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Effects of technical interventions on flexibility of farming systems in Burkina Faso: Lessons for the design of innovations in West Africa

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ABSTRACT

African farmers have always been exposed to climatic and economic variability and have developed a range of coping strategies. Such strategies form part of flexible farm management, an ability that may prove very valuable in the face of future climate change and market dynamics. The generally low productivity of African smallholder farming systems is usually addressed by research and development institutions by a variety of solutions for improving farm performance. However, changes to the system may affect the flexibility of farms and thus their ability to cope with variability. We quantified the added value of being flexible and how this flexibility is affected by technical changes, such as composting and cattle fattening recurrently proposed and promoted by research and development institutions and projects. The study was conducted in two villages of the agro-pastoral area of Burkina Faso, where livestock, cereals and cotton are the main farming activities. A whole-farm simulation model was developed based on information gathered during focus group meetings with farmers and detailed individual monitoring of farmers' practices. The model simulates farmers' decision rules governing the management of the cropping and livestock farm components, as well as crop and livestock production and farm gross margin. Using the existing decision rules, current farm performance was simulated by assessing the cereal balance, the fodder balance and the whole farm gross margin. Then, by comparing the mean and the coefficient of variation of these indicators resulting from (a) the existing decision rules (baseline scenario) and (b) a set of less flexible rules (rigid scenario), the added value of flexible management was revealed. The adoption of composting practices allowed a slight increase in gross margin associated with a decrease in its between-year variability in comparison with conventional practices. Cattle fattening only led to a higher gross margin in the years with high rainfall and low input prices when no management practices were used to limit dependence on external input. This kind of technical change thus requires increased management agility by farmers to deal with climatic and economic variability. We conclude that assessing the impact of technical interventions not only in terms of productivity but also in terms of changes in flexibility is useful for a better understanding of potential adoption of technical changes.

1. Introduction

Agriculture in sub-Saharan Africa is facing the challenge of increasing food demands driven by the increasing population (Herrero et al., 2010) in a context of increasing climatic and economic variability (Cooper et al., 2008; Stringer et al., 2009). African farmers have always been exposed to high variability in their production environment (Thomas et al., 2007; Twomlow et al., 2008), partly due to poorly developed value chains, inadequate access to credit and a lack of insurance systems (Adesina and Ouattara, 2000).

As a consequence, farmers use a broad spectrum of coping strategies including the selection of drought tolerant varieties or crops, the diversification of income sources by combining cropping with livestock rearing, off-farm activities, or use of forest products (Abdulai and CroleRess, 2001; Dostie et al., 2002; Robledo et al., 2012; Stringer et al., 2009; Thomas et al., 2007; Thornton et al., 2007).

To increase the preparedness of farming systems to an expected increase in climatic and economic variability, scientific research seeks to co-design with farmers the technical options that increase both farm productivity and flexibility (Dedieu et al., 2008; Lev and Campbell, 1987). Flexibility, a concept originating from management sciences, describes the capacity of a system to cope with or to adapt to changing conditions using strategies based on learning (Barthélemy and Donada, 2007; Chia and Marchesnay, 2008).

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It can be specifically applied to the analysis of decisions taken within a firm. The flexibility concept converges with other concepts such as vulnerability and resilience (Miller et al., 2010), as they are all used to describe the responsiveness of systems to variability and change. In agriculture, flexibility has been increasingly used to analyse the coping strategies of farmers in relation to climatic and economic variability (Adams and Mortimore, 1997; Dedieu et al., 2008; Havet et al., 2014; Ingrand et al., 2006; Nozières et al., 2011; Weiss, 2001).

The flexibility of a farm can be assessed through the variability in its technical and economic results (Andrieu et al., 2008; Berkhout et al., 2011; Gicheha et al., 2014). In other words, a farm is deemed to be flexible when it maintains or increases its performance when faced with a shock or a change in the production environment. This flexibility can be evaluated ex-post in the real world (Bell et al., 2014; Cortez-Arriola et al., 2015; Errington and Gasson,1996) or ex-ante using modelling tools to simulate performance in a variable environment, including joint climatic and economic variability and/or change (Kingwell et al., 1993; Veysset et al., 2010). Whole-farm models are particularly relevant for this kind of analysis since they capture the links between farm subsystems and decisions taken by the farmer (Whitbread et al., 2010). Many of the whole-farm models used so far in Africa for ex-ante assessments have been optimisation models (e.g. Claessens et al., 2012; Stonehouse et al., 2002; Torkamani, 2005). Such models are useful for determining the best technical choices to fulfil various objectives while taking into account sets of constraints. However, assuming rational decision making, optimisation models are less useful to assess the consequences of decision rules that might seem irrational from an optimisation point of view. In the African smallholder context, technology adoption rates are often far below expectations (Cooper et al., 2008; Sumberg, 2005; van Rijn et al., 2012), which could be related to decreased flexibility as a result of changes in farm practice. In some cases maintaining flexibility is deemed more important by farmers than optimising farm profit (Darnhofer et al., 2010). Hence, a better understanding of how farm flexibility is affected by interventions could help to address this problem.

