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Research Article

An inquiry on north-eastern Italian farmers' perception of climate change and related risks to agriculture

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Abstract. Even though agricultural activities have always had to face systemic risk, increasing uncertainty linked to market conditions, policy revision and climate change require the adoption of extensive, functional and informed risk management strategies. Our study aims to investigate north-eastern Italian farmers' perception of climate change-related risks and attitudes towards adaptation strategies, in order to promote the adoption of effective communication strategies and the development of more attractive insurance schemes to widen famers' interests. Cross-sectional survey data were analysed using structural equation modelling to explore concerns over the impact of climate change on agricultural activities and identify the factors that promote the adoption of coping strategies. According to the results, the actual experience of negative consequences linked to specific extreme meteorological events is the main driver for the adoption of mitigation strategies. Further efforts on awareness of climate change and its consequences, coupled with the provision of simpler and more tailored insurance schemes, are required to support a widespread diffusion of adaptation strategies among farmers.

Keywords: risk mitigation, insurance, adaptation, structural equation modeling, Italian farmers.
JEL codes: Q10, Q14, Q18, Q54.

1. INTRODUCTION

In recent years, risk management has become an increasingly important issue in agriculture. Farmers have limited or no control over shocks and events related to external factors, as in the case of negative climate conditions or market and policy changes, even though such events directly impact agricultural outputs and outcomes such as yields, revenues and incomes (Komarke *et al.*, 2020). Growing uncertainty and instability due to high price volatility in commodity markets, the reduction of traditional market regulation instruments in the European Union (EU) and the increase in extreme climatic events are pushing farmers to adopt instruments and strategies to manage the different sources of risk in agriculture (Iyer *et al.*, 2020). Indeed, compared to other industries and economic activities, the spectrum of risks affecting agricultural outcomes is quite broad, and directly impacts the stability of food production and supply, hence food security, and the cost efficiency of agricultural activities (Calicioglu *et al.*, 2019).

The primary source of risk in agriculture is linked to nature: unfavourable weather conditions, plant or livestock disease outbreaks, pests and other natural factors may reduce yields. Weather phenomena and climatic events in particular are hard to predict and even harder to mitigate, at least at the beginning of the growing season. Other types of weather risks to consider as unforeseeable are sudden events like hail, heavy rain, windstorms or frost. In light of the complexities that characterize global climate and related evolution trends, the effects of weather are also difficult to generalize; at the same time, the impact of such events may vary considerably according to local and context-specific conditions of production systems such as crop characteristics, soil composition and structure or hydrogeological profile (Tarolli, Straffelini, 2020). In addition to this, other factors such as drainage and irrigation systems and the quality of farm management interact with weather conditions and are likely to enhance and magnify their effects (OECD, 2020; Porrini *et al.*, 2019). Under this perspective and taking into account the fact that weather conditions often affect large areas, the vulnerability and susceptibility of the agricultural sector determine the existence of systemic risks, which is one of the main limits for insurability.

Another source of risk in agriculture is related to changes in the market and the institutional context. Changes in agricultural policies and connected legal frameworks, such as trade liberalization, the introduction of new standards or environmental protection laws, funding and subsidizing, all contribute to rapidly modify the institutional environment in which agricultural entrepreneurs operate and require rapid adaptation to avoid facing operational and financial difficulties (El Benni *et al.*, 2012; Koundouri, 2009). Moreover, the global supply chain crisis, related to the consequences of the COVID-19 pandemic, and increasing political instability worldwide are determining increasing intersectoral systemic risk (Zhu *et al.*, 2021).

Various classification criteria have been used to categorize risk in agriculture (Komarek *et al.*, 2020; Marin, 2019). According to its nature, agricultural risk may be defined as natural–climatic, agrobiological or technogenic. Moreover, risks can be classified with respect to their intensity and extent (minor/acceptable, critical or catastrophic) or following the response of the policyholder (controllable, partially controlled or uncontrollable). Further classifications take into account other factors and characteristics, for example the degree of typicality of the risk phenomenon to the given area, its frequency and intensity of occurrence, degree of predictability and its impact on specific stages of crop development.

