Agricultural Systems 167 (2018) 17–33

Contents lists available at ScienceDirect

Agricultural Systems

journal homepage: www.elsevier.com/locate/agsy

Modelling cropping plan strategies: What decision margin for farmers in Burkina Faso?

Jahel C.*, Augusseau X., Lo Seen D.

UMR TETIS, CIRAD, TA C-91 / MTD, 500 Rue J.F. Breton, Montpellier Cedex 5 34093, France

ARTICLE INFO

Keywords:
Cropping plan strategies
Decision influencing factors
Spatial modelling
Burkina Faso

ABSTRACT

In a context of strong climatic and economic uncertainty in West Africa, agricultural statistics reveal interannual variations in the proportions of crops. The underlying causes of these variations remain, however, poorly documented although their understanding is essential for crop production monitoring and agricultural policy-related decision-support. Regional scale cropping plan fluctuations arise directly from multiple individual farmer decisions. The purpose of this study is to understand the decision-making processes involved when farmers choose their cropping plans, in order to assess the respective weight of the different factors underlying the observed fluctuations in cropped areas. The study zone is the Tuy Province, occupying around 6000 km^2 in central-western Burkina Faso. An initial field work showed how farmers' decision-making processes depend on external factors. This led to a separation and prioritization of the decisions taken in response to the physiological needs of the family (primary objectives) from those taken in response to other needs (secondary objectives). Four decision-influencing external factors were identified: i) climate, ii) price of cash crops, iii) incentive measures and dissemination processes and iv) credits for inputs. Decision-making rules were then determined by combining the objectives with the external factors. A decision model built on these rules was applied to Tuy Province between 2002 and 2014 to simulate every year the decision-making process of each farmer depending on several influencing factors. The model was verified by annually comparing the proportions of each crop grown in each cultivated area with those recorded in the agricultural statistics. The annual weight of each of these factors was then assessed: over the study period, 55% of the cropping plans satisfied unavoidable primary needs (the factors involved being internal determinants and credit), and 45% concerned secondary objectives (influenced by prices and promotion drives). With this approach, we evaluated the weight of the price factor to be only 6%. This result did not tally with the literature where the price factor is seen as a major element influencing cropping plan decisions. It is then discussed and considered in the specific context of this study. Sixty percent of the areas planted in cotton were linked to the access to credit granted by the cotton company in the zone, and tallied with the primary objectives of the farmers. The farms were therefore fully dependent on the cotton company. This study also illustrates the merits of modelling to assess how the respective weights of factors change over time, and to provide some major methodological perspectives for using spatial models to strengthen and validate typologies and processes arising from field analysis.

1. Introduction

Farmers in West Africa have to cope with climatic, economic and political contingencies, limited access to credit and markets, and little backing from public policies (Gafsi et al., 2007). While, at first glance, this lack of means and opportunities combined with all these constraints might suggest that cropping plans will hardly vary from one year to the next, agricultural statistics seem to show the opposite (FAOSTAT, 2017). Understanding the reasons of these fluctuations is essential for the monitoring and control of the agricultural production of a region and for agricultural policy-related decision-support (Edwards-Jones, 2006). These cropping plan dynamics, which can be seen on a regional scale, arise directly from the decisions taken individually by farm managers. The purpose of this article is to explore cropping plan dynamics on a regional scale, through an analysis of farmers' decision-making processes and the decisional factors involved, in order to understand what decisional factors lay behind the observed fluctuations in cropped areas.

Although family farms in Burkina are characterized by their great diversity, they have one point in common in producing goods and

* Corresponding author.
E-mail addresses: camille.jahel@cirad.fr (C. Jahel), xavier.augusseau@cirad.fr (X. Augusseau), danny.lo_seen@cirad.fr (D. Lo Seen).

https://doi.org/10.1016/j.agsy.2018.08.004
Received 25 January 2018; Received in revised form 12 July 2018; Accepted 5 August 2018

services in the aim of creating wealth and satisfying the family's needs (Byerlee and Collinson, 1980; Gafsi et al., 2007). These two main objectives are accompanied by a raft of other more precise objectives, varying from one farm to another depending on the motivations, abilities and experiences of the farm manager, on the stage in the life cycle of the farm, or the particular needs of the family. For example, it may be a matter of developing the farm, or preparing for it to be taken over by an heir, etc. (Gafsi et al., 2007). Achieving these objectives, by producing goods, means combining the internal resources of the farm, which are often limited (labour, capital, land), with the information farmers have about external opportunities and constraints (Dillon, 1980; Jean-Pierre and Bernard, 1993).

Over the length of a farming year, a farm is managed in three stages: planning, implementing and monitoring (Gafsi et al., 2007; Kay and Edwards, 1999). Planning consists in knowing what to grow, in what amount and in which way, in relation to the specific objectives of the farm. The achievement of that planning means bringing into play the means at the farm's disposal and making operational decisions (Duru et al., 1988). Work progress is monitored regularly in order to take decisions to redress any drift.

