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Guest Editor: Charles B. Moss

1 Editorial boards
2 Guest editorial
4 Contribution of policy change on maize varietal development and yields in Kenya
   Latha Nagarajan, Anwar Naseem and Carl Pray
22 Building African agribusiness through trust and accountability
   Kristin Franklin and James Oehmke
44 Political will and public will for climate-smart agriculture in Senegal: opportunities
   for agricultural transformation
   Eric D. Raile, Linda M. Young, Adama Sarr, Samba Mbaye, Amber N.W. Raile, Lena Wooldridge,
   Diaminatou Sanogo and Lori Ann Post
63 Farmers’ usage preferences for Rwanda’s Volcanoes National Park
   Ildephonse Musafili, Jean Chrysostome Ngabitsinze, Fidèle Niyitanga and Dave Weatherspoon
78 Distribution of agricultural productivity gains in selected Feed the Future African
   countries
   Charles B. Moss and Andrew Schmitz

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The Journal of Agribusiness in Developing and Emerging Economies (JADEE) showcases research about the farm-to-fork value chain and its implications for economic and societal development in Asia, Africa, Latin America and Eastern Europe. JADEE interprets agribusiness as a discipline that studies the food and agriculture system – the individual elements and their interdependencies.
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Impact analysis of interventions in feed the future countries in Africa

The papers in this issue examine the impact of a variety of Feed the Future efforts in North Africa. The first paper (Nagarajan, Naseem and Pray) examines the impact of maize development policies in Kenya. Maize yields in Kenya have been stagnant since the 1980s. While a variety of issues from macroeconomic considerations to shifts in the importance of trade liberalization has been identified, a large portion of the stagnation can be attributed to the slow adoption of new varieties. Nagarajan, Naseem and Pray examine the extent to which the slow adoption of new varieties of maize can be attributed to changes in government policy. They find that past R&D efforts have made marginal contributions to increase the yield. In fact, the largest impact appears to be the introduction of plant breeder rights. Based on these findings, they suggest that the R&D efforts in Kenya be directed to the adoption of new varieties that target the replacement of old varieties. In particular, the focus should be on traits that manage biotic and abiotic stresses.

Franklin and Oehmke develop a model of trust in building agribusiness channels in Africa. The “hold-up” models found in Oliver Williamson’s research are well known in a developed economy context. In these models, the uncertainty of valuation in a vertical marketing channel can be overcome by one firm purchasing ownership in the next firm in the marketing channel. However, in a development context as developed in the models of Elinor Ostrom, the firms in the vertical channel lack access to capital so vertical integration is not an option. As a result, some other social convention – such as trust – must be used in place of integration. Franklin and Oehmke examine the use of trust, accountability and mutual accountability and the implementation of each factor to establish a marketing channel in African agribusiness. As a case study, they analyze the quality channel for Rwandan coffee. In general, the coffee channel developed within the context of two USAID efforts – the Partnership to Enhance Agriculture in Rwanda through Linkages and Sustainable Partnerships to Enhance Rural Enterprises and Agricultural Development. During the active intervention by USAID, trust and accountability were easier to maintain. However, the study finds that after the termination of the programs, the international market price for higher valued coffee softened and the gains in trust and accountability were more difficult to maintain.

The paper by Raile et al. takes a somewhat different approach to impact analysis. Specifically, this paper examines both the political and public will required to make a policy commitment in a developing economy. Specifically, Raile et al. examine whether the political or public will is sufficient in Senegal to make the policy commitment for Climate Smart Agriculture (CSA). From a political will perspective, Senegal has a well-defined system of leadership and that leadership has a common understanding of the problem. However, there may be a disconnect between the state problem – adoption of agricultural technologies that are resistant to climate variations and will not contribute to further climatic degradation – and the perceived political program which is the need for Senegal to be self-sufficient in rice. While rice production is a component of CSA, increased production of rice may have an adverse impact on some climate dimensions (i.e. increased production of rice will probably imply increased irrigation which means increased use of energy (and, hence, carbon emissions), and increased use of chemical fertilizers). Similarly, there may difficulties in defining a small number of policy prescriptions. Raile et al. find that there are 200 different efforts led by different donors and other agencies which purport to represent CSA.

Musafili et al. examine the willingness of farmers in the area around Rwanda’s Volcanoes National Park to adopt production rules, which benefit the environmental quality of the...
national park. The Volcanoes National Park is located in Northern Rwanda on the border with Uganda. It is probably best known for its Mountain Gorillas. Agriculture in the area of the park yields several different crops from Pyrethrum (a pesticide derived from chrysanthemum), mushrooms, jatropha and honey. The environmental consequences of each production process can be managed to a greater or lesser extent by a variety of production systems. Using a choice experiment, Musafili et al. examine the willingness of farmers in the area to adopt these modified production systems.

Moss and Schmitz take a more traditional welfare approach to examine the implications of investments in supply chains in developing countries. Specifically, Moss and Schmitz examine the export vs domestic market scenario to examine the potential benefits and costs of a variety of potential interventions. They begin by examining the costs and gains of cassava improvements in Uganda. First, they assume that cassava is largely consumed as a food stuff in the local market. These results are contrasted with the possibility that improvements in cassava production are used in the production of ethanol. Building on the concept of domestic demand vs export demand, they develop an extensive model of Rwanda coffee. In this framework, high-valued coffee is exported. Hence, the gains within the economy are improved income to coffee producers.

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Contribution of policy change on maize varietal development and yields in Kenya

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Abstract
Purpose – Since the start of seed and other market reforms in the 1990s, the annual number of improved varietal releases for maize in Kenya has increased substantially. Prior to the reforms, private firms were restricted in introducing new varieties, could not protect their intellectual property and farmers had to rely exclusively on improved seeds developed and marketed by the public sector. Reforms have resulted in not only private firms entering the market and releasing improved varieties, but also an increase in varietal releases by the public sector. The purpose of this paper is to review some of the key policy reforms related to maize in Kenya, and their impacts on varietal development and yields.

Design/methodology/approach – The authors estimate a yield model that relates national maize yields to a number of input policy variables. The authors employ a two-stage least square regression, as one of the explanatory variables – the number of varietal releases – is likely endogenous with yield. The authors use policy variables such as public R&D, the number of plant breeder’s rights issued, and the years since private varieties have been introduced as instrument variables to estimate their influence new varietal releases directly, and then new varieties, inputs and other policies to measure their impact on yields.

Findings – The results show that policy changes such as the introduction of intellectual property rights had an important impact on the number of improved maize varieties released. However, the outcomes of the policy change such as the number of varieties and the share of area under improved varieties has no impact on increasing maize yields. The authors argue that this is because farmers continue to use older improved varieties because of the dominance of a parastatal in the maize seed market and that newer improved varieties may not have the assumed yield advantage. Future policy and programs should be directed toward increasing the adoption of improved varieties rather than simply releasing them.

Originality/value – This paper provides evidence that while policy change may lead to new varietal development and release, its aggregate productivity impacts may be limited without additional reforms and intervention.

Keywords Kenya, Maize, Policy impact, Private sector development

1. Introduction

Raising productivity is essential to sustain economic and income growth. In turn, technical change is the main driver of increased productivity, underlining the ongoing importance of focusing on technology as a primary change agent. The experience of industrialized countries confirms this insight where empirical findings consistently show that technical advances have been the main contributor to growth. This has also been the case within agriculture where rapid increase in productivity is often due to the adoption of specific technologies, such as hybrid maize, genetically modified crops, mechanization and the use of chemical inputs.

Despite the recognition that technology is important for growth, it remains underutilized in many countries, particularly in Sub-Saharan Africa (SSA). Modern input use remains low, exemplified by the low rates of fertilizer application. For SSA, fertilizer use intensity averaged less than 16 kg/ha of arable land in 2014, whereas it averaged 160, 345 and 130 kg/ha for...
South Asia, East Asia and Latin America, respectively (FAO, 2018). The use of improved seed varieties (IVs) – a key ingredient to the success of the Asian Green Revolution – is also low, accounting for 35 percent of all food crops grown in SSA in 2010 (Walker and Alwang, 2015).

The low use of farm inputs in SSA is at odds with the considerable farm-level evidence that shows SSA farmers benefit when they use improved varieties, especially for maize (Doss et al., 2003; Evenson and Gollin, 2003; Renkow and Byerlee, 2010; Mathenge et al., 2014; Fuglie and Marder, 2015). Evenson and Gollin (2003) estimate that 88 percent of the cereal yield growth in Asia between 1960 and 1986 was due to crop genetic improvements and the use of IVs, but only 28 percent for SSA, reflecting the limited role that IVs have played in yield growth in SSA.

There are many reasons for the low use of modern inputs and technology in African agriculture, and significant differences exist across and even within countries (e.g. Sheahan and Barrett, 2017). Ultimately, the non-adoption of productivity improving technologies rests on a combination of economic (the technology is not profitable), institutional (regulatory barriers and poor governance may limit availability) and social constraints. Policy – or lack thereof – can also be an important determinant of technology adoption. Providing subsidies and other incentives are the most direct ways that governments encourage IV adoption. More subtle are policies related to market competition and innovations that can lower input prices and increase choices for farmers to suit their specific economic and agro-ecological needs.

Whether or not a given policy or a set of policies has the desired outcome is an empirical question and is the focus of this study. Specifically, our interest is to understand the role that policy changes have had on the supply of improved maize varieties in Kenya and maize productivity. In particular, we examine whether market-friendly policies designed to encourage private sector participation in Kenya’s seed sector have contributed to improvements in maize productivity. Since the late 1990s, Kenya’s market reforms have resulted in the entry of a number of private firms in the maize seed market and a marked increase in the number of IVs that have been released (Swanckaert, 2012). As shown in the following sections, of the 354 IVs of maize released between 1964 and 2015, 333 (94 percent) were introduced after 1999. Identifying the role of policy change in increasing the number of maize IVs and changing maize yields is the main objective of this paper.

Such an analysis is important for a number of reasons. First, the main rationale for liberalizing agricultural input markets has been to encourage competition, innovation and higher productivity. An analysis of productivity trends before and after liberalization will help establish whether this occurred in Kenya. Second, some have suggested that the liberalization policies for Kenya’s seed markets have only been partially implemented as evidenced by the continued dominance of the Kenya Seed Company (KSC) (a public sector firm) in the market (Swanckaert, 2012) and the presence of older maize varieties (Smale and Olwande, 2014). If it can be shown that there is an association between the number of new maize varieties released and increased productivity, it would lend support to further reforms that enable greater varietal releases in Kenya, as well as in other countries. For example, Gisselquist et al. (2013) contend that regulatory hurdles discourage firms from releasing new varieties in Africa, with the implication that it limits productivity. Finally, while there are a number of studies that assess the impacts of modern inputs, nearly all have been at the farm-level, seeking to understand either farm impacts or determinants of farm adoption. To our knowledge, there has been no macro-level assessment of productivity changes from policies designed to increase input use in SSA.

As such in this paper, the macro-level determinants of maize productivity in Kenya are examined, with a focus on policies to encourage private sector participation and the role of improved varieties. The analysis consists of first examining production and yield trends to see whether yields changed post-liberalization by employing a yield model to relate national maize yields with a number of exogenous factors. One of the explanatory variables – the
number of varieties – is likely endogenous with yield. As a result, public research and development (R&D), the number of plant breeder’s rights (PBRs) issued, and the years since the introduction of varieties as instrumental variables for the number of varieties are deployed in a two-stage least square (2SLS) regression.

This paper proceeds by providing a background to maize production in Kenya, in particular a description of the maize seed system and policies and institutions affecting maize development. Section 3 presents the empirical model relating policy change ion innovation and maize productivity to innovation. The results are discussed in Section 4. Section 5 concludes the paper.

2. Background

2.1 Maize in Kenya

Maize is the main staple in Kenya, accounting for nearly 40 percent of the cultivated area, 2.4 percent of Kenya’s GDP and 12.65 percent of the agricultural GDP (FAO, 2018). More than 75 percent of the maize production comes from small farms, although only 20 percent of what is produced by smallholders is sold in the market (Chemonics, 2010). Kenya’s per-capita maize consumption (measured in kilograms (kg)) is estimated to average 103 kg/person/year (average for 2012–2014), compared to 73 kg/person/year for Tanzania, 52 kg/person/year for Ethiopia, and 31 kg/person/year for Uganda (FAO, 2018).

In spite of maize’s importance for food security and Kenya’s economy, maize productivity and production growth rates are well below global averages. Figure 1 plots the trends in production, area and yields, while Figure 2 presents the same trends as indices (with 1961 = 100). As is evident from these trends, while production has increased from 1 MT in 1961 to 3.5 MT in 2015, much of it was due to the increase in area (increased by 180 percent) rather than yields (increased by 32 percent) (FAO, 2018).

Compared to other regions, Kenya’s maize yield is below that for SSA as a whole, and even below the regional average for East Africa (Table I). Maize yields in Kenya are even lower than what US farmers were able to obtain prior to the widespread adoption of hybrid maize. Adoption rates of IVs appear to have leveled off at 70 percent since the mid-1990s in spite of the large number of new varieties that have been released since 1999 (Figure 3).
The low yield growth, in spite of the increasing adoption of IVs is peculiar and could be due to a variety of reasons. First, it could be that many farmers are using older varieties, even though modern varieties are available. Varietal turnover – not just simply seed replacement – has been found to be important for increasing productivity (Smale and Olwande, 2014; Spielman and Smale, 2017). New varieties not only allow farmers to aspire to the yield gains of a previous generation, but also help farmers to withstand new forms of pests and diseases, as well as drought and floods. The optimal rate of varietal turnover depends not only on the crop in question and environmental factors, but more importantly on economic factors. A weighted average (WA) age of less than ten years and adoption rates of 35 percent are generally considered indicators of good progress in plant breeding (Walker and Alwang, 2015).

Studies on varietal turnover for maize in Kenya suggest that the WA age has been declining but is still above ten years. Smale and Olwande (2014) using a panel survey from 2004–2010 estimate the WA age at 17.3 years in 2010, while a more recent survey by Abate et al. (2017) estimates the WA age at 13 years for 2013. Our own estimates based

<table>
<thead>
<tr>
<th>Region/Country</th>
<th>Average Yields (kg/ha) 2010–2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asia</td>
<td>4,896</td>
</tr>
<tr>
<td>Sub-Saharan Africa</td>
<td>2,188</td>
</tr>
<tr>
<td>East Africa</td>
<td>1,772</td>
</tr>
<tr>
<td>Kenya</td>
<td>1,680</td>
</tr>
<tr>
<td>West Africa</td>
<td>1,631</td>
</tr>
<tr>
<td>Southern Africa</td>
<td>4,238</td>
</tr>
<tr>
<td>Latin America</td>
<td>3,912</td>
</tr>
<tr>
<td>North America</td>
<td>9,444</td>
</tr>
<tr>
<td>Europe</td>
<td>6,249</td>
</tr>
<tr>
<td>World</td>
<td>5,268</td>
</tr>
</tbody>
</table>

Source: FAO (2018)

Figure 2. Trends in maize yield, production and area indices for Kenya (1961 = 100; 1961-2015)

Table I. Maize yields by key regions (2010–2014)

Contribution of policy change
on 2009 survey data from DIIVA[2] suggest the WA age at 19 years, with nearly 43 percent of the area cultivated by varieties that are 10 years old or less (Table II).

Second, the new varieties that are adopted may not significantly improve yields compared to those of the varieties they are intended to replace. Karanja (1996) found for

<table>
<thead>
<tr>
<th>Variety</th>
<th>1993 % Area</th>
<th>Variety</th>
<th>2009 % Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>H614D</td>
<td>41.8</td>
<td>H614D</td>
<td>22.6</td>
</tr>
<tr>
<td>H625</td>
<td>22.9</td>
<td>SC DUMA 411</td>
<td>7.2</td>
</tr>
<tr>
<td>H626</td>
<td>12.8</td>
<td>H624</td>
<td>4.7</td>
</tr>
<tr>
<td>H511</td>
<td>7.2</td>
<td>Katumani</td>
<td>3.8</td>
</tr>
<tr>
<td>Katumani</td>
<td>5.3</td>
<td>H6210</td>
<td>3.1</td>
</tr>
<tr>
<td>Rest (5 var)</td>
<td>7.6</td>
<td>Rest (60 var)</td>
<td>35.5</td>
</tr>
<tr>
<td>Total</td>
<td>97.6</td>
<td>Total</td>
<td>76.9</td>
</tr>
</tbody>
</table>

**By type (public vs private)**

<table>
<thead>
<tr>
<th>Public (KARI/KSC)</th>
<th>100</th>
<th>Private</th>
<th>25.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seedco</td>
<td>9.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Punnar seed</td>
<td>7.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pioneer</td>
<td>3.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Western seed company</td>
<td>3.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monsanto</td>
<td>3.7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**By age**

<table>
<thead>
<tr>
<th>Group</th>
<th>1993 %</th>
<th>2009 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 10 years</td>
<td>55.4</td>
<td>42.7</td>
</tr>
<tr>
<td>10–20 years</td>
<td></td>
<td>14.2</td>
</tr>
<tr>
<td>&gt; 20 years</td>
<td>42.8</td>
<td>43.1</td>
</tr>
<tr>
<td>Weighted age</td>
<td>23</td>
<td>19</td>
</tr>
</tbody>
</table>

**Table II.**
Maize varietal adoption in Kenya (1993 and 2009)

**Source:** Hassan and Karanja (1997) for 1993 and CGIAR (2015) for 2009
the 1960–1990 period that some of the released varieties of that era had small yield advantages, with research yields then exhibiting something of a “plateau” effect. For example, H626, which was released in 1989, had only a 1 percent yield advantage over H625, which had been released eight years earlier.

Figure 4 presents more recent data on average research yields of released varieties by year of release as documented by the Kenya Plant Health Inspectorate Service (KEPHIS) together with fitted linear trends. Average yields of high-altitude, late-maturing varieties have increased more than all varieties combined (at more than 150 kg/ha/year), although yields across all varieties have been stagnating and may have even declined in more recent years.

Finally the mere release of new IVs – whether private or public – on its own will not necessarily and positively affect yields. To have a positive impact on overall yields, the new varieties have to be superior to what is currently being grown, widely adopted and perhaps complemented with other inputs, especially fertilizer. Based on a survey of smallholder maize farmers in Kenya, Nyangena and Juma (2014) find that inorganic fertilizers and improved varieties result in an increase in maize yields if adopted as a package, rather than separately. Similarly, Muraoka et al. (2016) find significant positive impacts on land productivity in the highlands of Kenya from agricultural intensification (i.e. the use of high-yielding varieties, fertilizer and intercropping).

2.2 Seed development and policies

Maize has been grown in Kenya since the sixteenth century when it was introduced by Arab traders to the coastal areas; it expanded farther with the arrival of European settlers. By the mid-twentieth century, nearly 44 percent of Kenya’s agricultural land was under maize cultivation – a proportion that has not changed much since then. Formal development of the seed industry began in the 1950s when the colonial government initiated a maize

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**Notes:** Each scatter point represents the average experimental yield of varieties released that year. We differentiate between all released varieties and varieties intended for the high altitude (high potential) areas.

**Source:** Generated using Kenya Plant Health Inspectorate Service (KEPHIS) (2017)
research program in western Kenya. Since then the industry has gone through distinct
development phases that can be delineated by productivity growth[3].

The initial phase, a period spanning from the early 1960s to the early 1980s saw
relatively high productivity growth, averaging around 3 percent per year. The period was
characterized by a strong national maize program involving inputs and supportive policies
(Karanja, 1996, 2007). Pre-independence maize development was geared to the needs of
large-scale farmers with the first hybrid (H611) being released in 1965 and widely adopted,
especially in the high potential Highlands (Gerhart, 1975). After Kenya gained independence
in 1963, additional varieties suitable for other agro-ecological conditions were released.
The government’s maize seed program was complemented by an extension program that
introduced farmers to best agronomic practices (Karanja, 2007). This led many smallholders
to adopt improved varieties. Their yields were lower than those of large-scale farmers due in
part to the limited use of fertilizer (Karanja, 1996; Hassan and Karanja, 1997). This may
explain why even though IV adoption was increasing in the initial periods, maize yields
were fairly stagnant, averaging around 1,200 kg/ha for much of the late 1960s and early
1970s. Productivity improved for the 1975–1982 period as IV adoption expanded to other
areas. By the end of 1982, seven improved varieties were released, as documented by the
varietal registration records of KEPHIS[4].

The second phase – from 1983 to 1999 – experienced a decline in productivity even
though there were more varieties released (Table III). The new varieties, however, had a
small yield advantage over the ones that they were intended to replace (Karanja, 1996).
Other factors that have been cited for the decline in productivity growth include a decrease
in maize research funding, reduced competitiveness of maize, droughts and political
instability (Hassan and Karanja, 1997; Karanja, 2007). During the 1980s, Kenya faced
deteriorating macroeconomic conditions and balance of payment problems that forced it to
cut back on agricultural research, including research on maize. Real maize R&D expenditure
fell from a peak of 232,000 Kenyan shillings in the 1970s to 133,000 by the mid-1980s
(Karanja, 2007). This was also the period of structural adjustment programs and the general
liberalization of the economy, whereby agricultural markets were deregulated and
privatized, trade barriers were reduced, price distortions were removed, exchange rates
were adjusted and decentralization occurred. While liberalization was meant to encourage
competition in markets and make more efficient use of resources, it led to a weakening of
some government institutions in coping with limited resources (Gitau et al., 2009). Moreover,
the private sector did not have the capacity to undertake the role that was formerly being
performed by the government sector, resulting in poor performance of the agricultural
sector and the economy as a whole (Monitoring African Food and Agricultural Policies
(MAFAP), 2013).

The most recent phase – from 2000 onwards – can be regarded as a period of renewal,
with productivity growth reversing the trends of the prior decade. This post-liberalization
period involved measures that sought to rationalize and consolidate the policies instituted
during earlier periods (Monitoring African Food and Agricultural Policies (MAFAP), 2013).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield (%)</td>
<td>2.99</td>
<td>–0.86</td>
<td>1.72</td>
<td>1.40</td>
</tr>
<tr>
<td>Area (%)</td>
<td>2.89</td>
<td>2.28</td>
<td>2.62</td>
<td>2.62</td>
</tr>
<tr>
<td>Production (%)</td>
<td>5.97</td>
<td>2.27</td>
<td>3.91</td>
<td>4.20</td>
</tr>
<tr>
<td>Varieties released</td>
<td>7</td>
<td>16</td>
<td>294</td>
<td>317</td>
</tr>
</tbody>
</table>

Munyi and Jonge (2015) document 131 pieces of legislation that have been overhauled since 2000, many of them through a consultative process of the different stakeholders involved as noted by Gitau et al. (2009). Some of these changes were part of the government’s Strategy for Revitalizing Agriculture (SRA) that was initiated in 2005. There were two notable shifts that occurred under SRA (Monitoring African Food and Agricultural Policies (MAFAP), 2013; Poulton and Kanyinga, 2014). First, Kenya was to move away from the goal of achieving food self-sufficiency (the objective that guided much of the agricultural policy in earlier periods) to one that emphasized wealth creation and employment generation as a way to ensure food security. Second, private and public sectors were to play complementary roles to ensure efficient functioning of markets and optimal resource allocation. Under SRA, the public sector was to provide a limited number of goods and services, and a reduced but more focused approach to regulating the market that likely cannot be achieved through private self-regulation (Alila and Atieno, 2006; Monitoring African Food and Agricultural Policies (MAFAP), 2013).

Policies that directly affect the supply and demand of improved maize varieties have also evolved over the years. Many of these policies relate to varietal trade, registration and eventual release of varieties to farmers as most varieties are developed abroad and need to be imported. Prior to liberalization, while foreign germplasm and knowledge transfer was encouraged, the import of maize varieties was severely restricted. Like many import substitution policies, the goal was to promote the development of a local seed industry, but in reality only the KSC – a government-owned parastatal created in 1956 – benefited. It had exclusive rights to market maize varieties developed by the (then) Kenyan Agricultural Research Institute (KARI). Even to this day almost two decades after liberalization, KSC maintains exclusive rights to popular varieties and hybrids developed by public breeding programs. Nevertheless, by 2015, there were 19 companies that had released 157 varieties and accounted for 32 percent of the market share (The African Seed Access Index (TASAI), 2016).

The focus of policy reform has been on the ease and speed by which new varieties are made available to farmers. In Kenya, the introduction of new varieties is regulated under the 1972 Seed and Plant Varieties Act (SPVA) and its subsequent amendments, which require that firms submit them for official tests for value in cultivation and use. Varietal testing and registration is meant to ensure the genetic identity of a variety while protecting consumers, farmers and the environment from inferior varieties. Prior to liberalization, the approval and certification process was under the domain of KARI’s National Seed Quality and Control Board. Reforms during the late 1990s relegated this responsibility to KEPHIS – a newly created independent regulatory body.

Despite the administrative change, the process of the registration of new varieties in Kenya is long and costly (Gisselquist et al., 2013; Smale et al., 2013). According to a survey by TASAI it took, on average, 32 months for a variety to go through the release process in 2016 in Kenya, but only 19.5 months in neighboring countries such as Uganda (The African Seed Access Index (TASAI), 2016). The total cost of registering and releasing a new variety is estimated by the World Bank to be nearly $3,240 (World Bank, 2017).

A key provision of the 1972 SPVA was PBRs as a way to protect the intellectual property of breeders and growers. However, it was not until 1995 that regulations relating to PBR provisions in the 1972 SPVA were put in place, leading to the first granting of such rights in 1997 (Munyi and Jonge, 2015). Initially, Kenya acceded to UPOV under the 1978 convention and to the 1991 UPOV convention when the SPVA was amended in 2012. Kenya’s PBR legislation allows for the use of protected material for research, but prohibits the unauthorized marketing of “essentially derived varieties”; that is, varieties that are distinct from, but based almost entirely upon protected varieties (Swanckaert, 2012). Furthermore, it recognizes “farmers’ privilege” allowing them to save seeds of a protected variety, but not exchange it with other farmers (Munyi and Jonge, 2015).
Besides South Africa, Kenya is the only other country in Africa to have a system in place to grant PBRs, which are issued by KEPHIS and are available for all new plant varieties as long as they meet the criteria of being distinct, uniform and stable. From the time PBRs came into force in 1997 and up until 2014, a total of 1,384 PBRs were issued, of which 154 were for maize (or 11 percent) (Figure 5). PBRs for maize account for the majority of the PBRs issued for food crops.

Advocates for PBRs argue that they will stimulate research investments, and will allow for greater flows of foreign-sourced technology and a more competitive market. This will eventually lead to a greater number of yield-increasing varieties. The evidence on the productivity impacts of PBRs in the USA and Canada suggests that there may be a small positive impact, but this may depend on the crop being studied (Spielman and Ma, 2014). For example, Perrin et al. (1983), Carew and Devadoss (2003) and Naseem et al. (2005) find limited positive yield impacts of PBRs on soybean, cotton and canola, respectively. However the evidence is more mixed for wheat, where Alston and Venner (2002) found no evidence of a positive impact of PBRs on yields, while Kolady and Lesser (2009) did.

Along with policy and regulatory changes that affect the introduction of new maize varieties, policies related to the marketing and trade of maize were also being reformed. Before liberalization, maize prices were heavily controlled and set by the government and thus affecting everyone along the maize value chain. Maize was marketed by the government’s National Cereals and Produce Board (NCPB), which had a monopoly over all aspects of internal and external trade. Private trade across districts was illegal, except for permit holders. Such a regulated environment severely distorted the maize market and reduced the incentives for farmers to innovate and adopt productivity enhancing technologies.

