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Enhancing the adoption of climate-smart technologies using public-private partnerships: lessons from the WEMA case in South Africa

RESEARCH ARTICLE

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Abstract

Climate-smart agricultural technological innovations have the potential to reduce climate change impacts on agriculture. Due to several barriers, their current rate of adoption and diffusion is low. Public-private partnerships (PPPs) have the potential to facilitate technology development and dissemination to smallholder farmers. The aim of this paper is to examine the role of the water efficient maize for Africa (WEMA) project in enhancing technology adoption by smallholder farmers in South Africa. This study explores how PPPs enhance technology adoption and highlights the challenges faced within PPPs using WEMA case. A critical analysis, involving iterative process helped to construct a comprehensive narrative. We found that disputed outcomes, stakeholder concerns, shortage of seeds, disinclination of local companies to market new seeds, upkeep of previous relationships, contractual arrangements and high level of expertise and skills required from farmers were the main factors that affected the efficacy and impact of WEMA on the targeted output and beneficiaries.

Keywords: climate-smart agriculture technological innovations, public-private partnerships, water efficient maize for Africa, technology adoption, smallholder farmers
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1. Introduction

1.1 Background

Climate change would exacerbate developmental challenges in Africa. Agricultural production may be significantly impacted due to changes in rainfall patterns, increases in temperature and variations in the frequency and intensity of extreme climatic events such as droughts and floods (Brida *et al.*, 2013; Elum *et al.*, 2017; Hellin *et al.*, 2012; Khatri-Chhetri *et al.*, 2017; Lobell *et al.*, 2011, 2012; Ziervogel *et al.*, 2010). Some of the impacts of climate change on agriculture may include changes in crop cultivation, agriculture biodiversity, decreases in input use efficiency, increased prevalence of pests and diseases, and disruption to markets (Khatri-Chhetri *et al.*, 2017; Lipper *et al.*, 2014; Norton, 2014). South Africa, like many African countries, has been identified as being especially vulnerable to the impacts of climate change (Department of Environmental Affairs, 2011; Elum *et al.*, 2017), partly because the agricultural sector is a major employer in South Africa. For these reasons, the country needs supportive policies to develop and implement technological innovations to enhance climate change adaptation among farmers, and particularly smallholder farmers (Elum *et al.*, 2017; Senyolo *et al.*, 2018). Smallholder farmers are often less able to adapt to climate change as they often lack the means to improve their adaptive capacity due to factors such as lack of credit, limited access to input and output markets and no insurance to hedge against climatic risks (Elum *et al.*, 2017). Yet, the adverse effects of climate change demand that they adapt to these changes in order to safeguard their food and livelihood security (Andrieu *et al.*, 2017; Elum *et al.*, 2017; Maponya and Mpandeli, 2012; Mullins *et al.*, 2018).

Numerous potential adaptation options to reduce climatic risks exist (Khatri-Chhetri *et al.*, 2017; Makate *et al.*, 2019). Climate-smart agriculture (CSA) is recognised as one innovative approach to effectively achieve the developmental goals of vulnerable populations (for example, smallholder farmers) dependent on agriculture (Partey *et al.*, 2018). For instance, CSA is about transforming and reorienting agricultural systems, with a focus on developing resilient food production systems that lead to food and income security under climatic change and variability (Khatri-Chhetri *et al.*, 2017; Lipper *et al.*, 2014). The CSA concept is already embedded in many indigenous practices, tools and approaches that have helped farmers produce food in the face of past climate change and variability. Still, advances in CSA research have drove development and dissemination of somewhat new approaches, tools and policies such as high yielding and drought resistant seeds, agricultural insurance, climate information systems, solar-powered drip irrigation systems, integrated tree-crop-livestock systems, precision agriculture and infield rainwater harvesting (Mapfumo *et al.*, 2014; Partey *et al.*, 2018; Senyolo *et al.*, 2018).

There is no doubt that CSA technological innovations (hereafter CSATIs, including technologies, practices and services) individually or in combination, have the potential to reduce the impact of climate change on agriculture (Bedmar Villanueva *et al.*, 2016; Khatri-Chhetri *et al.*, 2017, Senyolo *et al.*, 2018). However, their current rate of adoption and diffusion is low due to several barriers encountered by both the end-users (i.e. farmers) and technology providers (Asfaw *et al.*, 2016; Khatri-Chhetri *et al.*, 2017; Long *et al.*, 2017; Partey *et al.*, 2018). Factors, such as affordability, local availability, access to production credit, size of land, preferences and attitudes, gender and marital status of the farmers, as well as related training and demonstration affect farmers' adoption decisions. Agri-technology providers also experience difficulties and barriers. Provision of technology alone does not fully address the challenges that smallholder farmers are facing, as they require additional support. Thus, smallholder farmers within the base-of-the-pyramid (BoP) often require production credit in addition to proof of impact of some of the promoted CSATIs.

To help overcome some of the barriers hindering the diffusion of CSATIs, numerous initiatives have been implemented. For instance, government agencies and agricultural research institutions have conducted different types of pilot programmes and projects to demonstrate the benefits of CSA by highlighting how CSA can deliver 'triple-win' outcomes (Cavanagh *et al.*, 2017). The 'triple win' outcomes suggests that CSA approach pursues the triple objectives of sustainably increasing productivity and incomes, adapting

to climate change and reducing greenhouse gas emissions where possible (FAO, 2010). As a result, this does not imply that every practice and/or technology applied in every location should produce 'triple wins', instead the CSA approach seeks to reduce trade-offs and foster synergies by taking these objectives into consideration to inform decisions from the local to the global scales and over short and long-time horizons, in order to derive locally-acceptable solutions. Likewise, the government and the private sector have joined forces in public-private partnerships (PPPs) to intervene with the aim to enhance adoption and diffusion of agricultural technologies under climate change related risks within smallholder agriculture.

Public-private partnerships started in the 1990s and describe the provision of public assets and services through the participation of the government, the private sector and the consumers (Grimsey and Lewis, 2005). These PPPs are a popular approach for several reasons which include achieving improved value for money and sharing of risks (Cui *et al.*, 2019; Grimsey and Lewis, 2005). In agricultural research and development, PPPs are increasingly considered an effective way of conducting advanced research, commercialising new technologies, and deploying new products for the benefit of small-scale, resource-poor farmers; food insecure consumers; and other marginalised groups in developing countries (Spielman *et al.*, 2007). According to Grimsey and Lewis (2005), PPPs are well-established practices in countries such as the United Kingdom, Australia, the Netherlands, South Africa, Canada and Japan. Theoretically, PPPs are suitable to create the innovations necessary to promote the adoption and diffusion of technologies, yet in practice they are subject to several constrains. Consequently, barriers which can be described in terms of market failure, institutional constraints and systematic weaknesses tend to impede the otherwise smooth process of exchanging and using knowledge necessary to the innovation process (Spielman *et al.*, 2007).

