low yields are attributed to the limited use of quality inputs such as certified seeds, fertiliser, and pesticides.

9. Odeny, 2007
10. Walker *et al.*, 2015
11. Ibid
12. Ibid

Given low input use, commercial interaction between input suppliers and pigeon pea farmers is generally confined to donor supported initiatives. However, market dynamics in the seed sector are shifting. Seed companies such as Phoenix Seeds, Oruwera, and IKURU are marketing certified pigeon pea seeds to farmers. In addition, entities such as International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), International Institute of Tropical Agriculture (IITA), and Mozambique Institute of Agricultural Research (IIAM) in collaboration with seed producers are selecting, testing, and introducing new pigeon pea varieties.

Pigeon pea produced in Mozambique is largely traded with India- the world's largest consumer of pulses[13]. Mozambique's exports to India have grown significantly, becoming the third largest supplier, behind Tanzania and Myanmar.[14] Increased trade with India is supported by a 2016 Memorandum of Understanding (MoU) that commits India through private and government to government channels to purchase 100,000 tonnes of pigeon pea in 2016-17 agricultural season and increasing to 200,000 tonnes by 2020-21. This steady increase in trading volume is to be supported by improved extension services facilitated by Indian government financial and technical assistance (TA).[15]

Mozambican pigeon pea reaches India and other global markets through a network of formal exporters and informal traders. ETG is the largest buyer and exporter of smallholder farmer production, with approximately 60% of the market share. ETG's trading is supported by a network of approximately 400 traders throughout the country who purchase from farmers at the farmgate and village trading posts. ETG's two processing centres in Beira and Nacala, process about a quarter of the total grain produced in Mozambique. Secondary formal traders and exporters include HP IMPEX, SUMO. Lda and AFRIGOLD. In addition, the sector is supported by a multitude of small-scale traders who include locally based entrepreneurs embedded in the community as well as spot traders who only engage with farmers during the harvesting season. Both categories of small-scale traders purchase during the harvest season for onward sale to larger buyers/exporters and/or processors.[16] Mozambican pigeon pea is exported either raw or partly processed (split).

The Mozambican pigeon pea sector is increasingly integrated into global value chains. Greater global integration entails that the sector's performance is dependent on the production and consumption trends and policies in key export markets. Critical to this innovation model's performance, in August 2017 the Indian government restricted pigeon pea importation to stabilise domestic prices after good rains led to a bumper crop. Although the bilateral agreement between Mozambique and India protects Mozambican pigeon pea farmers from the restriction, the policy announcement generated sufficient uncertainty in local markets to dampen demand from both large and small buyers. The impact has been a depression in farm gate prices (5-8 Meticais per kilogram during the 2016-17 season against an average of 34 Meticais per kilogram during the 2015-16 season), with the attendant negative impact on farmer profitability and enthusiasm to expand pigeon pea production in the next season.

1.4 The nature of the problem facing smallholder pigeon pea farmers

Smallholder pigeon pea farmers face an interrelated threat from both climate and market related factors. The unpredictability of climatic conditions–particularly water availability–means that producers face unreliable productivity and production levels and, as a consequence, struggle to secure year-on-year market access for their offtake.

Given the climate risks and their production and livelihood impacts, farmers are receptive to adaptation options. In particular, low-cost options that insulate them from the negative impact of climate change on agricultural productivity.

13. Ahlawat *et al.*, 2016
14. Walker *et al.*, 2015
15. GoI & GoM, 2016
16. InovAgro, 2017

These include 'climate-smart' practices such as intercropping with legumes and mulching, as well as conventional practices related to improved post-harvest handling and storage, and appropriate spacing. In addition to current adaptation practices, farmers expressed a need for short season and improved variety seeds, mechanical threshing services, mechanised land preparation services, and improved market information to allow them to more effectively plan their cropping strategy. Farmers, however, rarely expressed demand for these options with the specific objective of insulating them from climate change, but as a necessity to increase their agricultural productivity and improve their livelihoods more generally.

Farmers' awareness of climate change and adaptation options are supported by NGOs and public-sector extension agents. Solidaridad extension workers actively linked practices such as slash and burn production techniques to climate change; promoting good agricultural practices for climate change mitigation and its impact on agricultural productivity. From a public-sector perspective, the Ministry of Agriculture, in particular, the National Directorate of Extension (DNAE), has provided conservation agricultural training to farmers since the 1999-2000 season.

The trainings are currently being formalised and aligned to CSA through the development of a CSA handbook and CSA manual for individual trainers. However, the under-resourced public extension service-with approximately 1,000 extension workers-is unable to service Mozambique's over 3 million farmers. Critical to enhancing farmers' knowledge of adaptation options includes increased public extension services resources, improved synergies between the DNAE and the approximately 2,000 private and NGO extension officers as well as farmers associations, and the creation of scalable knowledge dissemination platforms.

From a buyer perspective, there is greater recognition of the link between climate change, its threat to productivity and the risk to their supply chains. Nevertheless, this has not led to significant and consistent investment in CSA extension and information provision. Instead, buyers such as ETG have attempted to mitigate that risk by investing in extensive buying networks and storage capacity, ensuring that overall required volumes can be maintained despite individual farmer productivity decreases as a result of climate shocks. ETG's practices are mirrored by other large buyers operating in other commodity markets (e.g. OLAM) who have invested in increasing storage capacity and engaging in farmer support programmes at a pilot level. Small traders, limited by financial constraints, manage yield fluctuations by sourcing at the farm gate and paying cash on the spot.