Maize market reforms that were initiated in the late 1980s intensified during much of the 1990s (Nyangito and Karugia, 2002; Ariga and Jayne, 2009; Aylward et al., 2015). Early on, the reforms under the Cereal Sector Reforms Program were designed to allow for interdistrict private trade and a reduced role for NCPB in the procurement of maize. However, prices were still controlled by NCPB and rather than increasing the margin between purchase and

Figure 5.
Number of plant breeders’ rights issued in Kenya (1997-2014)

Source: Generated using The International Union for the Protection of New Varieties of Plants (UPOV) (2017)
selling price to encourage private participation, margins declined (Sheahan et al., 2016). Further reforms were implemented in the mid-1990s that allowed for the free movement of maize, and the removal of both price controls and direct subsidies to millers. The private sector was allowed to import maize but faced a changing tariff structure. Initially, the maize import tariff was removed in 1993, but was reimposed in 1995. Jayne et al. (2008) find that the maize import tariff over the 1995–2004 period raised average domestic prices by roughly 4 percent, although in several particular years, the import tariff caused domestic prices to increase by well over 10 percent. More recent trade measures have included the removal of tariff barriers with neighboring countries. Nevertheless, the government continues to impose tariffs and export bans often in an unpredictable fashion.

Alongside reforms specific to the maize market, the fertilizer market has also been subject to considerable policy changes. Before market reforms, the market was controlled by government-run agencies with limited private trade and controlled (subsidized) prices. Due to mismanagement, weak distribution networks and poor coordination, fertilizer did not reach many farmers. Reforms introduced in the early 1990s sought to address this as restrictions on private traders, tariffs and price controls were either abolished or considerably relaxed. As a result, by 1996, there were 12 major importers, 500 wholesalers and nearly 5,000 retailers (Ariga and Jayne, 2011). Fertilizer consumption grew at nearly 10 percent per year between 1990 and 2005, nearly double the rate 15 years prior (FAO, 2018).

More recent policies and programs directed at maize and fertilizer markets have sought to target resource-poor smallholders, often by providing input subsidies. In particular, after the 2008 world food price crisis and 2009 post-election violence, the government intervened to aid farmers. Nearly 30,000 tonnes of fertilizer were imported and distributed via NCPB branches and private retailers at a 40 percent subsidy. However, the subsidies through NCPB have been found to lack clear targeting criteria and have been diverted to non-targeted beneficiaries by as much as 33 percent (Jayne et al., 2013).

3. Empirical analysis

Crop productivity is a function of a number of exogenous factors, such as the types and amount of inputs used, agro-climatic conditions, technology employed and the incentives/disincentives created by the policy environment. It is hypothesized that the policy reforms that led to the opening of markets, technology development (in the form of new varietal releases) and PBRs all had an impact on maize yields. Testing this hypothesis, however, is challenging for a number of reasons. First, the process of reforms takes time and its effects may not be evident until years later. As discussed earlier, liberalization of the agricultural sector in Kenya began in the late 1980s but was enacted slowly and with considerable hesitancy, especially with regards to maize marketing and trade. Second, policy reform is a broad concept that involves changes to a number of different specific policies that may or may not have an impact on productivity. It is unclear, for example, whether reforms directed at removing price distortions (price policy) have the same impact on productivity as those that seek to improve farmer access to technology (technology policy). If technology policy is more important to increasing productivity than price policy and the latter is implemented first in the reform process, then the impacts of policy reforms may not be evident until after the technology policy comes into force. As such, there needs to be clarity in terms of what is meant by policy reforms and when a specific policy change occurs. Third, data required to perform such a hypothesis test may not be available. For example, in a model that relates national maize yields to input use over time would require actual inputs (fertilizer, pesticides, labor) used by maize farmers, details on their use of improved varieties (how old, whether private or public, whether hybrid or not) and the agro-climactic conditions faced. Although farm-level surveys of input use have been carried out by different researchers, consistent aggregate-level data specific for maize production are not available.
With these considerations in mind, the following general yield model can be used:

\[
Y_t = \beta_0 + \beta_1 RAINFALL_t + \beta_2 FERTILIZER_t + \beta_3 IV\_MAIZE_t
+ \beta_4 P\_MAIZE_{t-1} + \beta_5 VAR\_MAIZE_t + u_t,
\]

where \(Y_t\) is the national maize yield for Kenya in kg/ha in year \(t\). \(RAINFALL_t\) is the total annual rainfall amount (mm) for Kenya in year \(t\). Almost all agricultural production in Kenya is rainfed, since less than 0.5 percent of the arable land is irrigated. While rainfall is an important factor in yield, the aggregate nature of this specific variable may misrepresent the actual rainfall received in maize-growing regions located in the western (Highlands) part of the country, which are likely to be higher, as they benefit from bi-modal rainfall patterns (from short and long rain seasons). In the absence of such more detailed micro-level rainfall data for the time period under study, total annual rainfall is used as a proxy. \(FERTILIZER_t\) is the amount of total fertilizer consumed (kg/ha of maize area) in year \(t\) and is constructed by dividing the approximated total fertilizer nutrient (NPK) applied on maize by the maize area. The variable \(FERTILIZER_t\) is an approximation for the actual fertilizer used by maize farmers as consumption data are not disaggregated by crop. However since 50 percent of the fertilizer consumption is for maize (Oseko and Dienya, 2015) and maize is the most widely grown crop by area, we divide total fertilizer consumption by 2 and divide it by the maize area in year \(t\). We feel this is a reasonable approximation and indeed closely corresponds to those reported in farm-level surveys (Ariga and Jayne, 2011). Application of fertilizer may not be a linear relationship as implied by our specification, as there may be diminishing returns after a certain amount is applied. However, we do not feel this to be a concern given that application rates are fairly low and the maximum amount is still considerably less than for other maize-growing regions around the world. \(IV\_MAIZE_t\) is the share of maize area under improved varieties. The data for this variable come from the DIIVA project, which uses secondary sources and survey data to create a time series of area under modern varieties for different crops. It is assumed that the share for all years between the two survey points is constant, resulting in the step-wise logistic curve as depicted in Figure 3. Including both \(FERTILIZER_t\) and \(IV\_MAIZE_t\) raises the possibility of multicollinearity (the correlation coefficient between the two is 0.8). As such we estimate the model with these two variables separately. Total maize area (\(AREA_t\)) is used as an alternative measure of maize cultivation when \(FERTILIZER_t\) is used as one of the explanatory variable. \(P\_MAIZE_{t-1}\), which is the average producer price of maize in year \(t-1\). Finally, \(VAR\_MAIZE_t\) is the total number of new maize varieties released in year \(t\). We assume that newer varieties are likely to be as productive (if not more) than varieties currently grown, and hypothesize that the greater the number of varieties released in a given year the greater the impact on yield in subsequent years.

There are three issues with the last of these variables that need further elaboration. First, the number of maize varieties released provides little information on their adoption, as many released varieties may never get adopted. Data limitations prevent obtaining an annual estimate of how many of the released varieties are being adopted, but estimates from DIIVA from 2009 provide some indication. Of the 204 varieties that had been released and approved for cultivation up to that year, only 65 varieties were being grown. Of these, five varieties accounted for 65 percent of the cultivated area (see Table II). Furthermore even if the varieties are adopted, the impact may not be contemporaneous, and it is likely the case that it takes a year or longer for a variety to be sown after its introduction. To account for this, we introduce lags and cumulative number of varieties registered with KEFIS in any given year in our specification.

A second issue is that \(VAR\_MAIZE_t\) is likely to be endogenous in Equation (1) and the point estimates will be biased and inconsistent. Endogeneity is suspected here
because there may be unobservable factors that jointly determine yield \( (Y_t) \) as well as the number of varieties released \((\text{VAR}_{\text{MAIZE}})_t\). For example, greater spending on research and technology development would lead to an increase in higher yielding varieties, and to more varieties and varietal choice. In order to control for such endogeneity, a two-stage least squares (2SLS) regression approach is used to introduce instrumental variables that are determinants of the number of varietal releases, but may not affect maize yields directly.

A two-stage least squares estimation involves a first-stage regression of \(\text{VAR}_{\text{MAIZE}}_t\) – appropriately lagged – on all exogenous variables plus variables to be used as instruments. Some candidates for exclusion restrictions are: R&D expenditures related to maize development (or alternatively the number of researchers), varieties released by private firms and varieties protected by PBRs. All three variables are also related to policy change. Greater R&D – both public and private – would be suggestive of a policy shift that seeks to focus on increasing the productivity of agriculture and maize specifically. Unfortunately, a continuous time series for private R&D is fairly recent. Even so, the amount of private R&D expenditure is estimated to be extremely small relative to public R&D ($1.6–$3.2m vs $263m in 2008 as reported by Pray et al. (2011). We also do not have research expenditures by commodity. Given these limitations, total agricultural R&D expenditures in year \( t \) is used as one of the instruments (denoted as \( \text{RESEARCH}_t \)) measured in constant 2011 US$million dollars). The \( \text{RESEARCH}_t \) variable used here includes expenditures by not only the Kenyan government, but also spending by donors and CG centers. We also use research spending by CGIAR centers with mandates on maize research (notably CIMMYT and IITA).

As noted earlier, in the pre-reform period, there were no private firms developing or marketing maize seeds. This changed around 1996 with the first private variety being released. The presence of private firms is captured by a dummy variable \((\text{PRIVATE}_t)\) to indicate the release of varieties by private firms since 1996 (1 for \( \geq 1996 \); 0 otherwise). Finally, PBRs – a policy tool in its own right – would also indicate the availability of productive and valuable varieties. Kenya has been providing PBRs since 1996, issuing 154 PBRs for maize between 1996 and 2014. However, not all PBR-protected varieties are released and not all released varieties have a PBR associated with them. Since only released varieties could directly impact productivity, we use the cumulative number of released varieties with PBRs in year \( t \) as the instrument (denoted as \( \text{PBR}_t \)).

Table IV shows the summary statistics of the variables used in our analysis.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
<th>Data source</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>( Y_t )</td>
<td>Maize yield (kg/ha)</td>
<td>FAO</td>
<td>1,555.47</td>
<td>258.60</td>
</tr>
<tr>
<td>( \text{FERTILIZER}_t )</td>
<td>(Log) Fertilizer consumption (kg/ha)</td>
<td>FAO</td>
<td>3.04</td>
<td>0.56</td>
</tr>
<tr>
<td>( \text{RAINFALL}_t )</td>
<td>Rainfall amount (mm)</td>
<td>World Bank</td>
<td>54.87</td>
<td>8.85</td>
</tr>
<tr>
<td>( \text{P}<em>{\text{MAIZE}}</em>{t-1} )</td>
<td>(Log) Maize price (US$/tonne)</td>
<td>FAO</td>
<td>4.80</td>
<td>0.61</td>
</tr>
<tr>
<td>( \text{IV}_{\text{MAIZE}}_t )</td>
<td>Share of maize area under improved varieties (IV)</td>
<td>DIIVA</td>
<td>0.36</td>
<td>0.31</td>
</tr>
<tr>
<td>( \text{AREA}_t )</td>
<td>Maize area (‘000 ha)</td>
<td>FAO</td>
<td>1,487.23</td>
<td>282.30</td>
</tr>
<tr>
<td>( \text{VAR}_{\text{MAIZE}}_t )</td>
<td>Number of maize varieties releases in year ( t )</td>
<td>KEHPIS</td>
<td>6.22</td>
<td>10.87</td>
</tr>
<tr>
<td>( \text{RESEARCH}_t )</td>
<td>Public agricultural R&amp;D expenditures (2011 US$m millions)</td>
<td>ASTI</td>
<td>190.78</td>
<td>60.89</td>
</tr>
<tr>
<td>( \text{PBR}_t )</td>
<td>Number of released maize varieties protected by PBRs</td>
<td>UPOV &amp; KEPHIS</td>
<td>13.73</td>
<td>20.05</td>
</tr>
<tr>
<td>( \text{PRIVATE}_t )</td>
<td>Dummy variable to indicate private varieties (1 if ( \geq 1996 ), 0 otherwise)</td>
<td>KEPHIS</td>
<td>0.33</td>
<td>0.48</td>
</tr>
</tbody>
</table>

Note: Number of observation for all variables is 51, except maize price (50 observations) which was lagged by one year.

Table IV. List of variables used in regression analysis

Contribution of policy change
4. Results and discussion

The empirical analysis on factors determining yield are explained under two sets of specifications and derived from Equation (1) using both OLS and 2SLS as presented in Table V. In the first OLS regression with (Column 1), coefficients that are significant (at the 5 percent level) that directly accounts for yield are the number of varieties released and fertilizer. As one would expect, higher fertilizer application results in an increase in yields. More specifically, yields increase by 2.1 kg/ha from 1 percent increase in fertilizer use. Intensification can also occur through the use of other inputs such as high yielding seeds, pesticides or labor. Maize area ($\text{ARE}_t$) is found to be positive and insignificant (Table V). This would suggest that, although maize area has been increasing over time, it is unclear whether the expansion includes maize that is being grown in productive regions with productive cultivars resulting in increased yield variability across different agro-climatic zones (Abate et al., 2015). Column 3 presents the OLS results when the share of improved maize varieties is included in lieu of fertilizer. Under this alternative specification, maize price lagged one year is significant but not $\text{IV}_{t-1}\text{MAIZE}_t$. Since the coefficients on fertilizer is positive and significant but is insignificant for share of maize to improved varieties, it would appear that intensification is occurring through higher fertilizer use or some other input not accounted for here (such as manure) and not due to the use of improved varieties.

For two sets of 2SLS estimates, yields are positively impacted by a lagged maize price variable and fertilizer (both significant at the 1 percent level). As was the case with OLS estimates, the coefficient on the share of improved varieties is still insignificant with high standard errors. As discussed above, all of the selected instruments (R&D expenditures, presence of private firms, and PBRs that affect $\text{VAR}_{t-1}\text{MAIZE}_t$ directly) are also expected to impact yield ($Y_t$) besides the number of varieties released. From the results of the first-stage estimation of varietal releases only the coefficient on the PBRs variable is found to be significant (see Table VI). This suggests that PBRs are incentivizing breeders to release more varieties, as evidenced in the literature. The insignificance of the $\text{RESEARCH}_t$ coefficient is surprising at first, but one should note that the variable is imperfect as it is measuring total R&D and that the dependent variable is the total number of varietal releases (both private and public). Because all the variables in the data set by type (i.e. public and private) cannot be differentiated, public R&D may be an inefficient predictor of total releases.

To justify the appropriateness of the use of 2SLS over OLS, a series of post-estimation tests are performed for both specifications. In the specification with $\text{FERTILIZER}_t$ (Column 2 in Table V) endogeneity tests for $\text{VAR}_{t-1}\text{MAIZE}_t$ with the null hypothesis that it can be treated as exogenous is rejected (Durbin (score) $\chi^2 = 3.94$ ($p = 0.05$; Wu-Hausmann $F = 3.67$ ($p = 0.06$)). Second, using $F$ statistic for the joint significance on the coefficients of the

<table>
<thead>
<tr>
<th>Variables</th>
<th>(1) OLS</th>
<th>(2) 2SLS</th>
<th>(3) OLS</th>
<th>(4) 2SLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{VAR}_{t-1}\text{MAIZE}_t$</td>
<td>$-9.773^{**}$ (3.693)</td>
<td>$-17.560^{***}$ (5.696)</td>
<td>$-7.979^{**}$ (3.633)</td>
<td>$-14.52^{***}$ (4.984)</td>
</tr>
<tr>
<td>$\text{FERTILIZER}_t$</td>
<td>208.7^{**} (82.68)</td>
<td>249.1^{***} (89.88)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\text{RAINFALL}_t$</td>
<td>3.710 (3.341)</td>
<td>3.730 (3.354)</td>
<td>3.295 (3.529)</td>
<td>3.042 (3.494)</td>
</tr>
<tr>
<td>$\text{P}_{t-1}\text{MAIZE}_t$</td>
<td>154.3 (94.68)</td>
<td>164.0^{*} (94.23)</td>
<td>265.9^{***} (98.45)</td>
<td>294.5^{***} (100.2)</td>
</tr>
<tr>
<td>$\text{ARE}_t$</td>
<td>24.92 (262.5)</td>
<td>224.0 (284.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\text{IV}_{t-1}\text{MAIZE}_t$</td>
<td></td>
<td></td>
<td>55.32 (195.0)</td>
<td>130.1 (194.7)</td>
</tr>
<tr>
<td>Constant</td>
<td>$-229.8 (1,721)$</td>
<td>$-1,822 (1,851)$</td>
<td>135.2 (454.0)</td>
<td>29.34 (468.0)</td>
</tr>
<tr>
<td>Observations</td>
<td>50</td>
<td>49</td>
<td>50</td>
<td>49</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.421</td>
<td>0.311</td>
<td>0.337</td>
<td>0.247</td>
</tr>
</tbody>
</table>

Table V.
Results of the yield function; dependent variable $Y_t$.

Notes: Standard errors are in parentheses; $\text{FERTILIZER}_t$, $\text{P}_{t-1}\text{MAIZE}_t$, and $\text{ARE}_t$ are in logs; $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.
additional instruments $F(3,41) = 10.10$ with $p = 0.000$, the null hypothesis that the instruments are weakly identified can be rejected. Finally, in the test for over-identifying restriction, under the null hypothesis that the instrument set is valid and the model is correctly specified, the $p$-values for both the Sargan (score) ($\chi^2 = 2.7378; p = 0.2544$) and Basmamn ($\chi^2 = 2.4264; p = 0.2973$) are greater than 10 percent, suggesting that the statistical model is indeed valid. Similar post-estimation results are obtained when $IV_{MAIZE_t}$ is used.

The key question to answer here is what is one to make of the negative but significant coefficient on the number of maize varieties released over years $VAR_{MAIZE_t}$ in all the specifications and the relationship to yield levels of maize. Taken at face value, an additional varietal release decreases yields by 8–17.5 kg/ha; which suggests a disconnect between yield gains and new cultivar releases. As has been suggested previously, this could be because newer varieties offer small yield advantages over the previously released improved varieties (Ariga and Jayne, 2011), and that not many varieties were developed to address the agro-ecological concerns, including issues related to varieties suitable for maize-based intercropping resulting in poor genetic gains. Furthermore, since not all released varieties are adopted and lags may be much greater than we had specified, the negative coefficient is likely to account for the non-adoption of new varieties. Note that the share of maize area sown to improved varieties while positive is insignificant. Since the share has not changed much over the past 20 years and already is above 70 percent, the yield gains from increasing improved varietal share are not going to be large if the same (older) varieties are going to be adopted.

It should be noted that a number of alternative specifications (not reported here) were tried but gave similar results. These included lagging the $VAR_{MAIZE_t}$ by two years and using a cumulative number of maize varieties available. In both these instances the number of varieties was found to be a negative predictor of yield. Additionally, we employed different measure of R&D, including one that accounted for R&D by CGIAR centers (notably CIMMYT and IITA that have maize research programs) in SSA but that too was found to be insignificant.

### 5. Conclusions
Since the early 1990s, Kenya has undertaken a number of reforms to liberalize its agricultural markets with a view of improving productivity. Agricultural input markets that were previously heavily regulated with little private sector participation have undergone dramatic changes, especially the maize seed market. Since 1999, for example, 333 improved...
varieties have been released, compared to 21 in all the years prior. Nearly half of the
varieties released since 1999 have been due to private firms.

While policy reforms have been largely focused on improving the supply of new varieties
and varietal development, it is yet unclear whether it has had the desired productivity
impact. In this paper, this question is addressed directly by relating Kenya’s national maize
yields to a number of exogenous factors, including those that are influenced by policy
changes. The results of the 2SLS regression – where the first stage relates how different
policies impact the development of new varieties and second stage on how those varieties
influence yields – suggest that the release of new varieties has not yet affected yields
positively to a measurable extent. The lack of a quantifiable increase in yield due to new
varietal releases may seem surprising, considering newer releases are usually regarded as
being more productive than the older ones they replace.

However, the results are not really surprising when one considers that the adoption of
the released varieties has not been widespread and that the yield advantage for many of the
released varieties (over existing varieties) has likely been quite small under prevailing farm
practice. Given the inherent variability in Kenyan maize yields, and the tentativeness
of the relationships being quantified in the analyses reported, there are highly limited
policy-relevant conclusions that can be drawn. One is that there is seemingly a need for both
patience and persistence in investing in R&D to improve the productivity of new varieties
and incorporate traits for better managing biotic and abiotic stresses. Patient investors can
be comforted by the vast global experience that investment eventually pays off, and mostly
handsomely (e.g. Alston et al., 2000). For Kenya, as it pursues crop improvement as an
ongoing challenge, effort needs to be directed toward encouraging the adoption of new
really improved varieties. This requires concerted extension and dissemination efforts
supported by the Ministry of Agriculture and the private sector.

Notes
1. WA age is defined as \( \sum p_i A_{it} \), where \( p_i \) is the proportion of the crop’s area cultivated in variety
   \( i \) in year \( t \).
2. DIIVA – or the Diffusion and Impact of Improved Varieties in Africa – is a CGIAR led project that
   seeks to collect improved varietal adoption data in Africa. Details about the project and associated
   data set is available from www.asti.cgiar.org/diiva
3. Hassan and Karanja (1997) also characterize Kenya’s maize industry going through different
   phases, but for different periods of time since their analysis was only up to 1991.
4. There are some discrepancies in the literature as to how many varieties were released. Data from
   KEPHIS suggest 7 varieties were released between 1962 and 1982, while Karanja (2007) reports 17
   were released and Hassan and Karanja (1997) report 13 were released.

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Contribution of policy change


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Building African Agribusiness through Trust and Accountability

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Abstract

Purpose – The purpose of this paper is to analyze the social institutions of trust, accountability and corporate shared value in creating an enabling environment for private sector investment in African agricultural and food systems.

Design/methodology/approach – This paper uses mixed methods. A value chain framework models interactions among stakeholders in the agriculture, agribusiness and food sectors. The social institutions of accountability and trust are introduced into the model, followed by a Rwanda premium coffee value chain case study.

Findings – The conceptual and case study results show that best practices can increase smallholder farmer, agricultural service provider, financial intermediary, and food processor investments in and benefits from the agriculture sector.

Research limitations/implications – Further research is needed on the economic foundations of development cooperation based on trust, accountability and shared values, best practices and the link with desired societal outcomes, such as the sustainable development goals.

Social implications – Mutual accountability processes, as they are maturing in Africa, are at the cutting edge of creating processes where multiple stakeholders, including agribusiness, can come together to make joint commitments to a shared development agenda, and where stakeholders hold themselves and others accountable for meeting these commitments.

Originality/value – This is the first paper to bring together cutting-edge advances in corporate shared values, trust and accountability in the context of African agricultural and agribusiness development.

Keywords Trust, Africa, Agribusiness, Value chain, Corporate shared value, Feed the Future, Mutual accountability

Paper type Research paper

1. Introduction

Current agricultural and agribusiness development thought has undergone a paradigm shift from state-directed development to private sector leadership of inclusive growth processes. As they are maturing, African mutual accountability processes emphasize including agribusiness as a full partner on the basis of shared values – this is one of the most exciting development innovations of this decade. This paper explores how such processes are emerging, in terms of cooperation for development based on trust, mutual accountability and corporate shared value.

Global governance bodies have long recognized the need for cooperation to advance a unified global development agenda on international growth and poverty reduction, but the approach has morphed over time from an emphasis on governments as the key driver of development to the broad recognition of the private sector as essential to achieving development goals. After the Second World War, the establishment of the United Nations and the elevation of development to a global objective emphasized cooperation among governments, be they country-level or international governance bodies. In the 1960s, the United States Agency for International Development (USAID) was established, with an emphasis on individual empowerment. Development continued to advance on the global agenda through a series of high-level forums focused on modernizing, deepening and broadening development cooperation and the effective
delivery of aid – the first High Level Forum on Aid Effectiveness was held in Rome in 2003, followed by Paris in 2005 and Accra in 2008. These forums introduced mutual accountability for development effectiveness and an increasing role for non-state development partners. The Fourth High Level Forum on Aid Effectiveness in 2011 led to the signing of the Busan Partnership for Effective Development Cooperation, which squarely emphasized the importance of the private sector as a development partner. The importance of partnering is now codified in Sustainable Development Goal 17: Partnerships for the Goals.

Simultaneously, the private sector has witnessed a sea change in its orientation – from profit motivation to corporate social responsibility to corporate shared values (Porter and Kramer, 2011).

Private sector engagement is particularly important in African agriculture and agribusiness to achieve development results, for a variety of reasons. First, African demographics determine that many if not most of Africa’s youth will be employed at least initially in agriculture. Second, even aspirational levels of donor and government funding are insufficient fully to fund the needed investments in agricultural and agribusiness modernization. Indeed, recent evidence has shown that in developing-country agriculture, private sector on-farm investment far exceeds government, donor and foreign private investment combined (Figure 1). Third, the global food system’s interconnectedness means that farm service and input suppliers, farmers, processors, transporters and food market actors must all work together if local and global food systems are to provide access to affordable and nutritious foods for a growing world population. Food system globalization is transforming contemporary views of development and pathways toward ending hunger (Franklin, 2017; Richards et al., 2016; Reardon, 2016).

Despite the recognized importance of private sector stakeholders in development processes, progress has been restrained for a variety of reasons, not least of which are a lack of trust and a lack of communication and accountability around shared values. For example, in 2015, trust in African business leaders was the lowest on record: 42 percent of Africans surveyed believed that business executives were corrupt, and 38 percent believed government officials and 37 percent believed tax officials were corrupt (Pring, 2015). Covey (2006) argued that trust is

**Figure 1.** Investment in agriculture in selected low- and middle-income countries, by Source

Note: *Number of countries
Sources: Figure 5 reproduced from Food and Agriculture Organization of the United Nations (2012); Lowder, Carlsma and Skoet (2012)
necessary for business effectiveness, and Rademakers (2000) found that trust is the essential ingredient in effective African agricultural value chains.

More generally, Porter and Kramer (2011) argued that corporations that share values with society and invest accordingly both perform better as profitmaking corporations and help advance the economic and social conditions in communities where the corporation operates. Blodgett et al. (2014) found that “companies’ socially responsible acts are positively associated with overall firm value and financial performance.” Moreover, by operating on corporate shared value principles, the business community can “unleash a wave of innovation and growth” for the benefit of all stakeholders (Porter and Kramer, 2011). Rebuilding trust in business begins with the private sector making voluntary public commitments to actions in support of shared values, responsible execution of those commitments, improved corporate performance and improved sector performance.

Given the clear need for improved agriculture and food sector performance in Africa, this begs the question: How can stakeholders restore and build accountability and trust in African agricultural and food systems?

This paper examines exciting new interventions in African agriculture and agribusiness that help to build accountability and trust in the context of furthering shared values for agricultural and food systems development. This examination includes both conceptual underpinnings and programmatic examples. The next section provides the African agribusiness context. Next is a section on trust and accountability – defining these concepts and placing them in the Africa agribusiness and food system context and the corresponding literature. This is followed by a fascinating case study of the Rwanda fully washed-coffee value chain, which not only evolved into one of the highest quality premium coffee value chains in the world and enabled thousands of smallholders to emerge from poverty, but also helped build trust and healing in the aftermath of the Rwanda genocide on the shared values of reconciliation and growth. The final section presents conclusions.

2. African agricultural and agribusiness context

Many sub-Saharan economies are based primarily on agriculture. For countries without significant oil or mineral revenues, agriculture is the largest contributor to GDP and the largest source of employment. For example, in Tanzania, agriculture contributes 31 percent of GDP and 68 percent of employment; even in oil-producing Nigeria, agriculture contributes 21 percent of GDP and 31 percent of employment, and in mineral-producing Zambia, agriculture still employs 56 percent of the population (World Bank, 2019). In 2016, even in drought-stricken Ethiopia, agriculture provided 37 percent of GDP, although this was down over 10 percentage points from the recent pre-drought high rate of 48 percent in 2012.

Over the past two decades, sub-Saharan Africa has been a star agricultural performer, outpacing even Brazil, Russia, India and China in value-added agriculture, food production and economic growth (Figure 2). Hunger has diminished. Despite rapidly growing populations, the food deficit in the region was halved, from 250 kcal/person-day in 1992 to 130 kcal/person-day in 2016.

Despite this noticeable progress over the past two decades, food insecurity, hunger and undernourishment remain significant problems through large parts of the region. Undernourishment – the inability to acquire sufficient food to meet minimum caloric requirements throughout the year (FAO et al., 2017) – exceeds 40 percent in some countries (Figure 3). Meeting nutritional needs is even harder, for example the prevalence of anemia among Sub-Saharan children under five was 60 percent in 2016, a decline of only 12 percentage points from 2002. Stunting rates among children under five almost halved between 1990 and 2015 and, yet, nearly one in four children today is stunted (World Bank, 2019).