An example of a PPP formed with the aim to enhance the adoption and diffusion of agricultural technologies under climate change related risks within smallholder agriculture is the water efficient maize for Africa (WEMA) initiative, the PPP with the objective to improve food security and rural livelihoods among smallholder maize producers in sub-Saharan Africa. The project seeks to develop and disseminate seed technologies which are drought-tolerant and insect-pest-protected (Edge *et al.*, 2018). We argue that while PPP initiatives like WEMA have the potential to facilitate market access for, and technology development and dissemination to smallholder farmers (Bitzer and Bijman, 2014; Edge *et al.*, 2018; Ponnusamy, 2013), their impact and efficacy can be limited due to certain barriers (Bitzer and Bijman, 2014; Edge *et al.*, 2018; Ezezika and Daar, 2012, Ponnusamy, 2013). For instance, different perspectives on the challenges to and possibilities for innovation possessed by different actors within a partnership can be challenging to reconcile and combine due to cognitive, information and managerial gaps between actors involved (Bitzer and Bijman, 2014; Klerkx and Leeuwis, 2008). Also, power, knowledge, institutional or political strength and negotiation skills asymmetries among actors can complicate communication process and also influence and skew the innovation process in favour of the terms and priorities of the more powerful actors (Bitzer and Bijman, 2014; Bode *et al.*, 2008; Murphy *et al.*, 2012).

Against this background, the aim of this paper is to examine the role of the WEMA project in enhancing technology adoption by South African smallholder farmers in the context of moisture stress and water scarcity. By exploring the WEMA case, we seek to examine how PPPs can enhance technology adoption, and how hindrances faced by the partnership in enhancing technology adoption can be overcome and opportunities leveraged. The study seeks to highlight whether the WEMA initiative enhanced technology adoption by smallholder farmers, and what factors enabled and/or constrained the WEMA PPP. In doing so, the study focuses on 4 aspects: (1) the characterisation of the WEMA PPP; (2) the development of the WEMA PPP; (3) its management and operations; and (4) its performance and its contribution to development.

1.2 Case explanation and justification

Since the aim of this paper was to shed light on how the adoption of climate-smart technologies such as drought-tolerant seed varieties (DTSVs) can be enhanced using lessons learned from the WEMA project in South Africa, the premise of the study focused on the four main aspects mentioned in Section 1.1 as well

as the factors which enabled/constrained the WEMA PPP initiative. Consequently, in order to understand the aforementioned aspects within the context of our research, we explored the literature and the publicly available WEMA project documents, and corroborated this with data from informants associated with the WEMA project in South Africa. The WEMA partnership is coordinated by the African Agricultural Technology Foundation (AATF), drawing on its unique experience in PPP management, technology stewardship and project management. The AATF is working with the National Research Systems (NARS) in Kenya, Mozambique, South Africa, Tanzania and Uganda; the International Maize and Wheat Improvement Centre (CYMMIT); Monsanto; the Bill & Melinda Gates Foundation; the Howard G. Buffett Foundation and the United States Agency for International Development are funders of the WEMA initiative. In South Africa, the project is co-ordinated by the Agricultural Research Council (ARC). The NARS, farmers' groups and seed companies participating in the WEMA project, contribute their expertise in breeding, field testing, seed multiplication and distribution. The International Maize and Wheat Improvement Centre provide high yielding maize varieties that are adapted to African conditions and expertise in conventional breeding and testing for drought tolerance. Monsanto, a private agricultural company now part of Bayer, is contributing maize varieties from its global proprietary collection, drought-tolerant and insect protection genes, as well as its expertise in agricultural research and product development. Each of the WEMA partners contributes its technology, time and expertise to the project. Furthermore, participation by farmers' groups and government in the WEMA project is presumed to strengthen African capacities in crop breeding and biosafety.

Smallholder farmers' adoption processes and decisions are generally known to be multifaceted and hindered by several factors including biophysical and socio-economic constraints, barriers in the political process and institutional environment within which they operate. Therefore, in many cases interventions are necessary to help them overcome these adoption barriers. For that reason, public or private interventions with intentions to enhance the adoption by assisting smallholder farmers to overcome the adoption barriers can be seen as a relevant case (Patton, 2002) to understand the complexity of the adoption and diffusion processes. Since previous research showed that a PPP is an approach that offers the opportunity for public and private partners to combine efforts and resources in their interventions, resulting in better economic conditions and livelihood of target population (Edge *et al.*, 2018; Ponnusamy, 2013), we sought a case where interventions to enhance technology adoption by smallholder farmers was a result of PPP. During the time of our data collection, the WEMA case in South Africa offered a particularly interesting example to study how interventions to enhance adoption and diffusion of CSA technologies such as drought-tolerant seeds work in practice and the challenges that are likely to be encountered.

Drought is one of the major causes of reduced maize production and food insecurity, especially in sub-Saharan Africa, where agriculture is largely rain fed (Lunduka *et al.*, 2017). Projected changes in precipitation and increases in temperatures are likely to have implications for maize production, and consequently, food security and livelihoods of smallholder farmers (Cairns *et al.*, 2012, 2013; Lobell *et al.*, 2011). Therefore, to safeguard national food security and economic stability, adaptation to such climatic changes is essential. Development of the drought-tolerant maize varieties is recognised as one of the adaptation strategies in store to sustaining maize production (Lunduka *et al.*, 2017). While the development of drought-tolerant maize varieties continue to be the intention of breeding programmes and research institutes across the globe (Bänziger *et al.*, 2006), the majority of farmers in sub-Saharan Africa (SSA) still use traditional and unimproved low-yielding seed varieties (Langyintuo *et al.,* 2010). For instance, although South Africa has the most-developed formal seed system in Africa, the system is not necessarily best suited to provide smallholder resource-poor farmers with appropriate and affordable seeds (Edge *et al.*, 2018; Marechera *et al.*, 2016); to address this, a tailor-made intervention is necessary. Availability of good quality seeds that are resistant to heat and drought is essential to increase crop production and productivity. Factors such as decreasing soil fertility, a shortage of arable land, and moisture stress are likely to worsen because of high temperatures and erratic rainfalls related to climate change (Asfaw *et al.*, 2016; Marechera *et al.*, 2016; Phiri and Saka, 2008; Tripp and Rohrbach, 2001).

2. Literature review

2.1 Public-private partnerships

Partnerships between farmers, businesses, governments, NGOs and/or multilateral agencies are prevalent in agricultural development. Public-private partnerships help to realise innovation and sustainability goals that organisations acting alone would not otherwise be able to achieve (Bitzer and Bijman, 2014; Ponnusamy, 2013; Spielman *et al.*, 2007). For instance, they can facilitate smallholder farmers' access to seed varieties with resistance to insect pests or drought-tolerant varieties (Edge *et al.* 2018; Ezezika and Daar, 2012) According to Ponnusamy (2013) the PPP is a well-used strategy to realise public services and infrastructure goals in agriculture, education, science and technology, health, infrastructure development and extension. Generally, the motive behind the development of a PPP is a shortage of human resources, facilities and time; and within agriculture, the essence of the PPP is understood in terms of a shared mechanism for resources, markets, inputs, risks, technologies and benefits (Ponnusamy, 2013). Another reason cited for the adoption of PPP is related to the failure of civil servants to effectively deliver and maintain public services, for instance, due to corruption associated with public procurement (Otairu *et al.*, 2014). Public-private partnerships are also recognised for their ability to strengthen project monitoring as well as to ensure greater accountability (Ismail, 2013), which could be necessary to safeguard effectiveness of government interventions aimed at enhancing technology adoption and diffusion.

