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Coping With Production Risk: Effects of Sown Plant Diversity on the Attractiveness of Crop Insurance in Grasslands

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ABSTRACT

Increased frequency of extreme weather events, particularly droughts, threatens grassland farming by destabilizing yields and farms' economic viability. We examine, theoretically and through numerical simulations, how sown plant diversity (natural insurance) influences the attractiveness of indemnity and drought index insurance (formal insurance) in grassland systems across Europe. Our analysis shows that higher sown diversity reduces farmers' willingness to pay for indemnity insurance, suggesting adverse selection. In contrast, drought index insurance remains equally attractive regardless of diversity. These effects hold across different insurance designs and risk preferences. Our findings offer valuable insights for farmers, insurers, and policymakers aiming to build resilient, sustainable agricultural systems.

JEL Classification: Q570, Q540, Q140

1 | Introduction

Climate change and the intensification of extreme weather events, such as droughts, negatively impact agriculture (Ortiz-Bobea et al. 2021; Webber et al. 2018). Droughts are particularly damaging to grassland farming systems, which depend on a continuous water supply for feed production and are predominantly rainfed (Knapp et al. 2002; Soussana and Lüscher 2007). Expected impacts of more frequent and intense extreme weather events include lower and more volatile yields, implying potential negative effects for the economic viability of farms and food security (Bindi and Olesen 2011; Macholdt et al. 2023; Naumann et al. 2021; Ohlert et al. 2025).

Farmers can use on-farm and off-farm strategies to cope with these risks. For grassland-based farming systems, a key on-farm strategy is that farmers can increase grass species richness, which stabilizes yield against shocks, thus acting as a natural insurance mechanism. A key off-farm strategy is that farmers can share their risk with others via grassland insurance schemes (formal insurance) (Vroege and Finger 2020). Two main types of grassland insurance schemes are available on markets: (i) indemnity insurances that compensate farmers for effective yield losses, and (ii) weather index insurances that trigger payouts based on the realization of a specific weather index, for example, based on precipitation (Martin et al. 2001). The type of insurance scheme at hand has implications for farmers' behavior as indemnity insurance is more likely than index insurance to induce adverse selection, that is, they could be primarily adopted by farmers who use weak natural insurance practices, such as reduced plant diversity (Baumgärtner 2008; Müller et al. 2011).

The interplay between grassland plant diversity and different types of crop insurance schemes has so far not been addressed in the literature, and is becoming increasingly important due to increased relevance and subsidization of agricultural insurances

(Dalhaus et al. 2023; Müller et al. 2017; WWF and Deloitte 2023). Yet, a more comprehensive understanding of this interrelation is needed to guide industry and policy in the quest for more resilient, sustainable and productive farming systems.[1]

In this paper, we develop a quantitative model of farmer behavior to assess the degree to which different formal insurance schemes set incentives for adverse selection in a European context (see Figure 1). To this end, we first develop a theoretical framework to describe risk averse farmers' willingness to pay for two types of insurances: (i) indemnity insurance and (ii) drought index insurance, contingent on sown plant diversity, which we consider as the farmer's choice of natural insurance. We quantify this model utilizing data from grassland experiments across Europe, which experimentally manipulate plant species diversity and observe the effects on yield and yield variability. Numerical simulations allow us to assess how the farmer's type of natural insurance adoption affects the attractiveness of the two types of formal insurance schemes and draw industry and policy conclusions.

Previous research addressed the relationship between formal insurance and natural insurance (e.g., plant diversity) (Knapp et al. 2021). These interactions can be (i) complementary, when improved access to formal insurance increases the uptake of natural insurance, or (ii) substitutive, when improved access to formal insurance reduces the uptake of natural insurance. The previous theoretical literature suggests that natural insurance and formal insurance are substitutes due to the overlapping income stabilizing properties provided by both types of insurances (Baumgärtner 2008; Baumgärtner and Quaas 2010). However, empirical studies found both negative (Di Falco and Chavas 2009; Di Falco et al. 2014; O'Donoghue et al. 2009) and positive correlations between on-farm diversification and formal insurance uptake (Enjolras et al. 2012; Lefebvre et al. 2014; Mishra et al. 2004). Another part of the literature explores the substitutability between formal insurance and self-insurance or self-protection (Ehrlich and Becker 1972; Just et al. 1999; Bulte and Lensink 2023). Both theoretically (Courbage 2001) and empirically (Carson et al. 2013; Pannequin et al. 2020) formal insurance and self-insurance have been shown to function as substitutes. Given the context of our paper, this body of literature has two main gaps. First, only one paper focuses on grassland (Müller et al. 2011) and only few investigate specifically plant diversity or biodiversity as a diversification strategy (Baumgärtner and Quaas 2010; Di Falco and Chavas 2009), with the main accent placed on diversification within the farm as a broader concept (e.g., O'Donoghue et al. 2009). This research gap is relevant because plant diversity has an ecological component that renders its effect different from that of other diversification strategies (e.g., Tilman et al. 1996). Second, no study has included weather index insurance designs in a quantitative analysis of the complementarity between such (formal) insurance and diversification as a natural insurance. This consideration holds significance (i) because (weather) index insurance