Africa’s difficulty in continuing to make progress against hunger is not unique. After years of seeing a steady decline in global hunger, the 2017 State of Food Security and Nutrition in
Figure 2. Annualized rate of increase in agricultural value added, food production and national income for sub-Saharan Africa, BRIC Countries and the World, 1996 to 2013–2015

Source: Oehmke (2017)

Figure 3. Prevalence of undernourishment (percent of population)
the World report concluded that “global hunger appears to be on the rise, affecting 11 percent of the global population,” resulting in an increase in the number of chronically undernourished people by approximately 30 million from 2015 to 2016 (FAO et al., 2017). In addition, droughts and famines are hitting regions harder than before – the El Niño-induced Ethiopian drought that started in 2015 is the worst in a generation, and diseases such as fall armyworm are taking away food from already strained and hungry populations.

In response to this situation, African governments and donors have elevated attention to improving food systems, through greater engagement with the private sector. Feeding hungry populations is not just a moral imperative, it is not just a development necessity, but there are also significant budgetary and political implications of an underfed lower class (Resnick, 2014; Resnick and Thurlow, 2014). Covic and Hendricks (2016) quantified the annual costs of undernutrition in a study of seven African countries and found that costs ranged from 3.1 percent of GDP in Swaziland to 16.5 percent in Ethiopia. The response is to seek systemic approaches to accelerate agricultural growth including agro-processing because this is typically the most inclusive growth process in agricultural economies (Dorosh and Thurlow, 2014). The African Union’s Malabo Declaration, the Comprehensive Africa Agricultural Development Programme 2025 Implementation Plan and the US Government’s Global Food Security Strategy all emphasized systemic change in agricultural and food systems to accelerate inclusive agricultural and agribusiness growth, based on partnerships with the private sector.

The elevation of the global food system has transformed the way pathways are viewed toward ending hunger, but the challenges remain as large as ever. Particularly challenging is how to catalyze, sustain and orient systemic change in food systems to achieve both private and societal goals – in other words, how to move forward on the basis of shared values.

3. Trust and accountability

To be successful, aligned and complementary actions taken by different enterprises and other development stakeholders in pursuit of shared values require a degree of trust in the other stakeholders as well as a degree of accountability that the necessary actions will be responsibly executed. This section delves into trust and accountability as they influence agricultural and food systems.

3.1 Trust

Trust is a pervasive component of positive, enduring relationships, including business relationships. Covey (2006) argues that trust is the “one thing that is common to every individual, relationship, team, family, organization, nation, economy, and civilization throughout the world – one thing which, if removed, will destroy the most powerful government, the most successful business, the most thriving economy [...]”. Nobel laureate Kenneth Arrow (1972) noted that “virtually every commercial transaction has within itself an element of trust, certainly any transaction conducted over a period of time. It can be plausibly argued that much of the economic backwardness in the world can be explained by the lack of mutual confidence” (p. 357). The basic issue is that in developing countries (and to a large extent in developed countries as well), formal contracts are unavailable and/or incomplete and, often, unenforceable or enforceable only with high costs to the plaintiff. This suggests that trust has a role both in informal systems and in improving the effectiveness of formal contracts, which is supported by the literature (Makombe, 2018).

The importance of trust in developing-country agribusiness is established in a small but informative literature. Wilson (2000) argued that social capital and trust have significant influence in agribusiness: trust can alter terms of trade and create transactional and resource efficiencies. The result that trust can affect terms of trade in agribusiness deals clearly demonstrates that impersonal price signals in and of themselves are not sufficient in
complex interactions. For example, Theron et al. concluded that trust and satisfaction are critical components of decisions to stay in business-to-business relationships in the financial services industry. Downing and Campbell (2014) argued that a common characteristic of effective agricultural input supply systems is that they are perceived as fair, based on “trust and transparency […] in addition to valued goods and services […] to ensure that the smallholder customer has a good experience as a result of the transaction.” In Vietnam, the institutional framework limits long-term investments by small and medium agribusiness; instead of formal mechanisms, these businesses rely on trust-based friendship networks (Thai and Hjortso, 2015). Trust is also an important component of social capital within smallholder cooperatives in Vietnam. In the Vietnamese apple industry, trust is an important component of the enforceability of formal contracts (Cai and Ma, 2015). Batt and Rexha (2000) found that trust replaced third-party quality verification in Asian potato seed industries. As in most cases, the quality of potato seed is not fully ascertainable upon purchase, and, in this case, no third-party verification was available. However, smallholder trust relationships with seed suppliers allowed the market to function. Franklin and Oehmke (2018) provided a categorization of the trust relationships important in agribusiness and food systems.

In the African agribusiness context, Lyon (2006) in Ghana and Lyon and Porter (2009) in Nigeria demonstrated the importance of trust among farmers, traders and input suppliers in the absence of fully enforceable legal contracts. The conclusion was that trust in agribusiness dealings can replace formal contracts, but only if that trust is linked to a deep set of cultural mores and behaviors. Dowla (2006) described the Grameen Bank’s success in microfinance as “fostering a new level of social trust to solve the collective action problems of poor people’s access to capital” (p. 102). Paul et al. (2016) conducted social capital experiments in Ethiopia, determining that stronger trust facilitates smallholder contributions to social goods that facilitate adaptation to climate change for all. Turyahikayo and Edson (2016) found that a lack of smallholder trust limited the effectiveness of private sector extension provision in Uganda. Nandonde et al. (2017) conducted case studies of the Tanzanian fresh meat and processed peanut butter value chains in two parts of Tanzania, concluding that the establishment of trust between small agribusiness entrepreneurs and modern food helps small-scale agribusinesses access modern food supply chains. Growiec and Growiec reformulated the poverty trap issue as a “low trust trap” (p. 282): the solution to the poverty trap is, thus, to increase the level of trust and associated social capital. Conversely, it is important to note that exclusion or marginalization of individuals from the social capital and trust process can lead to poverty traps for these individuals and/or a vicious cycle of increasing inequality perpetuating greater exclusion and social inequality (Growiec and Growiec, 2014; Gould and Hijzen, 2016; Levien, 2015).

However, there is also surely a relationship between trust and prices received: Susanty et al. (2017) showed that dairy farmers’ trust had a positive effect on their loyalty as suppliers and that price satisfaction had a positive effect on trust. In case studies of sugar in Swaziland and timber in South Africa, Sartorius and Kirsten (2007) found that trust made the formal contracting mechanism between the smallholder and the processor operate more effectively – and conversely in the absence of trust.

The establishment of trust is linked to four core competencies in an individual or an organization, as follows: integrity, intent, capabilities and results.

Often believed to be the underpinning for trust, integrity is the foundation upon which a system of trust is established. Covey (2006) emphasizes that without integrity, an individual can more easily lose trust, leading the other cores of trust to fail short. To signal integrity, an individual or an organization should not only establish a set of guiding principles and values but adhere to them daily. Integrity should be seen as more than following the rules or doing what they should do. Some organizations try to force integrity upon their employees’ actions through policies, trainings and procedure manuals which, in the long term, do not help
establish trust. Integrity is deeper than just going along with the outlined or mandated principles, integrity is being consistent in your actions and humbly choosing what is right. This is how character is built. Choosing what is right takes courage as it may not be what is immediately best for an individual. Individuals and organizations who instill this deep level of character show no disconnect between what they intend to do and their eventual behavior, which is a key signal of integrity. They say, act, feel and think with consistency and with one voice. These types of interactions are reflected within the food system context through the adherence to quality controls, fair trade guidelines, or other standards – even if it costs the enterprise money to maintain their integrity. Intent as a core competency is observable through an individual’s or organization’s motives, as well as their actions when pursuing a collaborative agenda or determining a mutually beneficial solution. This demonstration of a motive based on a shared value is effective in signaling trustworthiness and respect for the other party. Behavior and communication are critical components of intent. Communicating your intent to act can build trust within a relationship. However, trust can just as quickly be lost if integrity is damaged or true intent questioned, should an individual not follow through on their declaration. Demonstrated through building a reputation based on excellence, capability is the third core competency of trust. Capability is not a static characteristic, as leaders and strong organizations constantly work to improve, advance and adapt. It is through this ability to inspire and adapt that capable leaders build trust. Leaders know themselves and their organizations and strive to work in line with their talents, attitudes, skills and knowledge. They understand within a given opportunity what their company’s situational capability is as well as the other roles and interests across the system. They are humble enough to understand weaknesses as well and pursue courses of action in alignment with the other three cores competencies. Results are vital; thus, the achievement of results is the final core competency. Companies and individuals who fail to deliver results fall short of establishing partnerships built on trust. Results, when pursued in alignment with the other cores, establish leadership and capability within a given field. However, not all results begin from positive outcomes. Leadership is being able to celebrate positive results as well as being able to reflect on negative or unexpected outcomes. This dimension is important to growth as lessons learned from negative situations can be turned into positive results. True leadership and trust can be built through the humility to learn from the outcome and the integrity of your actions moving forward. Trust is personal, in that it must be earned and extended to another party to be established within the relationship. Trust requires both individuals to signal their interest in mutual engagement and partnership through a level of vulnerability. This vulnerability is often rewarded because, once established, trust leads to increased accountability and a reduced fear of risk. Trust can build and create value through accelerated growth, enhanced innovation, improved collaboration, stronger partnering, better execution and heightened loyalty (Covey, 2006). The lack of trust manifests itself in negative results and consequences (Covey, 2006).

When trust and accountability systems become part of everyday interactions, change and innovation can be catalytic. To build on the concept of infusing trust into systems, individuals should not look at systems of trust as one dimensional. Instead, trust can be seen as fluid and moving throughout the system. For instance, think about all the other interactions throughout the food system – from the shop owner who sells seeds and the farmer who relies on the quality of seeds to ensure a large yield at the end of the season, to the exporter who relies on the consistency of regional policies to ship their products outside their country. All these relationships require a certain level of trust and engagement throughout the system. Trust that the system can consistently deliver a good quality product is derived from the flow of trust through each part of the production and processing chain, with reciprocating trust that the consumer dollar will flow back down the value chain in a fair manner that rewards each participant for their efforts to preserve and enhance the integrity of the value chain.
3.2 Accountability

Accountability is the counterpart of trust. An enterprise may trust its suppliers to grow produce according to specified consumer standards, but ultimately the suppliers and the enterprise are accountable for meeting the standards. “Even though trust is the oil that allows commercial machinery to turn, blind trust is a risky proposition in commercial relationships. A more prudent approach is to ‘trust but verify’” (Microlinks, n.d.b). Accountability is a verification process.

Accountability can take various forms – formal or informal mechanisms such as legal proceedings or third-party verification – or more casual approaches such as online product reviews. Accountability processes can be “top down,” e.g. tort law mandated by the state, or “bottom up,” such as agreements between farmers’ organizations and consumer groups. The maxim “say what you are going to do, then do what you said you would do” is a key part of building trust Covey (2006), but it is really an accountability mechanism based on a stated commitment and the responsible execution of that commitment.

One option for the agribusiness value chain is formal contracting with enforcement by legal mechanisms. Gow Streeter and Swinnen (2000) find that most developing countries lack formal, public, contract-enforcement institutions. When legal enforcement exists, it may be lengthy and expensive (Mkhabela, 2018). Moreover, it is particularly hard to establish efficient contracts in commodities where both quality and quantity are important. For example, Rwanda has experimented with two-part payments including a quality premium in its premium coffee value chain, which corresponds to what economic theory tells us is the incentive-compatible solution to the principal-agent problem (Milgrom and Roberts, 1992). Mkhabela (2018) examined formal contracting in a principal-agent model where both the principal and the agent contribute to the quality of the final product, and where quantity is important, as is the case in coffee. There are two issues. First, when an individual has more than two tasks to perform and performance is not well measurable, using incentives leads to a misallocation of effort (Holmstrom and Milgrom, 1991). Second, when both principal and agent have moral hazard, investment in quality by one leads to a decrease in investment in quality by the other (Mkhabela, 2018). Wessen and Oehmke (2001) documented these tradeoffs in the Cameroon premium coffee value chain: when the government parastatal acted as the principal (owner of rents) farmers did not have incentives to invest in quality, exacerbated by organizational problems within the parastatal. With liberalization, farmers became the principal with processors contracting services to cooperatives, but then processors had an incentive to ignore quality and focus instead on economies of scale. More generally, this phenomenon may explain why differentiated agricultural products rarely have contracts conditioned on retail price (Mkhabela, 2018). The cocoa value chain is an exception: a differentiated product with farm gate prices based on a single, uniform contract traded in London. In contrast, retail-based pricing has been tried in Rwanda’s premium coffee value chain, but with mixed results.

In environments when contracts and contract enforceability are limited options, the question becomes how can the value chain be organized in an effective and fair way? In a review of USAID experience with value chain programming, Dunn argues that a best practice is to facilitate “mutually beneficial relationships that build trust and reward cooperation” (Dunn, 2012). Trust can be strengthened both by building on existing trust and by introducing trusted facilitation especially when creating new relationships (Microlinks, n.d.a). In the absence of formal contracts, self-enforcing arrangements can be effective and trust plays an important role in these self-enforcing arrangements (Gow et al., 2000). Oehmke et al. (2018) introduced trust into a behavioral model of cooperative behavior and mutual accountability, finding that both trust in individuals and systemic trust lead to cooperative behavior with self-enforcing accountability. The question then morphs to what sort of mutual, self-enforcing mechanisms help to organize value chains – or the agricultural sector – in an effective and fair way?
3.3 Mutual accountability

Mutual accountability is the critical trust building and accountability concept in today’s African agricultural and agribusiness. Mutual accountability appeared in the Paris Declaration as a tool to manage aid effectiveness, but at that point it was largely a financial agreement between donors and partner-country governments. Donors agreed to align their off-budget support with country needs and priorities, and countries agreed to improve financial accounting to ensure that their public agricultural expenditures were actually being spent on agriculture. Since Paris, the mutual accountability concept has been maturing and currently recognizes that agricultural and food systems development is a complex process requiring both systemic and thematic change and involves stakeholders well beyond donors and governments, including civil society and the private sector. As articulated in the Malabo Declaration and the associated implementation documents, mutual accountability is now a process that seeks to improve all stakeholders’ commitment, alignment, contribution and accountability to inclusive agricultural growth processes. Stakeholder actions are expected to be taken for both the benefit of the individual stakeholder and for mutual benefit.

As currently implemented in African agriculture and agribusiness at the country level, the mutual accountability process has four essential components:

1. country ownership of an agreed plan for accelerating inclusive agricultural growth and other sectoral goals such as increased trade, job growth and reductions in hunger;
2. voluntary, specific and public commitments by all stakeholders to take actions consistent with stakeholder missions and contributory to the plan;
3. responsible execution of individual commitments and verifiable reporting out on such execution; and
4. joint responsibility to ensure that the set of commitments is sufficient to accelerate inclusive growth and make progress toward other sector goals (Oehmke, 2017).

African agricultural input supply issues provide an illustrative example of the potential of mutual accountability. Africa’s low smallholder productivity illustrates mutual accountability’s power. Low smallholder productivity stems from limited adoption rates of improved inputs among smallholders. Despite a vast literature explaining these limited adoption rates, remedies have been scarce. Governments often adopt input subsidies, which usually work well as long as the subsidy is in place, but eventually budget constraints curtail the subsidies and dis-adoption follows. An alternative approach is to focus on the broader system or socio-economic ecology in which the smallholder operates. Governments, the fertilizer industry, the financial sector, smallholders and other stakeholders may play significant roles in this ecology. The financial industry may limit credit because it does not trust smallholders to repay on time. The fertilizer industry may limit quantities because it does not trust smallholders to have sufficient cash or credit to buy large quantities. The government may regulate heavily because it does not trust the fertilizer industry to price competitively, especially with limited supply. Smallholders may not pay credit back regularly because of limited and late fertilizer delivery, depressing yields, and limiting their ability to earn cash at harvest. No single stakeholder group can solve this problem. The mutual accountability solution is one of coordinated commitments by all stakeholders to an integrated plan, with all stakeholders holding themselves and others accountable for successful execution of their commitments. For example, smallholders commit to repaying loans, agribusiness commits to delivering fertilizer on time, the financial sector commits to improving credit availability and government commits to an enabling policy environment. Stakeholders jointly hold themselves accountable for the portfolio of commitments to be sufficient to generate improved returns for all stakeholders. For instance, smallholders can repay loans because their harvest
improved, they got their fertilizer on time and the financial sector provided credit, the government guaranteed payment in the case of drought, etc. This process can then drive interest in continued increases in the supply and adoption of modern inputs, leading to a virtuous upward spiral (Oehmke, 2017).

The need for inclusive stakeholder engagement is critical to the solution of any complex problem. “A key conclusion of much of the literature about wicked policy problems is that effectively engaging the full range of stakeholders in the search for solutions is crucial” (Australian Public Service Commission, 2007). This engagement is most successful if built on the foundations of shared values, trust and mutual accountability.

3.4 Implementing mutual accountability at a country level

At the country level, there are a few key components of the mutual accountability processes. The first is the national agricultural investment plan. When constructed on the foundation of evidence-based, inclusive dialog, this is the agreed plan for organizing stakeholder contributions to the sector. Unlike previous agriculture sector plans, the current version of the national agricultural investment plan includes priorities for public and private investment, for public policy changes, and other actions necessary to accelerate sector growth.

Under the Comprehensive Africa Agriculture Development Programme guidelines, the national agricultural investment plan is followed by a business plan, which enumerates the strategies employed and the specific actions to be taken to implement these strategies. For the current round of planning, the ensuing business plan is to include commitments to actions by the government, donors, private sector and civil society. In the sense of Ostrom and Basurto (2011), commitments can be made to take actions that directly support the plan and can be made to take actions that are in the best interest of the committing organization but nonetheless help the sector move forward in alignment with the plan, and commitments can be made to operate in ways that avoid negative consequences, such as commitments to the Principles for Responsible Agricultural Investment.

Commitments are most effective when they are voluntary, public and SMART – specific, measureable, achievable, relevant (sometimes results-oriented) and time-bound. SMART commitments help to create complementarities and synergies – for example, a government making credible and SMART commitments to ease import regulations for agricultural inputs creates synergies with agro-inputs suppliers who wish to expand their businesses. Explicit commitment is important because writing down your goals and sharing them increases the likelihood of success by 70 percent (Mathews, n.d.; Locke et al., 1981; Dawson and Guare, 2016). SMART commitments are important because they define success in the context of enterprise and societal goals and because they are measurable; successful execution of the commitment can be confirmed and used to build trust for the next round of commitments.

3.5 Implementing mutual accountability at a micro level

Mutual accountability can also be a grassroots process, that is, created not by government but by enterprises and civic society. For example, Uganda’s AgVerify (www.agverify.net/) is an enterprise established by a consortium of private sector, agro-input service providers, in conjunction with civil society, to provide trustworthy services for farmers (and others) by building a voluntary quality standard and by providing third-party verification that inputs supplied by their members meet this standard. Their motto is “Farming Inputs, Food Products, and Ag Services you can trust.” By providing these services, they intend to “act as a catalyst for growth in the African seed and agribusiness sector.” In essence, this is an industry organization that provides a form of mutual accountability and third-party verification that an individual firm alone cannot provide and that the government of Uganda is unable to provide.
4. Case study: Rwanda coffee

This section continues the discussion of the relationships among shared values, accountability and trust through an illustrative case study of Rwandan premium coffee. Rwanda’s high altitudes, volcanic soils and heirloom bourbon coffee varieties make Rwandan coffee potentially one of the highest quality coffees in the world. The Belgians introduced coffee in the 1930s and required Rwanda smallholders to produce for export. This state-directed industry had few of the trust relationships necessary for successful agribusiness, and the relationships that did exist were more along the lines of colonial directives than interpersonal relationships. The industry was decimated by the 1994 genocide and remained incapacitated until the turn of the twenty-first century. Today, the situation has changed dramatically for the better. Almost 400,000 smallholder households in Rwanda grow coffee, using earnings to purchase food or medicine, pay school fees, or for other purposes. The revival of the industry since 2000 has been a story of progress and retrenchment in which shared values, trust and accountability played critical roles.

The recent history of Rwanda coffee falls neatly into three time periods: 2000–2010, 2011–2015 and 2016+ (Figure 4).

4.1 2000–2010: background

In 2000, Rwanda had emerged from the immediate aftermath of the genocide, but the country and (previously weak) economy had not yet recovered. Paul Kagame was formally sworn in as president, focused on reconciliation and erasing the lines between Hutu and Tutsi. Kagame used coffee as a key lever for reviving the economy and for reconciliation.

Figure 4.
Map of Rwanda

USAID began support for the fully washed-coffee industry in 2001 through the Partnership to Enhance Agriculture in Rwanda through Linkages (PEARL) program, and from 2006 to 2010 through the SPREAD program.

The key to reestablishing the industry was to access the fully washed-coffee market. In 2000, all of Rwanda’s coffee was sold as “C grade” or below, meaning at best the lowest grade of internationally tradable coffee, yet fully washed coffee could be sold at a significant premium on world markets (Moss, Oehmke, and Lyambabaje, 2016). Today’s fully washed-coffee value chain in Rwanda begins with the smallholder farmers, who grow coffee trees and who pick the coffee “cherries” by hand to preserve quality (for more detail, see Bihogo et al., 2011). Coffee grows as a bright, berry-like fruit known as a cherry that is hand-picked by smallholders – usually women – to preserve quality. Coffee ripens in “flushes” over a four- to six-month period and is harvested by hand so that only the ripe cherries are picked. The pit of this cherry is the bean that is roasted and becomes the coffee we drink. To preserve the quality of the bean, the cherry must be brought on the day of harvest to the next link in the value chain, the washing station. The typical washing station provides services for 2,000–5,000 smallholders. At the washing station, the cherry is cleaned and sorted, the cherry pulp is removed from the bean, and the beans are washed and dried. Delays in this process allow the cherry pulp to begin to ferment, introducing unwanted tastes into the bean (Moss, Oehmke and Lyambabaje, 2016). At the washing station, the highest quality beans from one or a few farmers can be handled separately to provide a localized branded product, or aggregated with other beans of similar quality.

The fully washed-coffee value chain begins with the input suppliers. In Rwanda, the European Union provided free seedlings. The National Agricultural Export Development Board (NAEB) and its predecessors were responsible for fertilizer supplies to smallholder coffee growers, but delivery was episodic. The next link in the value chain is the smallholders. Smallholders can choose to sell their cherries as “ordinary” coffee, that is, international C grade or below. Should they choose to sell into the fully washed-coffee value chain (Figure 5), they go through the more labor-intensive harvesting, transport and sorting described above.

The third link in the value chain is the coffee washing station. Because of Rwanda’s rough terrain, limited transport and need for rapid washing of harvested coffee, smallholders typically choose to sell into the fully washed-coffee value chain only if there is a nearby washing station, and then they typically don’t have a choice (for logistics reasons) of which washing station. There are two types of washing stations in Rwanda: those that are cooperatively owned by a group of smallholder coffee farmers, and those that are privately owned either by an integrated international coffee retailer or by a private investor such as a domestic roasting company.

The roaster is the fourth link in the value chain. There are two main types of roasting enterprise in Rwanda. The first is the vertically integrated roaster, which is part of a larger exporting and retailing company and may invest in and own one or more coffee washing stations. Some international retailers fit this profile. In this case, the coffee flows from the roaster through the vertically integrated company to the consumer. The second type of roasting enterprise is a self-contained enterprise, purchasing and roasting specialty, branded coffees usually for wholesale distribution. In either case, the roaster may buy most or all of the coffee from a particular washing station, and because of the quality will still sell it as premium coffee but as the core entry into this premium market segment. Alternatively, the roaster may buy a small, high-quality lot for use in premium brands and high-end retail spaces within the premium market segment. For example, both Green Mountain Roasters and Starbucks offer Reserve coffees, which often include a selection from Rwanda. Finally, a small amount of Rwandan coffee does sell at international auction (not through a roaster) for reserve brands featuring only the rarest and most exotic coffees.
and commanding top dollar – prices in the Rwanda Cup of Excellence auction typically reach $20–$30/lb. ("green" or unroasted) or more for the winning lot.

However, in 2000, none of this fully washed-coffee value chain was in place. The recent development of the fully washed-coffee value chain began with a smallholder cooperative called Abahuzamugambi ba kawa ya Maraba (AKM). Abahuzamugambi is a Kinyarwanda word meaning people who work together toward a common goal (Fraser, 2006). The AKM cooperative was started in 1999 by 220 coffee smallholders who wanted to improve quality. In 2001, PEARL provided support for AKM’s construction of the first, modern, small-scale coffee washing station in Rwanda, which began operation in 2002. Under PEARL, smallholders harvested their coffee and brought it to the washing stations that same day, many on “coffee bikes” that PEARL had designed and distributed specifically to move heavy loads of coffee over Rwanda’s hilly terrain. In 2002, AKM sold 37,500 pounds of coffee under the brand name Maraba to Community Coffee, a Louisiana coffee roaster and retailer (Fraser, 2006).

The Government of Rwanda was strongly enabling of the industry because of the potential of the fully washed-coffee industry in Rwanda both to facilitate rapid increases in smallholder income throughout the country, and as part of the reconciliation process and reconstruction of Rwanda’s social fabric. The shared values were the cultural more of individual responsibility and accountability for the common good: “We won’t achieve unity and progress unless, in the exercise of our freedoms, we are able to think about the interests of others and not just think about ourselves. There comes a point when every one of us has to be responsible and accountable to each other” (Kagame, 2015). Kagame explicitly
followed a strategy of building social cohesion and unity through building successful business relationships and successful businesses:

Sometimes direct and simple conversations make a difference [...] People grasp it very quickly. They start valuing each other. They say, “Oh, I need him for what I don’t have and he needs me for what he doesn’t have.” That’s creating an awareness in society like never before: Yes, we need each other. We are more similar than different. It helps the society to move forward [...] At the end of the day we’re just human beings. You want food and you want it for your family. Plus, you really need dignity, to be able to do something on your own and benefit from it. And there’s nothing that does that better than being able to do business. (Paul Kagame, quoted in Fox, 2013)

In the 2002 National Coffee Strategy, the Government of Rwanda explicitly committed to developing the fully washed-coffee industry.

Coffee played a key role in both income growth and reconciliation. Talking about the early role of coffee, Kagame stated that “Some of the best coffee in the world is produced by Rwanda. We have worked to make this industry more productive and beneficial to citizens, who had previously given up on growing coffee because there wasn’t much coming from it. Now they’re involved in growing coffee and they add value by washing the coffee before exporting it. We are now beginning to roast our coffee as well.” Cooperatives and washing stations were also significant contributors to the country’s reconciliation plan because at washing stations and elsewhere in the fully washed-coffee value chain, “genocide widows work side by side with women whose husbands are in jail for participating in the killing” (Fraser, 2006). The smallholder became engaged because the government encouraged them to think not about problems or differences, but about what they could accomplish by working in unison, and people trusted this vision (Kagame, 2015). Tobias and Boudreaux (2011) found statistically significant correlations between economic outcomes and positive attitudes toward reconciliation, “especially where intergroup contact has increased alongside new incentives for collaboration across group boundaries” (p. 217) including in cooperatives; cooperatives were also found to reduce distrust. Kamola (2008) and Koss (2016) also put forth the contrapositive hypothesis – deterioration of the Rwanda coffee market after the collapse of the International Coffee Agreement in 1989 significantly increased the risk of systemic collapse in Rwanda and contributed to the conditions leading up to the genocide.

The AKM washing station and coffee were a great success on several fronts. First, they were able to access the international premium coffee market with its higher prices (Government of Rwanda, 2006), often earning premiums of 100 percent or more over conventional (partially washed) coffee (Figure 6). Second, they were able to pass on the income from the higher prices to member smallholders. Third, they were able to assure consistent quality and sell some of their coffee at retail under the newly created Maraba brand. Fourth, they were able to increase membership and production rapidly; by 2006, there were over 2,000 members and the cooperative sold about 161,000 lbs of premium quality coffee.