Insurance schemes and policies aimed at stabilizing agricultural income, reducing outcome uncertainty and increasing resilience to macroeconomic shocks (Heiman and Hildebrandt, 2018) are the most effective risk mitigation tools available in the agricultural industry (Wang *et al.*, 2020). Since the early 2000s, the development and adoption of agricultural insurance tools have been increasingly promoted at EU level (Capitanio, De Pin, 2018; Meuwissen *et al.*, 2018). In recent years, the 2014-2020 Common Agricultural Policy (CAP) explicitly provided specific funds and programmes for the ex-ante subsidization of agricultural insurance contracts, and similar measures have been extended to the transition period before the enforcement of the upcoming 2021-2027 CAP (Pieralli *et al.*, 2020).

Our research focuses on the natural-climatic risk and farmers' related responsiveness in north-eastern Italy. As demonstrated by the 2022 drought (Toreti *et al.*, 2022), the Po River valley, Italy's most important agricultural area, is already witnessing the impact of climate change. The vulnerability of the local agricultural industry (Monteleone *et al.*, 2022; Nickayin *et al.*, 2022) calls for the development of better risk management strategies and further involvement of farmers. To this end, this study proposes a theoretical model that imposes the relationships between latent constructs related to climate change beliefs and concerns among north-eastern Italian farmers. While the literature on Italian famers' risk perception and adaptation mainly focuses on case studies and specific crops/production (Perrone *et al.*, 2020; Rosa *et al.*, 2019; Sarvia *et al.*, 2019; Vitali *et al.*, 2019), the aim of our research is to generalize the analysis of farmers' perceptions of climate change and their intentions to take action to mitigate its negative consequences. Based on a cross-sectional survey, our analysis sheds light on farmers' perceptions of environmental risk in agriculture and their attitude towards adaptation and mitigation strategies; structural equation modelling was used to study the influence of climate change beliefs on the adoption of risk mitigation strategies, climate change concerns and barriers to adaption. The results highlight the limits of current approaches and support the identification of optimal strategies to maximize farmers' involvement in agricultural risk management.

Section 2 provides the theoretical background of the study. The research methods are detailed in Section 3, while we discuss the results in Section 4. Concluding remarks are then presented in the final section.

2. BACKGROUND AND RESEARCH HYPOTHESES

In order to measure farmers' concerns over climate change and intention to adopt mitigation strategies, we developed a theoretical model based on four constructs: Climate Change Beliefs, Perceived Barriers to Adaptation, Climate Change Concerns and Likelihood to Adopt Strategies. Validated scales to describe the constructs were taken from the literature and adapted to the specific research design.

Climate Change Beliefs (CCB): the CCB construct aims at observing farmers' perceptions and opinions on general climate change trends. More specifically, the construct was designed to identify whether farmers believe climate change is real and, if so, how human activities influence it. While there is a broad expert consensus on anthropogenic climate change (Oreskes, 2018), public opinion on these topics is still polarized (Benegal, 2018). Social and economic factors such as age, education and income, influence the perception of climate change (Benegal, 2018; Bromley-Trujillo, Poe, 2018; El Barachi *et al.*, 2021), and similar attitudes have been recorded among farmers (Ricart *et al.*, 2018, Woods *et al.*, 2017), including in Italy (Milone, Ventura, 2019). The literature confirms that farmers' personal beliefs on climate change and its extent are the primary factors that drive the necessity (or not) for reaction and adaptation strategies (Adger *et al.*, 2009; Arbuckle *et al.*, 2015).

Perceived Barriers to Adaptation (PBA): the adoption of risk management strategies is not straightforward, and there is widespread consensus among farmers on the existence of barriers to adaptation (Le Dang *et al.*, 2014; Woods *et al.*, 2017). The PBA construct deals with the complex of structural, contextual and individual obstacles to the selection of mitigation strategies and their integration in farming management activities (Chenani *et al.*, 2021; Eakin *et al.*, 2016). In the context of our analysis, the construct encompasses the perception of the negative consequences of non-adaptation and its costs for the farm in the long term (Pickson, He, 2021; Woods *et al.*, 2017; Wu, Mweemba, 2010).