2.2 The importance of public-private partnerships in the agricultural sector

Global climate change as well as land and water scarcity are emerging as key challenges to agricultural sustainability. Climate impacts are compounded by market related failures, weak institutions, inappropriate policies and low use of technologies (AATF, 2014). To tackle these kinds of challenges, multidisciplinary and multi-institutional efforts forging partnerships across institutions and sectors, are necessary (Kpadonou *et al.*, 2017; Ponnusamy, 2013). Smallholder distress comes from a mix of challenges, and therefore solutions will depend on a combination of both technological and non-technological interventions (AATF, 2014). Examples of technological interventions include replenishment of soil nutrients, injection of mechanisation, better post-harvest management, better agronomic practices and improved seed varieties. Non-technological interventions include enabling policies to come to efficient and adequate markets, sufficient government support, strong agricultural finance systems leading to adequate funding, capable institutions, such as extension services and the development of effective PPPs (AATF, 2014). Other reasons cited for the promotion of innovative partnerships that bring together business, government and civil society actors to improve productivity and to drive growth within agriculture and food sectors around the world, are limited government resources and expertise (FAO, 2016). In general, each partnership is designed to address a specific national problem, and related economic, social and/or environmental issues.

3. Research approach and methods

3.1 Data collection

A qualitative research design was chosen due to its ability to permit the researcher to value and capture the in-depth nature of a phenomenon or behaviour (Taylor and Bogdan, 1998). We adopted the inductive qualitative case study approach to gather data from key informants. A mix of data sources was used to increase validity. The suitability of this approach is based on the research objectives, which involved exploration of how smallholder farmers' adoption of CSA technologies such as the DTSVs have been enhanced, through different viewpoints of those involved. Literature review, interview data and focus group discussion (FGD) were the main sources of evidence to discover relevant themes related to the research objectives. Data collection was conducted during 2015 and again in July-August 2017. Data collection was conducted by the first author as the PhD candidate of the study for which this paper is part of. The research proposal for the PhD was evaluated and approved by the Wageningen School of Social Sciences of Wageningen University,

the Netherlands, the permission to conduct the study in the Limpopo Province and to interact with the farmers in province was so sought with and granted by the Limpopo Department of Agriculture and the informed consent and voluntary will to participate in the research was sought with and granted by the respondents prior to each interview.

An interview guide was developed using literature and from a discussion with knowledgeable key informants working in CSA in general and water management in particular. Considering the nature of this study, open-ended questions were posed for all interviews and during the FGD. Subsequently, secondary data was collected by literature review including academic articles, news articles and publicly available (at the time) documents on the WEMA projects. Semi-structured face-to-face interviews with ten individuals were also conducted. This included five key informants (representing the public and the private sectors) to gain an understanding of how the WEMA project evolved in practice in South Africa, including the outcomes as well as the challenges experienced. These key informants included the WEMA South Africa coordinator, two officials from the provincial department of agriculture, one university researcher, and one manager from one of the four local seed companies that were licensed to sell the WEMA products. The other five semi-structured interviews were conducted with five out of the fourteen farmers that were sub-contracted by the licensed local seed companies to plant and produce WEMA seeds to be sold to smallholder farmers. Furthermore, a FGD was held with nine farmers participating in the WEMA project at Mokaba Village in Limpopo Province. These respondents, together helped to provide insights from different viewpoints as they served various functions within the WEMA project, and gave different perspectives. This enabled triangulation of the information among different respondents. Interviewees were identified first by making a list of key individuals associated with the project. This list was then populated further through snowball sampling by engaging with the partners in the project and stakeholder informants who were familiar with the WEMA project. For a brief outline of the respondents for this study see Table 1.

Individual farmers IF1 through IF5 have practical experience in agriculture. Some of them were considered very successful as land reform beneficiaries and/or are emerging to become commercial farmers. For example, IF4 was even crowned Limpopo female farmer champion during the annual provincial female entrepreneur of the year awards in Polokwane in 2016.

3.2 Data analysis

To analyse the empirical data, several steps were taken, since most interviews were audiotaped and where this was not the case, comprehensive notes were taken during the interviews. First, the interview data were transcribed, and during this process, key initial observations like the WEMA project setting and partners, as well as topics that were relevant, were noted. This process was considered necessary as transcribing is an interpretative act rather than a merely technical procedure, and a solid observation that it requires have the potential to lead researchers to detecting unanticipated phenomena. Secondly, data was organised and sorted by looking closely at the role of the respondents within the WEMA initiative itself, their interactions and/or relationships among the respondents' institutions/businesses and the relationship between other respondents and the smallholder farmers, their opinions about the potential of DTSVs as well as what they considered to have been barriers to adoption in their views. The analysis was performed by reading through the transcripts iteratively, identifying relevant points related to our research questions, possible trends and organising them into major themes. The results were critically analysed to construct a comprehensive narrative on barriers that were identified within the WEMA project that were impacting its efficacy and impact on the targeted output (technology deployment and adoption) and beneficiaries, the smallholder farmers in this case. Individual data items were coded based on their relevancy to the research objectives and frequency to recognise the relevant themes that will help in making sense of what key factors constrained the arrangement intention and subsequently, the adoption of DTSVs in South Africa.

For a theme to be established at least two of the respondents had to mention it as a factor. For example, KI4 represented an official who manages scientific research and is involved when it comes to field trials and

Table 1. Respondents and brief outline of their role in WEMA project.[1]

No	Field of study	Responsibilities within organisation or farm	Roles within WEMA project
KI1	Plant breeding, biotechnology and genetics as well as crop science and agricultural biotechnology	Senior official in Agricultural Research Council, Institute of Grain Crops.	Official, main participant, regional project leader and coordinator. Coordinates and leads WEMA project activities in South Africa. Also involved in research, field and on-farm trials and demonstrations of the WEMA products, both hybrid and open pollinated varieties. Furthermore, engaged to give advice to the licensed seed companies and to monitor if they deliver on their commitments.
KI2	Agriculture: agronomy	Professor, responsible for lecturing and supervision of student projects. Conduct research on crop rotation, indigenous vegetables, different varieties of maize cultivars (for example WEMA).	Conduct research on some of the WEMA materials with farmers and/or in farmers' fields to test them and compare them with alternative varieties that are already recommended and used in farmers' regions.
KI3	Agricultural economics	Senior personnel of the company which produces and sells certified seeds, who work closely with farmers, mostly under contract arrangements.	Licensed to produce and market certified WEMA seeds, both hybrids and OPVs. The production is done through sub-contracting of farmers.
KI4	Plant breeding	Senior official in the Research Directorate within research section of Department of Agriculture.	Involved in research, field trials and demonstrations of WEMA products. Also responsible for awareness raising regarding WEMA seeds, both hybrids and OPVs.
KI5	Plant science: agronomy	Senior official on agronomy and seed multiplication, within Department of Agriculture.	Involved in projects of community-based seed production.
IF1-IF5	Secondary and post-secondary education with background in agriculture	Makes all the major decisions regarding what crops to plant at any given time and season in accordance with various contracts or independently.	Sub-contracted by the licensed company to produce on its behalf the certified WEMA seeds.