With government attention to coffee, donor support and the success of AKM and other early washing stations, the fully washed-coffee industry in Rwanda grew rapidly throughout the remainder of the decade. Other smallholders sought assistance to organize cooperatives and establish washing stations. Internationally known retailers such as Green Mountain Coffee Roasters, Starbucks, Costco and others began sourcing coffee in Rwanda, and some even started their own washing stations. These and other companies both engaged in corporate shared values, and, in turn, shared these values with their consumers. For example, Green Mountain has made its reputation in part on the basis of “fair trade” coffee. And at the time of writing, the Starbucks Reserve website is offering a Rwandan coffee from the Musasa washing station. The offer states in part, “For these Rwandan coffee farmers, Musasa is a gathering place, a coming together, a symbol of collaboration and trust. Farmers are accountable to each other; the quality of the coffee depends on everyone delivering beans of superb quality. This dynamic brings people together, helping strengthen the community and build a sustainable
Owners and operators of washing stations – either self-standing stations or those fully integrated into an international retailer – built relationships with smallholders near their privately owned washing station, as well as with roasters and exporters. Even within vertically integrated companies, the company became more trusting that the washing station could deliver high-quality coffee consistently, based in large part on continued quality improvement. Smallholders learned what was necessary to produce the best quality coffee and began to trust washing stations to pay them fairly for that level of quality. Donors and government facilitated the development of three laboratories for roasting and cupping coffee to provide quality feedback to washing stations and others. Roasters began to trust smallholders’ ability to produce at the quality levels necessary, as well as understand what the international market would pay for quality Rwandan coffee. Roasters also built relationships with their buyers (or internal departments) based on continued ability to deliver high-quality roasted coffee. Prices paid to smallholders for quality coffee rose and provided significant income increases (Bihogo et al., 2011; Moss et al., 2017; Koss, 2016).

Intent, integrity, capability and results all played critical roles. The clear intent and shared value was to develop an inclusive, smallholder-based value chain. Value chain integrity was based in large part on maintaining the integrity of coffee quality. This process required significant building of the capability and capacity to deliver quality at every level of the value chain from smallholders improving their harvesting practices, to the establishment of the Cup of Excellence international auction linking cooperatives to international buyers of top-quality coffees. The first Cup of Excellence auction for Rwanda took place in 2008; the winning lot from the Buremera Mig cooperative sold for $18.00/lb (Alliance for Coffee Excellence, 2008). Industry-wide events helped to connect participants from different ends of the value chain. For example, the Bourbon Coffee retail outlet in Kigali hosted live viewings of the online Cup of Excellence international auction of Rwandan coffee, attended by cooperative leaders, roasters, government officials, USAID officials and others.

At the end of this period, Rwanda had established itself as one of Africa’s success stories, with significant and inclusive growth in income and poverty reduction. The benefits were distributed throughout the value chain. For example, the improved coffee quality and prices,
passed through to smallholders, helped reduce Rwandan poverty by 14 percentage points over
the 2005–2010 period (Moss et al., 2017). This success was based on a technical agricultural
development strategy that featured reinvigorating the fully washed-coffee industry. But
perhaps more importantly, the industry’s development was a relationship-building process that
started with commercial relationships but extended well beyond into the country’s social fabric.
In other words, this success was based in part by strengthening relationships among
individuals and organizations participating in the value chain, by strengthening trust and
accountability, and the pursuit of shared values.

4.2 2011–2015: changes in Rwanda

From 2010 to 2016, Rwanda witnessed important changes in that reverberated throughout
its fully washed-coffee industry.

International coffee prices peaked at over $6.00/lb in 2011, and, by the end of 2013, it had
fallen to less than half of that level. In 2012, donors reduced or delayed aid in response to
Rwandan support of a rebel group operating in the Democratic Republic of the Congo. At this
point, donor investment in sustaining the fully washed-coffee value chain had essentially
vanished. In 2014, the significant emergence of potato taste defect caused by a combination of
insects, bacteria and possibly mold raised issues about the quality of Rwandan coffee,
especially because the defect is not observable until the coffee is roasted and cupped.

During this period, the Government of Rwanda began to refocus its attention on food
security and self-sufficiency. This decision was based, in part, on a belief that as the private
sector was investing heavily in coffee washing stations, the fully washed-coffee value chain
could sustain its growth rate with a much smaller level of government and donor intervention
(Bihogo et al., 2011). It was also partly a response to the empirical finding that even in localities
with significant poverty reduction, nutritional improvements did not necessarily follow quickly
(Moss, Oehmke, Lyambabaje, and Schmitz, 2016). The Government of Rwanda elevated
attention to its crop intensification program, initiated in 2007, which, in the 2010–2016 period,
began full-scale implementation with emphasis on monocropping maize, beans or Irish potato.

The NAEB was reconstituted in 2011 by consolidating pre-existing government agencies
and had nominal control over coffee pricing and fertilizer distribution to coffee smallholders
but remained weak throughout this period. As a consequence of the emphasis on sustained
value chain growth through private sector investment and continued NAEB weakness, the
social more developed that only the roasters and exporters understood the international
market and so the exporters had to be kept happy or Rwanda would lose its foothold in the
market. This change was a significant departure from the social mores of shared value that
was pervasive in the earlier period. By 2015, NAEB had established a minimum farm price
for coffee of $1.36/kg, based on a consensus of coffee exporters about what price they
needed to protect themselves from both international price fluctuations and declines, and
from potentially lower quality coffee from potato taste defect.

By 2016, farmers’ compensation had deteriorated and coffee production saw a significant
decline. Many cooperative managers had been successful and hired away by non-coffee,
private sector firms, but others had never reached the needed competency level to operate the
cooperative efficiently. Even when farmers were growing high-quality coffee, sometimes it
was poorly processed by the washing station. Nor was all coffee delivered to a washing
station fully washed and graded as specialty coffee, for example, in 2015, only 68 percent and
in 2016 only 71 percent of coffee delivered to a washing station was sold as premium coffee.
This situation led to low prices and diminishing incentives for smallholders to produce
high-quality coffee. Many farmers abandoned their trees and shifted their resources to other
crops. Farmer sales of high-quality, specialty coffee were low, coffee washing station capacity
was underutilized, and some roasters and exporters struggled to find sufficient quantities of
high-quality coffee. In short, the value chain had lost trust and accountability. The fully
washed-coffee industry, which, just a few years earlier, had helped to heal the wounds of the genocide and contributed to massive poverty reduction, was threatened.

4.3 2016-present: present-day Rwanda
Church (2017) Africa Great Lakes Region Coffee Support Program (AGLC) was initiated in October 2015 with two objectives: to reduce antestia bug/potato taste defect and to raise coffee productivity. The approach was to delineate, in conjunction with stakeholders in the fully washed-coffee value chain, the key issues and then discuss proposed solutions in inclusive, evidence-based dialogs. The pricing dialog is especially relevant, as it directly raised the issue of designing pricing and other mechanisms that incentivized production and processing of fully washed-coffee for the specialty coffee market.

The first critical question was whether farmers were receiving a fair payment especially for their high-quality coffee – one that enabled them to earn a positive return from their coffee plantations and in turn ensured that they would produce an adequate supply of coffee for a successful export industry. AGLC conducted detailed research and analysis to address the issues. This process included gathering and analyzing data on farmer’s cost of production, quality premiums, and returns to farmer labor. A primary result quantified farmer costs of production of $1.41/kg, 5 cents above the designated floor price. In contrast, the exporters’ total costs at a purchase price of $1.36/kg totaled about $1.81/kg, leaving 47 percent of the average export price of $3.40/kg or $1.59/kg as profit for exporters, whereas farmers were losing an average of 5 cents on every kg. A second critical issue was that even though some farmers received a small premium for higher quality coffee, the compensation was too little to compensate for the extra work in producing the higher quality and returns to labor declined as coffee quality improved (Church, 2017).

Results and findings were introduced via policy roundtable dialogues among farmers’ cooperatives, coffee washing station owners including both cooperatives and private owners, exporters and NAEB officials. Evidence-based, inclusive dialogues are a critical part of trust building on the basis of common commitments to improving the coffee industry and holding one another accountable for those commitments. The question became one of how to distribute compensation throughout the high-quality, coffee value chain in a way that was “fair” and also met farmer needs for consistent and transparent markets for their coffee and exporter needs for consistent quantity and quality and ensured that both farmers and exporters earned profits. Both top-down and bottom-up approaches were implemented.

In a top-down approach, the NAEB set the minimum farm gate price in 2017 at $1.92/kg, sufficient to cover the farmer’s cost of production with a little profit for the farmer but still leaving exporters with a 30 percent profit margin. In the bottom-up approach, several privately owned firms and cooperatives voluntarily addressed the problem of low farmer incentives by working with their smallholder suppliers to provide them with even better value for quality coffee. Actions included one or more of the following: establishing a farm gate purchase price of $2.39/kg; transparent quality assessment at the washing station; rejecting low-quality coffee; training farmers on quality; and providing overall improved farmer compensation, including second payments based on the exporter’s final sale price (Church, 2017 AGLC Support Program, AGLC Policy Roundtable).

The 2017 Rwanda coffee harvest is complete and initial results are positive. Soon the final results will show how farmers have started to respond to the new (higher) pricing. Because coffee is a perennial crop, the effect should be even bigger next year, assuming the higher floor prices and quality premiums can be maintained. Continued adoption of innovative quality-pricing mechanisms along the entire high-quality coffee value chain could generate a distribution of payments that is both more equitable and more opportunistic in creating a value for both farmers and exporters.
5. Conclusions
Today, the development profession recognizes that agriculturally led development is a complex problem affecting multiple stakeholders through a variety of relationships and connections. Successfully tackling this complex problem requires that the multiple stakeholders work cooperatively. Of particular current interest are processes for greater private sector involvement with actions that further both the goals of the private sector enterprise and society.

A conceptual review of such practices as they apply to the inclusion of African agribusiness in development processes provides evidence of three key components, namely, trust, accountability and corporate shared values. Trust, long understood as a key to business and social dynamics, is a critical piece in building successful institutions, partnerships and relationships among organizations and stakeholders within the African agro-food system. Accountability goes hand-in-hand with trust, specifying exactly what other stakeholders are being trusted to do and holding them societally accountable for executing these actions. Corporate shared values define the set of corporate actions that help both the corporation and society achieve mutual goals. Mutual accountability processes as they are maturing in Africa are at the cutting edge of creating processes where multiple stakeholders, including agribusiness, can come together to make joint commitments to a shared development agenda and where stakeholders hold themselves and others accountable for meeting these commitments.

This paper has also illustrated the power of this multi-stakeholder approach based on trust, accountability and shared values in the context of the development of the Rwanda fully washed-coffee value chain. The development of this value chain on the basis of shared values not only helped tens of thousands of Rwandans emerge from poverty, but it also helped the society heal after the genocide. The ups and down of this value chain development are directly associated with stronger or weaker levels of trust and accountability.

The conclusion from both the conceptual foundation and the case study is that mutual accountability processes are the tool of choice for accelerating multi-stakeholder development efforts including the acceleration of inclusive agricultural growth. The policy implications are donors and governments elevate attention to and invest in strengthening mutual accountability processes, and agribusiness and civil society engage in these processes as they offer new and more productive opportunities for creating shared value.

A clear limitation of this paper is that it has not analyzed alternative approaches apart from formal contracting – i.e. alternative informal approaches that could be successful even where trust is lacking. Whether or not such alternatives exist and/or are as effective as mutual accountability remains a topic for future research.

There are three critical thrusts of future research within the context of mutual accountability. First, further work is needed on delineating and disseminating best practices, from both successful and less successful cases. Second, basic research is needed on the economic foundations of development cooperation based on trust, accountability and shared values. This research will help provide a solid foundation against which to evaluate new and innovative practices that are emerging in African agriculture. Third, empirical validation of the links between mutual accountability processes and societal outcomes will help institutionalize these processes and guide future investment.

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**Further reading**


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Political will and public will for climate-smart agriculture in Senegal

Opportunities for agricultural transformation

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Abstract

Purpose – Agriculture must transform as climate change progresses. The international community has promoted climate-smart agriculture (CSA) as a set of solutions. Previous analyses of opportunities for scaling up CSA have not looked closely at building political and social support for policies, practices and programs. The purpose of this paper is to fill that gap in the case study country of Senegal.

Design/methodology/approach – The study applies the conceptual definitions, operationalizations and assessment targets from the political will and public will (PPW) approach to social change. Semi-structured interviews and documents constitute the sources of data and information.

Findings – The analysis identifies opportunities to generate political will for supplying an enabling environment for the widespread adoption of CSA. On the public will side, the analysis identifies opportunities to generate and channel demand for CSA.

Research limitations/implications – Researchers investigated some definitional components more completely than others due to resource and access constraints. Further, the context specificity of the components limits generalizability of certain findings.

Social implications – Social structures may need to change for successful adoption of certain CSA innovations, but improved agricultural outcomes are likely to result.

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1. Introduction

The need to transform agriculture to adapt to climate change is already urgent for some low-income countries. Senegal, for example, is suffering from rising temperatures, flooding and greater variability in precipitation and seasons (Jalloh et al., 2013; National Agency for Civil Aviation and Meteorology of Senegal et al., 2013; Bonilla-Findj et al., 2016; Feed the Future, 2016). Over one-half of households in Senegal are living in multidimensional poverty, about one-third in “severe” multidimensional poverty, and about one-third on a daily income below the US equivalent of $1.25 per day (UNDP, 2016). Ultimately, many Senegalese are living on the edge of survival and are quite vulnerable to perturbations. At its core, climate change is a set of serious perturbations. For households and populations growing their own food, these perturbations become even more immediately dangerous.

As a consequence, experts assert that countries like Senegal need to take advantage of opportunities to enhance their food security. In recent years, the global community has begun using the term “climate-smart agriculture” (CSA) to label various agricultural policies, practices and programs aimed at dealing with climate variability (FAO, 2013). The current project applies the political will and public will (PPW) approach for evaluating social change (Post et al., 2010; Raile et al., 2014; Raile, Raile and Post, 2018) to the examination of opportunities and obstacles as they relate to CSA. The primary aim of this study is to address the following research question:

RQ1. What opportunities exist for generating PPW for the adoption of CSA practices and policies in Senegal?

Secondary questions examine what would be required to scale up CSA efforts, as well as the potential roles for policy and agribusiness entrepreneurs in doing so. Widespread adoption of CSA would constitute a fundamental transformation in the practice of agriculture in Senegal.

The methods and approach for this study are relatively unconventional for agricultural economics. The primary methods are interviews and the examination of documents, with the goal of assessing information against the definitional components within the PPW approach. The study applies a descriptive analytical framework but also includes case study and action research elements. While more quantitative analysis underlies parts of the larger project, this particular piece focuses on identification of opportunities for transformation. Consequently, this piece emphasizes more comprehensive listings of problem and solution understandings. Without the resources for a mass survey, the goal here is more in line with contextual understanding than generalization of results. The former is a goal that is typical of qualitative research (see Bryman, 2016). However, the overall subject matter is firmly within the domain of economics. For various reasons (e.g. limited information, input supply difficulties, infrastructure problems, risk aversion, tradition, etc.), a widespread market for CSA is unlikely to emerge quickly on its own. Governmental supply of an enabling environment might help considerably. Further, while experts might see benefits clearly outpacing costs for adoption of CSA, the case will need to be made to producers. What are the opportunities for stimulating public demand for such an enabling environment? More conventionally, opportunities may also exist for stimulating demand for the information, goods and services necessary to transform agriculture along CSA lines.

The prospective benefits of this research extend to theory and methods and to global improvement of food security. This study provides an example for applying the PPW approach to CSA.
approach, which can be employed by researchers and practitioners as action research for achieving systemic change (Raile, Raile and Post, 2018). Other authors have used the definitions and certain elements of the PPW approach in subject areas like inter-ethnic violence (Fiedler, 2018) and corruption (Hope, 2017). However, this study represents the most complete application of the PPW definitions and elements to date. Further, though contexts are highly important, the examination of PPW for CSA efforts in Senegal should enhance understanding of problem–solution linkages and agenda crowding more generally.

2. Background
Conceptual definitions of political will (Post et al., 2010) and public will (Raile et al., 2014) are the foundation of the PPW approach. The authors provide operationalizations, assessment targets and ideas about measurement for each of the definitional components. Application of the PPW approach enables identification of specific strengths and insufficiencies in political and public support for social change. However, the approach also recognizes that PPW can vary across geographic areas, issue areas, specific initiatives and groups of people. Further, the PPW approach focuses on participatory communication processes and emphasizes the importance of stakeholders sharing common problem and solution definitions in order to achieve social change.

Attracting significant attention is often crucial for innovations to produce social change (see Post et al., 2008). Scholars have sometimes differentiated between the public agenda on the one hand and the formal governmental agenda on the other (e.g. Cobb et al., 1976; Eyestone, 1978; Kingdon, 2003). The former is the list of issues or conditions to which the general public is paying close attention, while the latter is the list of problems the government intends to address somehow. Importantly, these agendas have limited carrying capacity due to the logistics of governance and limits in mass attention (Carmines and Stimson, 1986; McCombs and Zhu, 1995). The limited carrying capacity of these agendas is a form of scarcity that generates a highly competitive environment for attention.

Scarcity and competition are conditions under which entrepreneurs can profit – whether more traditional business entrepreneurs or “policy entrepreneurs” or “claims makers” (Spector and Kitsuse, 2000; Mintrom and Norman, 2009). Policy entrepreneurs might work with business entrepreneurs or might pursue ideological, public interest or humanitarian goals. One prominent role of policy entrepreneurs is helping to set or build an agenda, which means to establish the agenda items and their ordering (Eyestone, 1978; Baumgartner and Jones, 1993; Kingdon, 2003). Getting an issue to achieve “problem” status (i.e. something must be done) with a spot on the agenda typically involves “problem definition” and linking the problem to a specific solution via a broader “issue frame.” Issue framing simplifies an issue area by constructing a model that excludes certain considerations and emphasizes others, thereby influencing perception of a problem (Entman, 1993; Druckman, 2004; Crow and Lawlor, 2016). Problem understandings can shift dramatically when a skilled issue framer is at work.

A policy entrepreneur trying to get a problem on the agenda usually has an associated solution in mind. The problem–solution linkage is important and should be relatively direct and logical. While problems precede solutions in traditional views of policymaking (e.g. deLeon, 1999), other scholars have allowed for solutions preceding problems (e.g. Zahariadis, 2014). Joining problems and solutions on the agenda requires waiting for necessary “focusing events” to occur or requires more proactive creation of “windows of opportunity” (Kingdon, 2003). Delays can create unfortunate situations in which the public realizes the severity and consequences of problems too late (Downs, 1972). Such a delay could have catastrophic consequences for the people of Senegal based on their vulnerability to the serious perturbations of climate change.

The potential solutions considered in this study are CSA solutions. The three elements of CSA generally recognized by the international community are “(1) sustainably increasing agricultural productivity and incomes; (2) adapting and building resilience to climate
change; and (3) reducing and/or removing greenhouse gas emissions, where appropriate” (FAO, 2013, p. ix). CSA is a systems approach to managing crops, livestock, forests and fisheries, both on the farm and in a broader institutional context; this approach calls for management of landscapes as well as adaptation of technologies, practices and policies to local conditions (FAO, 2013). CSA advocates have differentiated the concept from “conservation” or “sustainable” agriculture by pointing to its broader, more general nature (Shreeg, 2015). The prospective answer for reconciling the goals of greater agricultural productivity and reduced greenhouse gas emissions is agricultural “intensification,” or greater production per unit of inputs. This balance is particularly challenging in places like Sub-Saharan Africa, where input use (like inorganic fertilizers) is relatively low and production must increase dramatically to feed growing populations.

3. Methods

This case study of Senegal and certain regions within the country employed a mix of methods, including semi-structured interviews and the examination of documents. The primary purpose in collecting this data and information was to supply the material necessary for applying the definitional components of PPW. This research also used certain elements of stakeholder analysis (Brugha and Varvasovszky, 2000; Schmeer, 2000), as identification of stakeholders is a core task in the PPW approach (Raile, Raile and Post, 2018). Researchers reviewed documents and worked with in-country experts to identify “priority” stakeholders (Schmeer, 2000), who are also deemed experts in their respective domains. The sampling approach emphasized speaking with a variety of different types of priority stakeholders in diverse areas of the country.

Researchers conducted semi-structured interviews during two separate field research trips in Senegal. The first trip, in late 2015, focused on the capital of Dakar and multiple communities along the Senegal River Valley in the north of the country. Over five days, researchers conducted 21 semi-structured interviews involving approximately 35 speaking participants, with an average interview length under 1 h. Attendees at each interview included two researchers, an interpreter and occasionally a facilitator. The follow-up trip in late 2016 focused again on Dakar but also on the central part of the country, including the regions of Kaolack, Kaffrine, Diourbel and Thiès. Speaking with people in different parts of the country was essential because the climate-driven agricultural problems, the types of crops grown, the growing methods and a number of other factors differ from one area to another. Over five days, researchers conducted 18 semi-structured interviews involving 40 speaking participants. The average interview length was again less than 1 h. Attendees at each interview included four researchers and an interpreter.

Researchers gathered data from the same four stakeholder groups on each trip: national and local government employees (12 interviews); government and other researchers (8 interviews); agricultural producers (8 interviews); and non-governmental organizations (NGOs; 5 interviews). However, the second trip also added a category for CSA project administrators (six interviews). Researchers took field notes during the interviews and typically made audio recordings, which a few research participants refused as they were informed they could do.

The sets of questions in the semi-structured interview protocols differed somewhat across the two field research trips. The Appendix supplies language for most of these questions. In 2015, the relevant questions emphasized interviewee perspectives of major climate-driven agriculture problems, social and economic problems and nutritional problems in the country. The questions also asked about priorities and decision makers at different levels of government. In 2016, the questions again included perspectives of problems and government priorities. However, the questions this time focused more on CSA projects and their linkages to problems as understood. Consequently, the protocol included questions regarding knowledge
of the CSA projects, messaging and information about CSA projects, and perceptions about problems addressed or potentially addressed by CSA projects.

Transcripts of the audio recordings were uploaded into qualitative analysis software (NVivo) for coding purposes. When transcripts were not available, researchers uploaded the typewritten field notes instead. Coding proceeded using a mixture of deductive and inductive approaches (Miles et al., 2014). Questions in the semi-structured interview protocols derived directly from elements in the PPW approach. The coding nodes then tracked from these PPW elements in a deductive manner (e.g. a node for solution understandings). Within each node, however, responses from the interviewees themselves were the basis for the construction of subnodes in an inductive process (e.g. subnodes for improved water use and for organic fertilizers within solution understandings). Researchers collaboratively refined these subnodes in multiple rounds of work by reconciling any differences and by combining subnodes when possible.

4. Political will findings
The analysis begins with political will for CSA in Senegal. The formal definition of political will includes four components:

1. A sufficient set of decision makers
2. With a common understanding of a particular problem on the formal agenda
3. Is committed to supporting
4. A commonly perceived, potentially effective policy solution (Post et al., 2010, p. 659).

The following subsections discuss operationalization and assessment for each of these definitional components.

4.1 Sufficient set of decision makers
The first component of political will is a sufficient set of decision makers, or any combination of decision makers with the ability on their own to approve and implement the necessary policies in an issue area (Post et al., 2010). Assessment involves looking at institutions and factions. Senegal, a presidential republic with elements of federalism, has taken important steps toward democracy since achieving independence from France in 1960. However, the current president’s party, the Alliance for the Republic, dominates the legislature with about 80 percent of the seats. The executive office remains relatively powerful and must be part of any sufficient set of decision makers.

The researchers asked stakeholders about entities or persons important in making public decisions and establishing priorities. Stakeholders agree with the influence of the president and his government (i.e. the cabinet and other important advisors), with several interviewees identifying them as being by far the most influential. Stakeholders also identify a variety of other meaningful actors. Officials at government ministries have a role in making and implementing policy. However, stakeholders sometimes see a disconnect between such centralized decision making and what happens at the district and local levels due to capacity shortages and different needs across localities. Decision-making processes sometimes include domestic NGOs, though some stakeholders express skepticism about the meaningfulness of this participation. Stakeholders also point to local decision makers like chiefs, wise men, imams, mayors and social regulators as being important. The inclusion of religious figures in this list is crucial, as some experts assert that the greatest political power resides in the “leaders of the country’s Islamic Sufi brotherhoods” (Polity IV, 2010, p. 2). Influential decision makers at all levels tend to be men. In summary, the crucial actors appear to be the president’s government and local leaders.
4.2 Common understanding of a particular problem on the formal agenda

The second component of political will is a common understanding of a particular problem on the formal agenda. Operationalization for this component involves looking at whether the frame and terminology for a problem show convergence across decision makers and whether a particular problem is on the formal agenda (Post et al., 2010). Information availability limits the scope to the national government level. The sources of evidence are formal documents that outline government views of problems and priorities as well as stakeholder perspectives about government priorities. Information about government priorities is not a perfect proxy for government problem understandings, but such information should reasonably reflect government views of problems and their placement on the formal agenda.

The Senegalese government has laid out its general priorities in the Emerging Senegal Plan (PSE) and associated documents. As shown in Table I, the PSE’s Priority Actions Plan (PAP) establishes and weights general governmental priorities, many of which relate directly to agriculture due to its importance to the economy. Agriculture represents the second highest area for expenditures through public–private partnerships in the PAP, right

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<th>Source</th>
<th>Priorities/Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Improving living conditions (30% weight)</td>
</tr>
<tr>
<td></td>
<td>Acceleration of economic growth or productivity (20%)</td>
</tr>
<tr>
<td></td>
<td>Impact on local development (12%)</td>
</tr>
<tr>
<td></td>
<td>Reducing inequality (10%)</td>
</tr>
<tr>
<td></td>
<td>Job creation (8%)</td>
</tr>
<tr>
<td></td>
<td>Sectorial good governance (8%)</td>
</tr>
<tr>
<td></td>
<td>Improving the business environment (7%)</td>
</tr>
<tr>
<td></td>
<td>Improving the management of public finances (5%)</td>
</tr>
<tr>
<td>Agricultural sector</td>
<td>Construction of 3–4 grain corridors</td>
</tr>
<tr>
<td></td>
<td>Aggregation projects for high-value agriculture and livestock</td>
</tr>
<tr>
<td>Accelerated Program for Agriculture in Senegal (PRACAS) (Ministry of Agriculture and Rural Equipment, 2014)</td>
<td>Factors limiting agricultural development</td>
</tr>
<tr>
<td></td>
<td>Low use of inputs</td>
</tr>
<tr>
<td></td>
<td>Agricultural equipment is worn down, insufficient, and not well distributed</td>
</tr>
<tr>
<td></td>
<td>Deficits of economic infrastructure</td>
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<tr>
<td></td>
<td>Unsuitable financing system</td>
</tr>
<tr>
<td></td>
<td>Marketing of products is disorganized and insufficiently regulated</td>
</tr>
<tr>
<td></td>
<td>Low level of human capital development</td>
</tr>
<tr>
<td>Priority sectors</td>
<td>Construction of 3–4 grain corridors</td>
</tr>
<tr>
<td></td>
<td>Aggregation projects for high-value agriculture and livestock</td>
</tr>
<tr>
<td>Senegal’s Intended Nationally Defined Contributions for the United Nations Framework Convention on Climate Change (Ministry of Environment and Sustainable Development, 2015)</td>
<td>Climate change impacts and system vulnerabilities</td>
</tr>
<tr>
<td></td>
<td>Decreased hydrologic reserves</td>
</tr>
<tr>
<td></td>
<td>Decreased biodiversity and ecosystem functioning</td>
</tr>
<tr>
<td></td>
<td>Soil degradation</td>
</tr>
<tr>
<td></td>
<td>Erosion and salinization (due to rising oceans)</td>
</tr>
<tr>
<td></td>
<td>Reduction in tourism (largely due to coastal erosion)</td>
</tr>
<tr>
<td></td>
<td>Decreased fishing stocks</td>
</tr>
<tr>
<td></td>
<td>Decreased fishing stocks</td>
</tr>
<tr>
<td></td>
<td>Flood effects on habitat and health</td>
</tr>
<tr>
<td>Stakeholder interviews (September, 2015; November, 2016)</td>
<td>National government’s top general priorities: agriculture, infrastructure, health, education</td>
</tr>
<tr>
<td></td>
<td>National government’s agricultural priorities: rice and other food self-sufficiency, water, fertilizer and seed</td>
</tr>
</tbody>
</table>

Table I. Government of Senegal: problems and priorities
behind infrastructure and transport services. The Accelerated Program for Agriculture in Senegal (PRACAS) reveals government views about problems and priorities more specifically in the agricultural sector. The factors discussed as limiting agricultural development in this document (e.g. insufficient agricultural equipment and inappropriate financing system) are often not ones that CSA can solve directly. Also worth noting here is that rice self-sufficiency (i.e. growing all domestically consumed rice in the country) often occupies a prominent spot in formal documents. Political actors in Senegal are acutely aware of the threat of not having a sufficient supply of affordable rice for the country’s residents (see Seck et al., 2010). The real problem leading to the high-priority status of rice self-sufficiency is that a shortfall of affordable rice for consumption could destabilize the government. Being subject to the swings of international food markets is a related problem.