2 Innovation model description

2.1 Innovation model rationale

While the drivers for pigeon pea producers (income and livelihoods security) and buyers (supply volumes secure against climate change) are different, nonetheless, they are aligned. The basic rationale of the ETG led innovation model is to integrate climate smart agricultural practices into pigeon pea production in order to increase farmer productivity and incomes and secure improved supply for ETG.

For smallholder producers, improving pigeon pea productivity represents an important means of livelihood and income security. Its importance as a cash crop as well as its inherent drought tolerant features mean it is a highly valued crop for many smallholders. Raising awareness of the link between more climate smart practices and productivity gains, therefore, offers opportunity for stimulating practice change and greater investments by smallholders.

As the largest domestic pigeon pea trader and processor, ETG's rationale for investing in improving pigeon pea productivity levels is to increase the overall volume of pigeon pea available for purchase. In the 2016-2017 season, the total estimated tonnage of pigeon pea available for purchase was 200,000 tonnes. In the 2017-2018 season, an estimated 300,000 tonnes were available for purchase. From an ETG perspective these increases help to "validate their support". Further, as a global commodity company that specialises in the purchase of smallholder dominated crops such as mung beans, sesame, pigeon peas, and cashews at the farm gate, developing strong relationships with smallholder

farmers through farmer development programmes encourages future trade relationships. Developing a close relationship with pigeon pea farmers in Mozambique is particularly of benefit, as Mozambican farmers harvest their pigeon pea from September to January; prior to the harvest of India's seasonal crop. Thus, the availability of East and Southern African production is synchronous with the seasonal incidence of high prices in the Indian market.[17]

Thus, the model's rationale is to support farmers' improved nutritional outcomes, positively impact productivity of both pigeon pea and the crops it is intercropped with and ultimately incomes, while ensuring that ETG maintains a secure supply of a key crop in its trading portfolio.

2.2 The innovation model

To achieve these objectives, ETG co-invested in the provision of CSA aligned extension services by Solidaridad to farmers. Solidaridad extension agents selected and trained lead farmers to establish demonstration plots where farmer groups were taught CSA production practices and business management skills. The intended impact of farmer training was increased productivity, and when translated to sales, incomes. At the onset of the marketing campaign, ETG was responsible for marketing and/or purchasing produced pigeon pea on a non-contractual basis. The impact of which was increased produce for sale by ETG into their largest export market-India. Through these activities, the model sought to build the resilience and economic viability of participating farmers and ETG.

The structure of the model is illustrated in Figure 2.

17. Walker, *et al*., 2015

Figure 2:. ETG business model (Adapted from Vuna 2016)

2.2.1 Key stakeholders and roles

The ETG model is based on a partnership with a number of different market actors. Table 1 summarises the model's key stakeholders and their roles.

Table 1:. ETG model stakeholders

Stakeholder	Type of organisation	Roles
ETG Projects Department	Private sector agricultural commodity trader	• Co-designing and co-financing improved extension, demonstration and outreach activities • Contracting and providing strategic direction to Solidaridad Southern Africa • Providing inputs (medium duration certified pigeon pea seeds and bio-catalysts) for the demonstration plots
ETG Export Marketing Company Limitada (EMCL)	Private sector agricultural commodity trader	• Procuring produced pigeon pea on a non-contractual basis from participating farmers
Solidaridad Southern Africa	International NGO	• Providing CSA training to participating lead farmers (practices include land clearing, minimum tillage, composting, organic pest management, mulching, post-harvest handling, and marketing) • Oversee demonstration activities to ensure quality and consistency
Lead farmers	Private producers	• Assisting in the identification of participating farmers, supporting farmer group formation • Using demonstration plots to cascade CSA production techniques to train a group of 30 farmers each • Mobilising neighbouring farmers to adopt CSA production techniques • Regular group meetings to follow-up on farmers' experience applying taught practices in their own fields and address any specific concerns emerging on participating farmer's fields
Farmers	Private producers	• Apply skills and techniques learned through demonstration, training and extension to pigeon pea production • Sell produce to ETG on a non-contracted basis
Directorate of Extension Services	Local government	• Facilitating access to and supporting the identification of lead farmers and participating farmers in addition to participating in demonstration plot activities
Phoenix seeds	Seed input suppliers	• Sell pigeon pea seed to ETG for demonstration plot activities

2.2.2 Model theory of change

How the model is designed to build resilience

The model had two key objectives: to increase farmer's resilience by improving crop productivity and incomes and improve ETG's security of supply through productivity enhancing investments. In order to achieve these objectives, ETG co-invested in the provision of CSA aligned extension services by extension partner. Solidaridad Southern Africa. Solidaridad extension agents selected and trained lead farmers to establish demonstration plots where groups of approximately 30 farmers were taught CSA production practices and business management skills.

"We (Solidaridad) partnered with ETG, whereby ETG provided the overall management of Vuna project and Solidaridad provided the field support to farmers. We deliver agricultural technologies to farmers, designed to improve resilience to climate changes and its impacts in the production. The delivery model is based on lead farmers, selected based on past performance in agriculture production, proved leadership and communication skills with the peer farmers. Each lead farmer works with 30-35 farmers under their zone of influence.