[1] IF = individual farmer; KI = key informant; OPVs = open pollinated varieties; WEMA = water efficient maize for Africa.

demonstrations at farmers and community levels. During the interview she noted that shortage of seeds is a thorny issue, even if farmers are interested in trying the seeds. The respondent emphasised that at times demonstrating seeds to farmers and giving them hopes only to find that comes next season companies can't deliver is problematic. She attributed the problem of shortage of skills to the insufficient technical know-how leading to poor quality seeds. While KI1 and KI4 concurred that hybrids gives farmers some harvest even when is dry, they emphasised the need for expertise and skills in handling and marketing seeds by some of the contracted companies. The coding process started first by identification of these key issues and factors and based on the message conveyed by the respondents. Eventually, these excerpts were initially underlined and then categorised based on commonalities and generalisations among our respondents. Finally, the main elements of the WEMA arrangements and key factors noted to constrain the arrangement and subsequently the adoption are elaborated in the results section.

4. Results

This section presents the results of the of the study, where interview data on the main aspects of the case collected from the respondents were summarised and presented in the form of text and tabular forms in order to shed light on the composition and operation of the WEMA arrangement. The section will subsequently present the results from critical analysis which was constructed with the view to give a comprehensive narrative on the factors that constrained the WEMA arrangement and subsequently hindering its aspiration to enhance adoption of CSA technologies such as the DTSVs.

4.1 Characterisation of the WEMA arrangement

The results from the interview highlighted that the AATF mandate within the WEMA project was actually to negotiate and provide access to proprietary technologies to smallholder African farmers' royalty-free, in order to make the technologies affordable. Accordingly, the respondents noted that AAFT was the major grantee of the project in terms of funding. Bill and Melinda Gates Foundation and the Howard G Buffett Foundation were noted to have funded the project during 2008-2012 and the United States Agency for International Development (USAID) was reported to have funded the project during 2013 to 2017. Monsanto on the other hand, was noted to have donated the drought traits as well as the Bt[1] traits to the project. The respondents further noted that the company also donated part of their germplasm and assisted with some of their advance breeding tools. Furthermore, respondents noted that CIMMYT, which is a non-profit research and training institution dedicated to maize and wheat science, that have germplasms or maize lines that are tolerant to biotic and abiotic stresses, and therefore targets critical challenges including food insecurity and malnutrition, climate change and environmental degradation.

Five countries noted by the respondents to be participating in the WEMA project through their respective NARS, from the East and Southern African region were identified as: Kenya, Uganda, Tanzania, Mozambique and South Africa. In South Africa, the NARS in question is the Agricultural Research Council (ARC). Therefore, according to the respondents within the WEMA partnership, ARC developed varieties, to ensure that they are taken up by seed companies, whereby the AATF then provided sub-licenses to each seed company so that they could produce and market the seeds.

In order to ensure that smallholder farmers get access to those improved WEMA varieties, it was further highlighted that the WEMA PPP saw the need to stimulate private-sector involvement to tap into private seed companies' abilities to invest in production and selling of those varieties. Apparently, this was felt important as the respondents noted that the ultimate goal of WEMA partnership was also to deploy rather than only develop seeds. Respondents also noted that all seed companies were targeted to produce and market WEMA products. Consequently, in order to get buy-in all local seed companies were invited to see the WEMA varieties in Potchefstroom and apply for the basic material to multiply and market the seeds. However, the respondents mentioned that seed companies that came forth to produce and market the WEMA varieties were Capstone, Advance Seed, Seed Co and Jermart Seed.

4.2 Development of the public-private partnerships (WEMA) arrangements

Respondents noted that the WEMA partnership officially started operating in 2008 even though the negotiation of the various WEMA partners to formalise the idea into a funded project started in 2007. For instance, respondents commented the AATF with its notable leadership and unique experience in PPP management, and highlighted that it was for that reason that it became a central player in WEMA in 2007 and at the request of Monsanto, took the lead in preparing an investment plan to the Bill and Melinda Gates Foundation. Subsequently, the AATF went further to extent its invitation to CYMMIT to participate in WEMA in 2007.

[1] *Bacillus thuringiensis* (Bt) is a naturally occurring soil bacterium that Monsanto used in some of its corn and cotton seed products to provide protection from damaging insects.

Respondents further highlighted that CYMMIT was invited to the partnership to provide high-yielding maize varieties that are adapted to African conditions and for their expertise in conventional breeding and testing for drought tolerance. Evident to CYMMIT expertise was when by 2002, the institution had managed to develop maize hybrids with yields under drought conditions averaging 20% above local hybrids not improved through stress breeding. Respondents highlighted that given CYMMIT's possible progress at low cost through the use of conventional breeding methods in Africa, other partners within the participating countries raised a question asking why should anyone employ the more expensive approach of genetic engineering. However, a counter response was that genetic engineering offers the potential to provide improved drought tolerance to the already improved CYMMIT hybrids. Respondents further highlighted that the question of whether the scientifically justified approach of employing genetic engineering to develop drought-tolerant maize would be sufficient to overcome the potential political barriers, remained unclear to CYMMIT in 2007.

Considering the role of policy makers in food security and climate change adaptation in developing countries, it was necessary to engage the governments of the WEMA participating countries. Similarly, respondents noted that government support and the political will to introduce biotechnology for smallholder farmers in Africa were understood as critical components for the success of the WEMA project. In the same light, the NARS of the five WEMA participating countries which were supportive of developing, biosafety laws for the commercial cultivation of genetically modified crops agreed to join the partnership. According to respondents the NARS in those countries had no experience with the unique challenges of integrating biotechnology into their programs and in 2007 they indicated their desire to learn as well their willingness to try. Respondents further indicated that the reason Bill and Melinda Gates Foundation officers were inclined to fund an initiative like the WEMA partnership is because they have identified drought tolerance as one of the most important crop improvement goals for helping smallholder farmers in Africa though the foundation in 2007 did not yet have specific strategy to embrace genetically engineered crops for Africa. However, they had established a platform to support crop improvement projects that used technologies most likely to address the effects of drought in the continent. Table 2 gives a summarised timeline of events concerning WEMA PPP project.

4.3 Management and operations

Respondents noted that the WEMA partners organised themselves into global and in-country teams. They were of the opinion that a good management leadership structure was necessary to manage the complexity, facilitate the cross-functional connectivity, while keeping everyone focused on the ultimate goal of the project: farmers need to purchase and plant the seeds and get yield advantages to create a scalable and sustainable adoption of the technology. To reach this goal, within the WEMA project, there was a product development team (PDT), which was responsible for setting the technical milestones and to conduct the variety development. There was also a product deployment team (DEPT) which was tasked to develop the project commercialisation strategies, to guide certified seed production, promotion, distribution, as well as to stimulate private-sector involvement. Moreover, since WEMA partners used two approaches in terms of developing the varieties (namely, conventional and genetic engineering), they had a regulatory team (RT) which task was to obtain necessary regulatory approval in the in WEMA participating countries. The WEMA project also had a communication and outreach team (COT), responsible for deployment and implementation of the communication outreach, strategy and planning, and also capacity building. The fifth and last team was the legal and license team (LLT), responsible for drawing up legal and licensing documents.