At any given moment, these three stages require decisions to be taken to address waves of opportunities and constraints that occur (Brossier et al., 1997; Gafsi et al., 2007). Kay and Edwards (1999) described decision-making processes as a permanent mechanism that consists in making resource allocation choices.

Decisions can be of three types: strategic decisions, tactical decisions and routine decisions (Gafsi et al., 2007). Strategic decisions concern long-term decisions focusing on the major orientations of the farm, such as investments in equipment to be used over a number of years. Tactical decisions establish the major lines of agricultural operations over a season and are taken in the planning phase. They include the cropping plan choices, technical decisions, choice of product use, etc. Lastly, routine decisions are taken on a day-to-day basis and consist in implementing and adapting the chosen techniques to everyday events and occurrences.

In this article, we primarily focus on tactical decisions concerning the choice of cropping plan, which is largely made during the planning phase and may be readjusted during the monitoring phase. Kay and Edwards (1999) divided this process into three stages, which we have simplified for the choice of cropping plan: i) identify the objectives to be fulfilled, ii) recap the available sources, i.e. labour, capital and land, along with the external influencing factors and iii) allocate resources to the different crops.

The study of these three stages in the choice of cropping plan is often complicated since it means taking into account a complex combination of factors which evolve over time and to which not all farmers will react in the same way. Resorting to modelling is a recognized way of working on these complex issues, since it makes it possible to represent a complicated reality in a simplified manner in the aim of understanding it better. For instance, a great deal of work has contributed to the modelling of these decision-making processes and their impacts on farm efficiency. Whilst most of that work has concerned technical strategies and how farming operations are conducted (Dury et al., 2011; Aubry et al., 1998a; Cerf and Sébillotte, 1997; Aubry, 2007; Dounias et al., 2002; Schaller, 2011; Jain et al., 2015), only a small part of it has concerned the processes involved in the choice of cropping plan and how external factors affect those choices (Houet, 2006; Deressa et al., 2009; Seo and Mendelsohn, 2008; Robert et al., 2016; Robert et al., 2017). Few studies have scrutinized the combinations of factors leading to cropping plan choices, using models retrospectively to address this issue.

Nevertheless, we adopted the approach commonly taken when modelling decision-making processes, which consists in constructing decision-making rules depending on the influencing factors. The influencing factors are the means or information at the farmers' disposal for making their choice. They may be internal to the farm, such as the amount of land available or the labour that can be called upon; or external such as prices or the climate (Wood et al., 2014). Decision-making rules (Sebillotte and Soler, 1990; Aubry et al., 1998b; Mérot et al., 2008; Schaller, 2011) are rules drawn up by the farmer when making a decision. For example, one rule might be: “if the season is late, cotton areas are reduced and sesame areas are increased”.

Our study uses this “influencing factors/decision-making rules” approach to assess the weight of each of the factors influencing the ultimate cropping plans. The study zone is the Tuy Province in western Burkina Faso. Over the last 15 years, the crops in that province have seen some major fluctuations, with maize for example increasing from 25% to 40% of the total areas cropped. Such variations are particularly visible from one year to the next, the most striking example being the reduction in cotton proportions by a half between 2006 and 2007.

The first section of the article presents the data used and the method developed. The preliminary results are then described, namely identification of the objectives, influencing factors and decision-making rules for the different types of farming systems in the study zone. Based on those initial results, a model was constructed, calibrated and validated and was used to explore the impact of the different influencing factors on the cropping plans. A final section puts into perspective this impact with the degree to which farmers are free to make their decisions, given their integrated contractual relationship with the cotton company in the zone. This final section comments on the original approach taken, prioritizing farmers' objectives, along with the importance of modelling for strengthening field results.

2. Material and method

2.1. Description of the study site

The study zone is the Tuy Province, occupying around 6000 km^2, located in central-western Burkina Faso. The climate is of the Sudanian type. The zone is crossed by a line of hills not exceeding 400 m in elevation, separating two broad plains of ferruginous soils (Fig. 1). Twenty percent of the territory has been protected forest since 1990, the remainder being primarily devoted to crops, of which the main ones are cotton, maize and sorghum. Table 1 shows the main crops grown in the zone and their use.

A typology of farming systems in the zone was taken from literature (Vall et al., 2017; Marre-Cast and Vall, 2013). It distinguishes between crop farmers (less than 10 cattle), crop-livestock farmers (more than 10 cattle and more than 6.5 ha) and livestock farmers (less than 6.5 ha). Crop farmers make up 80% of the farms in the region, crop-livestock farmers 15%, and livestock farmers, 5% (Jahel et al., 2017).These three types of farming system will then have different strategies when choosing cropping plans.

2.2. Input data

Two types of data were used: those used as input data for the model, and those used to calibrate and validate the model.

The model input data were price trends for the main crops, rainfall and soil texture. The rainfall data came from a TAMSAT time series from 2001 to 2015, with a spatial resolution of 4 km and a daily time step. Soil texture came from soil maps drawn up by the *Institut Géographique du Burkina* (IGB). Prices were taken from the paper archives of the Agriculture Services and concerned the annual mean of prices paid to farmers in Tuy Province. Appendix 2 presents all the data used in this study.