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Are subsidies to weather-index insurance the best use of public funds? A bio-economic farm model applied to the Senegalese groundnut basin

Aymeric Ricome[a,1], François Affholder[b], Françoise Gérard[c], Bertrand Muller[d,e], Charlotte Poeydebat[f], Philippe Quirion[g,*], Moussa Sall[h]

[a] IRD, Centre International de Recherche sur l'Environnement et le Développement (CIRED), F-94736 Nogent sur Marne, France
[b] Centre International de Recherche Agronomique pour le Développement (CIRAD), UPR AIDA, F-34398 Montpellier, France
[c] CIRAD, UPR GREEN, F-94736 Nogent sur Marne, France
[d] CIRAD, UMR AGAP, F-34398 Montpellier, France
[e] Centre d'étude régional pour l'amélioration de l'adaptation à la sécheresse (CERAAS), Thiès, Sénégal
[f] CIRAD, UPR AIDA, F-34398 Montpellier, France
[g] CNRS, Centre International de Recherche sur l'Environnement et le Développement (CIRED), F-94736 Nogent sur Marne, France
[h] Institut Sénégalais de Recherche Agricole (ISRA), Dakar, Sénégal

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ABSTRACT

While crop yields in Sub-Saharan Africa are low compared to most other parts of the world, weather-index insurance is often presented as a promising tool, which could help resource-poor farmers in developing countries to invest and adopt yield-enhancing technologies. Here, we test this hypothesis on two contrasting areas (in terms of rainfall scarcity) of the Senegalese groundnut basin through the use of a bio-economic farm model, coupling the crop growth model CELSIUS with the economic model ANDERS, both specifically designed for this purpose. We introduce a weather-index insurance whose index is currently being used for pilot projects in Senegal and West Africa. Results show that insurance leads to a welfare gain only for those farmers located in the driest area. These farmers respond to insurance mostly by increasing the amount of cow fattening, which leads to higher crop yields thanks to the larger production of manure. We also find that subsidizing insurance is not the best possible use of public funds: for a given level of public funding, reducing credit rates, subsidizing fertilizers, or just transferring cash as a lump-sum generally brings a higher expected utility to farmers and leads to a higher increase in grain production levels.

1. Introduction

In west African countries, agricultural production per capita has decreased over the past half century due to a slow increase in agricultural production compared to the rate of population growth (Pretty et al., 2011). With continued population growth and the diminishing availability of marginal arable land, there is now a common view that crop yield must increase in this region, especially as there is a wide gap between actual and potential yields (World Bank, 2008; HLPE, 2013; Teklewold et al., 2013; The Montpellier Panel, 2013). At field scale, low nutrient availability in soils and high weed pressure predominantly explain this yield gap (Affholder et al., 2013). At farm level, the fact that households are strongly resource-constrained and exposed to risk is widely recognized as a key explanation (Rosenzweig and Binswanger, 1993; Carter and Barrett, 2006). Indeed, risk discourages the adoption of high-risk, high-return agricultural technologies, especially when farmers are poor, which in turn impedes the improvement of yields (Affholder, 1997).

This is the reason why, for over a decade, weather-index insurance (WII) has been seen as a promising tool to mitigate agro-climatic risks at farm level and thus in the improvement of yields (Hazell and Hess, 2010). Here we define WII as insurance whose indemnities are triggered by the value of a weather index chosen for its high correlation with yields or economic losses. As WII does not require loss assessment as in conventional insurance, transaction costs are lower. Additionally, the use of an objective indicator prevents information asymmetries among contractors, while with conventional insurance based on yield loss, the insurer cannot always determine to what extent the loss is due to a bad weather or to farmer's lack of work.

Despite the allocation of many resources by international

* Corresponding author.
E-mail address: quirion@centre-cired.fr (P. Quirion).
[1] The author works now at the European Commission, Joint Research Center.

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development organizations, results from pilot WII programs showed up to a recent period very limited success. Binswanger-Mkhize (2012) explained it by the lack of demand. While better-off farmers prefer to use cheaper self-insurance strategies rather than WII, poor farmers would be interested but could not afford it because of lack of liquidity.

Ex-post analysis confirmed this argument by highlighting several factors explaining the low take-up of WII: steep negative price elasticity (Karlan et al., 2014; Cole et al., 2013; Mobarak and Rosenzweig, 2013), liquidity constraints (Cole et al., 2013), lack of trust and misunderstanding of the products (Hill et al., 2013), lack of relevant social networks (Giné et al., 2013) and existence of informal insurance which acts as a substitute (Mobarak and Rosenzweig, 2013). Another key limitation of WII is the basis risk i.e. the imperfect correlation between the index and losses at farm level (Tadesse et al., 2015).

Ex-ante assessments do not provide more optimistic conclusions. McIntosh et al. (2013) compared an ex-ante WTP for WII with ex-post demand based on an actual WII in Ethiopia. They found that the lack of cash (and access to credit) to pay for the WII product reduced the interest of farmers and that subsidizing premium improved the take-up of insurance but not as much as expected.

Other ex-ante assessments are based on agro-economic simulation models. Berg et al. (2009) and Leblois et al. (2014) found that the benefits of insurance were very limited for, respectively, maize growers in Burkina Faso and cotton growers in Cameroon. These results were explained by the large basis risk and, in the case of cotton, the higher exposure of farmers to price risk than to climatic risk.