Climate Change Concerns (CCC): linked to the first construct, CCC examines farmers' judgement on the consequences and potential events linked to climate change and the extent to which their activities are threatened by each of them. The construct items refer to the main negative events commonly associated with climate change, such as floods, drought, plant diseases, extreme weather events, soil erosion and water eutrophication (McBean, Ajibade, 2009). Several studies confirm that risk perception acts as an antecedent of adaptive behaviour (Azadi *et al.*, 2019; Tran, Chen, 2021), and its effect is amplified by risk aversion (He *et al.*, 2020). Besides the abovementioned individual beliefs on climate change, farmers' perceptions of negative events and the associated risks for agricultural activities may also be influenced by the specific type of farm and its pedoclimatic context, as well as individual and personal factors such as education, income and social networks (Mirzaei *et al.*, 2022; Yin *et al.*, 2020). Under this perspective, the actual experience of extreme weather events and other negative circumstances related to climate change is not equal among all farmers. Therefore, the perception of the need for adaptation and, eventually, the selection of optimal mitigation strategies may vary.

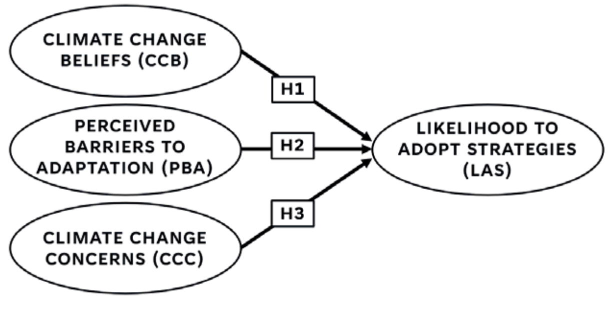
Likelihood to Adopt Strategies (LAS): the actual probability to adopt mitigation strategies is described by the LAS construct. The items that describe this construct include the main risk management actions, either linked to production and primary activities (production optimization, income diversification, adoption of new technologies, switch to conservative agriculture), financial management (insurance policies, sale or renting of part of the farm, management of cash flows and debt) or individual choices (side business or second job, exit from the farming sector) (Pagliacci *et al.*, 2020; Woods *et al.*, 2017).

This study proposes a theoretical model to analyse the relationships between the four latent constructs. Based on the existing literature, three hypotheses were developed to assess these factors and empirically test their impact on the adoption of mitigation measures. Figure 1 graphically represents the theoretical framework, with the proposed causal relationships among climate change beliefs, perceived barriers to adaptation, climate change concerns and likelihood to adopt strategies. Specifically, the hypotheses to be tested are as follows:

Hypothesis 1 (H1): climate change beliefs affect the likelihood to adopt mitigation strategies.

Hypothesis 2 (H2): perceived barriers to adaptation have a significant impact on the likelihood to adopt mitigation strategies.

Fig. 1. The proposed model.



Hypothesis 3 (H3): climate change concerns have a significant impact on the likelihood to adopt mitigation strategies.

3. MATERIALS AND METHODS

In order to collect data for hypothesis testing, a computer-assisted web interview (CAWI) was forwarded to 3,000 north-eastern Italian farmers in the Condifesa Friuli-Venezia Giulia (an Italian farmers' consortium involved in atmospheric risk management) mailing list. A total of 105 farmers took part in the survey. The first section of the questionnaire included questions on farm structure, size, activities and characteristics. The second section was organized into four subsections, one for each construct. Each subsection included a set of seven-point Likert-like psychometric scales to measure participants' knowledge of climate change, perception of related risks for farms, attitude towards potential adaptive strategies and intention to undertake mitigation actions, respectively. As detailed in the previous section, the items used to describe the constructs were based on validated scales taken from the literature. Descriptive statistics were used to describe the sample, and a structural equation model was developed to test the importance of the cognitive factors underpinning farmers' likelihood to adapt.

Data analysis was conducted by first assessing the measurement models via confirmatory factor analysis (CFA), which determines whether the latent variables were correctly measured. Thereafter, the proposed hypotheses were tested via a structural equation model (SEM) because this method is more suitable for making the structure of the causal relationships among latent variables explicit (Cohen *et al*., 1990). The CFA for each measurement model was estimated using maximum likelihood to identify the four latent constructs. The specification of the SEM was composed of three equations:

$$y=A^{y}\eta+\varepsilon \qquad (1)$$

$$x=A^{x}\xi+\delta \qquad (2)$$

$$\eta=B\eta+\Gamma\xi+\xi \qquad (3)$$

Equations 1) and 2) are measurement models, which tie the constructs to observable indicators. The p x 1 vector y contains the measures of the endogenous constructs, and the q x 1 vector x consists of the measures of the exogenous indicators. The coefficient matrices and A^{y} and A^{x} show how y relates to η and x relates to ξ, respectively. The vectors of disturbances e and d represent errors in variables (or measurement error). Equation 1) is called the structural model and expresses the hypothesized relationships among the constructs in the conceptual framework. The m x 1 vector η contains the latent endogenous constructs, and the n x 1 vector ξ consists of the latent exogenous constructs. The coefficient matrix B shows the effects of the endogenous constructs on each other, and the coefficient matrix Γ signifies the effects of exogenous on endogenous constructs. The vector of disturbances ς represents errors in equations. Generally (but not always) the measurement model possesses simple structure such that each observed variable is related to a single latent variable.

4. RESULTS AND DISCUSSIONS

Descriptive statistics are presented in Table 1 as a summary of the social and demographic characteristics of the sample. Most respondents (88.58%) were agricultural entrepreneurs, farm owners and/or shareholders, and about half of them had completed high school. Farms greatly varied in size, ranging from 1.5 ha to 201 ha, with the mean equal to 36.73 ha. While distant from the national average of 7.9 ha (Caffaro, Cavallo, 2019), these figures confirm that land ownership in Italy is generally fragmented, and most farms fall into the small to medium size category. Respondents' farms represented all the main specializations (arable crops, grapevine, woody fruit, pasture, livestock) that characterize the national agricultural industry structure.

Tab. 1. Main characteristics of the sample.

Characteristics	Classes	N	%
Role of respondent	Owner	93	*88.58*
	Collaborator	6	*5.71*
	n.a.	6	*5.71*
Education	Elementary	3	*2.86*
	Middle school	23	*21.90*
	High school	54	*51.43*
	Vocational training	8	*7.62*
	University	23	*16.19*
Farm size	Min	1.5 ha	
	Max	201 ha	
	Mean	36.73 ha	
Workers (excl. seasonal)	1-5	83	*79.05*
	6-10	4	*3.81*
	More than 15	1	*0.95*
	n.a.	17	16.19

The hypotheses were tested via a SEM by using the LISREL 10.2 software. This method is best suited to explicit causal relationships in a latent structure. The purpose of this work is to test the relationships among the four latent dimensions proposed in the model in Figure 1.

First, the factor analysis with varimax oblique rotation approach is used to identify the four latent dimensions of the survey. This is useful to obtain four latent factors as a linear combination with minimum loss of information. The reliability of each latent factor is positively analysed by the Cronbach's α coefficients and the average variance explained (AVE), as summarized in Table 2.

Furthermore, the analysis conducted with LISREL 9.1 allowed us to test the hypotheses made in the proposed model. The fit indexes of the model (Tab. 3) are produced in order to verify how well the hypothesized model reproduces the observed covariance matrix (Nassivera, Sillani, 2017; Sillani, Nassivera, 2015; Cheah *et al.*, 2018). Specifically, the selected indexes are: the goodness of fit index (GFI) and adjusted goodness of fit index (AGFI), both proposed by Schumacker and Lomax (2004); the incremental fit indexes or normed fit index (NFI), proposed by Bentler and Bonnett (1980); the non-normed fit index (NNFI), as proposed by Bollen and Liang (1988); the comparative fit index (CFI), proposed by Bentler (1990); and the root mean square error of approximation (RMSEA), proposed by Browne and Cudeck (1992). The results indicated a good fit between the model and observed data and allowed for the analysis of the assumptions of the hypotheses.

Of the hypotheses, one of the three is well supported (Tab. 4). The correlation between CCC and LAS is statistically significant (y = 0.60, t = 2.75), supporting H3. The relationship between PBA and LAS is not statistically significant (y = -0.05, t = -0.30); hence, H2 is not supported. Lastly, CCB statistically influenced LAS (y = 0.22, t = 1.70). Supporting these hypotheses, the model depicts a particular reactivity of farmers to adopt strategies.

Tab. 2. Reliability and AVE of latent constructs.