Table I also provides information about government views of problems related to climate change. Senegal has been active in defining its intended nationally defined contributions for the United Nations Framework Convention on Climate Change (UNFCC). Institutional support for climate change initiatives comes from Senegal’s National Climate Change Committee and from the National Science-Policy Dialogue Platform for the Adaptation of Agriculture and Food Security to Climate Change (see Feed the Future, 2016). Though not shown in Table I, PRACAS and the PAP for PSE talk about various risks related to climate change and measures to deal with them.

The researchers also asked stakeholders about their perceptions of the national government’s priorities. In terms of comment frequency, stakeholders see agriculture as sharing high-priority status with infrastructure, health and education. Stakeholders often observe that agriculture (including food security) appears to be the first priority and that certain other areas (like infrastructure) are necessary for agricultural success. Other stakeholders see the primary positioning of agriculture as mostly rhetorical and believe that agriculture does not feel like the first priority at the local level. Some stakeholders believe that much of the government’s expenditure on agriculture goes toward administration and subsidies. Further, some question the accuracy of decision makers’ knowledge about technical problems due to a lack of effective communication with technicians, scientists and other researchers. In sum, though agriculture appears to hold a prominent spot, it is subject to considerable agenda competition from other sectors. As stated by one interviewee, “The reality is that everything is the top priority in Africa.”

Among agricultural priorities, stakeholders believe that rice self-sufficiency is at the top for the government, claiming that strong consumer preferences make rice a good strategic crop. Stakeholders also point out that agricultural problem understandings and priorities sometimes differ between the national and local levels. According to these stakeholders, such differences arise when intermediaries legitimately defend their own interests or when government does not consult with farmers about problems. An example of such failure is families selling or eating certified seeds subsidized and distributed by the government. Stakeholders disagree about the level of government concern over climate change in the agricultural arena.

4.3 A commonly perceived, potentially effective solution
A third definitional component of political will is a commonly perceived, potentially effective solution. Operationalization begins with examining whether the frame and terminology for the solution show convergence across decision makers (Post et al., 2010). Evidence takes the form of government policies and programs and stakeholder perspectives. Given this project’s focus on CSA, the emphasis here is on government views of CSA as a solution. This component appears out of order in relation to the previous list due to the need to understand the identities of solutions before evaluating commitment to them.

Competition among agricultural programs is considerable. Stakeholders note that over 200 food security projects are currently active in Senegal, many of them driven by donors and
other external entities. Based on stakeholder observations, the government agricultural programs with the greatest visibility are in the areas of irrigation, quality and storage of fertilizer, access to machinery, access to certified seeds, processing facilities for crops and giving women opportunities and resources in agriculture. Overall, stakeholders disagree about how much the national government is promoting CSA solutions. However, government representatives see a marked increase in CSA components in recent projects. Among the more prominent projects discussed, Senegal participates in the West Africa Agricultural Productivity Program, which has a subprogram on CSA technical adoption. Additionally, the Ministry of Agriculture and Rural Equipment is working with the Senegalese Agricultural Research Institute (ISRA) on producing seed varieties better adapted to climate change and has a national program on climate change. In conjunction with external entities, the National Civil Aviation and Meteorological Authority (ANACIM) has been working on a project that uses radios to get weather information to producers (Ndiaye et al., 2013; CCAFS, 2015). As discussed later, national government entities have worked closely with the climate-smart village (CSV) at Daga-Birame near Kaffrine. Finally, the government has developed adaptation options for agriculture in its intended nationally defined contributions document for the UNFCC (Ministry of Environment and Sustainable Development, 2015, p. 15).

Given the importance of rice self-sufficiency, the natural question concerns its fit with CSA. Some stakeholders see the use of irrigation to grow rice as a reasonable adaptation to climate change. This is particularly true as the world moves into an era of greater climate uncertainty and as rice growing conditions improve in the Senegal River Valley due to shorter winters. Domestic production of rice could serve as a buffer against international market perturbations that are likely to result from climate change. However, other stakeholders emphasize opportunity costs and negative impacts. Such stakeholders mention deforestation (thereby eliminating income- and food-producing trees), loss of biodiversity, potential water overuse and the heavy demands on soil as concerns. Additionally, some believe irrigated rice systems produce too many greenhouse gases via fuel for irrigation pumps and heavy use of inorganic fertilizers. Some stakeholders also see sustainability problems with the plan and worry about increased climate vulnerability as a consequence of lesser diversification in crops. In short, many of the downsides of rice self-sufficiency may work to worsen climate-related agricultural problems and vulnerabilities.

Operationalization of a “potentially effective” solution involves looking at capacity and resources for making the solution work (Post et al., 2010). On the one hand, the government provides some level of support for institutions like ISRA and ANACIM that are working on CSA initiatives. On the other hand, stakeholders identify coordination and funding problems and difficulties with scaling up successful programs. The national government lacks the capacity to manage, coordinate and communicate about all these projects, particularly given the involvement of so many external actors. Many of these projects have short time horizons, and stakeholders observe that continuing or scaling up successful projects is a challenge once external funding is gone. The national government is working to overcome these administrative difficulties by holding coordination meetings, attempting to reduce project overlap and developing innovation platforms.

4.4 Commitment to support
The final definitional component of political will is the level of commitment by the relevant political actors to support the identified solution(s). Operationalization here emphasizes the credibility and level of obligation produced by statements about particular solutions, as well as the incentives and disincentives for the political actors (Post et al., 2010). Overall, Senegal in recent years has met its obligation under 2003s Maputo Declaration on Agriculture and Food Security to devote over 10 percent its national budget to agriculture (Ministry of Agriculture, 2013), which provides general evidence of commitment. More specifically, the
public claims about rice self-sufficiency are highly visible and come from the most prominent officials in the national government. Rice self-sufficiency has long had the backing of an influential figure – Papa Abdoulaye Seck (Mohapatra, 2014). The former head of the Africa Rice Center, Seck, is now the Minister of Agriculture and Rural Equipment. As for the public claims being binding, the latest plan for rice self-sufficiency is built on top of a series of failed attempts, including 2008s Grand Offensive for Agriculture. Conversely, programs more explicitly about CSA have not received as much publicity from the national government to this point. In terms of incentives, strong consumer preferences for affordable rice and widespread agreement about the wisdom of the plan for rice self-sufficiency put pressure on policymakers to follow through with the plan. Pressure for CSA programs is not so cohesive. In short, then, the commitment to rice self-sufficiency is a clear and meaningful one, while commitments to CSA programs are presently weaker and more ambiguous.

5. Public will findings
The analysis continues with public will for CSA in Senegal. The formal definition for public will includes five components that run roughly parallel to those for political will:

1. Social system
2. Shared recognition of a particular problem
3. Resolve to address the situation
4. In a particular way
5. Through sustained collective action (Raile et al., 2014, p. 111).

The following subsections discuss operationalization and assessment for each of the definitional components.

5.1 Social system
The first component of public will is the existence of a social system, or “a set of interrelated units that are engaged in joint problem solving to accomplish a common goal” (Rogers, 2003, p. 23). Operationalization of this component involves looking for “interconnected people, groups, organizations, or subsystems” (Raile et al., 2014, p. 112). Building large social systems in a developing country is often challenging due to obstacles for flows of information, money or anything else linking members. In Africa, local language differences can also constitute a barrier. Though broad social systems might be ideal for adopting CSA innovations in a widespread manner that would constitute agricultural transformation, presently the social systems operating in this issue area in Senegal tend to be local or externally driven or a combination of the two.

Assessment of this component typically involves looking at association of people through information or other flows and examining social identities and cleavages (Raile et al., 2014). The country is multiethnic and multilingual, with Wolof, Pular and Serer ethnic groups making up significant portions of the population. The country is almost entirely Muslim. Village-level organization is common, with leadership assuming various forms: chiefs, mayors, religious authorities, etc. When examining developing countries, the analyst must also consider the participation of outside entities like multilateral organizations, international non-governmental organizations and donor countries. Based on the interviews, stakeholders generally see little direct influence of external entities on priorities and decision making at the national level in Senegal. However, stakeholders do see strong roles for external entities in implementing programs locally. Such implementation work represents an opportunity to influence priorities and decisions by becoming part of locally based social systems.

Despite the difficulties of building broader social systems, community radio constitutes a success story in Senegal. In total, 7m Senegalese people in rural areas can access climate
information provided in local languages (Sanogo et al., 2016). The researchers interviewed personnel from multiple radio stations, some of which grew out of local development projects. The radio stations serve as platforms for experts, local technicians and practitioners to communicate about effective agricultural practices and to share scientific, marketing and other forms of information. Additionally, the information provided by the earlier-mentioned ANACIM radio project includes forecasts and rainy season predictions – information also shared via text messages to mobile phones. In short, community radio stations are very much creating social systems given the way they are linking populations through information flows, though some stakeholders have concerns about politicization of community radio.

5.2 Shared recognition of a particular problem
The second component of public will is shared recognition of a particular problem. Operationalization starts with “a common belief something should be done about the situation” and the use of a “similar frame and terminology” for the problem (Raile et al., 2014, p. 112). Assessment can proceed by looking at “attitudes and beliefs about problem status,” the “nature and volume of expressions of concern” and converging “beliefs about the situation and its causes” (Raile et al., 2014, p. 112). As this component is the in-depth focus of a recently published companion paper (Raile, Young, Bonabana-Wabbi, Kirinya, Mbaye, Wooldridge, Raile and Post, 2018), the current paper spends less time on it.

Based on the first-round interview data, inadequate rainfall and variability in precipitation and seasons are the climate-driven agricultural problems most “ripe” to be addressed based on frequency and breadth of mentions among stakeholders who could form potential publics (Raile, Young, Bonabana-Wabbi, Kirinya, Mbaye, Wooldridge, Raile and Post, 2018). However, these problems compete with a number of other climate-driven agricultural problems like seawater intrusion, deforestation and loss of biodiversity (Raile, Young, Bonabana-Wabbi, Kirinya, Mbaye, Wooldridge, Raile and Post, 2018). All these problems also compete for public agenda space with socioeconomic and infrastructure problems like urban migration, insufficient irrigation, lack of mechanization, access to water and persistence of traditional agricultural methods (Raile, Young, Bonabana-Wabbi, Kirinya, Mbaye, Wooldridge, Raile and Post, 2018). The researchers asked the same types of questions during the second round of field research, and perceptions of the foremost climate-driven agricultural problems again center on inconsistent and insufficient water supply for crops. According to the second-round stakeholders, competing socioeconomic and infrastructure problems include the spotty availability of high-quality seed and fertilizer, unemployment, poverty and disadvantages for women in agriculture.

Table II supplies a comprehensive list of the problems mentioned by stakeholders, as divided into the following four categories: agricultural practice, socioeconomic and infrastructure, communication and administration and nutrition. These four categories emerged through a team-based, iterative coding process. The table demonstrates the degree of competition for attention on public agendas. The other noteworthy aspect of the table is that CSA could feasibly address many of the problems listed if linked effectively to the types of solutions discussed in Section 5.4 (e.g. using drought- or flood-resistant seeds to deal with precipitation variability). Again, a comprehensive listing seems more appropriate here to the goal of identifying opportunities.

5.3 Resolve to address the situation
The third component of public will is resolve to address the situation. “Perceived collective efficacy” (i.e. what groups believe they can achieve) and “willingness to commit significant resources” are means of operationalizing this component (Raile et al., 2014, p. 112). Assessment of the latter can involve evaluation of “credible commitments to expend resources” and “stakeholder incentives and motivations” (Raile et al., 2014, p. 112). According to stakeholders, the problem of sustaining programs or projects after donor funding or technical assistance has disappeared can detract from collective efficacy for
social systems. Conversely, the success of community radio and of some local demonstration projects has clearly empowered some social systems. In terms of credible commitments, the researchers observe willingness on the part of families and villages to make sacrifices to enable program success. They are willing to contribute labor and to make investments and changes to working structures. Individuals and families risk a lot by reorganizing work structures and practices. The incentives and motivations for families or villages can be complex, but the consequences of inaction here potentially include starvation. Though resistance to change and risk aversion can be common among agricultural families, the need for food security and for a basic income are strong motivators.

### Table II.

<table>
<thead>
<tr>
<th>Stakeholder problem understandings related to agriculture (comprehensive alphabetical listing)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Agricultural practice</strong></td>
</tr>
<tr>
<td>Biodiversity loss</td>
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<tr>
<td>Crops</td>
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<tr>
<td>Low quality</td>
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<tr>
<td>Low yields/productivity</td>
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<tr>
<td>Deforestation</td>
</tr>
<tr>
<td>Ecological fragility</td>
</tr>
<tr>
<td>Inputs (seeds, fertilizer)</td>
</tr>
<tr>
<td>Adulteration</td>
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<tr>
<td>Limited availability</td>
</tr>
<tr>
<td>Livestock</td>
</tr>
<tr>
<td>Diseases</td>
</tr>
<tr>
<td>Flooding deaths</td>
</tr>
<tr>
<td>Insufficient food/grazing land</td>
</tr>
<tr>
<td>Pests increasing (species, numbers)</td>
</tr>
<tr>
<td>Soil erosion</td>
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<tr>
<td>Soil quality low/degrading</td>
</tr>
<tr>
<td>Temperatures increasing</td>
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<tr>
<td>Use of traditional agricultural methods</td>
</tr>
<tr>
<td>Water</td>
</tr>
<tr>
<td>Increased evaporation</td>
</tr>
<tr>
<td>Increased variability in rainfall</td>
</tr>
<tr>
<td>Insufficient rainfall</td>
</tr>
<tr>
<td>Salinization as sea levels rise</td>
</tr>
<tr>
<td><strong>Communication and administration</strong></td>
</tr>
<tr>
<td>Coordination across projects/programs</td>
</tr>
<tr>
<td>Excess government overhead costs</td>
</tr>
<tr>
<td>Farmer participation in projects</td>
</tr>
<tr>
<td>Lack of buy-in and ownership</td>
</tr>
<tr>
<td>Flawed government statistics</td>
</tr>
<tr>
<td>Government subsidization of export crops</td>
</tr>
<tr>
<td>Inability to communicate problems upward</td>
</tr>
<tr>
<td>Inability to communicate solutions upward</td>
</tr>
<tr>
<td>Inappropriate use of government funds</td>
</tr>
<tr>
<td>Inter-institutional cooperation difficulties</td>
</tr>
<tr>
<td>Lack of farmer organizations</td>
</tr>
<tr>
<td>Low funding for research</td>
</tr>
<tr>
<td>Marketing information shortfalls</td>
</tr>
<tr>
<td>NGOs’ focus on own employees</td>
</tr>
<tr>
<td>Subsidized inputs (seeds, fertilizer)</td>
</tr>
<tr>
<td>Insufficient quantities distributed</td>
</tr>
<tr>
<td>Low quality</td>
</tr>
<tr>
<td>Resold or eaten</td>
</tr>
<tr>
<td>Translation of science/research</td>
</tr>
<tr>
<td>Transmission of knowledge</td>
</tr>
</tbody>
</table>
5.4 In a particular way

The fourth component of public will is a commonly perceived solution to the problem. Operationalization and assessment here emphasize convergence on a solution frame and associated language among members of the social system (Raile et al., 2014, p. 112). Much of the interviewing for the second round focused on perceptions of CSA solutions. Some stakeholders (typically producers) have only heard of CSA, others have knowledge but say CSA is in its early stages, and some (like certain researchers or CSA project administrators) know a great deal. Given their lack of exposure, some stakeholders do not really address CSA as a solution. However, other stakeholders, including producers and other targets of CSA projects, are able to talk about innovations they see most closely linked to CSA principles. Food security projects that emphasize agroforestry and tree growth, improved water use, organic fertilizers and climate-adapted seed varieties emerge most prominently in the interview data (again by frequency and breadth). Table III summarizes the types of projects that fall into these categories.

A crucial question is the extent to which such CSA solutions fit with stakeholder views of important problems. Given the breadth of the CSA concept, the types of projects listed in Table III have logical linkages to a range of problems in Table II. For example, CSA projects that involve planting or preserving trees map well to certain climate-driven agricultural problems mentioned prominently by stakeholders (e.g. inadequate rainfall, deforestation and loss of biodiversity). The types of projects in Table III also help with other important agricultural problems mentioned by stakeholders like the low quality of soils. However, CSA cannot address certain infrastructure problems like the unavailability of reliable and high-quality seeds and machinery. Items in Table III also map to some of the infrastructure and socioeconomic problems mentioned by stakeholders, though the linkages are more indirect. For example, CSA often requires additional labor to enhance productivity. This need for additional labor potentially helps with urban migration, unemployment rates and some agricultural disadvantages for women. Also, more efficient water use can decrease problems of access to water, and sharing the fruits of increased productivity can reduce poverty. In summary, CSA projects potentially fit as solutions to many kinds of problems as understood by the various types of stakeholders consulted for this study.

Another important consideration is that feasible and optimal solutions depend on local needs. For example, the Senegal River in the north is a good source of water for irrigation, while the Saloum River in central Senegal cannot be used for irrigation due to its high salinity. Other areas of the country are too distant from rivers and irrigation canals, so irrigation in these places depends on borehole wells. In other places, even drip irrigation is not feasible, so producers must rely on alternative solutions for water retention like no-till farming, agroforestry and retention basins. Such contingencies also extend to individuals within a community, as experiences with the effects of climate change can differ based on social position (Kristjanson et al., 2015).

<table>
<thead>
<tr>
<th>Agroforestry and tree growth</th>
<th>Improved water use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated crop systems with trees</td>
<td>Drip and other forms of irrigation</td>
</tr>
<tr>
<td>Restrictions on cutting down trees</td>
<td>Water towers for storage</td>
</tr>
<tr>
<td>Shrubs for water retention and fixing of organic materials</td>
<td>Linking seeding and fertilizer application to weather forecasts</td>
</tr>
<tr>
<td>Big Green Wall to prevent desertification</td>
<td>Planting vegetables with low water needs</td>
</tr>
<tr>
<td>Fuel-efficient stoves (to save trees)</td>
<td>Water retention basins</td>
</tr>
<tr>
<td>Pruning of trees</td>
<td>Climate-adapted seed varieties</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Organic fertilizers</th>
<th>Drought-resistant seeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural organic composts</td>
<td>Flood-resistant seeds</td>
</tr>
<tr>
<td>Cheap organic fertilizers</td>
<td></td>
</tr>
<tr>
<td>Elimination of slash-and-burn agriculture</td>
<td></td>
</tr>
<tr>
<td>No-till agriculture</td>
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</table>

Table III. Stakeholder views of CSA project elements
5.5 Through sustained collective action

The final component of public will is an intention to sustain collective action to implement change. Operationalization for this component involves looking at “commitment to collective action” and “intention to sustain collective action” (Raile et al., 2014, p. 112). Targets for assessment are “evidence of group formalization and identification,” “stability over time of beliefs and attitudes” and “level of publicity of commitments” (Raile et al., 2014, p. 112). At the local level, social systems are often pre-existing, though external actors may become part of these local social systems. Assessing the stability of beliefs and attitudes related to CSA solutions would require more time, especially given the relative newness of CSA. However, project participants have clear incentives (e.g. food security) to remain engaged. Producers place a lot of weight on successful demonstration projects for CSA practices and techniques that require little capital to implement. This support seems likely to persist, though reversion to old ways is possible. The level of publicity of commitments looks different in the developing world given the limited forums for proclaiming views. However, the willingness of villagers to spread news of CSA innovations to neighboring villages, a phenomenon witnessed on multiple occasions, does serve as an important public statement of sorts.

Sustained collective action may be unnecessary if adoption of CSA practices happens in piecemeal fashion. A farmer only needs to learn about a smaller innovation somehow – whether from watching a neighbor or from listening to community radio or an agricultural extension agent. Sustained use of such an innovation also requires the producer seeing profit in the activity. This model of change would not require public will but is worth mentioning here.

6. The Daga-Birame climate-smart village

This section provides a brief discussion of the Daga-Birame CSV in Senegal as a concrete application for some of the findings and ideas in the previous sections. The researchers spoke with Daga-Birame villagers, associated researchers from ISRA, and other stakeholders concerned with the project. The CSV is an example of a project that meets local needs in a holistic manner, involving both new agricultural practices and a commitment to social change (see Sanogo et al., 2016). The robust involvement of the national government via entities like ISRA and ANACIM indicates a considerable level of political will for this specific CSA project. The willingness of the chief of Daga-Birame to donate his own land to enable success of the CSV is a clear manifestation of political will at the local level.

In terms of building a social system, the project has demonstrated a substantial commitment to participatory research in that villagers have had strong input from the start and testing of techniques has proceeded in inclusive ways. The broader social system appears to be strong, with villagers praising the involvement of ISRA in particular. As a result of training efforts, the villagers have significantly altered their production practices, and have adopted new crops. They have a good working knowledge of climate-driven agricultural problems and of the ways in which the CSV is addressing these problems (i.e. problem–solution linkages). The project’s components include creation of a village development plan, use of local knowledge and institutions, use of a variety of climate-smart technologies and use of climate information services (Sanogo et al., 2016). In terms of resolve and sustainability, the villagers identify rather strongly with the project and frequently mention the importance of the shared, collective work. The substantial changes made to work structures suggest a new equilibrium that is unlikely to change easily.

While the CSV clearly has much working in its favor in terms of PPW, what is required to scale up this approach in Senegal and beyond? While others have usefully considered the issue of scaling up the CSV (Sanogo et al., 2016), they have not done so through the PPW lens. Clearly, political support would need to remain and likely grow given an increased workload for organizations like ISRA and ANACIM. Policy entrepreneurs would need to ensure that key political leaders understand the problem–solution linkages and their own incentives.
Further injection of external resources would also be necessary. International actors like the CGIAR Research Program on Climate Change, Agriculture and Food Security; the World Agroforestry Centre; and the International Crops Research Institute for the Semi-Arid Tropics have worked with the Daga-Birame CSV. The project is seeking an additional $10m to expand the project to 100 more villages in Senegal (Sanogo et al., 2016). Supporting this type of program would fit with recommendations to scale up local demonstration programs that have proven effective (e.g. see Easterly, 2006; Karlan and Appel, 2012) and with a recent major evaluation of the US government’s Feed the Future initiative (USAID, 2016). If properly incentivized, the private agribusiness sector (e.g. information providers, equipment suppliers and financiers) could drive some of the expansion and could pick up when donor funding diminishes.

In terms of other PPW elements, a participatory, bottom-up approach adds to social system development and the consequent likelihood of success. Effective training and dissemination of information are also crucial for building public will. These activities can inform and persuade producers about problem–solution linkages in the climate-agriculture issue area, which also helps build supportive social systems. However, scaling up informational and training activities will require resources. Truly diffusing CSA will also require commitment on the part of local producers. Economic benefits might be enough on their own for change to persist, but transformative change like that undertaken by the CSV requires a significant commitment from farm households.

7. Conclusion and implications

This final section of the paper considers opportunities for agricultural transformation via CSA in Senegal, beginning with a summary of the findings and discussion of the relationship between political will and public will. The section then discusses opportunities for policy and agribusiness entrepreneurs. The paper ends with consideration of potential research extensions and of the usefulness of the PPW approach.

7.1 Summary

In terms of political will for CSA in Senegal, agriculture is an important priority for the national government. Agriculture competes with economics/finance, infrastructure, health and education for space on the formal agenda but also has strong linkages to such areas. Senegal has participated actively in international efforts and has supported domestic institutions and programs working on climate-related agriculture problems. Consequently, the government has created something of an enabling environment for addressing these types of problems. However, rice self-sufficiency (which in some ways does not fit well with CSA) appears to be the single most important agricultural priority, and some agricultural problems listed in prominent government documents are not directly solvable with CSA. Additionally, some stakeholders remain skeptical of the real importance to the national government of agriculture (apart from a few select commodities) and of dealing with climate change. Government work with CSA programs has increased, but stakeholders worry about tradeoffs and the capacity of government to do it all.

Looking next at public will, social systems supportive of CSA can emerge despite logistical obstacles. Stakeholders identify a variety of climate-driven agricultural problems and often hold views of CSA projects consistent with solving those problems. Given the stakes, commitments to these solutions can be strong and ongoing even when they carry significant costs. However, collective efficacy is sometimes lacking due to resource and administrative shortfalls. Additionally, local needs will determine whether solving these problems is as important as a priority like rice self-sufficiency.

CSA provides a good example of political will and public will complementing one another, with each contributing different necessary elements. Some of the necessary support emerges from national policies and programs, while other support emerges from...
local publics. The national government supplies important goods (e.g. technical advice, support for community radio, channeling of funding from donors and inputs like seeds) that fit with CSA objectives. In a complementary manner, communities can demonstrate public will through flexible implementation and willingness to take risks and adopt innovations. Many local stakeholders have problems that may motivate them to do so. External actors can provide technical assistance and funding as demonstrations of their support.

7.2 Opportunities for entrepreneurs
Opportunities exist for policy entrepreneurs and agribusiness entrepreneurs in this issue area. Despite heavy competition, CSA approaches and the types of problems they can address make strong claims for agenda status. Policy entrepreneurs have opportunities to join prominent problems and CSA solutions and to generate corresponding political support for such initiatives, especially if they focus on problems like drought and variable precipitation. Based on the interview data, policy entrepreneurs should also promote understanding of the linkages between environmental problems and poverty. Additionally, policy entrepreneurs are likely to find greater success if they use effective messengers already in place, such as community radio and ISRA. Producers may receive information from a variety of sources, and figuring out which ones they trust most is important.

Policy entrepreneurs should also be aware of obstacles like agenda competition and coordinating across projects. Further, policy entrepreneurs must be aware of the dangers of dilution and the fact that CSA is not a viable solution for all the problems on the public and political agendas. CSA is many different things – a variety of strategies, policies and techniques (Steenwerth et al., 2014) – and some are bound to work better than others for a particular locality. As a result, participatory methods and techniques (Odugbemi and Jacobson, 2008; Hacker, 2013) that involve local populations from the start are more likely to be effective. This means empowering local populations and having them participate in the demonstration of solutions. Despite the initial upfront costs, the overall cost effectiveness of such participatory programs may be better in the long run – if supported by appropriate technical assistance.

Agribusiness entrepreneurs, on the other hand, can look toward supplying the goods, services and information that producers need to solve their problems. Table II, with its stakeholder-generated list of problem understandings, should provide useful information in this respect. Table III provides more direct ideas about the types of goods and services that agribusiness entrepreneurs might supply. More traditional opportunities exist in providing goods like irrigation equipment, solar panels for water pumps, trees and shrubs, climate-adapted seeds and organic fertilizers. The provision of financing for the adoption of new CSA technologies represents another opportunity. Less orthodox opportunities are also evident. Much of CSA amounts to learning new practices. Though agribusiness entrepreneurs would need to earn the trust of producers, the dissemination of information about CSA practices across the entire country will be a tremendous job. On-site training and demonstration plots will be necessary, though community radio can also disseminate information. Donors will want to invest in solutions that the private sector can provide as CSA efforts scale up, which means that donor funding could be available now for solid problem/solution pairings.