Aware of these drawbacks, new programs were developed and seem scaling up and providing demonstrable benefits for a larger number of farmers, even if in a lower extent to poorest ones (Greatrex et al., 2015; Bertram-Huemmer and Kraehnert, 2015). The experiences in India, Kenya, Ethiopia and Mongolia innovated by linking insurance to credit or improved inputs, involved the farmers into the product design and were encompassed into a strong institutional setting favoring trust between farmers and insurers as well as improving the understanding of the products. It appears from those programs that when the WII is included in a larger basket of risk management options, the benefits of the programs are larger.

Although these studies and experiences are helpful to know the factors influencing the adoption of WII by farmers, knowledge of the impacts of WII on farmers' production decisions is still very limited: while De Nicola (2015), Elabed and Carter (2014), Karlan et al. (2014) and Mobarak and Rosenzweig (2013) provide evidence that WII can boost adoption of new technologies, Giné and Yang (2009) come to the opposite conclusion. Carter et al. (2016) have shown in a theoretical model that whether WII may or not boost the adoption of improved agricultural technologies depends in particular on the agro-ecological and economic environments, which calls for more applied work on this issue.

The objective of this paper is thus to evaluate the potential benefit from WII in terms of farmers' income and its impact on adoption of more intensive cropping and livestock systems. We write "potential" because our model represents simulated farmers who would be perfectly aware of the way WII works. We also assess whether insurance subsidies are the best use of public funds by comparing this policy option with others such as credit subsidies, fertilizer subsidies or lump-sum cash transfers, considered separately or in conjunction with WII. We develop a coupled whole-farm bio-economic model (Janssen and van Ittersum, 2007; Le Gal et al., 2011), reproducing the complexity of farmers' decisions in a risky environment, applied to typical farms in the Senegalese groundnut basin. The model explicitly represents the cropping and livestock systems, with a biophysical component simulating the impact on crop yields of changes in crop management techniques and of inter-annual variations of climate, as well as the various nutritional, financial and labor management constraints of the household. The coupled model simulates farm households' decisions in response to a series of historical weather data, which are assumed to represent the perception of the inter-annual variability of weather. Furthermore, we characterize the diversity of the farming systems in the study areas in order to account for possible differences between farm-types regarding the relevance and impacts of WII.

2. Material and methods

The analysis took place in the "groundnut basin" of Senegal. It is a region typical in many aspects of the Sudano-Sahelian region of Africa, with high levels of poverty, where family farming based on rainfed crops is overwhelmingly predominant, with a semi-arid climate, and with a steep South-North gradient of risks of drought limiting crop production (Boulier and Jouve, 1990). A consistent background was available about the farming systems of that region and their dependencies to both the biophysical and the socio economic environment of farms, thanks to many studies at field, farm and village scales that were carried out at regular time intervals in the past (Lericollais, 1972; Benoit-Cattin, 1986; Lhoste, 1986; Pieri, 1989; Boulier and Jouve, 1990; Garin et al., 1990; Badiane et al., 2000a; ISRA, 2008). However, a new survey was carried out within the framework of the present study at field and farm levels in order to get adequately updated data for the specific purpose of developing and calibrating our whole-farm model.

2.1. General presentation of the study area

We considered two subzones in the study area, the districts of Niakhar (14°28′N, 16°24′W, 25 km South of Bambey on Fig. 1) and Nioro du Rip (13°44′N, 15°46′W), respectively in the center north (locally known as the *Sine* region) and in the south of the groundnut basin (*Saloum*), corresponding to contrasting drought risk, expected to lead to contrasting constraints on crop intensification (Affholder, 1997). The average annual cumulative rainfall recorded during the period considered in this study (1991–2010) is 520 mm and 775 mm in *Sine* and *Saloum* respectively.

Throughout the basin the cropping systems are mainly cereal-leguminous rotations. In the *Sine* subzone the cereal used in the rotation is almost exclusively millet (the staple food) and the use of mineral fertilizers is extremely rare. Horses and donkeys provide traction power for carts as well as for sowing and weeding machines. In *Saloum* maize, grown as a cash crop or staple food, is common although millet remains the main cereal. Manure is more widely employed than in *Sine*. Traction power is provided by horses (carts) and oxen (cultivation tools). In both zones farmers also carry out very extensive cattle production and slightly more intensive breeding of a few small ruminants (sheep and goats), and in many cases a short-term fattening activity involving a few cattle or small ruminants. All this livestock activities provide manure that is used in several ways for organic fertilization of fields. Very few mineral fertilizers or pesticides are used. No improved seeds are available for millet. Groundnut seeds are all improved seeds produced and distributed under the control of public services. An important feature of the farming system is the ring cultivation system which involves dividing the landscape into two concentric circular areas around the household's compounds. The area closer to the compounds, the "home-fields", is under continuous cereal cropping and receives all of the household's organic waste, as opposed to the bush-fields, which are far from the compounds and where cereals alternate with groundnut. Crop yields obtained on home-fields are thus generally higher thanks to the higher levels of soil organic matter (Prudencio, 1993).

2.2. Data

The dataset comprises socio demographic and economic data from a farm household survey conducted in 2012. Local experts identified five representative villages for each study subzone, in which 18 households were randomly selected. 180 households were surveyed overall. The