



## Analysis

# Modeling the Relationship Between Pesticide Use and Farmers' Beliefs about Water Pollution in Burkina Faso

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## ABSTRACT

Burkina Faso is currently facing a serious deterioration of water quality due to the use of pesticides in agriculture, which is an even greater challenge for the government since farmers are unaware of the toxicity of these chemicals. Therefore, reducing pesticide use requires updating farmers' beliefs about the environmental and health consequences of their actions. Drawing on the theory of positional objectivism developed by Sen, this study seeks to determine the influence of various positional characteristics (gender, education level, socio-cultural factors, etc.) on individual beliefs. In so doing, it uses a recursive bivariate probit model. The model was tested using data collected from a sample of 389 farmers. The results from this model showed that the more farmers' had beliefs about the degradation of water quality, the less they were inclined to use pesticides. These beliefs were based on personal lived experiences and were also formed through interactions with other farmers. Moreover, government agencies and NGOs in regular contact with the farmers played a crucial role in shifting the farmers' observational positions.

## 1. Introduction

Contamination of drinking water by pesticides used in agriculture has become a major societal issue in industrialized countries (OECD, 2012; OECD, 2017). In economics, several studies have addressed this issue (Falconer and Hodge, 2001; Traversi and Nijkamp, 2008; Jacquet et al., 2011; Finger et al., 2017). Few, however, have examined this problem in the specific context of the developing world, although these countries are increasingly concerned about deteriorating water quality from pesticides (Ecobichon, 2001; Heisey and Norton, 2007; Schreinemachers and Tipraqsa, 2012). This is the case in Burkina Faso, a landlocked country in sub-Saharan Africa studied here. In recent years, Burkina Faso has recorded a strong increase in the use of plant protection chemicals<sup>1</sup> and, at the same time, a worrying degradation of water quality (Koné et al., 2009; Gomgnimbou et al., 2009; Toé et al., 2012; Toé et al., 2013). Intensifying production for crops such as vegetables, rice, and cotton, with an increasing use of organochlorine pesticides, is largely responsible for this situation. These pesticides contain highly active and persistent substances such as endosulfan and carbofuran (Somé et al., 2008; Tapsoba et al., 2008; Naré et al., 2014) that have been banned for over 30 years in most European countries. In

Burkina Faso, the risk of water contamination by organochlorine pesticides is even higher since the soil is poor in organic matter, which does not help the biodegradation of these pesticides (Savadogo et al., 2006).

Faced with this growing environmental hazard, in the early 2000s the Burkinabé public authorities redesigned their national water policy and established an Integrated Water Resources Management program (IWRM). This program seeks a more equitable and ecologically sustainable sharing of water resources. The core of this policy involves making the actors responsible for their actions (including farmers). As in other developing and industrialized countries (Falconer and Hodge, 2001), this responsibility is primarily attributed through the polluter pays principle. However, it is proving difficult to apply this principle in practice (GWP/WA, 2009), which is not surprising. First, as some research has pointed out (Sarker et al., 2008), while the polluter pays principle is appropriate in the case of point source pollution, it is much less so with diffuse pollution involving a large number of pollution emitters. In such a context, it is indeed difficult to know precisely each polluter's responsibility in the environmental damage observed. Moreover, in Burkina Faso, applying the polluter pays principle is hampered by the lack of resources of the local branches of state agencies that

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<sup>1</sup> This increase in the quantities of inputs results from the intensification of agricultural production and the expansion of farmed areas.

monitor compliance (Guesnier, 2010; Cherlet and Venot, 2013). These agencies do not always have the funds needed to pay for water quality tests and to do the research required on the individual responsibilities of farmers in degrading water quality. This lack of information is thus highly likely to compromise the effectiveness of the IWRM program.

In addition, several studies (Traoré et al., 1998; Lichtenberg and Zimmerman, 1999; Dasgupta et al., 2007; Ibitayo, 2006; Khan et al., 2015) on different regions of the world have shown that a profound transformation in behaviors cannot be achieved by simply changing the rules or applying stricter sanctions. These studies emphasize that the excessive use of pesticides is primarily the result of perceptions and attitudes that minimize the toxicity of these products. These perceptions and attitudes, as forms of knowledge shared by a social group, decisively guide judgments about the quality of natural resources (Moser, 1984; Michel-Guillou and Moser, 2006). Therefore, they can be important mental obstacles to changing farming practices and thus hinder the success of public water policies. In Burkina Faso, as in other developing countries, insufficient information about the environmental and health effects of an overuse of pesticides coupled with a low level of education makes it more difficult to change farmers' behaviors (Ntow et al., 2006; Stadlinger et al., 2011; Khan et al., 2015).

