Land Use Policy 38 (2014) 454–466

Contents lists available at ScienceDirect

Land Use Policy

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

Cost of best management practices to combat agricultural runoff and comparison with the local populations' willingness to pay: Case of the Austreberthe watershed (Normandy, France)

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ARTICLE INFO

Article history:
Received 26 August 2013
Received in revised form
17 November 2013
Accepted 21 December 2013

Keywords:
Runoff risk
Scenario
Dairy farm
Willingness to pay
LUCC
LPIS

ABSTRACT

Land Use and Cover Changes (LUCCs) significantly increase the frequency of mudflows in the silty areas of north-western Europe and particularly in the NUTS 3 Seine-Maritime region (France). Predicting the effects of a range of possible LUCCs helps local authorities choose policies that can help to mitigate the risks to which local populations are exposed. In this article we build scenarios for changes in farming systems, with a 2015 horizon and with 2007 as the initial situation. These scenarios are assessed through combined biophysical and economic approaches. Two scenarios for the disappearance of dairy farming are chosen. One scenario has no public-action program (StopMilk), while the other one has a program based on the funding of best management practices (StopMilk-E). These scenarios are assessed at the small watershed scale (7 km^2) in terms of both changes in farming systems and effects on runoff (use of the STREAM model). Finally, the economic evaluation of additional costs of StopMilk-E is extrapolated at the level of the Austreberthe watershed syndicate (214 km^2), using the French Land Parcel Identification System (LPIS) with a spatially referenced database of cropping plans. StopMilk leads to a significant increase in runoff whereas the local public-action program proposed under StopMilk-E reduces runoff to below the 2007 level. The Austreberthe watershed residents' willingness to pay for a 15-year program is around €395,000/year, which is not sufficient to balance the cost of the modified farming practices (€640,000/year over the first 3 years). Funding of the practices would require either subsidies from a higher level (Europe), borrowing by the community, and/or a more selective approach in the type and the location of farming practices to be funded. The method used for calculating costs at the watershed syndicate level shows the huge potential of new databases like LPIS (available in France since 2006) for the assessment of environmental issues.

Introduction

Recurring mudflows in the silty areas of north-western Europe constitute a substantial economic burden for local communities (Boardman et al., 1994, 2006; Evrard et al., 2007). These mudflows are the result of erosion occurring on agricultural land located upstream of urban areas. The extent of the damage depends on the spatial and temporal organization of cropping systems upstream (Joannon et al., 2006) and land use downstream (Heitz et al., 2009). For three decades, the local authorities have tried to prevent mudflows by setting up devices such as retention ponds (Verstraeten and Poesen, 1999) to hold back earth-laden waters flowing off agricultural lands. At the same time, policies have been followed – usually voluntarily – to develop some infrastructures to limit water concentration (e.g. hedges) or soil erosion in thalwegs (e.g. grassed waterways). The aim is also to modify the agricultural practices of the farmers concerned (Boardman et al., 2003a; Fullen et al., 2006), with a view to limiting the quantity of earth-laden water running off farmland. In this paper we will focus on local policies with regard to changes in farming practices.

Farmers' practices are based on both the internal logic of their farming system and on an adaptive response to external signals (Leenhardt et al., 2010). Some external signals such as soil and climate may be considered as constant in time (on a rather short

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0264-8377/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.landusepol.2013.12.014

time-scale). Many other external signals are more variable in time: existence of sales channels, price levels, technical innovations, and national regulatory constraints. For European farmers the Common Agricultural Policy (CAP) is a major external signal (Boardman et al., 2003b). Changes in the CAP and international regulations can have significant consequences on land use and cover (Rounsevell et al., 2003; Therond et al., 2009; Valbuena et al., 2010), with induced consequences on the variation in the runoff risk for local populations. Retrospective analyses have shown how prior changes in the CAP have led to local increases in mudflow risks (Souchère et al., 2003; Evrard et al., 2007). The future of the post-2013 CAP is still under discussion in mid-2013. For local communities subject to mudflow risks, it is important to know whether an adaptation of their local policies would be able to mitigate possible side effects of changes in agricultural external signals.

A scenario methodology can be used to test this adaptive ability (Godet, 2000). For a given region, a range of potential changes can be combined to define scenarios of changes in cropping systems (Ewert et al., 2009), which can then be used to test the impact of certain local policies. The tested impacts are likely to be both environmental (using biophysical models (Therond et al., 2009)) and economic (policy cost), at least.