7.3 Research extensions and usefulness
This study is subject to certain limitations but provides opportunities for future work. First, resource and access restraints prevented researchers from investigating some components as completely as others. For example, assessing the stability of beliefs and attitudes over time would require more of a longitudinal study. A more systematic review of promotional materials for CSA programs could yield extra insights, as well. Calculations that compare the cost effectiveness of bottom-up and holistic programs against other types of programs seem potentially useful, as well. Second, the analysis has generated additional questions for
the researchers. For example, how does political will interact across different levels (e.g.
international, national, regional and local)? Also, what does it mean to have political will
when some influential actors are external? The PPW approach has not yet addressed such
sovereignty questions. Finally, the context specificity of the components limits
generalizability of certain findings. Similar research in other contexts would provide
useful information about the degree of generalizability.

Overall, application of the analytical framework for PPW has proved useful as a means
of evaluating a social change project and identifying ways to move forward. The framework
allows for the integration of existing data and newly collected data in a way that provides a
clearer picture of the opportunities for social change in a specific context. The PPW
approach helps in sorting through the congruence between a crowded agenda for
government decision makers and a multiplicity of problems experienced by citizens. The
approach also recognizes features of human behavior in ways that should facilitate
long-lasting changes. Finally, application of the PPW approach has enabled identification of
opportunities for agricultural transformation and the potential roles for policy and
agribusiness entrepreneurs in such transformation.

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Appendix. Examples of semi-structured interview questions

Notes: Due to space limitations, this appendix does not list all interview questions. For example, this list excludes questions about the spread of information and certain obstacles to adoption. Complete question sets are available from the authors upon request. “F1” indicates the question was used in the first field research trip, while “F2” indicates the second trip. Questions differed somewhat across stakeholder groups on the second trip. Questions for CSA project administrators (generally not listed below) focused on: the nature of the project, the populations and problems targeted, language used in discussing problems and solutions, and resource and capacity issues.
Problems

- F1: what do you think are major climate problems related to agriculture in your country, if any, either now or in the future? (Question repeated for: nutrition problems, economic problems related to agriculture and social problems related to agriculture)
- F2 (government, project administrators): what are the biggest problems facing the people of Senegal?
- F2 (producers): what are the biggest problems for you and your family personally on a daily basis? (Question repeated for producers’ region of Senegal and country as a whole and for agriculture-related problems at all three levels)

Priorities

- F1: where does agriculture fit among government priorities? (Question repeated for CSA)
- F2 (government): what are the biggest priorities overall for the government of Senegal right now? (Question repeated for agricultural priorities)
- F2 (producers): what are the biggest priorities overall for the government of Senegal right now? What problems does the government see as most important to solve? (Question repeated for agricultural priorities of government)
- F2 (all groups): what are the priorities against which CSA projects are competing for attention or resources at the national level? At the regional or local level?
- F2 (government): how do government priorities differ across the national and regional levels?

CSA as solution

- F1: what do you think about what you hear the term “climate-smart agriculture?”
- F1: what types of agricultural problems do you think CSA innovations might help to lessen, if any? (Question repeated for economic and social problems)
- F2 (government): are you familiar with CSA projects in Senegal? If so, what do you know about these projects?
- F2 (project participants): how is the CSA project helping you with the problems facing you and your family? What problems do you think the project will help to reduce or solve?

Important actors

- F1: what organization or people are most influential in determining where agriculture fits among government priorities?
- F1: who do you think are crucial people or organizations in making decisions about the adoption of agricultural innovations?
- F2 (government): how influential are external donors in shaping government priorities?

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Farmers’ usage preferences for Rwanda’s Volcanoes National Park

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Abstract

Purpose – Policymakers and stakeholders lack empirical evidence on the effectiveness of community participatory management for agribusiness development and environmental conservation. The purpose of this paper is to assess the management preferences, approaches and practices of farm communities in Rwanda’s Volcanoes National Park (VNP).

Design/methodology/approach – Primary data collected from 191 farmers were used. A choice experiment on current and potential park management practices and utilization levels was conducted along with a survey on socioeconomic, farm and institutional behavior characteristics.

Findings – Results show that farmers prefer preserving VNP resources for the production of agribusiness crops that are low input and environmental friendly and provide high income to farmers in addition to handcraft production to enhance cultural, plant and wild animal tourism development. Farmers highly value integrated stakeholder participatory decision making about the parks natural resources. High-income farmers prefer to restore traditional cultural heritage park sites for recreation, and ancestral intellectual and cultural property rights.

Research limitations/implications – The sample size limited the analysis to a conditional logit model.

Originality/value – This is the first study to assess the management preferences of farm communities in the VNP area.

Keywords Farm management, Rwanda, Choice experiment, Community management

1. Introduction

Rural communities worldwide depend on forest resources as their main source of livelihood. It is estimated that 600m indigenous people depend on forests, 350m among them highly depend on forests for subsistence (World Bank, 2004). However, these communities often lose access when local forests are designated strict nature reserves. Demand on forest resources for products and services continue to rise as Sub-Saharan Africa’s population, urbanization and industrialization increase. Rwanda is a primary example of the enormous demands being placed on the forests and national parks where population pressure, prevalence of poverty, traditional religious practices and cultural heritage usage and the number of small farms adjacent to the parks are all increasing along with the park degradation rates (Katerere et al., 2009; RDB, 2013). Agribusiness including agri-products and services, sustainable agriculture, forest products and agrotourism can play a crucial role in preserving national park resources in the face of competing demands.

Traditionally, long before the prehistoric period, community user groups managed forests in Eastern Africa (Sackey, 2007). Up to the colonial period (1900–1960), forest administration concentrated on the conservation of wildlife and plant biodiversity, protection of water...
catchments and the regulation of forest extraction and hunting. Shortly after political independence in 1962, Rwanda reviewed its forest policies to avoid the acceleration of deforestation and illegal activities. This was also the case in other East African countries. For example, Kenya replaced its traditional forest guards with paramilitary forces (Larson, 2005).

Rwanda’s Volcanoes National Park (VNP), which was created in 1925 with 34,000 km², lost more than 55 percent of its surface area between 1960 and 2005. In 2005, the Rwandan government enacted Organic Law Number 04/2005, which has resulted in the VNP growing to an area of 16,000 km². To continue the trend of balancing the demands on the parks and forests with the needs of the population, the demand for their attributes must be better understood.

The largest identifiable group of residents surrounding the VNP is small farmers. Currently, they utilize the park for production of agribusiness crops including pyrethrum, mushroom, jatropha, honey and other production-based activities (watering, grazing) in addition to handcrafts. While a number of studies provide empirical evidence describing practices and approaches for agriforest management, few studies include the cultural, religious, medicinal and craft-making values that are important to the Rwandan society.

Rwanda offers a unique case where community participatory management can influence policy and management practices. This paper seeks to assess preferences and management approaches and practices of farm communities in Rwanda’s VNP area. The next section details the Rwandan context along with the importance of cultural heritage associated with the national parks. A review of past studies on community preferences for environmental conservation and management and a conceptual framework are presented on how to incorporate the competing alternative uses. Next, a model is developed. Results and conclusions follow.

2. Rwanda in context
The Rwandan government has intervened to address the massive degradation of its national parks, which are under threat from encroachment, and alternative uses of the parks’ natural resources. The largest identifiable group of households that live and work adjacent to these parks are small farmers. Rwanda has tried community participatory management with these farmers; however, there is inadequate empirical evidence to inform policymakers and other stakeholders on the preferences of those farmers and the success of this approach.

2.1 Ecosystems and degradation
Rwanda, with a total land area of 26,366 km², contains 8.4 percent diversified ecosystems consisting of mountain rainforests; gallery forests, savannas, wetlands and aquatic lands. Table I outlines the rate of degradation of the different ecosystems comprised of natural

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<td>114,025</td>
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<td>94,500</td>
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<td>28,000</td>
<td>23,000</td>
<td>8,800</td>
<td>3,800</td>
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<tr>
<td>Mukura Forest</td>
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<td>3,000</td>
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<td>2,000</td>
<td>1,600</td>
<td>1,600</td>
<td>47</td>
</tr>
<tr>
<td>Volcanoes National Park</td>
<td>34,000</td>
<td>16,000</td>
<td>15,000</td>
<td>14,000</td>
<td>12,760</td>
<td>12,760</td>
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<tr>
<td>Akagera National Park</td>
<td>267,000</td>
<td>267,000</td>
<td>267,000</td>
<td>241,000</td>
<td>220,000</td>
<td>90,000</td>
<td>66</td>
</tr>
<tr>
<td>Galleries and Wooded Savannah</td>
<td>150,000</td>
<td>150,000</td>
<td>90,000</td>
<td>50,000</td>
<td>20,000</td>
<td>–</td>
<td>87</td>
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<tr>
<td>Total</td>
<td>660,025</td>
<td>617,800</td>
<td>539,000</td>
<td>446,800</td>
<td>374,660</td>
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Source: Adapted from GoR (2003)
forests and wooded savannas in Rwanda. The impact of this degradation on rural livelihood, global environmental protection and cultural heritage is not fully understood (GoR, 2003).

Galleries and Wooded Savannas, Akagera National Park and the VNP receive the highest level of protection, but have the highest degradation rates estimated at 87, 66 and 63 percent, respectively. Degradation is a result of rapid population increases that create greater pressure on the parks in terms of encroachment and deforestation. In addition, there has been land conversion for pyrethrum production, and the resettlement of returnees from the civil war (GoR, 2003).

VNP is the major contributor to the national economy, with mountain gorilla-based tourism as the third source of income for the country (Gray, 2011; Martin et al., 2011; Mukanjari et al., 2013). VNP is located in the volcano forest area comprising both Virunga National Park in the Democratic Republic of Congo and Mgahinga Gorilla National Park in Uganda (Nkuutu et al., 2012). The park area extends to four districts: Burera, Musanze, Nyabihu and Rubavu. This zone has the highest population densities in the country (500–1,041 inhabitants per km²). The adjacent communities have little opportunity for diversification into agribusiness and other off-farm activities, and have limited investments in the tourism business and culture industry (Plumptre et al., 2003). Policies that promote the development of agribusiness and ecotourism activities in this area are crucial to help farmers diversify livelihood options and improve sustainable growth in the area.

Fauna and flora in the VNP is comprised of a total of 86 mammals, 258 birds and 878 plants species that are protected at national and international levels (Bush et al., 2010). The park is well known for its warm climate, which is favorable for mushroom production (well suited to smallholders due to its improved phytonutrient intake), beekeeping production (important to reduce the National Poverty Index estimated at 40.9 percent in the area) and Jatropha for biofuel production (GoR, 2009b; Pavageau et al., 2013). VNP’s water is a key ecological resource in the region and provides irrigation for crops and livestock watering. VNP is important for the natural production of medicinal plants, and to traditional religious heritage as well as for intellectual and cultural property rights. The medicinal plants, and traditional and cultural products and services are central to job creation, development of new infrastructure and the sales of handcraft products in the region. The degradation of VNP’s ecosystems due to natural and anthropogenic activities continues to be a source of public and policy debate.

VNP lost more than one-half of its surface area between 1960 and 2005. The government enacted Organic Law Number 04/2005 in 2005, which has reversed this negative trend. The park is rich in fauna and flora, which are protected under Rwanda biodiversity and wildlife policies (GoR, 2011) and are classified as endemic or threatened by the International Union for the Conservation of Nature (Plumptre et al., 2003). With the establishment of the law in 2005, people employed as guides and as gorilla group and anti-poaching teams have been deployed in the five protected sectors. In addition, the estimated 800 community members involved in day-to-day park management activities benefit from temporary employment and revenue-sharing support (GoR, 2009b). Two umbrella associations for park protection (Amizero or Hope) and community development activities (Iby’Iwacu) are supported by the International Gorilla Conservation Program, CARE International, and SNV Netherland Development Organization. Since 2007, Rwandan tourism has attracted more than 16,000 tourists at estimated earnings of $42m, which has boosted the local economy by providing a source of hard currency (Bush et al., 2010). About 90 percent of the tourism revenues are driven by mountain gorilla trekking (a gorilla permit costs $1,500 per person per trek with a portion of the permit costs going to the conservation of the mountain gorillas, GoR, 2009b). In spite of all these investments, progress in conservation has been slow and erratic, a situation partially attributed to the exclusion of local people from the decision-making process.
Farmers’ participation in the protection, conservation and recovery of biodiversity species of national and global importance is a key strategy to investment and tourism development. By 2020, the number of employees in the tourism sector is estimated to increase to 23,000, which does not include restaurant, transportation and retail trade employment (NISR, 2012).

2.2 Cultural heritage, medicinal plants and handcrafts in the VNP

A substantial portion of the United Nation’s World Heritage Sites (WHS) can be found in developing countries. The sites attract an increasing number of tourists and income to those countries (Tuan and Navrud, 2009). UNESCO has designated 135 WHS in Africa which include the VNP[3]. In 2013, Africa received approximately 3 percent of the world’s tourism receipts and 5 percent of tourist arrivals (African Tourism Monitor, 2013).

Cultural tourism is important in Rwanda because it improves cultural exchanges and raises the living standards for the local people. Through cultural tourism, cultural heritage includes the creation of jobs and new infrastructure for the sale of handcraft products. More recent, gorilla trekking also became part of cultural tourism through the gorilla naming ceremonies (Kwita Izina). Celebrities from around the world participate in these annual events. The revenue from the Rwandan tourism sector increased from $175m in 2009 to $281.8m in 2012, with revenue from cultural tourism activities increasing by 18 percent during the same period (RDB, 2013).

The government has taken the position that destroying heritage amounts to violating the conscience and mind of the nation, rendering its history and identity indistinguishable (GoR, 2011). The park is at great risk of degradation if cultural heritage is not accommodated in its conservation practices. There exists the political will and international support from the International Centre for Preservation of the Cultural Property and UNESCO to safeguard and promote Rwanda’s cultural heritage through promotion of cultural practices and traditional techniques recognized as meeting the expectations of the community as an expression of their cultural identity.

The majority of Africans depend on traditional African medicine despite revolutionary progress made in the field of healthcare. Rwanda cannot ignore the important role traditional medicine plays in maintaining the health of its population since an estimated 80 percent of the rural population relies on traditional medicine for their healthcare as part of their socioeconomic and sociocultural heritage (GoR, 2010). This is an untapped opportunity for the government to promote agribusiness and pharmaceuticals based on the VNP natural resource base.

Handcraft products have been identified by the Government of Rwanda’s vision 2020 as one of the key priority export sectors. Handcrafts are being positioned to positively impact economic development and reduce the share of agriculture’s contribution to GDP from 95 percent to 50 percent (RDB, 2013). In addition, the national tourism policy recognizes the potential of the handcraft sector in wealth creation for the rural population, especially for women, youth and people with disabilities (GoR, 2009a). Rwanda has already surpassed the 50,000 targeted tourist goal (GoR, 2009a), with few tourists leaving the country without a handcraft souvenir procured from roadside vendors or more formal markets such as the National Museum or the craft villages/centers (GoR, 2009a). While the handcraft strategy, Small and Medium Enterprises policies and the five-year handcraft strategic plan (2009–2013) have assisted in achieving these goals, Rwanda’s tourism and hospitality sector requires further development to sustain this growth.

3. Environmental conservation and management preferences

The formulation of forest management policies involves asking communities about their preferences for hypothetical transformations through management approaches and practices.
One approach is using choice experiment (CE) techniques to value nature conservation programs and attributes such as cultural heritage and agricultural production activities. The inclusion of such attributes in this study provides a more accurate estimate of the existing nature of the park and the benefit of attributes in the park.

Little is known about environmental and park management studies using CE in developing countries such as Rwanda. The literature includes only a few empirical CE studies from African countries, such as the marketing research in Ethiopia by Kassie et al. (2009) and Otieno et al. (2011) in Kenya. Kassie et al. (2009) identified and estimated the relative weight assigned to the preferred traits of indigenous cows in Central Ethiopia. The results show that fertility, disease resistance and calf vigor traits are at least as important as milk and that the origin of the cows matter. Otieno et al. (2011) analyzed cattle farmers' preferences for disease-free zones (DFZ). Findings show that farmers prefer to pay to participate in a DFZ where recordkeeping and disease monitoring are required; market information is provided; sales contract opportunities are guaranteed; adequate training is provided on pasture development; cattle are properly labeled for ease of identification; and some monetary compensation is provided in the event that cattle die due to severe disease outbreaks. Both studies suggest that CE methods can be used to value the ecological attributes of the VNP.

In environmental economics, valuation is a policy-oriented discipline that puts monetary values on environmental goods and services, many of which have no observed market prices. This requires the use of non-market valuation methods which is distinct from neoclassical price theory of market goods, whereby buyers and sellers reveal their preferences directly through their actions, which create the price of the commodity. Adamowicz et al. (1998) classified non-market values into use and passive use values. Passive values include option use (uncertainty over future demand as per direct and indirect), existence and bequest (such as the intrinsic value) values, and other values not typically expressed through any market. Empirical approaches to non-market valuation methods involve comparing the economic benefits using revealed preference (RP) or stated preference (SP) methods.

RP methods, which include travel costs and hedonic pricing, rely on the analysis of observable behavior and are applied primarily to use values such as direct and indirect uses. This approach is limited to analyzing only existing alternatives. SPs methods, including contingent valuation (CVM) and CE methods are capable of overcoming the limitation of RP methods. While CVM has two alternatives, CE has increasingly become its extension or variant. CE employs a series of questions to elicit responses for the estimation of preference over attributes of an environmental state with more than two alternatives.

In this study, particular care is taken to incorporate cultural, religious, medicinal and craft-making values of the park that are linked to potential participatory management approaches. Accommodating these values inform future management decisions regarding sustainable park resources and cultural heritage conservation.

4. Conceptual framework and methodology

In developing countries, where access to and use of natural resources are highly contested and are vital to rural livelihoods, improving management practices and use of public resources through cooperation is increasingly seen as a critical factor for sustainable conservation. Participatory management builds on the institutional analysis and development model by Ostrom (2005) and Poteete et al. (2010). It is based on the theory of collective action (CA). The CA requires the involvement of a group of people sharing the same action in pursuing shared interest. Its contextual background integrates three broad sets of attributes related to park resources, user resources and governance arrangement. The attributes of the park describe the biophysical conditions and trends. These entail
cultural heritage, park production resources, plant and animal biodiversity, park management decision making and park visitation fees. The degradation and scarcity of these attributes requires all stakeholders to reflect on what can be done and how to shift available resources so that local users can influence decision making more effectively.

Resource users encompass both local communities and extra-local users. Individual and institutional characteristics include but are not limited to age, gender, income, education level and farm group membership. These characteristics impact park resource management and are bounded in the form of groups, along with their social capital and assets. Group users, described by shared identity of cooperation, are more likely to engage in participation. Social capital such as social cohesion and networking (group membership) reduces conflicts between communities. Additionally, physical, human, social and financial assets are necessary for the implementation of livelihood strategies for effective participatory management and decision-making processes.

Governance arrangements are attributes that cover rules and regulations of the park, which are related to the pattern of decision making on issues of public importance such as park resource allocation, management and use (Ostrom, 2005). Issues with regard to policies and other compulsory features are also imperative in this case. All the aforesaid factors, as shown in Table II, have led to the focus of communities’ participation given their willingness and ability to work together toward improved participation in managing the park.

By examining the interaction between attributes, progress can be made in improving park resources protection. For this reason, management attributes, and socioeconomic and institutional characteristics are included in this study. This framework requires the community to state and rank the tradeoffs between the various attributes the VNP has to offer and the strategies that evolve that will simultaneously protect biodiversity and improve each community’s livelihood.

4.1 Data

This study uses primary data collected from the volcano national park corridor. Ten administrative cells (Gisizi, Cyahi, Bisoke, Kaguhu, Nyabigoma, Nyonirima, Mudakama, ...)

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<th>Attribute Levels for CE modeling and choice card</th>
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<td>Table II.</td>
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<td>Variables</td>
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<td>Cultural heritage</td>
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<td>Permitted enterprises</td>
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<td>Tourism development</td>
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<td>Park management</td>
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<td>Attributes</td>
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<td>Tourism development</td>
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<td>DM on park management</td>
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<td>Park visitation fee</td>
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<td>Which one would you prefer?</td>
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<td>Alternative A</td>
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<td>Alternative B</td>
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<td>Neither A nor B</td>
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<td>Description</td>
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<td>Traditional religion</td>
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<td>Traditional medicinal plants</td>
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<td>Handicraft management</td>
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<td>Jatropha production</td>
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</table>
Ninda, Kabeza and Kareba) from the six sectors were randomly selected. The sectors are located in three districts adjacent to the park (Burera, Musanze and Nyabihu). Information for the selected districts and sectors include the number and percent of farmers, access to roads and the number of administrative cells located within them. Consultations and meetings with local government at the sector and cell levels were held to obtain insights into the socioeconomics of the population in those cells. The cell leaders provided a list of farmers to form a sampling frame. The list used in each administrative cell was obtained using the available list for the last national population and housing survey (NISR, 2012) at the sector level. The households interviewed were then randomly selected from the population in the cell by selecting every sixth household. In total, 211 farmers were interviewed, with a total of 191 surveys being usable for this analysis.

The data collected consist of park management attributes and levels utilizing a CE survey in addition to socioeconomic, farm and institutional behavior and characteristics of respondents. The management attributes include cultural heritage, park production resources, tourism development, park management decision making and park visitation fees.

4.2 Choice experiment method

The first step of the CE experiment was to define the good to be valued in terms of park management attributes and their levels. CE then involved selecting attributes and their levels, experimental design, formation of choice sets and measurement of preferences. Attributes were selected via focus group discussions and direct questioning. Park management attributes were classified as mandatory or optional. The mandatory attributes are the laws and policies (environment, forestry, land use, wildlife, and biodiversity) regarding environmental protection that does not vary.

The CE utilizes statistical design theory to combine the levels of the attributes into alternative management scenarios or profiles that were presented to respondents. Factorial designs were used to study the effects of these attributes and their levels. A fractional factorial design was used to reduce the size of problems involving either small numbers of attributes, or levels, or both by selecting a particular subset or sample of complete factorials. During the survey, an orthogonal design of 36 scenarios was administered to 72 respondents for a preliminary survey. The 36 scenarios were divided into groups of six, with each group/profile being shown to 12 respondents (see Table II). This design ensured that the attributes presented to respondents were varied independently from one another and the effect of each attribute level was isolated to avoid multicollinearity between attributes.

After the 36 paired choice, scenarios were grouped into six profiles, each with six choice tasks, farmers were randomly assigned to one of the six choice sets. Using a CE card, each choice task was used to describe two improved park management alternatives (A and B) and a baseline alternative (C) that defined the current management of the park. An improvement of current park management status through a stakeholder (government, farmers, agribusiness and NGOs) participatory approach was suggested. Respondents were asked to choose the best management approach they preferred by clearly explaining the attributes and levels. Each farmer was then presented with a profile containing a series of six choice sets.

The CE survey presented respondents with a number of attributes and asked them to choose their most preferred attribute. Positive preferences were expected from farmers who showed the dissatisfaction of the current management policy and demonstrated a high desire to improve most of the park features. Data on socioeconomic and institutional characteristics were collected from farmers to help characterize park management approaches and practices. The information from these variables are hypothesized to influence preferences on improving the physical characteristics (or management attributes) of the park.
Following authors Lancaster (1966), Hoffman and Duncan (1988) and Train (1998), a conditional logit model was used to operationalize the model where explanatory variables include attributes of the choice alternatives as well as characteristics of the individuals making the choices. These attributes are related to management approaches and practices compared to socioeconomic and institutional characteristics of the individuals making the choices (such as the communities adjacent to the VNP). Suppose that \( y_i \) represents a discrete choice among \( J \) alternatives. Let \( U_{ij} \) represent the value or utility of the \( j \)th choice to the \( i \)th individual and where \( U_{ij} \) are independent random variables with a systematic component \( V(Z_j, S_i) \) and a random component \( \epsilon(Z_j, S_i) \) such that (Manski and Lerman, 1977):

\[
U_{ij} = V(Z_j, S_i) + \epsilon(Z_j, S_i). \tag{1}
\]

We assume that communities act rationally and seek to maximize their utility. Thus, respondent \( i \) will choose alternative \( j \) if \( U_{ij} \) is the largest of \( U_{i1}, \ldots, U_{ij} \). For any respondent \( i \), a given level of utility is associated with management attributes \( (Z_j) \), socioeconomic and institutional characteristics of respondents \( (S_i) \). The choices made between alternatives as a random component are a function of the probability that the utility associated with a particular option \( j \) is higher than that of \( i \). The probability of choosing a given management option depends on the choice between alternative A or B and the current management scenario referred to as 0, neither A or B, can be represented in the following equation:

\[
Pr(y) = \begin{cases} 
  ik = 0 \\
  ij = A & Pr(V(Z_{ij}, S_i) + \epsilon(Z_{ij}, S_i)) > Pr(V(Z_{ik}, S_i) + \epsilon(Z_{ij}, S_i)). \\
  ij = B 
\end{cases} \tag{2}
\]

The random term, \( \epsilon(Z_{ij}, S_i) \), cannot be observed, hence it is assumed to have a standard Type I extreme value distributions, where:

\[
P_{ij} = \frac{\exp(V(Z_{ij}, S_i))}{\sum_{k \in C} \exp(V(Z_{ik}, S_i))} \tag{3}
\]

The model was specified assuming that the observable utility function follows a strictly additive form:

\[
V_{ij} = \beta + \beta_1 Z_1 + \beta_2 Z_2 + \cdots + \beta_n Z_n + \delta_1 S_1 + \delta_2 S_2 + \cdots + \delta_l S_m, \tag{4}
\]

where \( \beta \) is the alternative-specific constant (ASC) which captured the effects on utility of any attribute not included in the choice specific attributes.

Equation (5) describes the dependent variable as the choice between the current management scenario and the improved management scenarios (A and B). The probability of selecting a given the park management approach was a function of management features and communities characteristics. The ASC was equal to 1 when either management approach A or B was chosen, or 0 when the current management was selected. Explanatory variables are VNP management or respondents’ characteristics:

\[
Pr[y = 0] = 0 \\
Pr[y = A] = \beta_0 + \beta_1 \text{ farmer characteristics } + \beta_j \text{ park characteristics } + \mu_i, \\
Pr[y = B] = 0
\]

where \( \beta_0 \) is the ASC, \( \beta_1, \ldots, \beta_29 \) are utility parameter coefficients and \( Z_n \) is a set of park management attributes from attribute \( j \) to \( n \).
5. Results

5.1 Socioeconomic and institutional characteristics of respondents

Respondents ranged in ages from 18 to 55 years old, which may be a sign of incentives to preserve VNP resources, and most of the respondents had attended primary school only (Table III). The majority of the households earned less than FRW 100,000 ($150) per month. The observed high average household sizes and low average farm sizes indicate a high level of dependence on the VNP’s resources. About 80 percent of respondents’ farms were located

<table>
<thead>
<tr>
<th>Variables</th>
<th>%</th>
<th>Min.</th>
<th>Mean</th>
<th>Max.</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Socioeconomic characteristics/membership</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Age (in years)</td>
<td>19</td>
<td>39</td>
<td>93</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Average household size</td>
<td>1</td>
<td>5</td>
<td>12</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Householder member over 18 years old</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Monthly income in your household (FRW)</td>
<td>7,500*</td>
<td>61,747</td>
<td>705,000</td>
<td>77,380</td>
<td></td>
</tr>
<tr>
<td>Average farm size (in acre)</td>
<td>0.2</td>
<td>0.89</td>
<td>7.50</td>
<td>1.09</td>
<td></td>
</tr>
<tr>
<td>Gender (% of male and female farmers)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>57</td>
<td></td>
<td></td>
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<tr>
<td>Female</td>
<td>43</td>
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<td>Marital status of respondents (%)</td>
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</tr>
<tr>
<td>Single</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Married</td>
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<td></td>
<td></td>
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<tr>
<td>Widow</td>
<td>9</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Education level (%)</td>
<td></td>
<td></td>
<td></td>
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</tr>
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<td>No schooling</td>
<td>30</td>
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<tr>
<td>Primary school</td>
<td>61</td>
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<td>Artisan school</td>
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<tr>
<td>Secondary school</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main occupation (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farming</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Off-farming</td>
<td>3.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Both farming and off-farming</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land within 1 km from the park</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>78.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>21.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other farms far from the park</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>63</td>
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<td></td>
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</tr>
<tr>
<td>No</td>
<td>36.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of farm management practices</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>95.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>4.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Institutional characteristics/membership</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance to the nearest school (km)</td>
<td>0.05</td>
<td>1.4</td>
<td>9.00</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>Walking time to the nearest school (minutes)</td>
<td>0.60</td>
<td>24.1</td>
<td>120.00</td>
<td>17.9</td>
<td></td>
</tr>
<tr>
<td>Distance to the nearest health center (km)</td>
<td>0.30</td>
<td>3.6</td>
<td>25.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walking time to the nearest health center (minutes)</td>
<td>9.00</td>
<td>50.2</td>
<td>318.00</td>
<td>41.6</td>
<td></td>
</tr>
<tr>
<td>Distance to the nearest market</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walking time to the nearest market (minutes)</td>
<td>0.00</td>
<td>5.2</td>
<td>34.00</td>
<td>5.09</td>
<td></td>
</tr>
<tr>
<td>Distance to the nearest paved road</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walking time to nearest paved road (minutes)</td>
<td>0.00</td>
<td>3.9</td>
<td>30.00</td>
<td>5.6</td>
<td></td>
</tr>
<tr>
<td>Member of any community-based organization (CBO)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>48.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>51.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: *The average exchange rate between June and July 2014, one USD was equivalent to Rwf 690

Source: Survey data (2014)
within one kilometer (km) from the VNP boundary. The institutional characteristics and group membership of respondents indicate that the average distance to the nearest infrastructure facilities (school, health center, market and nearest paved road) was approximately 1.4 km. The low proportion of participation in community-based organizations (CBOs) was an indicator of poor collaboration among interested parties and, hence, inadequate CA in managing VNP resources.