Therefore, addressing farmers' perceptions and beliefs is essential for government agencies in Burkina Faso. In order for public action to be effective, however, it is first necessary to determine the factors that influence those beliefs. This article seeks to do precisely that by proposing an econometric model to better identify these factors. The model draws on two main bodies of work in economics, starting with research on the role of beliefs on actors' rationality (Denzau and North, 1994; North, 2005; Sen, 2002; Hodgson, 2006; Bromley, 2006, 2008). These studies, especially those by Sen on positional objectivism, have identified the challenges involved in changing actors' beliefs. With this theoretical basis, the model's design was then informed by several recent econometric studies that have sought to identify the explanatory factors in the formation of beliefs (Elnagheeb et al., 1995; Lusk and Rozan, 2008; Livingston, 2010; Eiswerth et al., 2011). These various studies have been used here to examine how Burkinabé farmers' beliefs about the degradation of water quality guide their practices and determine whether they use chemicals. Therefore, this article (i) identifies the main explanatory factors for these beliefs; (ii) uncovers the interrelationships between beliefs and agricultural practices; and (iii) draws certain conclusions in terms of research and public policy.

The article has four sections. The first sets out the theoretical framework used in this study. This framework clarifies our hypothesis of an interrelation between farmers' beliefs about the degradation of water quality and their agricultural practices. The second part presents the recursive bivariate probit model with latent variables used to test the validity of this hypothesis. This model was developed using empirical data collected between 2011 and 2012 in three regions of Burkina Faso. The third section presents the main results. In particular, these results show the connection between actors' beliefs and the use of organochlorine pesticides. The final section discusses this study's contributions to the theoretical debate, the applicability of the results, and their implications in terms of public policy.

## 2. The Challenge of Updating Beliefs

The central hypothesis of this study is that it is difficult for farmers to establish a causal link between the use of pesticides and the degradation of water quality (DWQ) solely through their sensory perceptions (smell, taste, sight). The decision whether to use pesticides should thus be based on their beliefs about the impact of their practices on DWQ.

After clarifying the concept of beliefs, the positional objectivism approach (Sen, 1993) will be used to highlight the determinant role of sociocultural variables in forming and updating beliefs. Next, the econometric models in the literature that account for interrelations

between agricultural practices and beliefs will be critically analyzed, which will then be used to develop a better-performing econometric model (see Section 2).

### 2.1. Beliefs

A large part of the economics literature has focused on the factors that influence the adoption of agricultural practices respecting the natural environment (Feather and Amacher, 1994; Willock et al., 1999; Nkamleu and Adesina, 2000; Bekelé and Drake, 2003; Rahman, 2003; Asfaw and Admassie, 2004; Amsalu and Graaff, 2007; De Graaff et al., 2008; Jara-Rojas et al., 2013). These studies have primarily examined two types of factors: those related to farmers' individual characteristics (education level, gender, etc.) and those relating to the socio-cultural environment (belonging to one or more networks, agricultural advising, etc.). Yet work on the role of beliefs in adopting practices that use fewer chemical inputs is rare. This seems paradoxical if one accepts, following Commons (1931) and more recently Bromley (2006, 2008), Denzau and North (1994) and North (2005), that beliefs, as a system of knowledge, values, theories, and ideologies that have crystallized in the mental matrix of an individual, are constitutive of action. In this approach, any change in practices requires updating the actors' beliefs, i.e. changing their ways of thinking. The present study adopts this point of view: we consider that the fight against the degradation of water quality in Burkina Faso requires updating farmers' beliefs. Drawing on the concept of positional objectivism from Sen (1993, 2002, 2009), we will now explore the challenges involved in updating beliefs.

### 2.2. Changing Practices and Positional Objectivism

Since Mises (1949), a number of authors consider that beliefs are not an unchangeable given nor intangible; they can be updated through individual experiences and/or through collective learning processes (Sen, 2002; North, 2005; Bromley, 2006). For Sen (1993), the beliefs of an individual or group of individuals are primarily indicative of his/her "observational position" at a given moment. As Sen (1993) explains, this observational position is not primarily related to the specific place of an actor in space; it is above all the consequence of an ensemble of socio-cognitive factors. Thus, socio-demographic characteristics, knowledge, skills, abilities, and habits are all factors that influence a person's observations. Therefore, multiple actors observing from the same position, in other words, those who share the same socio-cognitive environment, will reach similar conclusions on the truth or falsity of a given phenomenon. For this reason, Sen (1993) calls this "positional objectivism," in the sense that the actors' observations may be considered objective with regard to information they have at hand collectively. As Sen indicates, the concept of positional objectivism is useful for understanding the reasonings that lead an actor to a hold particular belief, whether that belief be "true" or merely an "objective illusion."<sup>2</sup>

Positional objectivism has two very important implications for the present study since it examines a phenomenon that is not directly accessible by the senses and whose perception is very largely influenced by the positional characteristics of the actors. First, this concept invites us to examine the position parameters of Burkinabé farmers: their demographic characteristics, their knowledge of environmental degradation, the water attributes they take into account (color, smell, taste, turbidity, etc.), their socio-cultural environment, and so forth. The goal is to determine the extent to which these various parameters are likely to influence their observations, and on that basis, the rationales on which their water quality beliefs are based. Second, the positional perspective leads us to focus on practices and the learning that may

<sup>2</sup> Sen (1993, p. 132) borrows this concept of objective illusion from Karl Marx. He understands it as "a positionally objective belief that is, in fact, mistaken."

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