We train lead farmers in selected CSA themes and establish demonstration plots in their farms. The lead farmers scale down the training, working with the farmers in their zone of influence to disseminate the technologies and ensure adoption. The lead farmers also support the farmers in adoption of the practices demonstrated in the lead farmers demo plots. The training packages include conservation agriculture, intercropping with other crops, use of quality seeds and application of the biological enzyme in the pigeon peas, during planting season (due to unavailability in the local market the enzyme serves only for demonstration in the demo plots).

We also provide training to farmers on harvest, post-harvest and commercialization of pigeon peas, whereby we provide training to improve the capacity in processing pigeon peas and maize, storage methods by use of natural conservation pesticides, quantification of the crops produced, price negotiation and linkages with the market".

Mr. Piheter Suppinho, Extension Officer Solidaridad (Gurué)

Box 2:. Partnership between ETG and Solidaridad in delivering CSA practices to pigeon pea farmers in Gurué

The lead farmer and allied farmer group are the nuclei of the intervention. The farmer group represents a community of practice, where farmers are taught CSA production practices and 'farming as a business'. Through exposure to CSA production practices and business skills, participating farmers will apply taught practices on their own crops during production; post-harvest handling and storage; and marketing. The application of CSA production techniques will increase farmers' productivity on pigeon peas and the crops it is intercropped with and the use of a drought tolerant crop will support farmers' resilience in case of severe drought. The adoption of improved post-harvest handling and storage techniques will preserve the harvest for sale, while training on marketing and the facilitation of market linkages will increase volumes sold. The ultimate benefit to farmers will be increased incomes. At the onset of the marketing campaign, ETG and other pigeon pea traders will benefit from increased volumes available for procurement.

Local government through the Directorate of Extension Services are leveraging the presence of Solidaridad extension agents to learn CSA production practices through participating in demonstration plots. Public extension agents plan to integrate CSA practices into their extension provision, a process aligned with a nationwide move towards the provision of CSA relevant extension services to farmers.

How the model is designed for sustainability and scalability

The model is designed to be a buyer-led CSA extension delivery model. The design envisaged that ETG logistics would "fully incorporate" all project components "including funds for maintenance and continuing to service farmers" into ETG logistics operations[18].

Within pilot communities, lead farmers were expected to spread CSA practices. Lead farmers engaged with confirmed that they will continue to provide CSA production information and business skills to farmer groups and neighbouring farmers post the end of the programme. Lead farmers' continued willingness to adopt said role is due to the social prestige and obligation associated with being a lead farmer within a community.

18. ETG, 2016

In model design, three stakeholders are potential scale agents: ETG; the Directorate of Extension Services; and Solidaridad.

As the lead buyer, ETG is the primary scale agent capable of supporting model expansion and replication in its entirety (i.e. a lead buyer delivering CSA extension services). During year 1 of the project period, ETG was expected to support Solidaridad to provide extension services to 5,000 farmers. During year 2, this figure was expected to expand to 10,000 farmers. Post the project period, the model envisages that ETG will integrate the provision of extension services and other "services to farmers" into their operating model.[19]

As extension service providers, Solidaridad and the Directorate of Extension Services are secondary scale agents capable of expanding the CSA extension delivery component of the model. The model envisages a close relationship between Solidaridad and government extension agents with public extension agents participating in demonstration plot activities to improve their own CSA production knowledge. These techniques will then be integrated into their extension provision to other farmers. Solidaridad will leverage their project experience to adapt a CSA production manual for internal and external facilitators. The institutionalisation of CSA production knowledge will allow Solidaridad to further integrate CSA extension provision into other agricultural productivity enhancing projects.

3 Assessing the success of the innovation model adoption

3.1 Model success in delivering intended support services

The model has successfully delivered CSA extension services to farmers. As per design, Solidaridad has trained lead farmers (167) to cascade CSA production techniques to farmers organised in groups of 30 (on average). Through lead farmers, approximately 5,000 farmers have benefitted from exposure to CSA production techniques. This is in line with year 1 outreach targets. The training of the trainer model has been supplemented by the direct delivery of TA to 1,956 farmers. These farmers have been trained directly by Solidaridad on CSA aligned good agricultural practices, post-harvest handling, and "commercialisation" where farmers are taught to record information related to production costs, production area, and resulting yields. The purpose of which is to equip farmers with the information required to assess if a price offered will cover their breakeven production costs. Infield trainings are supplemented by farmer study groups where lessons are reinforced, experiences discussed, and challenges raised.

The uptake of improved practices, however, appears to have been partial. Farmers have adopted select taught practices such as minimum tillage, mulching, intercropping, crop rotation, improved threshing, and improved storage on a trial basis. The adoption of certified seed remains limited to lead farmer demonstration plots due to the price of pigeon pea certified seeds and the prospective return on investment of certified seed use.[20] Limited adoption of certified pigeon pea seed will rightly continue given current market dynamics. Looking forward, farmers indicated that they would apply two taught practices during production-minimum tillage and intercropping (or crop rotation with pigeon pea). Farmers' expressed reluctance to expand areas under mulch (despite understanding the benefits to productivity) because of the labour intensive nature of gathering and applying the grass. Alternatively, they requested Solidaridad to train them on green coverage using fava beans. Post-production, farmers indicated that they would adopt the improved threshing and storage techniques. In summary, farmers favoured the adoption of low-cost/low time production and post-production

19. ibid
20. Pigeon pea certified seed costs approximately 120 meticais per kilo; with 10 kilograms of seed required to plant a hectare (InovAgro Phase II Annual Report 2017, DAI Europe)

techniques that enhanced yields. This reflects farmers' current production and market realities, where the investment in higher cost technologies like certified seed would need to be remunerative enough to offer a decent return on investment.