Construct and items	Label	λ	α	AVE
CLIMATE CHANGE BELIEFS	CCB		0.64	0.45
Climate change is natural	CCB1	0.40		
Climate change is not happening	CCB2	0.79		
Climate change not confirmed	CCB3	0.69		
PERCEIVED BARRIERS TO ADAPTATION	PBA		0.81	0.5
My long-term success requires climate variability adaptation strategies	PBA1	0.46		
Farmers' long-term success requires climate variability adaptation strategies	PBA2	0.47		
Climate change is damaging me	PBA3	0.80		
Five years perceived increase in climatic instability	PBA4	0.81		
Climate change will likely damage me in the future	PBA5	0.68		
Long-term goals influenced by past extreme weather	PBA6	0.72		
CLIMATE CHANGE CONCERNS	CCC		0.81	0.5
Floods	CCC1	0.59		
Drought	CCC2	0.70		
Phytopathies	CCC3	0.57		
Heavy rain	CCC4	0.70		
Strong wind	CCC5	0.63		
Hailstorm	CCC6	0.79		
Frost	CCC7	0.69		
Plant heat stress	CCC8	0.69		
Water eutrophication	CCC9	0.78		
Soil erosion	CCC10	0.70		
LIKELIHOOD TO ADOPT STRATEGIES	LAS		0.75	0.58
Adapt/optimize production	LAS1	0.58		
Income diversification	LAS2	0.70		
Technological improvement	LAS3	0.57		
Conservative agriculture	LAS4	0.70		
Financing and debt management	LAS5	0.63		

Tab. 3. Main indexes of model fitting.

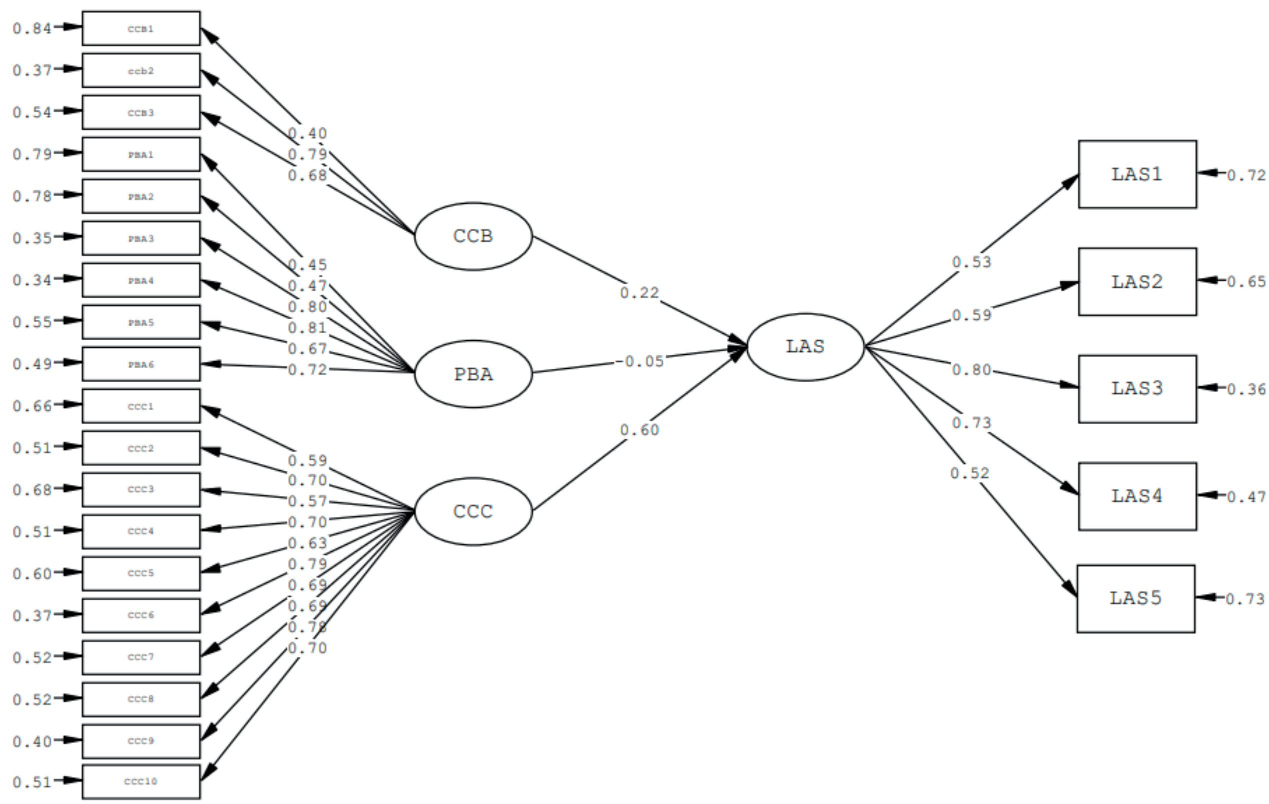
Global fit indexes	Value	gdl
GFI	0.74	
AGFI	0.68	
NFI	0.85	
NNFI	0.91	
CFI	0.91	
RMSEA (Test of Close Fit)	0.096	
$\chi 2$	492.53	246

Tab. 4. Direct effects among constructs.