Each WEMA functional team had specific performance goals. For instance, the PDT had tangible metrics to evaluate its success. This included, counting the number of rows planted per year, the number of new hybrids in national performance testing, and the number of new hybrids registered for commercial release and comparing the yield data on their newest hybrids to the best alternative on the market. The RT measured its progress based on the number of applications submitted and approved as well as the project's compliance with regulations for monitoring field trials. The DEPT measured its achievements by indicators, such as number of seed companies licensed, amount of basic and commercial seeds produced, brand awareness, and the number of seeds sold and planted by smallholder farmers. The LLT measured its success based on

Table 2. Timeline of events regarding WEMA public-private partnerships.[1]

Events	2007	2008-2012	2013-2017
Negotiation of partners to formalise the idea of WEMA PPP into a funded project started	X		
Monsanto requests the AATF to become the driver of the proposed WEMA PPP	X		
The AATF accepted the request and became central player in WEMA PPP formulation and preparing an investment plan for the Bill and Melinda Gates Foundation	X		
The AATF invited CYMMIT to participate in WEMA PPP	X		
The NARS of the five WEMA participating countries also indicated the desire to be part of the WEMA PPP	X		
Bill and Melinda Gates Foundation and the Howard G. Buffett Foundation funded the first phase of WEMA PPP		X	
WEMA PPP was formed and the phase one project started. Main activities of the first phase included bringing together parties from participating countries to work together in building the necessary scientific testing, regulatory procedures and protocols for the evaluation of maize varieties in the project within each of the five participating countries. Thus, activities included: collaboration agreements signed, WEMA project launched, formation of work teams and harmonisation of the work plans, and identification and development of trial sites, WEMA breeding and testing programme, Awareness campaign, study tours, strengthening capacity to deliver drought-tolerant maize and stakeholders rate WEMA.		X	
The USAID came on board and funded the second phase of WEMA PPP			X
WEMA PPP continued and the project moved to phase two. The following activities continued: field trials, awareness raising, application for regulatory approvals, launching of the approved conventional hybrids and application of the environmental release for the triple-stacked product.			X

[1] AATF = African Agricultural Technology Foundation; CYMMIT = International Maize and Wheat Improvement Centre; NARS = National Research Systems; PPP = public-private partnerships; USAID = United States Agency for International Development; WEMA = water efficient maize for Africa.

the number of seed companies and products licensed. The COT was able to monitor its success by tracking media coverage and cataloguing interactions with various stakeholders.

4.4 Performance and development outcomes

Respondents noted that he final product of the WEMA partnership was intended to be the seed varieties with enhanced drought tolerance as well as insect protection. As of 2017, WEMA had more than 60 conventional drought-tolerant white maize hybrids registered across the five WEMA countries and these hybrids were available for licensing royalty-free to all seed companies in sub-Saharan Africa. Seed companies have actually started seed production of the new hybrids for introduction and sales in four WEMA countries, namely: South Africa, Uganda, Tanzania and Kenya. For example, on 26 May 2015, the drought gene was approved for commercial release in South Africa. After the successful release of the drought gene in South Africa, the WEMA partners in South Africa started testing the drought gene stacked with the Bt gene, so that eventually they can give farmers the variety with both the drought and the Bt genes. In South Africa, the authorities require that regulated trials are conducted, before application for general release. The regulator release requires data from at least two sites for at least two seasons. During the discussion with one of the respondents in August 2017, it was indicated that WEMA had three sites and did more than two seasons, meaning that they fulfilled the requirements of the regulator release. As a result, the respondents reported

that they had the dossier ready for submission before the end August 2017 to get the stacked genes out for commercial release to farmers.

During the follow-up discussion on 16 November 2018, it was noted that the application for the approval was rejected. The respondents expressed their disappointment regarding the South African Executive Council for Genetically Modified Organism's rejection ruling on the application for general release of the product. The reason given for the rejection was that the data provided in the application were insufficient to demonstrate the efficacy of the drought tolerant and insect resistance.

During the FGD, farmers that participated in the WEMA trials expressed their satisfaction regarding the performance of the WEMA products. However, one of the issues related to the deployment of WEMA products from the farmers' point of view was the lack of WEMA products when needed. The farmers indicated that after being impressed with the performance of the WEMA products during the field demonstrations, they made a selection of the varieties to buy for their fields, but to their disappointment there was a shortage of seeds. This experience of the farmers was substantiated by KI1 during the discussion with him in 2017, where he mentioned that the president and CEO of ARC met with senior managers of the private seed companies Capstone and Jermart to discuss the lack of WEMA seeds and that they discussed the best way forward to ensure that the farmers would get their seeds in the next summer season.

Another issue that emerged from the FGD with farmers was more social and related to the farmers' association dynamics. For instance, some of the farmers were not happy with how the finances and financial records were handled. Some of the respondents cautiously indicated that they do not want to criticise fellow association members and leaders. Nevertheless, they indicated their desire for good governance, appropriate record keeping and financial management. For instance, they suggested using an association bank account to keep track of the financials and improve transparency and accountability. Although the respondents indicated that there was a treasurer, their concern was that financial statements were either unavailable or not shared. The respondents emphasised that record keeping was essential and should be enforced because the farmers did not feel comfortable reprimanding their fellow members. Alternatively, the WEMA partners could train and empower the farmers to be able to enforce good practices among themselves.

During the follow-up discussion with the WEMA partners in November 2018, KI1 revealed that the WEMA project ended with phase two at the end of 2017. The informant reported that when WEMA partners submitted the concept note and the proposal for the phase 3 of WEMA project, then their funders agree to fund them on condition of changing from being phase three to a new project, which concentrates only on the GMO technology instead of both the conventional and GMO technologies. According to the respondent, the funders said there was no point in continuing to emphasise on the conventional seed technology, but to actually put more focus on the GMO technology. Another reason was that, apart from South Africa, over the last 10 years of the WEMA project, no other WEMA partner country commercialised any GMO technologies. It was noted that other WEMA partner countries have made a lot of progress regarding the policies and the regulatory environment, but they were no GMO seeds approved for commercial release. The summary of the progress made by these countries is presented in Table 3. Each country has its own barriers and reasons as to why they have not yet given any approval. In Kenya, for instance, there is a ban for the import of GMO foods and that hinders the authorities giving approval to commercial release of GMO varieties. Thus, the respondent noted that although Kenya approved that Bt can now be evaluated in multi-location trials for the purpose of releasing and registering the varieties, the letter of approvals was written but withheld from the WEMA partners to essentially warrant them to actually go and do the trials in the field.

Table 3. Summary of progress in other WEMA partner countries.[1]

Conventional hybrids	GM component of WEMA: Bt (MON810) + DT (MON87460)	
Overall, there has been adequate progress on conventional hybrids. Many hybrids are registered within WEMA participating countries	Kenya	Environmental release of Bt (MON810) approved by regulators but no implementation due to current ban on imports of GM foods
	Uganda	Regulated trials completed but no regulations to enable commercial release
	Tanzania	Regulated trials started in 2016
	Mozambique	First regulated trial to be harvested August 2017
	Ethiopia	Regulated trials to start 2017
	Malawi and Nigeria	Want to join the WEMA public-private partnerships

[1] This table was compiled based on the presentation and discussion on WEMA progress with KI1 on August 2017. The follow-up discussion in November 2018 did not suggest changes regarding the progress of the other countries, except to indicate that the Executive Council for GMO from South Africa have rejected the application for the general release of the triple-stacked product. Bt = *Bacillus thuringiensis*; DT = drought tolerant; GM = genetically modified; WEMA = water efficient maize for Africa.