As the key private sector partner, ETG's adoption of the model has itself been partial. The innovation model as articulated by project stakeholders included two key elements[21] namely CSA aligned extension provision and assisting farmers to market and/or purchase produce directly. ETG supported one aspect of the model: co-financing and coordinating the provision of CSA aligned extension via lead farmers utilising demonstration plots. The provision of CSA aligned extension services was spearheaded by Solidaridad in the absence of ETG core marketing staff or field technicians. This institutional arrangement undermined ETG's ability to incorporate project activities into regular ETG operations and ensure continued funding for extension as per the original model design. While Solidaridad as a service provider will cease implementing model activities once the Vuna programme funding is withdrawn.

Further, the aspect of the model central to ETG's core business- assisting to market and/or purchase directly farmers' produce-and a key incentive for farmer participation was not adopted. According to Solidaridad, ETG's presence at sensitisation efforts raised farmer expectations that a secure market for pigeon pea was possible through project participation. However, as a result of a bumper crop in India, the pigeon pea price fell during the 2017-18 season, leading all buyers, including ETG, to limit buying and/or offer a price viewed unfavourably by farmers. As such, at this juncture the model's success in achieving improved farmer incomes through market linkages to ETG is limited.

However, ETG contends that in 2018 market dynamics will be different as globally farmers will exit the pigeon pea market and prices will rebound. This will open up opportunities for ETG to again purchase pigeon pea at a favourable farmgate price. As such, they will continue to implement the model in the 2017/18 season with Vuna support. However, post-Vuna completion, ETG will seek to leverage external funding (potentially channelled through the EFF) in order to continue model implementation.

3.2 Signs of model impact on sensitivity and adaptive capacity of farmers and other market players

3.2.1 Changes in level of sensitivity of current production systems

The model has positively impacted farmers' productivity in a context of shifting rainfall patterns and higher temperatures. Lead farmers reported that the adoption of taught practices, in particular, minimum soil disturbance and mulching improved soil water retention and led to "greater productivity". Improved productivity was further enhanced through "better spacing and timing of sowing for intercropping", which ensured that crops were not competing for nutrients and sunlight. Consequently, lead farmers that applied taught practices on their plots reported an increase in pigeon pea yield. For example, lead farmer Mr Abilio Alberto reported a yield increase from 300 kilograms per hectare of pigeon pea last season to 800 kilograms per hectare this season.

3.2.2 Impact on level and diversity of income profiles

As a result of the decline in farmgate pigeon pea prices – 3 to 8 Meticais per kilogram in the 2017-18 season, against an average of 34 Meticais per kilogram in the 2016-17 season[22] – the impact on farmers' incomes was marginally positive in

21. The initial grant application also included additional potential activities for implementation including the supply of/access to ETG tractors under the United States Agency for International Development Feed the Future (USAID FTF) programme, facilitating the supply of inputs (seeds, inoculants, and implements) through the establishment of a revolving loan fund, responsibility to market farmers produce and supporting sesame production. However, these activities were not selected for implementation.
22. Price estimates were provided in October 2017

a few cases but perceived as largely negative by most farmers. Depending on farmers' production costs (estimated at 2 Meticais per kilogram without certified seed use) and farmgate sales price, the impact of using own labour to harvest minimal quantities for sale could be marginally positive on incomes.

However, the majority of farmers view the unanticipated decline in pigeon pea prices as having a highly negative impact on incomes and livelihoods for the 2017-18 season. The low prices have seen engaged farmers opting to harvest reduced quantities for sale using own labour. Women at a focus group in Magige indicated that as a result of the pigeon pea price they will lose money on both their pigeon pea as well as other crops. Specifically, they will likely need to hand mill their maize instead of grinding it at a local mill - potentially reducing the quantity and quality of processed maize available for sale. Importantly, as processed maize flour garners a higher sales price than grain maize, the impact on income is potentially negative. In addition, the same group of women indicated that they will likely be unable to hire mechanised land clearing services, with the associated negative impact on hectares of land under cultivation next season. Further, women in the focus groups expressed concern relating to the overall impact of pigeon pea prices on their families' opportunities - particularly as it relates to schooling.

In terms of income diversity, the model has yet to directly encourage farmers to diversify their income sources. However, the creation or formalisation of farmers' groups involved in the model coupled with the significant depression in pigeon pea prices has encouraged farmers to discuss income diversification strategies. This includes adapting their cropping mix to include crops that are perceived to be more lucrative and with predictable market opportunities, for example tobacco, or including perennial tree crops in production. Farmer groups are also considering establishing savings associations that will enable them to invest in both agricultural and non-agricultural income-generating activities.

