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Can farming provide a way out of poverty for smallholder farmers in central Mozambique?

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ABSTRACT

Given that agriculture is a key economic activity of the majority of people living in rural Africa, agricultural development is at the top of the agenda of African leaders. Intensification of agriculture is considered an entry point to improve food security and income generation in sub-Saharan African (SSA). We used a farm optimization model to perform ex-ante assessment of scenarios that could improve gross margin, a farmer's objective, and maize sales, a national policy objective to improve food security, of large and small farms in maize-based farming systems in two posts representative of rural Mozambique (Dombe and Zembe Administrative Posts in Central Province). For selling maize, farmers first had to be maize self-sufficient. We explored two options for increasing agricultural productivity: (i) extensification, to expand the current cultivated area; and (ii) intensification, to increase input use per unit of land. We considered two scenarios for each of the two options. Extensification: current situation (SC1), hired labour (SC2) and labour-saving (SC3). Intensification: land-saving (SC4) and combined improvement (SC5). For each scenario, we maximized gross margin and maize sales for large and small farms and assessed the trade-offs between the two goals. We further explored the impact of increasing labour and land availability at farm level beyond the current observed levels. SC4 substantially increased both gross margin and maize sales of large and small farms in both posts. Minor trade-offs were observed between the two goals on large farms whereas we saw synergies between the goals for small farms. In Dombe, the gross margin of large farms increased from \$ 5550 to \$ 7530 y^{-1} and maize sales from 12.4 t to 30.4 t y^{-1}. In Zembe, the annual gross margin increased from \$ 1130 up to \$ 2410 per farm and annual maize sales from 5.1 t up to 9.5 t per farm. For small farms in Dombe, the gross margin increased from \$ 1820 to \$ 2390 y^{-1} and maize sales from 3.0 t to 9 t y^{-1}. In Zembe, the annual gross margin increased from \$ 260 to \$ 810 and annual maize sales from 2.0 t to 3.6 t per farm. With the most optimistic scenarios and conditions of more hired labour and labour-saving technologies, both farm types substantially increased both gross margin and maize sales. We conclude that with available resources, the possibilities for increasing gross margin and maize sales are greater where agroecological conditions are more favourable and are much higher for larger farms. Without interventions that allow small farms to access more labour and land, intensification of agriculture is likely to happen only on farms of better-resourced households, indicating the need for alternative forms of on- and off-farm income generation for poorer farmers. The contribution of agriculture to national food security has to come from the large farms, requiring policy support.

1. Introduction

Global food demand for agricultural products will increase due to rising incomes in developing countries, and growth in world population, expected to reach 9.8 billion people by 2050 (United Nations, 2017). In addition, food production is threatened by climate change (Eriksen and Silva, 2009). This challenge will be more pronounced in agriculturally dependent economies such as those in sub-Saharan Africa (van Ittersum et al., 2016). Given that agriculture is the main economic activity of the majority of people living in rural areas, agricultural development is at the top of the agenda of African leaders (AGRA, 2015). Intensification of agriculture is considered an entry point to improve food security and to achieve inclusive economic growth in sub-Saharan Africa (SSA) (World Bank, 2008). Yet agricultural development is hampered by several factors, including depletion of soil fertility (Benson et al., 2012) and poor access to external inputs such as

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improved seed, mineral fertilizers and irrigation (Jayne et al., 2010). To tackle this problem, the African Union Member States committed to increase the use of improved seeds and fertilizers and promote good agricultural practices (Sanchez, 2015). This commitment is expressed through policies aiming at agricultural development such as the Comprehensive African Agriculture Development Programme (CAADP) and the Maputo Declaration to increase agriculture funding to at least 10% of the State budget policies aiming at agricultural development (NEPAD, 2003).

In Mozambique, agricultural productivity is poor with, for example, an average yield of only 0.9 t ha^{-1} (2005–2015) for the main staple crop maize (*Zea mays* L.) (MASA, 2015). Only 3% of the smallholder farmers use fertilizers (MINAG, 2012). The Government of Mozambique developed a Strategic Plan for Agriculture Development (PEDSA) which made increasing agricultural productivity of smallholder farmers its top priority (MINAG, 2011). However, PEDSA is criticised for being too broad, and therefore being unable to achieve its primary goal of poverty reduction (Woodhouse, 2009). A main concern is the lack of attention for the diversity of socio-economic conditions of smallholder farmers: how can this be addressed in the endeavour for increased productivity?

Although the Mozambique Government had gradually increased its budget allocation to agricultural development from 5.4% in 2003 to above 10% in 2005 after the Maputo Declaration, effectively the average expenditures in agriculture were only 3% in both years due to the slow delivery of the budget (Chamusso et al., 2013).

Two main options available to smallholder farmers to increase agricultural production are: (i) extensification, to expand the current cultivated area; and (ii) intensification to increase output per unit of land either through more use of labour for crop management or capital to pay for mechanization, fertilizers, improved seed and other external inputs (Erenstein, 2006). Our previous study on agricultural production in central Mozambique showed differences in labour and land productivities among different types of smallholder farms with yields only a fraction of the potential (Leonardo et al., 2015a). Expansion to farm larger areas was constrained by labour availability, especially during the weeding periods. Intensification was constrained by the lack of capital to buy external inputs such as improved seed and fertilizers.