Hypothesis	Estimate (*Standardized*)	s.e.	t
(H1) CCB→LAS	0.22	0.13	1.70
(H2) PBA→LAS	-0.05	0.17	-0.30
(H3) CCC→LAS	**0.60**	**0.15**	**2.75**

The opinions on climate change of Italian farmers who reside in the north-eastern regions are mixed. While most of them do not believe that climate change is not happening (mean response equal to 2.6), no clear consensus emerges over its natural or anthropogenic origin. This duality in perceptions, already reported in the literature (Niles *et al.*, 2013; Ricart *et al.*, 2018), likely drives respondents' limited concern over climate change *per se*, which is in line with the existing literature (Woods *et al.*, 2017). In fact, climate change appears to be classified as a future, rather than current, problem: this biased temporal perspective, coupled with the feeling of limited control over it, may explain the small effect of CCB on LAS. On the contrary, with respect to PBA, the existence of barriers, though acknowledged, is not a deal breaker: similar to Eakin *et al.* (2014), agricultural entrepreneurs are confident in their adaptive capacity. Finally, the strong positive correlation between CCC and LAS indicates the likelihood to undertake adaptive action in the future and identify potential opportunities from climate change impacts. In this perspective, the more a farmer has experienced or is afraid to experience negative consequences linked to specific extreme meteorological events, the more likely he is to adopt mitigation strategies. In fact, risk-coping strategies are generally based on adequate perception of risks

Fig. 2. Path analysis of the proposed model.



(Sulewski, Kłoczko-Gajewska, 2013); therefore, if the impact of climate change or the vulnerability of their own businesses are perceived as purely hypothetical or a far future matter, adaptation would definitely not be considered a priority (Hitayezu *et al*., 2017; Waldman *et al*., 2019). In line with existing knowledge on the topic (Pagliacci *et al*., 2020; Woods *et al*., 2017), farmers apparently prefer incremental and flexible adaptations in the face of uncertain future climate change impacts.

5. CONCLUSION

Our research contributes to the literature on agricultural risk perception by providing localized insights on the opinions and attitudes of north-eastern Italian farmers. The results of our inquiry call for the necessity to promote sensibilization and spread awareness over the issues related to global climate change trends and their growing impact on agricultural activities and productivity. The analysis confirms that the primary element pushing farmers' intention to adopt risk-coping strategies is the perception of risk and consequent vulnerability (Weber, 2010). Under this perspective, in order to maximize farmers' engagement in mitigation strategies, more effective communication strategies by institutions, policymakers and insurance scheme providers should increase understanding of climate change mechanisms and impacts, and stress that it is already altering the basic conditions for agriculture at our latitudes (Asmi *et al*., 2019; Azadi *et al*., 2019; Whitmarsh, Capstick, 2018). Moreover, the results confirm that pluri- and multi-risk insurance schemes are expensive and barely understood by agricultural entrepreneurs (Georgievich, 2021); more flexible insurance schemes, able to cope with effective risk management and, at the same time, in line with farmers' sentiments and perceptions, would likely be more attractive (Ceballo and Robles, 2020; Doherty *et al*., 2021; Santeramo, 2018). Replication of the study in other regions and nations is desirable to overcome weaknesses and limitations, in particular with respect to geographical representativeness and generalization of the results (Coletta *et al*., 2018, Capitanio *et al*., 2014; Miglietta *et al*., 2021; Pontrandolfi *et al*., 2016).

While the results of our analysis might hardly be generalized outside the specific, though extensive, study area, the model can easily be adapted for replication in other contexts. Further investigations on barriers to adaption might promote policymakers and practitioners' commitment to their removal, hence enhancing farmers' engagement and the adoption of mitigation measures.

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