From the perspective of other market actors such as ETG and Phoenix the impact of the model on procurement and sales respectively is inconclusive. Seed supplier Phoenix Seeds did not actively participate in demonstration plots as a marketing opportunity. Further, given the current price of pigeon pea the company's local marketing representative was unclear as to whether or not Phoenix would invest in stimulating market demand of certified pigeon pea seeds for the 2017-18 season. On the other hand, ETG has adopted a "wait and see" approach, maintaining current stores of pigeon pea in anticipation that the export price might increase.

3.2.3 Changes in market integration

Due to dynamics in the Indian market ETG has limited pigeon pea procurement. As a result, farmers reported, "knowing ETG extension (*in reference to Solidaridad*) but not knowing ETG commercial (*in reference to ETG-aligned traders*)". This points to the standalone nature of the extension services provided which focused on improving productivity and post-harvest management, and the absence of important information on markets, pricing and market trends. Thus, the level of market integration as defined by sales into the ETG (or other formal pigeon pea traders) supply chain has been minimal.

With regards to input supply, in Northern and Central Mozambique seed companies (with the support of development programme InovAgro[23]) have sought to market their seed products through the establishment of demonstration plots and hosting of field days. Demonstration plots and aligned marketing efforts are managed by company extension agents or agro-dealers respectively. Despite the presence of InovAgro in the region, the pilot did not appear to actively promote the engagement of Phoenix seeds local sales representatives in demonstration plot establishment or hosting of field days.

23. InovAgro is donor funded rural and agricultural development programme operating in Northern Mozambique.

3.3 Local sentiment and perspectives on the success of the innovation model

Local sentiment and perspectives on the success of the innovation model are divergent.

From a TA perspective, key stakeholders ETG, Solidaridad, and farmers perceive the model as a success. As a result of the model, farmers' knowledge and awareness of CSA principles and practices have improved. This has led to small-scale adoption of some taught practices, for example, minimum tillage, intercropping and rotating with pigeon pea, and threshing in bags. As well as requests to adapt TA to be locally suitable e.g. green coverage with fava beans in lieu of mulching. From a farmer's perspective, the adoption of select practices has increased their resilience against the two primary climate change threats-drier and hotter weather-while intercropping with pigeon pea has helped their crop productivity generally. In addition, as pigeon pea protects against wind and water erosion farmers perceive that planting pigeon pea will increase their resilience in instances of extreme events, specifically the heavy flooding that has occurred in recent years.

The farmers' positive sentiments are echoed by Solidaridad. Solidaridad believes that as a result of the model, interest in CSA has risen sharply, with farmers within and outside the project boundaries reacting positively, and showing willingness to adopt CSA practices. There is anecdotal evidence that this is the case, with lead farmers indicating that neighbouring farmers have approached them to engage in demonstration plots in the upcoming season. As the lead private sector partner, ETG also views the productivity enhancing aspect of the model favourably. They estimate that an additional 7,000-10,000 tonnes of pigeon pea would have been available for purchase from supported farmers.

From a market integration perspective, farmers' and Solidaridad's perceptions of the model are negative. During interviews, farmers relayed that the price of pigeon pea and the lack of purchase from ETG was "demoralising." Solidaridad highlights in their latest project report that the "failure of the model to deliver on the promise of market security represents a major risk to farmer participation in the upcoming season and implementer reputation"[24]. This sentiment is echoed by some lead farmers who contend that farmers will exit the pigeon pea market as well as the programme given its pigeon pea production focus. Thus, perceptions of the continued success of the model are mixed, with both Solidaridad and farmers uncertain of the extent to which the current pigeon pea market dynamics will result in farmers exiting the programme and/or pigeon pea market.

> "From an ETG perspective, the innovation is financially unviable unless they can leverage external funding. In the absence of external funding, the tenous link between productivity enhancing activities and revenues entails that it is difficult to justify funding farmer development initiatives without cost sharing with external funders.

24. Solidaridad, 2017

We are thankful to ETG/Solidaridad for working with us, transmitting appropriate technologies to improve our resilience to the effects of climate changes, while improving productivity of pigeon peas, through conservation agriculture, use of drought tolerant seed varieties, intercropping opportunities and use of biological enzyme. Solidaridad has been supporting us technically by training us how to use land efficiently to produce pigeon pea and deliver to the market secured by ETG.

Although we are adhering to the CSA technologies, this season (2016-2017) the market scenario was not as expected. Buyers were not buying from us and later started buying at a significantly low price. As a result, some of us did not harvest our produce while others harvested but did not sell because the buyers were not buying. There are cases, where the crop was left in the field and burnt by other farmers during preparation of their fields and by locals hunting wild rats. The temporary shutdown of the market and low prices will definitely impact significantly the agricultural season 2017-2018 and our livelihoods, whereby some of us will not be able to pay for land preparation, thus not being able to prepare enough land for the season, on the other hand will be short of money to support our livelihoods.

Although the situation impacted significantly the decision of most of us, the majority continue hoping for a better situation in the coming years and showing interest in continuing pursuing pigeon pea cultivation rather than shift to another crop.

Box 3:. The impact of the changes in the market in 2017

Despite positive sentiments related to CSA extension provision, farmers did suggest improvements to the innovation model. Farmers suggested the inclusion of mechanisation services such as land preparation and threshing in addition to the provision of market information related to pigeon pea price and marketing dynamics. This sentiment was echoed by Solidaridad, who requested that ETG engage with farmers around the market dynamics driving limited purchase and the low prices offered.