Given the favourable agro-ecological conditions for crop production in Mozambique, productivity enhancing technologies, such as improved seed and fertilizers could increase maize yields up to 6 t ha^{-1} (Rusinamhodzi et al., 2012). Land is abundant, hence technologies that reduce the amount of labour needed for cropping activities, for example the use of herbicides, may allow farming of larger areas. Cultivation of legume crops such as soybean and pigeonpea also appear promising options to improve production due to the emerging market and the contribution of nitrogen (N) to the soil-crop system. Soybean and pigeonpea have been widely promoted in Mozambique (MINAG, 2011). Improved crop management combined with intercropping of maize with pigeonpea (*Cajanus cajan* (L.) Millsp.) resulted in yields up to 4.8 t ha^{-1} without fertilizer inputs in central Mozambique (Rusinamhodzi et al., 2012). However, to realize the potential offered by yield increasing technologies is not straightforward. At farm level, adoption of technologies depends on compatibility with biophysical conditions, resource availability and priorities of the household (Giller et al., 2006; Tittonell et al., 2007).

Smallholder farmers have multiple objectives that may compete or complement each other in terms of resource demand (Stoorvogel et al., 2004), for instance achieving food security and increasing income from farming. Farmers' objectives may conflict with or contribute to objectives at higher levels such as national food security (Bolwig et al., 2010) or production of biomass for biofuel (Arndt et al., 2008). Therefore, quantification and analyses of trade-offs and synergies of farmers' and national objectives could guide policymakers and planners towards better-informed policy decisions for agricultural development.

Optimization models have been extensively used to explore alternatives to current systems, for example the use of legumes to increase maize yields in Tanzania (Baijukya et al., 2004; Janssen et al., 2010), to assess the trade-offs between economic and environmental objectives of Dutch dairy and arable farmers (Kanellopoulos et al., 2012; Van de Ven and Van Keulen, 2007), and to analyse the impact of alternative crop residue management practices on crop and livestock productivity at different scales (Mujaya and Yerokun, 2003). In this study, we developed and used a farm optimization model to explore the contribution of labour and land saving technologies to development opportunities for smallholder farmers. We focused on a region with a high agro-ecological potential for crop production, the Manica Plateau, aiming at increased income from agriculture and food security at farm level. These objectives are aligned with the PEDSA. The Manica plateau is of particular importance as maize is consumed locally and sold to southern Mozambique, which has a large population and low agricultural potential. The Manica Plateau also produces cash crops (e.g. sunflower and sesame) for national and international markets. The study was conducted on maize-based smallholder farming systems in two districts, Gondola and Sussundenga, and on multiple farm types to cover the existing biophysical and economic variation among farms.

2. Methods

2.1. Farming on the Manica Plateau

We selected two administrative posts on the Manica plateau, Dombe (19.97° S and 33.39° E) in Sussundenga district and Zembe (19.295° S and 33.354° E) in Macate district (newly created district covering South Western areas formerly part of Gondola). These posts are located about 145 km and 25 km from Chimoio, a major market centre, respectively. Rain-fed agriculture, with rainfall distributed in a unimodal pattern between October and March, dominates the farming systems of the smallholder farmers. Dombe receives on average 930 mm rainfall annually and Zembe 880 mm (USGS/FEWSNET, 2011). The predominant soil types in Dombe are Eutric Fluvisols and Arenosols and in Zembe Ferric Acrisols and Haplic Lixisols (FAO-UNESCO, 1988). Due to the relatively better bio-physical conditions (soils and water), crop yields are higher in Dombe than in Zembe (Leonardo et al., 2015a). For instance, the average maize yield in Dombe is 1.9 t ha^{-1} whereas in Zembe is 1.5 t ha^{-1}.

In this study we focused on the large farms hiring in and the small farms hiring out labour (Table 1) as they represent both sides of the spectrum. Our previous study (Leonardo et al., 2015a) indicated that

Table 1
Description of two farm types in Zembe (n = 21) and Dombe (n = 28) based on a household survey and on-farm measurements (Source: Leonardo et al., 2015a).

Sites	Unit	Dombe farm groups		Zembe farm groups	
Variables		Large	Small	Large	Small
Proportion of the total no households	%	24	15	17	23
Cultivated area	ha	4.4	1.3	2.1	0.8
Fallow area	ha	1.1	0.3	0.5	0.2
Maize yields	t ha^{-1}	2.3	1.5	2.0	1.1
Sunflower yields	t ha^{-1}	–	–	0.3	0.3
Sesame yields	t ha^{-1}	1.3	0.9	–	–
Household size	#	9.8	5.2	8.1	4.0
Household labourers	#	4.2	3.2	3.8	2.6
Land:labour ratio (LLR)[a]	ha person^{-1}	0.8	0.4	0.6	0.3
Hired labour in a farm	d y^{-1}	16	–	18	–

[a] LLR is calculated as the cultivated area over household labour, taking into account children < 12 year as 1/4 labourer and excluding hired labour.