For European countries, the economic performance of policies applied to a range of farms can be evaluated using accounting databases like the FADN (Farm Accountancy Data Network). The FADN provides extensive data on the characteristics of individual farms throughout the EU. Accounting data are generally used for the NUTS2 level (NUTS = Nomenclature of Territorial Units for Statistics) (Reidsma et al., 2009). For instance, in France, NUTS2 regions correspond to "*région*" (e.g. Haute-Normandie), and NUTS3 to "*département*" (e.g. Seine-Maritime). Econometric optimization techniques have been developed to determine new combinations of practices and their associated cost under a constraint function (Jacquet et al., 2011). These techniques are adapted to areas above the regional level (NUTS0 to NUTS2). For lower levels corresponding to the local communities (Local Administrative Unit or LAU) that we are working on, FADN databases can be inconsistent with local farm diversity (Jacquet et al., 2011). At the LAU level we also have a problem of border effects: local policies can develop incentives for farmers but these incentives are limited to the parcels located within their jurisdiction, as the local authorities see no advantage in subsidizing their neighbors' parcels. Individual farm areas in Western Europe are often large and scattered across different LAU, whereas information in an accounting database is not spatial. The "border effect" can be neglected when accounting data are used at the regional level, but not at the local level. Assessment of the local policy effects should use spatial databases, including the boundaries of farm areas. This type of database has been generalized in Europe in the framework of the CAP regulations. Article 20 of the European Regulation (EC) No. 1782/2003 stipulates the use of a Land Parcel Identification System (LPIS) established on the basis of maps, land registry documents, or other documents (Inan et al., 2010). For France, this type of data has been available since 2007 in the RPG (Registre Parcellaire Graphique) database. This database includes the delimitation of each farm area (scale of 1:5000) with its production blocks (e.g. fields of the same farm with common borders), and both the list of crops and corresponding areas cultivated in each production block. This type of data has been used in various countries – France (Fuzeau et al., 2012), Austria (Schönhart et al., 2010), and Belgium (Leteinturier et al., 2006) – but as far as we know, no paper has taken the farm level for scenario building. As no accounting data are given with LPIS information, the cost of agricultural practices needs to be found elsewhere, using interviews with farmers on their expert knowledge, or literature reviews.

The cost of local policies is generally financed by local taxes. This raises the question of local populations' willingness to pay (WTP) (Hanemann, 1994) for this type of program. The contingent valuation method (CVM) can monetarily quantify the values that individuals assign to an environmental good. This method has emerged as one of the few that includes values of both use and non-use, including the value of existence (Quiggin, 1998a,b). There has recently been a number of CVM-based economic studies on the risk of flooding. Zhai and Ikeda (2006), for example, discuss the acceptability of flood risks and the economic cost of evacuation in case of a disaster in Japan. Brouwer et al. (2009) examine the economic evaluation of exposure to flood risks in developing regions such as Bangladesh. In a survey of over 1000 households in the Shonai-Toki river basin in Japan, Zhai (2006) studied residents' WTP for flood risk reduction.

Our paper deals with the side effects on mudflow risks of potential changes in major determinants of agricultural practices in Europe (e.g. CAP), at the local level. In considering a predefined scenario of changes by 2015 and a first environmental assessment of this scenario (Ronfort et al., 2011), we have two objectives. First, we want to quantify the costs for local communities wishing to create incentives to change agricultural practices in order to counter the initial scenario. To this end we have tested the use of LPIS data in combination with findings from farmers' interviews and a literature review. The second objective is to estimate the local populations' willingness to pay for such an incentive program (using the CVM method) and to compare it with the estimated cost of the program.

Materials and methods

The study zone

The work was conducted in the French NUTS3 Region, Seine-Maritime, which is part of a NUTS2 region, Normandy. Seine-Maritime is representative of the European Loess Belt agricultural regions concerned by mudflows (Boardman et al., 1994; Verstraeten and Poesen, 1999). Natural conditions (e.g. deep fertile silty soils and regular rainfalls ranging from 650 to 1000 mm/year) and local agro-industrial networks are suited to a huge range of industrial crops and livestock production. The regional capital (Rouen) is the top-ranking grain port in Europe, and livestock farming, mostly with cattle, occupies 31% of the regional usable agricultural area (figures for 2010 from the national agricultural census). But Seine-Maritime is also characterized by a regular decrease of grassland areas due to encroaching urbanized areas and croplands, which leads to an increase in runoff risk (Souchère et al., 2003). In 2000, after several years of mudflow crisis, the 745 municipalities of Seine-Maritime organized themselves into 20 watershed syndicates in charge of protecting people and properties from mudflows (Fullen et al., 2006; Martin et al., 2010). We chose to work at the level of one of those syndicates called Austreberthe. The Austreberthe watershed extends over all or part of 37 municipalities inhabited by around 37,000 residents in an area of 214 km^2 in Seine-Maritime. At the beginning of the research program the two objectives presented in this paper (cost quantification and WTP assessment) were separate. Despite the fact that the WTP assessment was carried out for another watershed called Commerce (Fig. 1), we decided to compare the WTP data of Commerce with the cost evaluation carried out for Austreberthe because these two watersheds have many common features. They are geographically close to each other, are both tributary river basins of the Seine with high population density, located mainly in the valleys, and have high mudflow risk exposure. The Austreberthe watershed experienced an average of 27 days of flooding between 1983 and 2000, against 24 days for the Commerce Valley. Since 1983, as referenced in the national natural disaster database, every