4.5 What factors enable and/or constrain the WEMA arrangement?

■ *Disputed outcomes*

Despite the findings of WEMA partners in South Africa, that the drought gene gave at least a 10% increase under drought conditions, soon after the release, the African Centre for Biodiversity (ACB) appealed the release in August 2015. According to KI1 the ACB was questioning the release process since every technology should undergo a process of evaluation by the regulator release authorities. The allegations included that the drought gene did not provide the benefits that were claimed, there was inadequate risk assessment into the adverse effects of the drought gene; there was no comparison with conventional maize under drought conditions, and no information on the impact of Bt on insects. However, KI1 denied the ACB's allegation that there was comparison with conventional seeds under drought conditions by noting that the WEMA partners were actually testing the conventional seeds against the GMO seeds. The respondent indicated that WEMA partners did those trials with a minimum of eight pairs or ten pairs (namely, one hybrid with the gene and the same hybrid without the gene), depending on the seed availability during the season. Given this contested situation, the minister of agriculture eventually set-up an appeals board to rule on the matter, and they ruled against the allegations of ACB.

During the follow-up discussion in November 2018, it became apparent that the ACB continued disputing the release of WEMA triple stacked products, and that time around the ACB succeeded. Thus, after Monsanto agreed with the WEMA partners that it can make triple stacked products accessible to smallholder farmers wherein the smallholder farmers will pay only the technology fee for the round-up ready while large scale commercial farmers have to pay fees for the three (namely, Bt, drought gene and round-up ready) technologies, the WEMA partners stopped submitting the dossier for the double stacked product and instead stipulated the application for the triple stacked product. The reason for this is that WEMA partners emphasised that the best products for smallholder farmers in the long term would be a triple stacked because these farmers spend a lot of time and efforts controlling weeds. Furthermore, the WEMA partners believe the best seed technology that supplement drought gene under drought situation would be the technology that enables farmers to have a crop that is weed free. Consequently, the WEMA partners maintained that round-up ready would enlarge better complementary gene than the Bt if they are able to compare the two, to say which one is better.

We then asked WEMA partners what does the outcome of the rejection means beyond just their disappointment. The WEMA partners maintained that decision of the Executive Council for GMO from South Africa to reject the application for the general release of the triple stacked does not make sense:

> They are saying we didn't do enough. We didn't generate sufficient data to convince the decision makers that the technology is working, but then it does not make sense. Why, because the Bt gene is already in commercial use on its own as well as in combination with the round-up ready. The drought gene was approved for commercial release in 2015 and the African Centre of Biodiversity appeal to say there is no sufficient data. So, if the executive council approved the drought tolerant gene on its own and the appeals board approved the drought gene, the Bt gene is in commercial use on its own and in combination with round-up ready, what other information do they really need from us to say these three technologies are working? It doesn't make sense. (KI1)

Therefore, the WEMA partners indicated that the implication of the final decision taken by the regulator release in South Africa puts to risk the whole WEMA project. They indicated that the outcome is essentially is fundamentally a victory for the ACB as far as South Africa is concerned and that it also puts the difficult position in the minds of everyone else who is in WEMA project in the other countries because all along other partner countries were looking at South Africa to say it is progressive. South Africa was considered progressive since it has already commercialised GM technologies since 1990s and as a result other WEMA partner countries looked up to it in commercialising and deploying GM technologies. Therefore, the concern was that when the other partner countries hear that the same technologies that WEMA partners are trying to get out of the WEMA project, South Africa has now rejected them, this would really just confuse them.

■ *Stakeholder concerns*

It is relevant to get buy-in of and/or feedback from other stakeholders (other than WEMA partners) directly and indirectly involved with farmers, concerning new products. Therefore, the WEMA partners in South Africa pro-actively engaged Grain SA (GSA) to gauge how GSA would evaluate the double-stacked product, i.e. the Bt gene plus the drought gene. GSA 'provides commodity strategic support and services to South African grain producers to support sustainability.'[2] KI1 mentioned that GSA reaction raised three concerns. The first concern was the export implications to countries like Korea. According to the informant, GSA argued that it is important that those who provide and facilitate the technology check with all the potential markets to ensure that the resulting products are acceptable, before any technology is made available to farmers. Accordingly, GSA revealed to WEMA partners that even if WEMA partners get the Bt plus drought resistance approved for production in South Africa, the implication could be that when the maize is mixed (that is if there is no separation of the crops), this would jeopardise their ability to market their produce to places like South Korea, where the product is not approved.

Another concern was that Monsanto Commercial, had, in February 2017, submitted an application to Department of Agriculture Forestry and Fisheries (DAFF) to get the triple-stacked seeds (Bt, drought and herbicide resistance (namely, round up resistant seeds)) approved for commercial release. According to KI1 WEMA partners negotiated that Monsanto provide the WEMA project with drought gene and the Bt gene. Further, it was reported that at the time of the launch of the triple-stacked product Monsanto had undertaken that it will make available at least three triple-stacked hybrids for WEMA. The discussion with the company was whether it would give the 'round-up ready' technology royalty-free as well or whether they will charge a developmental fee for 'round-up ready' to the smallholder farmers. Consequently, the WEMA partners in South Africa concluded that farmers could pay for the round-up ready. The argument was that Monsanto cannot just give everything for free, hence the WEMA partners are then saying: 'let Monsanto give farmers two genes for free, and then they will pay for the third one'. Therefore, WEMA partners and Monsanto agreed that WEMA provides the double-stacked as well as the triple-stacked product, and let the farmers decide if they want the product which is 100% royalty-free (the double-stacked), or whether they want the technology which will be a full package (triple-stacked). However, in the latter case, farmers must pay an additional fee.

[2] Available at: https://www.grainsa.co.za/pages/about-grain-sa/overview

> So as much as the Grain-SA was putting the brake to say we don't want the double stacked products for smallholder farmers, because then you are giving them an inferior product when you are giving large-scale commercial farmers a triple stacked. As WEMA South Africa, we were actually in agreement with them to say let them shoot us down because we also want a triple stacked for our farmers, and that helped us to put pressure on the technology provider. (KI1)

■ *Shortage of seeds*

One of the issues concerning technology transfer components in agriculture that came out during our interactions with the farmers during focus group discussions was that sometimes the demonstrated seeds were not available. Our informants (namely KI1 to KI5) corroborated what the farmers said, that lack of seeds was indeed sometimes a challenge within the WEMA project. These informants reported that they used several ways to create awareness and demand by farmers, which include farmers' field days, demos and workshops. They also organise demos and meetings to engage local seed companies by getting them aware of the hybrids and to get them to produce the seeds. Despite these efforts, there was a lack of WEMA seeds in the last summer season (specifically 2016/2017). In response, our informants again held meetings with the local seed companies to discuss the best way forward. During these meetings the two private companies committed to produce and market certain quantities of seeds. Thus, Capstone company committed 50 tonnes and Jermart seed company committed 80 tonnes. This was surprising, as one would expect that Capstone being a bigger company than Jermart would commit relatively more tonnes. However, this was not the case, because according to KI1 Capstone indicated that they have their own varieties that are already marketed and known to farmers. Jermart is a start-up company and therefore, putting all its efforts on selling WEMA seeds.