From a market integration perspective, the farmers were clear. The model would be vastly improved if ETG purchased pigeon pea from participating farmers at a favourable price. This reinforces the fact that models for building resilience of smallholder farmers need to tackle both production and market related risks for them to be sustainable at any scale.

4 Assessing model adaptation and potential for sustainability

4.1 Extent of model adaptation

There was evidence of model adaptation in response to implementation experiences and emerging market realities. As the extension partner, Solidaridad adapted TA to better respond to local needs, for example, through introducing improved threshing techniques and committing to integrate green coverage as an alternative to mulching. In response to the prevailing low price of pigeon pea, Solidaridad recommended to farmers that they store, rather than sell, their harvest. They also provided training to farmers on improved storage techniques to limit pest damage. Although welcome, this adaptation only partially addressed farmers' most pressing needs regarding improved access to markets.

In addition, engagement in the model has resulted in farmers requesting locally suitable adaptations to the model. For example, in Gurué the burning of grassland and crop residue is quite common. As a result, collecting grass for mulching is both time and labour intensive. In response, lead farmers requested that Solidaridad train them on "live mulching"[25] using fava beans as a green cover. In addition to providing ground cover, fava beans have other benefits including nitrogen fixing, improving soil texture, suppressing weeds, and supporting microbial activity in the earth.

Given the implementation timeframe (less than one season) the application of taught practices has been limited to lead farmer demonstration plots and in some instances the learning section of participating farmer plots. However, farmers did indicate that they intend to continue the application of select taught practices, in particular, minimum tillage, intercropping, and correct spacing across their entire field in the 2017-18 agricultural season. It is anticipated that the application of these practices will have a beneficial impact on productivity within the context of hotter and drier weather. Thus, through extension services part funded by a commodity buyer, production systems have been put on the path to increased resilience.

At a broader level, ETG is looking to strengthen the sector by stimulating domestic demand for pigeon pea. ETG is currently approaching development partners including the World Bank, JICA, the Embassy of the Netherlands, and the World Food Programme (WFP) to co-invest in the integration of ready-to-eat pigeon pea products into the WFP school feeding programme. The ready-to-eat pigeon pea products would be produced by ETG. Similar to efforts to integrate soy into Mozambican household diets, targeting children would be the entry point into the larger market. By developing domestic demand for pigeon pea, ETG will no longer be dependent on a "single buyer" and the often-volatile export market. This greater diversity of demand could help to stabilise the price of pigeon pea in Mozambique, encouraging more farmers to plant the drought resistant crop.

4.1.1 Institutional changes as a result of innovation model

Implementation experiences have resulted in ETG reconsidering the long-term institutional arrangements for delivering farmer development programmes. Currently, the innovation model is being managed by a unit within ETG's core business, albeit a non-commercial department (the ETG Mozambique Projects Department) dedicated solely to farmer development. However, ETG is now considering for Mozambique a farmer development model adopted in other operating countries.

In other operating countries farmer development initiatives are managed by EFF. Established in 2013, EFF is a non-profit organisation founded in response to ETG commercial centres not having sufficient resources to dedicate to farmer development. Thus, the foundation seeks to formalise and build on ETG's existing farmer development work by creating new public-private sector partnerships. For example, in Tanzania, the foundation (as the lead implementing partner), ETG (as the private sector partner) and local government (as the extension partner) are working to increase productivity in pigeon pea and mung bean by improving public sector extension provision. The resulting produce is then available for purchase by ETG as the private sector partner[26].

In Mozambique, ETG now plans to register EFF locally to implement select farmer development initiatives. As in Tanzania, EFF will work in close collaboration with ETG. The foundation will be overseen by the ETG's projects department, acting as the implementing vehicle for farmer development programmes that require an NGO partner to access funding. Thus, ETG's current institutional relationship with Solidaridad will be transferred to the EFF in Mozambique.

25. The group of farmers that requested "live mulching" benefitted from previous exposure to the practice under a CLUSA programme.
26. ETG Farmers Foundation (EFF)

4.2 Model's commercial viability

From an ETG perspective, the innovation model is financially unviable unless they can leverage external funding. In the absence of external funding, the tenuous link between productivity enhancing activities and revenues entails that it is difficult to justify funding farmer development initiatives without cost sharing with external funders. This statement suggests that the pilot is yet to demonstrate to ETG the business case of shifting from an extensive sourcing strategy to an intensive sourcing strategy predicated on increasing the productivity of smaller cohort of farmers.

"We are committed to continue working with the farmers, providing support to improve production and productivity as well as integrating production to end markets. ETG has been working in the field with donor-funded projects such as the United States Agency for International Development (USAID) to enhance the storage capacity and bring the markets closer to the farmers.

Being a commercial/for-profit entity, ETG seeks external funds to co-finance the implementation of the majority of the projects that are implemented in the field and will continue seeking partnerships to pursue the improvement of the entire chain production to market, thus making available the produce for export.

We are currently designing strategies and looking for partnerships with donor agencies, to continue the CSA project started with Vuna funding in Zambézia Province."