5.2 Farm management practices in park area
Erosion control, animal and crop husbandry, and agroforestry are farm practices identified in the government’s Vision 2020 document as key pillars to transform agriculture from subsistence to a productive, high-value, agribusiness-oriented farming sector that is environmentally friendly. As shown in Table IV, more than half of the respondents never applied radical terraces and two-thirds always applied anti-erosion ditches. Less than one-half of the farmers always used zero grazing. A relatively small number indicated that they had mostly applied animal husbandry techniques such as rarely allowing animal grazing in the park. Similarly, a high proportion of farmers indicated that they never applied mixed cropping, compared to less than one-half who never applied both intercropping and integrated crop–animal system as crop husbandry practices. A few respondents indicated that monocropping, crop rotation and residue management were never applied. Four types of agroforestry systems were identified: agrisilvicultural (crop–tree system), silvopastoral (animal–tree system), agrosilvopastoral (crop–animal–tree system) and apiculture with trees. Less than one-third of respondents indicated that agrisilvicultural, silvopastoral, agrosilvopastoral and apiculture with trees systems were not applicable to their farms. The comparatively low level of agroforestry practices in the area suggests that restoring the park and the neighboring land is still a major challenge and may negatively affect soil fertility, farm productivity and agribusiness development, and forest conservation.

<table>
<thead>
<tr>
<th>Farm management practices</th>
<th>Not applicable</th>
<th>Never</th>
<th>Rarely</th>
<th>Mostly</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Erosion control</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AE Ditches</td>
<td>0</td>
<td>9.6</td>
<td>8.6</td>
<td>13.9</td>
<td>67.9</td>
</tr>
<tr>
<td>Radical Terraces</td>
<td>34.8</td>
<td>54.0</td>
<td>7.5</td>
<td>2.1</td>
<td>1.6</td>
</tr>
<tr>
<td>Progressive Terraces</td>
<td>0</td>
<td>44.4</td>
<td>9.1</td>
<td>24.6</td>
<td>21.9</td>
</tr>
<tr>
<td><strong>Animal husbandry</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zero grazing</td>
<td>0</td>
<td>31.0</td>
<td>11.8</td>
<td>14.4</td>
<td>42.8</td>
</tr>
<tr>
<td>Fodder Bank</td>
<td>0</td>
<td>35.3</td>
<td>20.3</td>
<td>25.1</td>
<td>19.3</td>
</tr>
<tr>
<td>Grazing in VNP</td>
<td>0</td>
<td>69.0</td>
<td>16.6</td>
<td>14.4</td>
<td>0.0</td>
</tr>
<tr>
<td><strong>Crop husbandry system</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mixed cropping</td>
<td>0</td>
<td>79.7</td>
<td>12.8</td>
<td>3.2</td>
<td>4.3</td>
</tr>
<tr>
<td>Intercropping</td>
<td>0</td>
<td>43.3</td>
<td>18.2</td>
<td>21.9</td>
<td>16.6</td>
</tr>
<tr>
<td>Monocropping</td>
<td>0</td>
<td>5.9</td>
<td>5.9</td>
<td>35.8</td>
<td>52.4</td>
</tr>
<tr>
<td>Crop–Animal system</td>
<td>1.1</td>
<td>40.6</td>
<td>16.0</td>
<td>26.2</td>
<td>16.0</td>
</tr>
<tr>
<td>Crop rotation</td>
<td>0</td>
<td>4.8</td>
<td>5.9</td>
<td>18.3</td>
<td>71.1</td>
</tr>
<tr>
<td>Residue management</td>
<td>0</td>
<td>5.3</td>
<td>15.0</td>
<td>26.2</td>
<td>53.5</td>
</tr>
<tr>
<td><strong>Agroforestry system</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agrisilvicultural</td>
<td>4.8</td>
<td>46.0</td>
<td>16.6</td>
<td>21.4</td>
<td>11.2</td>
</tr>
<tr>
<td>Silvopastoral</td>
<td>25.1</td>
<td>63.6</td>
<td>4.3</td>
<td>5.3</td>
<td>1.6</td>
</tr>
<tr>
<td>Agrosilvopastoral</td>
<td>28.9</td>
<td>59.4</td>
<td>6.4</td>
<td>3.2</td>
<td>2.1</td>
</tr>
<tr>
<td>Apiculture _tree</td>
<td>22.5</td>
<td>66.8</td>
<td>5.9</td>
<td>0.5</td>
<td>4.3</td>
</tr>
</tbody>
</table>

*Source*: Survey data (2014)
5.3 Farmers’ preferences for volcanoes park management attributes

Table V shows the results of the conditional logit model for assessing farmers’ preferences for participating in the management and decision making for the VNP. The log likelihood value of 829 suggests a strong significance of the model, which implies that utility parameters for attribute levels were statistically different from one another. The Pseudo $R^2$ of 0.34 indicates overall good model fitness.

The CL results show that farmers had positive and significant preferences for handcraft inputs over both traditional religious heritage and medicinal plants. Handcrafts contribute to promoting cultural tourism, increasing rural incomes and strengthening collaborations among rural communities and other stakeholders. It is also a coping strategy by farmers to mitigate risk and vulnerability from climate stress. Farmers preferred to protect agribusiness crops as production resources in the VNP which include Jatropha, beekeeping and mushroom. Jatropha helps combat the greenhouse effect, stop soil erosion, create additional income for the rural poor and provide a major source of energy (Wahl et al., 2009).

The strong link between forests and traditional beekeeping create opportunities for promoting beekeeping as an incentive for sustainable forest management. Preferences for mushroom production results in increasing and diversifying business and employment opportunities, and provide income opportunities for disadvantaged groups, including small family farms in rural areas. Its cultivation offers benefits to vegetables and fruits that are grown for sale when it is integrated into the existing production systems.

<table>
<thead>
<tr>
<th>Management variables</th>
<th>Coefficients</th>
<th>SE</th>
<th>t-ratios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional religion heritage</td>
<td>0.19</td>
<td>0.54</td>
<td>0.35</td>
</tr>
<tr>
<td>Handcraft materials</td>
<td>0.32*</td>
<td>0.21</td>
<td>1.50</td>
</tr>
<tr>
<td>Jatropha production</td>
<td>1.53***</td>
<td>0.47</td>
<td>3.25</td>
</tr>
<tr>
<td>Handcraft management</td>
<td>1.50***</td>
<td>0.47</td>
<td>3.20</td>
</tr>
<tr>
<td>Mushroom collection</td>
<td>1.37***</td>
<td>0.42</td>
<td>3.22</td>
</tr>
<tr>
<td>Diverse biodiversity</td>
<td>1.45***</td>
<td>0.19</td>
<td>7.61</td>
</tr>
<tr>
<td>Plant species</td>
<td>-0.08</td>
<td>0.19</td>
<td>-0.40</td>
</tr>
<tr>
<td>Management by government only</td>
<td>1.52***</td>
<td>0.16</td>
<td>9.79</td>
</tr>
<tr>
<td>Management by government and farmers</td>
<td>1.68***</td>
<td>0.47</td>
<td>3.58</td>
</tr>
<tr>
<td>Income × Traditional religion heritage</td>
<td>0.74***</td>
<td>0.15</td>
<td>4.82</td>
</tr>
<tr>
<td>Age × Traditional religion heritage</td>
<td>-0.45***</td>
<td>0.17</td>
<td>-2.57</td>
</tr>
<tr>
<td>Gender × Traditional religion heritage</td>
<td>0.07</td>
<td>0.08</td>
<td>0.96</td>
</tr>
<tr>
<td>Education × Traditional religion heritage</td>
<td>0.12</td>
<td>0.12</td>
<td>1.06</td>
</tr>
<tr>
<td>Education × Water collection</td>
<td>0.11</td>
<td>0.13</td>
<td>0.79</td>
</tr>
<tr>
<td>Education × Management by government/farmers/private sector</td>
<td>0.22*</td>
<td>0.13</td>
<td>1.75</td>
</tr>
<tr>
<td>CBOME × Water collection</td>
<td>0.37**</td>
<td>0.18</td>
<td>2.03</td>
</tr>
<tr>
<td>CBO × Management by government/farmers/private sector</td>
<td>0.31*</td>
<td>0.19</td>
<td>1.60</td>
</tr>
<tr>
<td>Log likelihood</td>
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</tr>
<tr>
<td>Pseudo $R^2$</td>
<td>0.34</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of respondents</td>
<td>192</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes:** TMEPL, traditional medicinal plants; HAMA, handcraft materials; MUCO, mushroom collection; DIBIO, diverse biodiversity; WACO, water collection; JAPRO, Jatropha production; WICO, wildlife conservation; PLASPE, plant species; COGO, conservation by government; COGOF, conservation by government and farmers; COGOFP, conservation by government, farmers and private sector; AGE, age of the respondents; EDUC, education level of the respondent; GE, gender of the respondent; INCOME, monthly income levels; FAMP, farm management practices; CBOME, membership in community-based organizations; INFRA, infrastructure development. ***Significant at 0.1, 0.05 and 0.01 levels, respectively

**Source:** Authors

**Table V.** Conditional logit results for farmers’ preferences for VNP management attributes
Interactions between income and traditional religious heritage as well as between income and water resources were positive and significant. High-income farmers prefer to restore and preserve the traditional cultural heritage for personal and public enjoyment and recreational purposes, and as a source of intellectual and cultural property rights in their former ancestral territories. Farmers with high incomes prefer to have safe and clean water rather than extract water resources from the park. The interaction term between gender and religious heritage was negative. Compared to the men, women had limited awareness of natural resource preservation and often lacked detailed knowledge of their local environment, which meant that they often engaged in harmful environmental practices. Rwanda’s women lack control over key resources or gender-based divisions of labor exacerbate this issue (Bush *et al*., 2010).

Interactions between education and decision making by all the stakeholders on park management are positive. Highly educated farmers have high levels of environmental consciousness, and therefore have high participation levels in decision making. Similarly, user groups such as farmer groups and other cooperatives recognize the great need to conserve and improve the forest. Thus, membership in a farmer organization is positively correlated with preserving VNP for water resources through CA.

6. Conclusions
This study assessed the management approaches and practices of farm communities in Rwanda’s National Volcano Park. Rwanda is dominated by traditional subsistence farming. Due to high population densities, farming land per household is decreasing and most of the soils have been exhausted. As a result, cultivation has moved into marginal areas, particularly in steep slopes, leading to widespread landslides, soil erosion and high salinity levels. These negative impacts within the natural resources domain are putting severe pressure on what the government perceives as the life-support systems of the country. The national park’s flora, fauna and animals provide more than an ecosystem; they also provide products and services that farmers need to increase their income. Understanding the preferences and management practices of farmers and agribusinesses who use the resources of the VNP is the first step to creating policies, programs and incentives to address income needs and the degradation of the park. In this study, particular care is taken to incorporate cultural, religious, medicinal and craft-making values of the park that are linked to potential participatory management approaches. Accommodating these values informs future management decisions regarding sustainable park resources and cultural heritage conservation.

The development of sustainable forest management and agribusiness management practices are important to the conservation of VNP resources. Agribusinesses provide many products for the VNP region including food, fiber and animal feed. The study finds that farmers prefer to preserve the park for handcraft production to enhance and preserve cultural tourism and knowledge. Farmers also prefer to protect both plants and animal biodiversity for tourism development. Household and institutional characteristics that influence preferences suggest that high-income farmers prefer to improve current park management for religious heritage and water resources. This may increase the quality of life such as recreational activities and improved water quality in the area. The study findings also indicate that educated people and CBO members prefer to improve the current management of the VNP through an integrated decision-making process. Therefore, membership in a CBO or social group improves farmers’ participation in CA for park resource management.

6.1 Policies
This paper adds to the policy discussion on how to improve the management of natural resources in Rwanda while growing the agribusiness sector. The study directly contributes
to the government’s Vision 2020 forestry strategic plan to improve forest and park practices such that land restoration occurs. Farmers’ preferences to protect park production resources (jatropha and mushroom) provide the government options to promote agricultural programs and agribusinesses that are environmentally friendly, low input and scalable, while simultaneously improving income, food production and consumption, nutrition, and health.

The key finding that farmers highly value participation in integrated stakeholder decision making to enhance self-responsibility in planning, management and use of these natural resources allows policymakers to partner with local farmers. Organic Law Number 04/2005 can be enhanced by using an integrated participatory decision-making approach. This is important because illegal activities (poaching, overuse of water resources) continue to be a major source of park degradation. The integrated approach would help improve production, processing and marketing of agribusiness products (mushroom and beekeeping production). This approach will reduce the government’s high exclusion cost related to information, monitoring and enforcement. Farmers’ preferences to preserve VNP encourage policymakers to incorporate them into buffer-zone production activities of cooperatives to ensure sustainable use and management of the park. To formalize the current government-sponsored, revenue-sharing program (5 percent of park tourism dollars are reallocated to support community projects to compensate farmers for not abusing the VNP, that is, opportunity cost of park usage), participating farmers could share in the revenues from tourism while being held accountable for negative outcomes (e.g. forest fires, killing wild animals and tree harvesting).

Farmers recognize there is value in the flora and fauna in the VNP; however, there are few mechanisms that formally convert those resources into consistent revenue streams. Rwanda’s plant and animal biodiversity policy as well as the cultural heritage policies lacks protocols that designate specific plant and animal (other than gorillas) for tourist attractions. Cultural heritage, especially through its main attractions of cultural tourism, is increasingly being seen as a resource for cultural promotion and economic growth for the region. Emphasis beyond gorilla tourism requires further cultural heritage development to increase conservation of the park. Preferences for preserving the traditional cultural heritage is an indication of how deeply these communities value traditions as a source of intellectual and cultural property rights with respect to their ancestral territories.

The laws and strategies governing human-wildlife conflict compensation and employment provision in the area are not well established. Farmers’ preferences to protect plant and animal biodiversity should translate into protection, conservation, management and utilization by community user groups to meet current and future resource demands. There should also be alternative investment opportunities in the park that combine tourism, culture and agribusiness development. Moreover, the farmers’ desire to protect biodiversity informs the Ministry of Agriculture and Animal Resources and the Ministry of Forestry and Land Management in designing environmental protection programs.

6.2 Study limitations
One limitation to this study was the survey sample size which limited our analysis to a conditional logit model (Train, 1998; Christiadi and Cushing, 2007). The CL was the most appropriate method that yielded improved estimates over the multinomial logit (Haan, 2006). Further research should focus on preference heterogeneity in management conservation of available national parks in Rwanda. Studies should be conducted on the cost-benefit analysis of human-wildlife conflict compensation because farmers showed desire to collaborate with other stakeholders to protect both plants and animals. Finally, studies on cultural heritage aspects of the park should be conducted since farmers have shown preferences for them.
Notes

1. Galleries are forests that form corridors along rivers or wetlands and project into landscapes located in Eastern Rwanda; these galleries comprise four forest blocks: Muvumba, Ibanda-Makera, Rugomero and Rwakivunji.

2. A district is an administrative unit with a population estimated at between 350,000 and 400,000 rural inhabitants.

3. Rwanda participates in UNESCO’s Man and the Biosphere Programme, and has one biosphere reserve, the Volcanoes National Park (UNEP, GA and MOP2, 2011).

4. A sector is an administration unit with a population estimated to be between 25,000 and 35,000 in a rural area.

5. See Table III for specific variables.

References


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Distribution of agricultural productivity gains in selected Feed the Future African countries

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Abstract
Purpose – The purpose of this paper is to examine investments in selected Feed the Future countries in Africa.
Design/methodology/approach – The authors examine three investments in Feed the Future countries (e.g. Rwanda and Uganda) in the context of non-traded goods, exports and imports. These investments include research and development in Ugandan cassava production, a value chain intervention in the coffee market channel in Rwanda and a program to increase the use of fertilizer for maize production in Rwanda. The authors also stress the importance of distributional impacts in terms of policymaking.
Findings – The results show that while there can be net gains from each investment discussed, the distributional effects of each are very different.
Originality/value – The findings will be useful for the development community and agribusiness policymaking.
Keywords Coffee, Maize, Cassava, Benefit-cost analysis, Distributional effects, Input subsidies

1. Introduction
President Barrack Obama pledged at least $3.5bn over three years in response to the global hunger crisis in 2009 at the G8 conference in L’Aquila, Italy. This pledge led to the US Government’s Feed the Future initiative which was implemented with the US Agency for International Development (USAID) as the lead agency (Bahn and Lane, 2012). Feed the Futures’ goal is to “sustainably reduce global poverty and hunger.” Feed the Future countries are Ethiopia, Ghana, Kenya, Liberia, Malawi, Mali, Mozambique, Rwanda, Senegal, Tanzania, Uganda and Zambia in Africa; Bangladesh, Cambodia, Nepal and Tajikistan in Asia; and Guatemala, Haiti and Honduras in the Americas. Feed the Future efforts have focused on staple food value chains and the disruptions that occur, but there is an ongoing dialog over whether the focus should include smallholder cash crops as a critical intervention for reducing poverty. For example, the USAID invests in marketing channels such as the Sustainable Partnerships to Enhance Rural Enterprises and Agribusiness Development (SPREAD) in Rwanda. In turn, SPREAD then invests in the marketing channel for coffee and pyrethrum (a natural pesticide).

Typically, these interventions or investments are to be evaluated using cost-benefit analysis (CBA). The UNIDO Guidelines for Project Evaluation (Dasgupta et al., 1972) provides a basic framework for its application in a development context. USAID (2017) renewed its focus on CBA to analyze proposed investments in developing countries due to both a general decline in the rate of official development assistance (ODA) donor funding in addition to the commitment to end extreme poverty under the Feed the Future initiative (USAID, 2017). According to Mason (2012), between 1990 and 2012, total ODA to lower-income and middle-income countries grew at an annual rate of only about 4 percent, while foreign direct investment (FDI) concurrently increased annually by about 16.5 percent. By 2012, FDI flows to the developing world were nearly five times larger than all ODA flows combined.

JEL Classification — D61, O22, D63, O13
Despite the emphasis on CBA analysis for projects in the Feed the Future African countries, little work has been done on assessing the payoff from various forms of government assistance from a theoretical perspective and how the expected results hinge on a theoretical basis. The purpose of this study is to demonstrate that the impact of various types of investments hinges critically on the nature of the market studied. For example, for many African countries, it is inappropriate to assume that the interventions in value chains have a terms of trade effect. Yet, these large-country assumption models are generally assumed in the theoretical base for CBA. Also, this study examines the effect of different market assumptions on the size and distribution of costs and benefits applied to development programs in selected Feed the Future African countries. Ravallion (2016) recognized that the market system yields a high level of poverty (or inequality), which could be due to distributional inequalities in original factors of production. However, one of the goals of many development interventions is to reduce the level of income inequality. We examine four case studies of development interventions in Africa, focusing primarily on the large-vs small-country assumptions and the effect these assumptions will have on costs and benefits to these interventions. We show for many countries the assumptions that are appropriate yield far less gains from interventions than found in the literature based on large-country assumptions.

This study focuses on four different potential interventions in USAID Feed the Future countries. First, we quantify the expansion of the supply of cassava in Uganda based on a closed economy model. We analyze the investment in improved cultivars, which increased the overall production of cassava, yielding increased consumer and producer surplus. Under this scenario, both consumers and producers share the benefits of expanding the production of cassava.

Second, we expand this model by considering the implications of increasing the supply of cassava given that some of the product is used to produce ethanol. In this case, extending the market to include ethanol production raises the concern that some of the consumer gains would be eliminated.

Third, we consider the investment in marketing channels in Rwanda that allows farmers to sell higher quality coffee, considering both the small-country and large-country cases. In the small-country case, prices are unaffected by this investment. In general, moving coffee from low-quality markets to high-quality markets benefits producers who previously were unable to sell high-quality coffee, while larger producers who were already able to sell high-quality coffee are hurt by the investment. In addition, most of the gains to consumers may accrue outside the country of interest. Specifically, in the case of Rwanda, the consumer gains may accrue in the USA and the European Union.

Fourth, we focus on maize production in Rwanda and the effect of fertilizer subsidies. Here the small-country assumption is critical as the world price of maize is unaffected by maize production in Rwanda. In this case, we examine efforts to reduce the price of fertilizer through subsidies or investments in the fertilizer marketing channel. We show that there are significant gains to producers from fertilizer subsidies, recognizing that the cost of fertilizer subsidies may exceed these gains. However, consumers do not benefit because of the fixed world market price for maize.

From these models, one can draw conclusions on the effect of development investments by country and commodity type. For example, the impact on food security of new developments in cassava is likely much greater than improving coffee marketing channels or subsidizing fertilizer for maize production.

From a policy perspective, if the objective is to lower food prices and increase food consumption, one strategy for investment in development projects might be to emphasize commodities whose production affects prices. If investments are targeted at improving only farmers’ income, the focus might be on those commodities whose production does not affect prices.
2. Case studies

2.1 Cassava in Uganda

This paper considers the potential investment in an improved variety of cassava in Uganda. Cassava, a major food item in Uganda and other countries in Africa, is affected by a variety of diseases that reduce the quantity and quality of root vegetables. One such example is Cassava Brown Streak Disease, which prolifically re-emerged in Uganda in 2007 (the disease was recorded in 60 percent of traditional cassava varieties and 20 percent of previously resistant varieties) (Alicai et al., 2007). Hence, in this case study, we assume that a donor investment in agricultural research and development (R&D) would either reduce the incidence of disease or increase the productivity of existing varieties. From an economic perspective, we assume a closed economy framework largely because transportation constraints, among other factors, rule out international trade (Otín-Nape and Bua, 1997).

In Figure 1, $S$ and $D$ are the supply schedules under traditional cassava varieties. The price is $p_1$ and quantity is $q_1$. We assume that through R&D, a new hybrid variety of cassava is developed that increases both yield and consumer acceptance (i.e. it may improve the nutritional quality of cassava). With the introduction of a new cassava hybrid, supply demand is $S'$ and the new equilibrium price and quantity are $p_2$ and $q_2$, respectively.

Consumers gain $p_1p_{ba}$ and producers gain $p_2db−p_1ca$.

Quality improvements can affect the return on investment. Consider the shift in demand from $D$ to $D'$. At the new equilibrium price $p_1$, consumption is $q_3$. Under this case, producers gain $p_1de−p_1ca$, while consumers gain $pp_1e−fp_1a$. Therefore, the rates of return are higher from projects that simultaneously create both demand and higher production, which is an important consideration for food security analysis.

Consider the instance in which production exceeds expectations, so at price $p_2$ production is $q^*$ so that price must fall. This appears to be what occurred in 2016 when cassava prices fell sharply. According to Sothear (2016), cassava prices, which were 6 baht (about 680 riel) per kg in 2015, dropped to 4.6 baht (about 525 riel) in 2016. As a result, producers in Uganda are lobbying for ethanol credits to divert cassava into fuel and away from its use as food due to higher demand and prices for ethanol (Oketch, 2016). In addition to producer lobbying, a large ethanol plant has been built in Northern Uganda, creating an ease of access for diverting cassava into fuel production.

![Figure 1. Research and development assuming a closed economy for cassava](image-url)

**Notes:** $p^*$ denotes the original equilibrium price; $q^*$ denotes the original equilibrium quantity.
2.1.1 Empirical analysis: new cassava variety for food use. Simiwe (2015) described the change in cassava prices and quantities in response to the World Bank’s East Africa Agricultural Productivity Project’s investment in R&D on cassava. Before this investment, Uganda produced 6.0m tons of cassava with a market price of USH 400 per kg (about $0.13/kg). After the investment in research, the production increased to 11.3m tons, but the price declined to USH 250/kg (about $0.08/kg).

In our empirical analysis on the impact of R&D (Figure 1), the demand price elasticity is $-2.356$. We hypothesize that consumers will benefit relatively more from the shift in supply than producers. This is because $p_1p_{db} - p_2ca$ is greater than $p_2db - p_1ca$. The numerical results presented in Table I are consistent with this hypothesis. The gain in consumer welfare is $432,480$, while the gain to producers is $70,880$.

One problem with the baseline example for cassava discussed in the preceding paragraph is that the implicit elasticity of demand is $-2.356$. While this elasticity may be adequate for cassava used to produce ethanol, it is extremely elastic for basic consumption goods. Hence, we change the model slightly to consider two alternative elasticities for cassava demand.

We first assume that the demand for cassava is unitary (a demand elasticity of $-1.000$). Under this scenario, the market price after the R&D intervention is $0.066/kg and the quantity produced and sold increases to 9.0m tons (compared to 11.3m tons above). As such, gains to consumers increase to $513,850$ while gains to producers fall to $-100,570$. Second, assuming an inelastic demand of $-0.750$, the price after R&D intervention falls to $0.062/kg, with 8.4m tons produced. Again, gains to consumers increase to $513,850$, while producer surplus falls to $-139,360$.

While farmers gain from technological change through decreased cost of production, the reduction in price under an inelastic demand falls significantly, which offsets the reduced cost of production. As a result, consumers gain from lower prices, while farmers lose from lower prices. However, because cassava is typically raised by near subsistence households, there may be significant gains to home consumption that are not captured in market transactions. Therefore, there may be unseen benefits that are not reflected by this model.

2.1.2 Empirical analysis: new variety of cassava for both food and fuel. The use of cassava for ethanol production resembles the use of corn to produce ethanol in the USA. The analysis by Schmitz et al. (2007) calculates the gainers and losers from the US corn ethanol program. They show that there can be net welfare costs from converting food into ethanol in addition to a potential conflict between food security and energy security.