> Farmers are interested and ask where they can buy the seeds that were used in the trials? Then we give the details of [company name]. But when the farmers contact [company name], the company indicates that it doesn't have the seeds? So, it means we give farmers hope that the next planting season seeds will be available. Then when the time for planting comes, there are no seeds available. (KI4)

> [Company name] is a bigger company, which has been operating for a long time and therefore have their own varieties that are already marketed and known by farmers; whereas [company name] is a start-up company with no varieties of its own, therefore basing all its efforts on WEMA seed. (KI1)

■ *Needed expertise and skills*

The KI3 (private company manager), stated that maize seed production requires a high level of management know-how compared to production of maize for consumption. Looking closely at the different responses from our informants (KI1-KI5) and farmers (FI1-FI5) as well the focus group discussion participants, we can indicatively say that the way of doing business between the smallholder farmers and the private sector is not yet normal in the sense that perhaps the levels of productivity are currently nowhere near the requirement of most private sector players to be interested in dealing with these farmers. This could explain the decision by the private sector company to have resorted to leaving the concerned farmers and to start working with a relatively established farmer, who according to the private company owner needed less technical and monitoring support from the company. However, KI1 indicated that the established farmer also received 100% technical support from the ARC. Based on the discussion with KI3, the informant seems to have expected certain levels of productivity, technical know-how and management capacity from the subcontracted farmers (IF1-IF5), and when his expectations were not met, he became disinterested and could not bear to continue working with them. However, from a public point of view there seems to be a general understanding that smallholder farmers need adequate support and backup before they can achieve a normal way of doing a business.

> If you don't produce good quality seeds, where do you expect to find a market? Because those are hybrids, it is not like OPVs. OPVs were easier to multiply; but with hybrids this is more difficult. (KI4)

> …because seed production requires a high level of expertise, [...] and because I was starting from scratch with farmers who have no experience with seed production, it takes time. With farmers who are used to seed production, the process is not costly because you just give them the seeds and leave them...and they will deliver the quality finished end products. (KI3)

Therefore, in addition to technology offering, provision of sufficient support such as technical back-up to the subcontracted farmers can help in building their resilience and by so doing private companies will also climate-proof their own business interest while unlocking the shared value and opening up to new opportunities. Another aspect to look at the source of the problem regarding this case could be that there was no formal agreement between the subcontracted farmers and the private company concerned. The result of this is that when something goes wrong another party may end-up not being liable. For instance, one of the respondent farmers indicated that at one point he agreed with the private company owner to hire extra labourers for weeding and in the end the company refused to cover all the costs of labour, meaning that the uncovered costs were subtracted from the farmer's profit. These kinds of issues can largely be addressed with a written agreement which includes all specific relevant details.

■ *Reluctance of local seed companies to market the new seeds*

One of the major challenges experienced was the disinclination of the local seed companies taking up WEMA products. A possible explanation was that large companies have their own breeding programmes. Therefore, KI1 suggested that WEMA partners should have included as many seed companies as they could. Thus, instead of working with only one large private partner (i.e. Monsanto) a reasonable option would have been to work with other private partners as well.

> What we found to be a big challenge was that the seed companies didn't rush to get our products as much as we thought. Why? Because they have their own breeding programmes and they said, oh well, we also have breeders developing cultivars that are tolerant to all different kinds of biotic and abiotic stresses including drought. What I think we should have done differently is that, when it comes to actual product development, we should include as many seed companies as we can in terms of doing the actual field evaluations before registration sessions. (KI1)

■ *Upkeep of previous relationships*

Regarding the deployment of technology from the public side, WEMA partners expected pro-activeness from the provincial departments of agriculture, yet their expectations were not fully met. KI1 noted their dissatisfaction regarding the activities of the provincial department of agriculture towards WEMA product deployment. This was despite their efforts to visits all provinces in 2018 to meet with different food security sections of the departments of agriculture. However, what emerged from the discussions of the WEMA partners and the provincial departments of agriculture was that the departments did not acquire seeds directly from seed suppliers (e.g. research institute or private companies), but they put contractors (through tenders) to provide the seeds and all other technologies. In most cases, these contractors have already established partnerships with different seed companies and they are not always ready to source from other companies to supply WEMA products. While it is acknowledged that the government itself has systems in place and relationships with other partners that cannot just be discarded, it is necessary to use policy space to create a conducive environment to introduce royalty free seeds to farmers.

> Actually, we would have wanted the provincial departments of agriculture to work with us much more closely than they did. In terms of deployment, they were actually our biggest disappointment

> because if the whole project is meant for smallholder farmers and they are the ones working for them, but it is also a question of expecting too much on our side. [...] So I can't simply dump that kind of a relationship simply because [...] is bringing drought tolerant WEMA seeds. So is a complex thing. So as [...], I wish that we can get more support from the province, but I guess as much as I say that, am also being unfair by not recognising the fact that the provinces have been getting seeds from their contractors and those contractors have built relationships that they cannot simply change overnight. (KI1)

- *Contractual arrangements*

Respondents IF1 through IF5 indicated that the WEMA varieties that they planted gave a good yield compared to the traditional seeds that they had planted before. However, they raised issues concerning the contractual arrangements they had with the private company that subcontracted them for seed production. The arrangement was the provision of seeds, fertilizers (in some cases) and technical expertise during planting season and that after the harvest their produce will be graded based on agreed quality and quantity standards, and at the basis of prices determined by the private company and after costs of the inputs (seeds and fertilizers in this case) are deducted, the profit for the farmer can be calculated. The respondent farmers shared their dissatisfaction when it comes to the profit they received and indicated that in some instances the company did not show up to collect the seeds leaving them frustrated and feeling abandoned with an output that is not marketable.

However, KI4 and KI5 from the provincial department of agriculture indicated that one of the main reasons the private company (i.e. of KI3) did not collect the output of the farmers was that the seeds were contaminated. The informants attributed this to inadequate support of the farmers. This was corroborated by another informant, KI1, who indicated that the lack of adequate support came about because the private company in question was a start-up and did not have enough human and financial resources to provide the needed technical support (see also under needed expertise and skills). These were his words:

> He was supposed to go back to tell them that it is a failed crop, rather than to simply abandon them. [...] But for me the major reason was that he didn't have the money to employ a seed production assistant to work with the farmers and to visit them to say if they are doing well and indicate the aspects they have to improve on. (KI1)

5. Discussion

5.1 Characterisation, performance and development outcomes of the WEMA public-private partnerships

Fundamentally, the involvement of institutions and industries to pursue collaboration and combining all available public and private skills and resources determine the beneficial impact of PPPs (Ponnusamy, 2013; Scharle, 2002). Similarly, the WEMA case highlighted elements of success. According to KI1 and KI2 the development of the PPP itself (namely the WEMA project) was considered to be a positive outcome and the informants reckoned that improving the PPP can actually be the best way forward in terms of mobilising financial resources, human resources and also in terms of developing future plans and finding new partners. The development of WEMA was probably considered a positive outcome because in general PPPs are difficult to be maintained. Therefore, developing one and getting it running is already a positive outcome as it suggests you have overcome at least one of the challenges, which is to get a buy-in of the partners. KI1 noted that within WEMA PPP, the partners brought in their different expertise, while the partners were also learning from each other.