Box 4:. Sustainability of ETG to continue providing support to farmers

4.3 Changes in market system triggered by model innovations

The model's impact on the wider pigeon pea market or CSA aligned extension provision is nascent due to the limited implementation timeframe. With regards to CSA extension provision, Solidaridad plans to leverage project experiences to create a CSA training manual for pigeon pea farmers. The training manual will be developed with reference to the Directorate of Extension Service's CSA manual and will be a practical guide to good agricultural practices and the application of climate smart agricultural techniques. The manual will be distributed to lead farmers participating in the project, empowering them with a guide to refer back to post-project completion. Going forward, the manual will be integrated into Solidaridad extension provision on other agricultural development programmes, providing a pathway for farm level resilience building beyond the current innovation model.

4.4 Expansion and wider adoption and benefits

The model is yet to influence activities or institutional arrangements beyond the original key stakeholders-ETG, Solidaridad, and farmers. However, Solidaridad will likely expand benefits should they successfully institutionalise the CSA pigeon pea production manual into their other programmes. At a community level, lead farmers remain committed to sharing CSA production knowledge with other farmers.

5 Findings and lessons for model improvement

The pilot phase of the innovation model offers some lessons on how to improve similar interventions as well as broader insights on how to support resilience building and sustainability of interventions in smallholder farming systems.

- **Selecting the Right Partners:** Selecting private sector parters with the right incentives and capacities (financial and operational) is critical to model sustainability. Only when a business has the commercial incentive to invest in farmer development activities are they likely to sustain these services beyond the lifetime of the programme. A commodity buyer's incentive to invest in extension provision is a function of their business model and wider market dynamics.

  Lesson: A rigorous analysis of the market system, focusing on what drives market player behaviour strengthens implementing partners understanding of the incentives and capacities of any stakeholder to invest in productivity enhancing extension services post-programme completion.

"Selecting private sector partners with the right incentives and capacities (financial and operational) is critical to model sustainability. Only when a business has the commercial incentive to invest in farmer development activities are they likely to sustain these services beyond the lifetime of the programme.

- **Establishing a realistic vision of sustainability:** The model's vision for sustainability rested on ETG integrating extension services into their operating model post-2020. ETG's intention to establish EFF suggests that the integration of extension services into their core business is unfeasible. Rather, as a commercial entity, ETG requires sustained external financing to cost share farmer development initiatives. The establishment of EFF, an external (albeit aligned) entity that can leverage funding provides ETG with the ideal partner institutional vehicle for delivering farmer support services in the long-run.

  Lesson: ETG's intended establishment of EFF as an institutional vehicle to mobilise external funding and provide farmer support suggests that the commercial case for ETG internalising extension services into their commercial operations was not sufficiently demonstrated.

- **Partnership negotiation and management:** Pilot implementation experiences demonstrate the importance of effective partnership negotiation and management. The model envisioned resilience building as a function of crop diversification and included the promotion of both pigeon pea and sesame. Similar to pigeon pea, sesame is a drought tolerant crop with a growing market. However, support to both crops was not detailed in the project's management plan. As a result, partners did not invest in enhancing sesame production through the provision of CSA extension services. Given current pigeon pea prices, the inclusion of sesame could have strengthened farmer resilience by diversifying risks.

  Lesson: Including model elements critical to model sustainability and resilience in the project's management plan supports their execution during implementation.

- **Planning for system-wide shocks:** The shock induced by plunging demand in the Indian end-market highlights that climate smart projects for agriculture should consider both climate and market risks. Importantly, ETG is aware of these dynamics and separate to the innovation model is exploring mechanisms for stimulating domestic pigeon pea demand to reduce their reliance on the Indian export market.

  Lesson: There is a need to look beyond production focused adaptation measures and explore, understand, and integrate into intervention design mitigation measures for potential economic and commercial shocks.

- **Building the business case for model scale-up:** Scalability relates to model replication by other market actors and invariably requires active promotion and intervention. Implementing partners have to go beyond farm level demonstrations to actively build the business case through the collection and dissemination of key data points, particularly with respect to buyer return on investment in extension services. Harnessing such information would allow programmes to make the business case for large trading-based businesses to shift from an extensive to an intensive sourcing strategy proximate to their warehousing facilities.

  Lesson: Capturing and disseminating the commercial costs and benefits of investing in CSA extension services is integral to catalysing wider market player adoption. This highlights the importance of adequately designed and resourced measurement frameworks that quantify the benefits from farm to business level.

- **Provision of Market Information:** Farmer's expectations that ETG would purchase produced pigeon pea were raised during project sensitisation efforts. Due to market conditions, ETG was unable to purchase pigeon pea from project participants at a favourable price, leaving some demoralised and frustrated. Farmers' frustrations were heightened by the lack of information on why ETG's purchases were limited and the market dynamics that dictated the low price being offered.

  Lesson: When market dynamics shift dramatically and key partners are no longer able to meet expectations (perceived or real), the partner should leverage extension officers to communicate the new position in a timely manner to project participants.

- **Step-wise approach to building resilient production systems:** ETG introduced a number of technologies in their demonstration activities, including: biocatalysts, certified seed, and organic pesticides, amongst others. However, farmers participating in the demonstration activities tended to adopt technologies that were low-cost and less labour intensive. This mirrors regional dynamics where resource-poor farmers tend to favour low-cost and low labour production and post-production techniques that enhance yields and income.

  Lesson: Implementing partners should consider farmers' relative commercialisation levels when designing productivity enhancing initiatives, adopting a stepwise approach that aligns with the farmers' level of commercialisation and appetite for new technologies and techniques.