The aim of this work was therefore to develop a whole-farm simulation model, which could simulate farmers' decision rules and the resulting farm performance for typical climatic and economic variability. Using the model, we aimed to assess the added value of being flexible in reacting to different conditions and the effect on farm flexibility of adopting two technical interventions. The two technical interventions chosen were composting and stall feeding of cattle, as these are recurrently proposed by research in West Africa (Bourzat et al., 1987; Landais and Lhoste, 1990; Okike et al., 2004; Vall, 2012), but slowly adopted. Based on the findings of the simulation experiment, we draw lessons for co-designing innovations in West Africa.

2. Materials and methods

2.1. Study site

The study was conducted in two villages located in the cotton area of Burkina Faso: Koumbia (3°41′15″ West; 11°14′47″ North) and Kourouma (4°47′29″ West; 11°36′44″ North). With an average rainfall of 900 mm, this area is relatively favourable for crop production but it is also characterised by high spatio-temporal variability of rainfall (Ingram et al., 2002).

In Burkina Faso, crop production and livestock keeping have traditionally been conducted by distinct ethnic groups (Dugue et al., 2004). However, with the development of cotton production and demographic pressure, most farming systems have integrated both activities in mixed crop–livestock systems (Vall et al., 2006).

Table 1
Mean structural characteristics of the three types of farming systems (n = 350).

	Crop system	Crop–livestock system	Livestock system
Total area (ha)	6.4	18.6	2.7
Number of breeding cattle (TLU)	0	27	55
Number of draught oxen (TLU)	2	7	3
Number of dairy cows (TLU)	3	15	20
Number of fattened steers (TLU)	0	0	0
Size of the household (person)	13	30	15
Cotton area (ha)	3.5	10.0	0.5
Maize area (ha)	1.9	6.0	1.7
Sorghum area (ha)	0.5	1.6	0.5
Cowpea area (ha)	0.5	1.0	0.0

Cotton production strongly links producers to the market through the semi-private Sofitex (Société Burkinabè des Fibres Textiles) company, which purchases cotton from farmers and supplies it to the textile industry. Sofitex also provides credit to farmers for the purchase of agricultural inputs, which are primarily intended for cotton production. However, inputs for maize grown on an area equal to one third of the cotton area are also provided to ensure the food security of the households.

Three main farming system types can be distinguished according to their specific focus on livestock and/or cropping activities (Vall et al., 2006). Firstly, predominantly crop farmers derive over 75% of their income from cotton production and from sales of surplus cereals. Even though many have acquired draught oxen and small ruminants, their herd size is small (<10 animals). Secondly, predominantly livestock farmers obtain over 75% of their income from sales of animals and animal products. They grow cereals for household consumption and sometimes cotton for cash in favourable economic conditions. Thirdly, for balanced crop–livestock farming systems the two sources of income are complementary. The three farming system types are described in detail by Vall et al. (2012) based on a comprehensive survey of 350 farms (Table 1), and are referred to as crop, livestock, and crop–livestock farming systems from this point onwards.

Farmer representatives of these three main farming system types were involved in the different design steps for the model described below.

2.2. Design of the model

In order to analyse the flexibility of the three farming systems, a model called Simflex was built to simulate the effects of farmer decision rules on the production results of the farm. The design of the tool was based on five complementary steps:

1) Development of a flexibility framework
2) Identification with farmers of the factors used to characterise "bad" and "good" years
3) Characterisation with farmers of the strategies they use to cope with "bad" and "good" years
4) Development of the model based on a synthesis of the above findings
5) Evaluation of the model

The five steps are described in more detail below.

2.2.1. Flexibility framework

Chia and Marchesnay (2008) distinguished between static flexibility, mainly linked to the existence of overcapacities making it possible to cope with expected shocks, and dynamic flexibility. The latter is similar to proactive flexibility requiring the capacity to anticipate a certain shock. It contrasts with reactive flexibility, where