In the case of WEMA, the local seed companies had the role of employing farmers to produce the seed varieties, so that they can make money. KI1 noted that getting the public and private organisations to work together within the WEMA project enabled the five WEMA countries to make 22 conventional drought tolerant varieties available to farmers. The WEMA is also valued by other countries. For instance, Ethiopia

is now the sixth WEMA country partner, and Nigeria and Malawi are also willing to join the partnership. KI1 indicated that this growing interest from other countries can only be generated by the success stories of the WEMA PPP. Thus, policymakers in countries like Ethiopia have realised the benefits of this kind of technologies and are, working towards adopting policy environments that allow for public research and testing.[3]

Furthermore, the fact that WEMA products were made available to farmers' royalty-free signifies that the WEMA partners took into consideration the fact that the majority of smallholder farmers tend to struggle with affordability of new technologies. Also, Ponnusamy (2013) recommended that those who want to take up a PPP as an empowerment model should pay attention to affordability of new technologies to smallholder farmers. Nonetheless, despite the above mentioned successes, factors were also highlighted that can enable or hinder the WEMA arrangement and eventually the adoption of CSA technologies by smallholder farmers. The following subsection will look at those factors within a broader literature context.

5.2 Important factors constraining the arrangement as reflected in previous studies

Shortage of seeds as a technology in question in this study, was considered a factor that can constrain the WEMA arrangement. One of the provisions of WEMA partnership was to offer private seed companies with the sub-licenses and basic seed materials so that they can produce and market seed of those WEMA varieties to ensure that the seeds are taken up by smallholder farmers. This was thought to can ease access of the WEMA seed varieties by smallholder farmers since literature noted that seeds business depends on the availability of good supply of high quality basic seed for production of certified seed that can then be distributed to farmers (Spielman *et al.*, 2012). However, our research shows that not only should good quality of basic seed be available, as the capacity to produce and market seeds is equally important to ensure that farmers actually get the seeds on the shelf. In other words, low adoption rates and shortfalls in the supply of improved seed varieties can be partly attributed to bottlenecks emerging from the actual production of seed which then affect the available quantity to be marketed. According to Mabaya (2016) the need for a diverse range of seed companies allows for increased focus on customer (i.e. smallholder farmers in our case). In the case of WEMA, bottlenecks happened because bigger companies with adequate capacities were not enthusiastic to producing WEMA varieties as expected due to various reasons. This saw smaller companies overcommitting and failing to deliver. This is not totally surprising given that South African seed sector though matured, has evolved to primarily serve the needs of large-scale commercial farmers, with the industry often performing poorly on measures that are specific for smallholder farmers (Mabaya, 2016). Therefore, partnerships like WEMA needs to take all these into account when negotiating for private sector involvement so that they can indeed improve access to seed technologies for smallholder farmers in rural areas.

Whilst PPPs in general serves as governance tools that formalise partnerships between stakeholders and involves strong political support (Qizilbash, 2011), maintaining previous relationships is also central to the effectiveness of most government supply chain process. It was evident from our research that the provincial department of agriculture valued their previous relationships with their procurement agents (namely, contractors) who also had their established relationships with different seed companies that may fall outside WEMA arrangements. In cases like this, some of the WEMA arrangements were not all fulfilled and this was in line with previous research where it was acknowledged that PPP in agriculture suffers due to problems associated with mode of procurement that tends to affect cooperation and coordination between the partners (Ponnusamy, 2013).

6. Conclusions

The WEMA case was found to be a good case to demonstrate how PPPs work in practice by highlighting the benefits of bringing partners together with different capacities. The WEMA case also demonstrated specific country contexts must be taken into account, more especially when the partnership is at the regional level.

[3] Available at: https://croplife.org/transforming-africas-agricultural-programs-with-plant-biotech/

For example, of the five WEMA partner countries, only South Africa has a mature seed industry, where big seed companies are competing and have their own breeding programmes. The driving force behind these companies is competition and profit. According to informants, that is the reason why some of these companies continue to sell old varieties, even when they have got new varieties in their companies, 'simply because they are their cash cows'. Therefore, the inference is that in a matured seed industry (like in South Africa) where profit matters and multiple companies compete with their own varieties, new varieties will not just easily make it.

However, other WEMA partner countries, like Kenya, Uganda and Tanzania, where a multitude of small-seed companies exist, without own breeding programmes can provide leverage points for projects like WEMA. However, PPPs must consider this alternative with caution, as relying on start-ups and emerging companies comes with a risk since such companies are more likely to lack the human and financial resources to deliver their commitments. Therefore, a strategic balancing act in terms of assistance and support to such companies is necessary.

This study also highlighted that the process of getting the seeds in the hands of farmers is equally a daunting process that do not depends on the views and standards of farmers alone. For instance, other parties working directly/indirectly with farmers or on their behalf can as well stand in the way of a new technology. Also, the failure of smallholder farmers to deliver when they receive the seed technologies but inadequate technical support and supervision must be taken into account.

The result of the study highlighted that the process of enhancing technology adoption through PPP is more challenging when other groups or organisations dispute the potential of that particular technology. For instance, in case of WEMA project the objection of the ACB against the potential of drought-tolerant GM hybrids which led to their objection against its authorisation had implications. If indeed the triple stacked product is a superior product and best seed technology that supplement drought gene under drought situation by enabling farmers to have a crop that is weed free, therefore its authorisation for the cultivation would be a significant step forward not only in reducing the impact of climate change and improving food security, but also in reducing the time and efforts farmers spend in controlling weeds. As a result, government through its policies can create an enabling environment that will ensure that access to 'good and beneficial' technologies is not unnecessarily delayed or opposed to serve interest of the minority groups at the expense of majority beneficiaries. This is not to suggests that government policies should undermine the extent to which related policies on biosafety that aimed at safeguarding health, environment and socio-economic wellbeing achieve their objective. Instead, the policies need to be based on the objective decision as much as it is possible.

Results also highlighted that despite the existing relationships and government systems in place, policy space can be used to create a conducive environment to introduce royalty free seeds to farmers. For instance, South African policy makers already have various programmes in place such as the programme for food security whereby they provide input support to smallholder farmers to enable them to get access to seeds, fertilizers, etc. As a result, the government is already working with farmers and can use the policy space to renegotiate the terms of engagements with their contractors (who source technologies on their behalf) to ensure that the targeted technologies end up with the farmers, whilst still safeguarding their relationships to the benefit of their targeted beneficiaries.

The provision of support services remains one of the key important interventions in the agricultural sector for rural development, climate change response, food security and poverty alleviation of farmers. Our results emphasised certain expertise and skills are needed in order for the way of doing business between the smallholder farmers and the private sector to be normal. Technical back-up related to the promoted technology to smallholder farmers need to complement the policies which are geared towards smallholder farmers' development. Production of hybrids crops for seeds require that crops be 100% de-tasselled to ensure that the seeds are not contaminated as the contaminated seeds are not marketable. All these technical know-hows are attainable with sufficient technical back-up.

Despite the lessons learnt from this case study, one of the limitations of this study is that first hand discussions were only held with WEMA partners in South Africa. Nevertheless, their insights and experiences were used to reflect on the WEMA partnership at the project as well as at the regional level while zooming in to what actually happened at the country level of South Africa. A follow-up study can zoom in at the regional level by using discussions with respondents from all the partner countries and organisations. Also, it would be beneficial to include all the companies that progressed with WEMA products in other provinces of South Africa to ascertain if they face similar or different challenges.

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Conflict of interest

The authors declare no conflict of interests.

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