ANNEX 1:
Climate trends and risks for pigeon pea production in Mozambique

Extreme weather events

Climate related hazards such as floods, cyclones and droughts are occurring with increasing frequency and intensity in the southern Africa region, including in Mozambique. An assessment of historical drought events in Mozambique indicates that Zambezia province in the north suffered the most drought incidents with a maximum of ten events between 1980 and 2003. In Gurué district, above average incidences of drought ranging between eight to ten incidents between 1980 and 2000 have been recorded (Figure A1, centre). In terms of historical flood events (1985-2003), there has been low flood prevalence in Gurué (pilot project area) with only two flood incidents recorded[27] (Figure A1, right). Furthermore, due Mozambique's coastal geographic location, flooding events are heavily influenced by tropical cyclones[28], for example, Cyclone Eline in 2000, Cyclone Japhet in 2003, Cyclone Favio in 2007 and Cyclone Dineo in 2017.

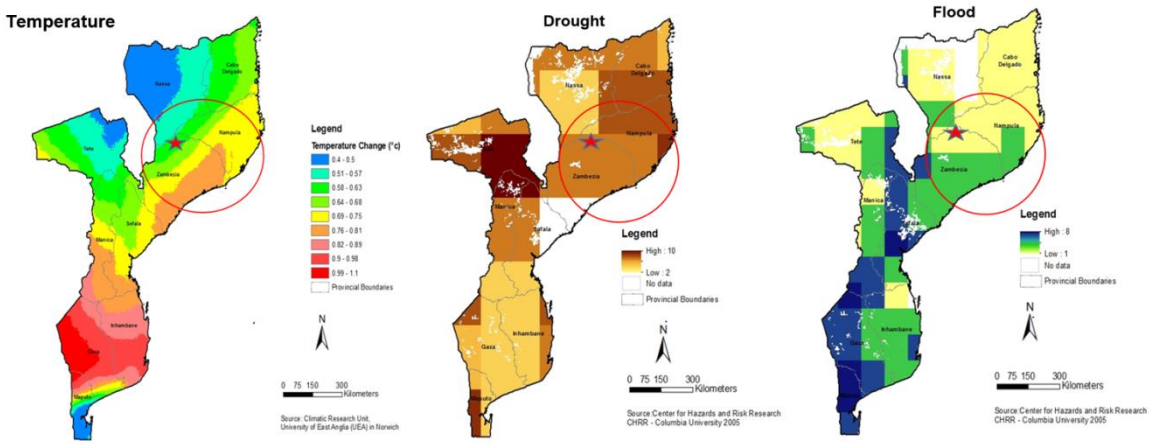

Figure A1:. Climate Risks in Mozambique. Temperature Change (left) Drought (middle), Floods (right). The approximate location of Gurué town is marked with a star. Gurué District, Zambézia provinces is highlighted with the red circle.

27. CHRR, 2005
28. Davis *et al*., 2017

Impacts of rainfall changes on pigeon pea production

The projected changes in rainfall patterns will result in a decrease of soil water recharge and will affect both ground and surface water resources. However, Pigeon pea is a drought resistant crop, so it can be grown in areas with less than 650 mm average annual rainfall[29]. Therefore, the reduction in water availability will have minimal effect on the production of pigeon pea.

Impacts of temperature on pigeon pea production

The climate will become as hotter and drier, as a result of increases in temperature affecting the growing of staple crops such as maize. However, pigeon pea being a semi-arid crop will be minimally affected by increases in temperature.

Impacts of extreme weather events in pigeon pea production

The projected increases in heavy rainfall and heat waves will probably result in an increase in extreme events, including droughts and floods[30]. More hot days during the harvest cycle and the less predictable onset of the rainy season increases the risk of crop failure particularly for farmers who plant prematurely. However, despite the high incidences of droughts, the low water requirements of the crop prevent massive crop failure suggesting that drought is not a threat for pigeon pea production in Gurué. Pigeon pea production, due to its resilience as a dry land crop will thus help farmers adapt to this changing climate.

Quick facts:

Climate Change Projections in Mozambique

Rainfall

- Variable rainfall patterns, with both increases and decreases anticipated.
- Rainfall from heavy rainfall events such as cyclones and tropical storms as well as the intensity and frequency of these events is expected to increase by 10% and 6% respectively between 2010-2100[27].

Temperature

- Significant increase (up to 4.6°C) in maximum temperature as well as increase in average temperatures, from 2010-2090.
- Inland temperature changes are expected to increase between +2,5°C and +3.0°C between 2046 and 2065[28] this is of particular significance in the pilot project area.

Extreme Weather Events

- Number of hot days and nights[25], are expected to increase by 20-35% for days and 26-76% for nights by 2090[27], especially between December and February.
- Long-lasting heat waves are expected to rise by 17 days on average by 2100[27].
- Maximum daily temperatures over 35°C are expected to occur 25% higher by 2090 compared to the present day[28].
- Increase in frequency of droughts, as a result of longer heat waves and dry spells, is anticipated for central and southern regions of the country; furthermore, dry spells will be prolonged[3].
- Cyclones are expected to continue as well increase in intensity and frequency. This will increase the number of flood events, particularly in the northern parts of the country[27].

Box A1:. Quick facts: climate change projections in Mozambique

29. Global Trading, 2016
30. NCEA, 2015

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