Consider Figure 2, where $S$ and $D$ are the supply and demand for corn. Consumers pay $p_1$. Producers’ output is $q_1$. A subsidy to produce ethanol from cassava shifts the total

<table>
<thead>
<tr>
<th>Welfare area</th>
<th>Original elasticity ($-2.356$)</th>
<th>Unitary elasticity ($-1.00$)</th>
<th>Inelastic ($-0.75$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without additional ethanol</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumer gain ($abcd$)</td>
<td>432.48</td>
<td>513.85</td>
<td>513.85</td>
</tr>
<tr>
<td>Producer gain ($0ca-0ba$)</td>
<td>70.88</td>
<td>$-100.57$</td>
<td>$-139.36$</td>
</tr>
<tr>
<td>Net welfare gain</td>
<td>503.36</td>
<td>410.33</td>
<td>374.49</td>
</tr>
<tr>
<td>With additional ethanol processing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 percent margin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumer loss ($p_1p_{ab}$)</td>
<td>326.49</td>
<td>383.82</td>
<td>296.46</td>
</tr>
<tr>
<td>Producer gain ($p_1p_{ac}$)</td>
<td>469.94</td>
<td>621.92</td>
<td>660.04</td>
</tr>
<tr>
<td>Net welfare gain</td>
<td>143.45</td>
<td>238.10</td>
<td>263.58</td>
</tr>
<tr>
<td>20 percent margin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumer loss ($p_1p_{ab}$)</td>
<td>116.91</td>
<td>222.46</td>
<td>241.87</td>
</tr>
<tr>
<td>Producer gain ($p_1p_{ac}$)</td>
<td>131.26</td>
<td>292.20</td>
<td>329.54</td>
</tr>
<tr>
<td>Net welfare gain</td>
<td>14.35</td>
<td>69.74</td>
<td>87.98</td>
</tr>
</tbody>
</table>

Table I. Cassava: technological change in Uganda
demand from $D$ to $D_E$ (Schmitz et al., 2010); output increases to $q_2$ and price rises to $p_2$. Output $q_2 - q_3$ is used for ethanol production. Because of the price increase from the ethanol subsidy, cassava producers gain $p_2 - p_1 b_a$, but consumers lose $p_2 b_c$. Thus, there is a conflict between food vs energy use from cassava.

Kleih et al. (2012) provided a detailed analysis of cassava use in Uganda. In Table II, the quantity of cassava that is marketed through formal market channels to agribusiness concerns is about 308,050 tons (about 5 percent of the baseline scenario presented above). The remainder of the product is most likely consumed by households – possibly passing through local producer markets. Of the 5 percent of cassava marketed through value-added channels, the largest share (39 percent) is used in large-scale mills primarily as a substitute for wheat flour. Kleih et al. (2012) also found that Uganda imports about 90 percent of its ethanol requirements (e.g. 90 percent of 20m liters per year).

Okorondu et al. (2009) suggested that 1 kg of cassava starch can produce 1.96 liters of ethanol. Hence, to produce 18m liters of ethanol would require 9,183,673 kg of cassava starch. Cassava root is typically 65 percent starch (Sanchez and Cardona, 2008). Thus, about 14.13m tons of cassava root would be required to meet the 18-m-liter target, which is over twice the baseline level of cassava production considered here.

![Figure 2. Model of cassava used in the production of ethanol](image)

<table>
<thead>
<tr>
<th>Use</th>
<th>Current use</th>
<th>Short term</th>
<th>Medium term</th>
<th>Long term</th>
<th>Demand – root cassava (mt/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large-scale mills</td>
<td>0</td>
<td>0</td>
<td>15,000</td>
<td>30,000</td>
<td>120,000</td>
</tr>
<tr>
<td>Bakeries (rural)</td>
<td>Limited</td>
<td>0</td>
<td>7,000</td>
<td>14,000</td>
<td>56,000</td>
</tr>
<tr>
<td>Bakeries (urban)</td>
<td>Very limited</td>
<td>0</td>
<td>0</td>
<td>8,000</td>
<td>32,000</td>
</tr>
<tr>
<td>Composite flour</td>
<td>700</td>
<td>700</td>
<td>1,000</td>
<td>2,000</td>
<td>8,000</td>
</tr>
<tr>
<td>Biscuit Man</td>
<td>Limited</td>
<td>200–300</td>
<td>1,000–2,000</td>
<td>3,500–4,500</td>
<td>16,000</td>
</tr>
<tr>
<td>Animal feed</td>
<td>300–500</td>
<td>1,200–2,000</td>
<td>3,000–5,000</td>
<td>2,000</td>
<td>24,000</td>
</tr>
<tr>
<td>Paperboard</td>
<td>150</td>
<td>500</td>
<td>900</td>
<td>1,400</td>
<td>5,000</td>
</tr>
<tr>
<td>Breweries</td>
<td>0</td>
<td>1,500–2,500</td>
<td>3,500</td>
<td>5,000</td>
<td>15,000</td>
</tr>
<tr>
<td>Distilling</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Textiles</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>150</td>
<td>500</td>
</tr>
<tr>
<td>Plywood</td>
<td>250</td>
<td>250</td>
<td>300</td>
<td>300–400</td>
<td>14,000</td>
</tr>
<tr>
<td>Sweets</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3,000</td>
<td>13,800</td>
</tr>
<tr>
<td>Other starches</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>500–1,000</td>
<td>3,750</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>308,050</td>
</tr>
</tbody>
</table>

**Table II.** Cassava use in Uganda

**Source:** Kleih et al. (2012)
However, for comparison, 1 kg of cassava root will produce 1.274 liters of ethanol, while one bushel of corn will produce 3.36 gallons (about 0.5 liters per kg) of ethanol (National Corn Growers Association, 2014). This contrast to corn indicates that estimates for cassava to ethanol conversion may be overly optimistic.

The price of ethanol (NASDAQ on November 17, 2017) was $1.40/gallon, implying a price in Uganda of USH 1,138/liter. Thus, the gross value of cassava root transformed into ethanol would be USH 1,450/kg, which far exceeds the original price of cassava in Uganda of USH 400/kg. This price implies that the cost of transforming cassava into ethanol exceeds USH 1,050/kg (or at least a margin of 71.7 percent). Without more data, we assume a margin of 75 percent; hence, the breakeven price for cassava would be USH 353/kg. Given these assumptions, the technological change in cassava production would be sufficient to lead to limited ethanol production in Uganda (i.e. the required price of USH 353/kg is higher than the new market equilibrium of USH 250/kg described in the original scenario).

The possibility of processing cassava into ethanol is presented in Figure 3. The total demand curve \( D \) in Figure 3 has been replaced by a “kinked” demand curve \( D_T \). This new demand curve is identical to the original demand curve for prices less than \( p^* \) and quantities less than \( q^* \). The demand curve to the left of this point is a traditional demand curve, where cassava is used for foodstuffs, including agribusiness processing and household consumption. To the right of this kink, the demand for cassava for food competes with the use of cassava to produce ethanol. According to our assumptions, this change occurs when over 7.55m tons of cassava are produced and marketed. This amount will form an implicit upper bound of cassava for food – the remaining cassava produced will be used to produce ethanol. With the possibility of using cassava to produce ethanol, the amount of cassava produced increases to \( q' \), which is 15.97m tons, given our numeric assumptions.

Under the ethanol scenario, those who consume cassava as food in Uganda will be worse off and cassava producers will be better off. Given that the use of cassava to produce ethanol produces a “price floor” for cassava in Uganda – the price consumers pay for cassava would increase from \( p_1 \) to \( p^* \) (numerically from USH 250 to USH 353). As a result of this, consumers lose \( p^* - p_1 \) \( b \) ($326,490), while producers gain \( p^* - p_1 \) \( ac \) ($469,940). The net welfare gain is then $143,450. To demonstrate the sensitivity of this analysis that arises from assumptions about

\[ S \]

**Notes:** \( p^* \) denotes the original equilibrium price; \( q^* \) denotes the original equilibrium quantity

**Figure 3.** Gains and losses in cassava production in Uganda with ethanol production
the cost of transforming cassava into ethanol, we reduce the profit margin for cassava starch to 80 percent – resulting in a cassava price of USH 282/kg, which is much closer to the food price observed after the increase in supply. Under this scenario, consumer loss falls to 816,910 while producer gain declines to 131,260. In fact, if the profit margin falls to 82.3 percent, the price of cassava used to produce ethanol will drop to USH 250/kg and no cassava will be used to produce ethanol.

2.2 Coffee in Rwanda

The SPREAD made investments that improved the market channels for coffee in order to increase the returns to smallholders. These include investments in coffee grading facilities and in coffee washing stations to process cherry coffee into green coffee.

Figure 4 presents a stylized model of the impact of SPREAD on coffee in Rwanda, which is an export good with two market channels. The first channel (a fully washed market channel) is of high quality in which coffee is sold at a premium on the world coffee market. The output is moved through coffee washing stations that fully remove the fruit (e.g. the cherry) from the coffee and dries the green coffee in a timely manner, which allows the coffee to be graded for higher quality. The second channel (the traditional partially washed market channel) is of lower quality (the cherry is partially removed in small batches) and is sold as filler coffee.

The supply of low-quality coffee in Rwanda is $S_L^Q$. We assume that only smallholders produce low-quality coffee. Producers face a perfectly elastic demand curve for low-quality coffee on the world market ($D_L^Q$). Before the policy intervention, there are two supply curves for high-quality (fully washed) coffee: $S_H^Q$ which is the quantity of high-quality coffee produced by smallholders and $S_C^Q$ which is the quantity of high-quality coffee produced by larger (or commercial) producers. Therefore, the total supply of high-quality coffee is $S_T^Q$.

Next, we assume the demand for high-quality coffee produced in Rwanda is downward sloping ($D_H^Q$). Technically, we assume that Rwandan coffee has a downward sloping total demand curve from specialty houses, such as Starbucks; however, we assume that there are several close substitutes, such as Kenyan coffee, which makes this demand curve

Figure 4. Benefits and costs from improving the quality channel for coffee in Rwanda
relatively flat. Before SPREAD, the intersection price is determined by the intersection of the total supply curve and the total demand curve.

To determine the impact of SPREAD, we assume that, before SPREAD’s implementation, 60 percent of all coffee in Rwanda is grown by smallholders (Table III) and that 40 percent of this coffee is marketed as fully washed. Using the average annual coffee production in Rwanda for 2008 through 2013, we assume that 43.4m pounds of coffee are produced in Rwanda in a representative year. Next, we assume that SPREAD increased the amount of fully washed coffee produced by smallholders from 40 to 60 percent. In Figure 3, the supply for smallholders shifts outward to $S_{HQ}^0$. This new supply relationship added to the supply curve for commercial producers shifts the total supply curve outward to $S_{TQ}^0$. The quantity of fully washed coffee increases from 27.8m pounds to 30.4m pounds (Figure 4). However, the price for high-quality coffee declines from $2.65/pound to $2.45/pound. Completing the picture, the quantity of partially washed coffee falls from 15.6m pounds to 11.4m pounds. In this analysis, we assume that the price for the lower quality filler coffee is $1.34/pound (the price of other mild Arabica coffees).

Table IV presents the benefits and costs of the policy intervention. The largest gainers are consumers who gain $5.9m. However, since 93 percent of Rwandan coffee is exported, most of this gain accrues to consumers in Europe and the USA. Furthermore, while small producers gain $4.7m from marketing more high-quality coffee, they sacrifice $2.0m from the lower price on their original production (e.g. $p_{HQ1}^1$-$p_{HQ1}^2$) and $1.3m from profits in the

<table>
<thead>
<tr>
<th>Percent of total output</th>
<th>Fully washed coffee</th>
<th>Partially washed coffee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original shares of coffee production</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large producers</td>
<td>40.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Small producers</td>
<td>60.0</td>
<td>40.0</td>
</tr>
<tr>
<td>Original coffee production (1,000 pounds)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large producers</td>
<td>17,348</td>
<td>17,348</td>
</tr>
<tr>
<td>Small producers</td>
<td>26,022</td>
<td>10,409</td>
</tr>
<tr>
<td>43,370</td>
<td>27,757</td>
<td>15,613</td>
</tr>
<tr>
<td>New coffee production (1,000 pounds)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large producers</td>
<td>15,508</td>
<td>15,508</td>
</tr>
<tr>
<td>Small producers</td>
<td>26,243</td>
<td>14,887</td>
</tr>
<tr>
<td>41,750</td>
<td>30,395</td>
<td>11,355</td>
</tr>
<tr>
<td>New shares of coffee production</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large producers</td>
<td>37.1</td>
<td>100.0</td>
</tr>
<tr>
<td>Small producers</td>
<td>62.9</td>
<td>56.7</td>
</tr>
</tbody>
</table>

Table III. Coffee production in Rwanda: large and small producers

<table>
<thead>
<tr>
<th>Benefit or cost (%)</th>
<th>Estimate – large country</th>
<th>Estimate – small country</th>
</tr>
</thead>
<tbody>
<tr>
<td>$bgh$ (gain to Rwanda smallholders)</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td>$p_{HQ1}^0$-$p_{HQ2}^0$ (gain to coffee importers)</td>
<td>4,735.23</td>
<td>4,089.36</td>
</tr>
<tr>
<td>Total benefits</td>
<td>5,853.55</td>
<td>4,931.59</td>
</tr>
<tr>
<td>$p_{HQ1}^iab$-$p_{HQ2}^i$ (loss to smallholders)</td>
<td>1,984.35</td>
<td>1,687.69</td>
</tr>
<tr>
<td>$p_{HQ1}^icd$-$p_{HQ2}^d$ (loss to largeholders)</td>
<td>3,307.25</td>
<td>2,829.48</td>
</tr>
<tr>
<td>Total cost</td>
<td>6,588.78</td>
<td>6,020.95</td>
</tr>
<tr>
<td>Net welfare increase</td>
<td>1,269.01</td>
<td>1,163.26</td>
</tr>
<tr>
<td>Benefit-cost ratio</td>
<td>1.61</td>
<td>1.58</td>
</tr>
</tbody>
</table>

Table IV. Benefit-cost analysis: improvements in coffee marketing in Rwanda
low-quality market (e.g. $p^{LQ}ij - p^{LQ}ki$). In net, smallholders only gain $1.4m. Finally, large producers lose $3.3m from the decrease in high valued coffee prices.

The story of whether SPREAD benefits Rwanda as a whole is indeed complicated. While the imputed value to smallholders is somewhat smaller than the observed benefits to rural households that produce coffee, the gains from the intervention are due largely to the consumer gains in developed countries. At the extreme, if we place a 0 weight on these benefits to foreign consumers, the benefit/cost ratio is far below 1.

Some may refute the assumption that the demand curve for high-quality Rwandan coffee is downward sloping because this implies that the analysis is conducted under the large-country assumption that is often used in international trade economics. As such, we consider how these results compare under the assumption that Rwanda is a small country in which the terms of trade are unaffected by the policy intervention. To analyze the impact of this assumption on our results, Table III includes a second set of “small-country” results. To generate these results, we increase the elasticity of demand to $-20$. Under this scenario, the benefits to consumers fall to nearly 0, from $5854$ to $841$, while the gains to smallholders increase from $4734$ to $5756$. Similarly, the loss to large producers ($p^{HQ}1 p^{HQ}2 dc$) approaches 0.

In terms of the distribution of benefits from the investment in the coffee marketing channel, as depicted in Table V, small producers received an economic surplus of $14.5m (24.0 percent of total surplus) while large producers received a surplus of $16.4m (27.3 percent of total surplus). The consumer surplus was $29.4m (48.7 percent of surplus). The investment in coffee value chains increased the economic surplus to small producers to $16.0m, or about 24.9 percent of all surplus, while reducing the rents to large producers to $13.2m, or 20.4 percent of the total surplus. Consumers gain the largest increase in relative economic surplus. They now receive 54.7 percent of the overall surplus in the coffee marketing channel, or $35.3m.

2.3 Maize in Rwanda
Rwanda, which imports corn while also providing a fertilizer subsidy for domestic production, is also a price taker in that its production does not affect the import price of corn (Rwanda Ministry of Agriculture and Animal Resources, 2014). In Figure 5, the demand for corn is given by $D$ and domestic supply by $S$. At price $p_1$, domestic production is $q_1$, consumption is $q_2$ and corn imports total $q_2 - q_1$.

The introduction of a subsidy on fertilizer shifts supply of maize to $S'$. Domestic production increases from $q_1$ to $q_2$, while imports fall to 0. However, this need not be the case. For example, if supply shifted to $S^*$ and not to $S'$, imports would total $e - d$. The effect of the subsidy is as follows: the producers of corn in Rwanda gain $abcd$, consumers are unaffected and there is a savings in foreign purchases of corn equal to $aq_1q_2d$.

<table>
<thead>
<tr>
<th>Surplus measure</th>
<th>Original equilibrium</th>
<th>60 percent increase from baseline</th>
<th>50 percent increase from baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total economic surplus</td>
<td></td>
<td>Level</td>
<td>Level</td>
</tr>
<tr>
<td>Small producers</td>
<td>14,529.46</td>
<td>16,011.33</td>
<td>1,481.87</td>
</tr>
<tr>
<td>Large producers</td>
<td>16,460.67</td>
<td>13,153.43</td>
<td>-3,307.25</td>
</tr>
<tr>
<td>Consumers</td>
<td>29,396.75</td>
<td>35,250.30</td>
<td>5,853.55</td>
</tr>
<tr>
<td>Total surplus</td>
<td>60,386.87</td>
<td>64,415.05</td>
<td>63,717.39</td>
</tr>
</tbody>
</table>

Table V. Investments in coffee marketing channels in Rwanda: consumers and producers

<table>
<thead>
<tr>
<th>Percent of total surplus</th>
<th>Original equilibrium</th>
<th>60 percent increase from baseline</th>
<th>50 percent increase from baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small producers</td>
<td>24.06</td>
<td>24.86</td>
<td>24.73</td>
</tr>
<tr>
<td>Large producers</td>
<td>27.26</td>
<td>20.42</td>
<td>21.39</td>
</tr>
<tr>
<td>Consumers</td>
<td>48.68</td>
<td>54.72</td>
<td>53.88</td>
</tr>
</tbody>
</table>
From the above result, producers are the major beneficiary of fertilizer subsides, which is quite different from the usual case. Consider Figure 5, where $S$ and $D$ are the supply and demand for corn in a closed model setting. At price $p_1$, corn production is $q_1$. A subsidy on fertilizer shifts supply to $S'$, causing price to decline to $p_3$ and the quantity to falls to $q_3$. Consumers gain $p_1 p_3 a$. Producers gain $p_3 c f - p_1 b a$. Depending on the price elasticities of both demand and supply, consumers can end up with more of the gain from the import subsidy than do producers (Schmitz et al., 2010).

Table VI presents an overview of Rwanda’s production, imports and exports of maize (Food and Agriculture Organization of the United Nations, 2017). In 2013, Rwandan production plus net imports amounted to 723,285 tons of maize. Of this total, production accounted for 92.3 percent. However, as recently as 2004, imports amounted to 26.8 percent of total maize in Rwanda. On average, between 2004 and 2013, domestic production accounted for 83.2 percent of maize consumed in Rwanda. Also, as shown in Table VI, the maize yield in Rwanda is quite low. The yield increased from 0.70 ton/ha in 2000 to 2.50

<table>
<thead>
<tr>
<th>Year</th>
<th>Yield (hg/ha)</th>
<th>Production (mt)</th>
<th>Area (ha)</th>
<th>Imports (mt)</th>
<th>Exports (mt)</th>
<th>Total maize (mt)</th>
<th>Corn price ($/mt)</th>
<th>Urea price ($/kg)</th>
<th>Yield (mt/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>7.018</td>
<td>62,501</td>
<td>89,053</td>
<td>30,000</td>
<td>0</td>
<td>92,501</td>
<td>88.22</td>
<td>101.12</td>
<td>0.70</td>
</tr>
<tr>
<td>2001</td>
<td>7.671</td>
<td>80,979</td>
<td>105,560</td>
<td>4,002</td>
<td>0</td>
<td>84,981</td>
<td>89.61</td>
<td>95.32</td>
<td>0.77</td>
</tr>
<tr>
<td>2002</td>
<td>8.763</td>
<td>91,688</td>
<td>104,628</td>
<td>25,170</td>
<td>0</td>
<td>116,856</td>
<td>99.33</td>
<td>94.36</td>
<td>0.88</td>
</tr>
<tr>
<td>2003</td>
<td>7.672</td>
<td>78,886</td>
<td>102,820</td>
<td>16,957</td>
<td>0</td>
<td>94,333</td>
<td>105.19</td>
<td>138.90</td>
<td>0.77</td>
</tr>
<tr>
<td>2004</td>
<td>7.670</td>
<td>88,209</td>
<td>115,000</td>
<td>32,362</td>
<td>0</td>
<td>120,571</td>
<td>111.78</td>
<td>175.29</td>
<td>0.77</td>
</tr>
<tr>
<td>2005</td>
<td>8.889</td>
<td>97,251</td>
<td>109,400</td>
<td>16,385</td>
<td>5</td>
<td>113,631</td>
<td>98.41</td>
<td>219.02</td>
<td>0.89</td>
</tr>
<tr>
<td>2006</td>
<td>8.531</td>
<td>96,662</td>
<td>113,312</td>
<td>29,076</td>
<td>552</td>
<td>125,186</td>
<td>121.59</td>
<td>222.93</td>
<td>0.89</td>
</tr>
<tr>
<td>2007</td>
<td>7.201</td>
<td>101,659</td>
<td>141,168</td>
<td>45,207</td>
<td>1,465</td>
<td>145,401</td>
<td>163.26</td>
<td>309.40</td>
<td>0.72</td>
</tr>
<tr>
<td>2008</td>
<td>11,515</td>
<td>166,853</td>
<td>144,896</td>
<td>7,791</td>
<td>138</td>
<td>174,506</td>
<td>223.25</td>
<td>492.73</td>
<td>1.15</td>
</tr>
<tr>
<td>2009</td>
<td>19,503</td>
<td>286,946</td>
<td>147,129</td>
<td>52,957</td>
<td>175</td>
<td>339,728</td>
<td>165.54</td>
<td>249.58</td>
<td>1.95</td>
</tr>
<tr>
<td>2010</td>
<td>23,416</td>
<td>432,404</td>
<td>184,658</td>
<td>118,064</td>
<td>1,633</td>
<td>548,835</td>
<td>186.01</td>
<td>288.59</td>
<td>2.34</td>
</tr>
<tr>
<td>2011</td>
<td>23,529</td>
<td>525,679</td>
<td>223,414</td>
<td>66,559</td>
<td>1,691</td>
<td>590,547</td>
<td>291.78</td>
<td>420.96</td>
<td>2.35</td>
</tr>
<tr>
<td>2012</td>
<td>22,587</td>
<td>573,038</td>
<td>253,698</td>
<td>101,154</td>
<td>7,245</td>
<td>666,947</td>
<td>298.41</td>
<td>405.40</td>
<td>2.26</td>
</tr>
<tr>
<td>2013</td>
<td>22,845</td>
<td>667,833</td>
<td>292,326</td>
<td>62,940</td>
<td>7,488</td>
<td>723,285</td>
<td>258.96</td>
<td>340.12</td>
<td>2.28</td>
</tr>
<tr>
<td>2014</td>
<td>25,009</td>
<td>583,096</td>
<td>233,150</td>
<td>–</td>
<td>–</td>
<td>233,150</td>
<td>–</td>
<td>192.88</td>
<td>2.50</td>
</tr>
</tbody>
</table>
ton/ha in 2014. The lower yields in the years around 2000 can be attributed to several factors, a major factor being soil depletion.

We consider Rwanda’s maize market in 2005 when the total maize production was 97,251 tons and Rwanda imported 16,385 tons. In 2005, Rwandan farmers planted 109,400 ha of maize, but produced only 0.89 ton/ha. Next, we assume the yields increased to 2.34 (or the observed level in 2010). The estimated supply elasticity of 0.0635 was obtained by regressing the log change in quantity on the log change in price. We then construct a linear supply curve using both 2005 and 2010 as base years. Finally, assuming a maize price of $192.88/ton, the supply of maize in Rwanda would be 103,179 tons based on the supply function in 2005 and 443,360 tons based on the supply function in 2010. To complete the model, we assume that demand of maize in Rwanda is the average of the total amount available (i.e. production plus imports less exports) for 2010–2013, or 632,404 tons. This implies a reduction in imports from 529,224 tons to 189,044 tons. Based on these assumptions, the gain in producer surplus is $65.6m. Given our assumption of a parallel shift in supply, the gain in producer surplus is identical to the saving in foreign exchange.

3. Overview
The overview of the above discussion on cassava and coffee can be put in context in Figure 6. Considering a simplified version of our coffee model, given the demand curve (foreign demand) for coffee of \( D_F \) and domestic supply of \( S \), the trade price is \( P_F \) and all of the coffee is exported \( (q^*) \). From a supply shift of \( S_0 \), the price falls to \( P_0 \). Foreign coffee consumers gain \( abP_F \), along with domestic producers. Domestic consumers are unaffected by the supply shift to \( S'_0 \).

Now consider cassava where demand is \( D_p \) and supply is \( S' \). The corresponding price is \( p_1 \) and the quantity produced is \( q_1 \). Unlike in the coffee case, a supply shift due to R&D causes the price to fall to \( p_2 \) and quantity to increase to \( q_2 \) where both consumers and producers gain. Consumers gain \( p_1q_1e \). Producers gain \( (p_2fi) - (p_1qe) \).

4. Summary and conclusions
We analyzed the impact of four different investments in development projects – for cassava, coffee and maize – in selected Feed the Future African countries. The results critically depend on several parameters, including the extent to which interventions affect both international and domestic prices. In the case of cassava, the price impacts of a donor investment can be significant. We analyzed the investment in better cultivars, which increased the overall production of cassava. This increase yielded both increased consumer and producer welfare. However, extending the market to include the possibility of ethanol.

Figure 6. Effect of technical change with foreign and domestic demands
production raised the concern that some of the consumer gains would be eliminated. For coffee, we examined the investment in marketing channels that allowed the farmers to sell higher quality coffee. In this analysis, we considered both the small-country and large-country cases. In the small-country case, prices were unaffected by this investment. This analysis highlights the complexity that may result from such interventions. Specifically, moving coffee from low markets to high-quality markets benefits producers who previously were unable to sell high-quality coffee, while larger producers who traditionally sold high-quality coffee are hurt by the investment. In addition, most of the gains to consumers may accrue outside the country of interest. Specifically, in the case of Rwanda, the consumer gains may accrue in the USA and the European Union. Next, we examined the small-country case for maize where world prices are given and are unaffected by maize production in Rwanda. In this case, we examined efforts to reduce the price of fertilizer either through subsidies or investments in the fertilizer marketing channel. In this scenario, we see significant gains to producers; however, we must recognize that the cost of fertilizer subsidies may exceed these gains. In addition, consumers do not benefit because of the fixed world market price for maize. From these models, one can draw significant conclusions of the effect of development investments by country and commodity type. For example, the food security impact of new development in cassava is likely much greater than improving coffee marketing channels or subsidizing fertilizer for maize production. Of course, there are many other options, including the investment in human capital.

From a policy perspective, if the objective is to lower food prices and increase food consumption, one strategy for investment in development projects might be to emphasize commodities, the production of which affects prices. However, if these investments are targeted at improving producers' income only, the focus might be on those commodities where production does not affect prices.

A role of economics is to point out the optimal use of scarce resources. The efficient allocation of resources depends on how investments affect the distribution of benefits to consumers and producers. A priori analysis of government actions such as interventions in developing economies yields insights into the potential payoffs from these investments. Ideally, in benefit-cost analysis, projects should be ranked before investments are undertaken. As our paper shows, the assumptions underlying the market structure provide critical information about ranking projects. Unfortunately, for many investments in African countries the payoff is relatively small because of the critical assumption that these investments fall under “the small-country case” where these investments do not affect domestic or international prices. Also, the distributional effect from investments and supply chains depends on the percentage of the good that is exported.

References


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Volume 9 Number 1 2019

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Agribusiness and food security in Africa
Guest Editor: Charles B. Moss

1 Editorial boards
2 Guest editorial
4 Contribution of policy change on maize varietal development and yields in Kenya
   Latha Nagarajan, Anwar Naseem and Carl Pray
22 Building African agribusiness through trust and accountability
   Kristin Franklin and James Oehmke
44 Political will and public will for climate-smart agriculture in Senegal: opportunities
   for agricultural transformation
   Eric D. Raile, Linda M. Young, Adama Sarr, Samba Mbaye, Amber N.W. Raile, Lena Wooldridge,
   Diaminatou Sanogo and Lori Ann Post
63 Farmers’ usage preferences for Rwanda’s Volcanoes National Park
   Ildephonse Musafili, Jean Chrysostome Ngabitsinze, Fidèle Niyitanga and Dave Weatherspoon
78 Distribution of agricultural productivity gains in selected Feed the Future African
   countries
   Charles B. Moss and Andrew Schmitz

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