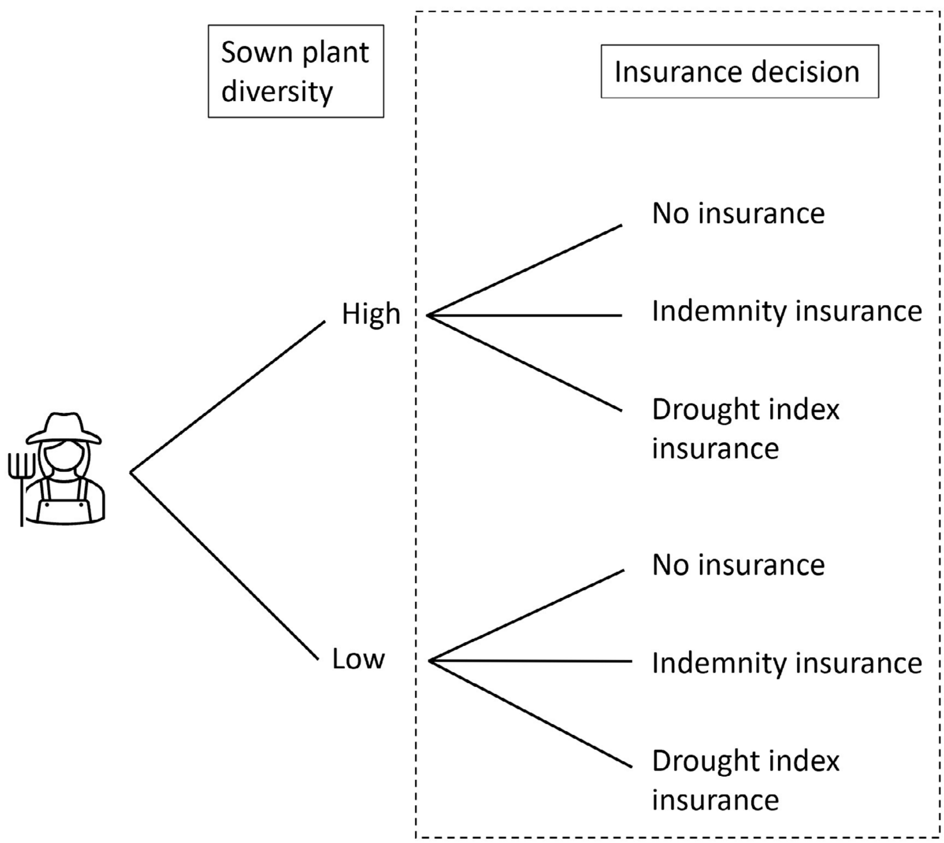

FIGURE 1 | Farmers' insurance decision contingent on sown plant diversity. Farmers' insurance decision can be different depending on the previous decision on sown plant diversity level. We focus on the contingent decision by farmers, represented by the insurance decision within the dashed frame.

becomes increasingly dominant in practice, especially for grassland production (Vroege et al. 2019), and (ii) due to the potential lower probability of moral hazard and adverse selection behavior, that is, lower feedback on farmer behavior, with index insurance coverage (Clarke 2016). Hence, index insurance may be more likely to act as complement with plant diversity than traditional indemnity insurances, but may less accurately model real losses (Jensen et al. 2018).

We contribute to addressing these gaps in previous literature in three ways. First, we analyze theoretically the relationship between different types of formal insurance schemes (indemnity insurance and drought index insurance) and natural insurance (sown plant diversity) within the context of grassland farming. We use drought index insurance as a specific example of weather index insurance. Second, we quantify this interaction by estimating the farmers' willingness to pay for the different formal insurances under different sown plant diversity scenarios. As robustness checks, we consider different insurance designs, namely different deductible types, loading of the insurance premium and different drought indexes. In addition, we run the simulations for different absolute risk aversion coefficients (0.5, 2, and 3) to account for the heterogeneity of farmers' risk aversion levels in Europe (Iyer et al. 2020; Garcia et al. 2024). Third, in contrast to previous research on the interplay between natural and formal insurances, we use experimental yield data to estimate the farmers' willingness to pay for formal insurance conditional on the level of plant diversity. We distinguish the farmer type by the uptake of natural insurance, measured as grassland plant diversity, and address the question of adverse selection, that is, whether farmers with low or high natural insurance adoption are more likely to make use of the respective formal insurance scheme. By using experimental data–as opposed to observational data–, we can establish clear effects of plant diversity on revenue and risk, mitigating potential selection bias arising from farmers' behavior.

Our key findings are twofold. On the one hand, we find that the willingness to pay for indemnity insurance is disproportionately higher for farmers with low natural insurance uptake, that is, sowing low diversity (28 ± 20 Euros per hectare) compared to farmers with high natural insurance uptake, that is, sowing relatively high diversity (-12 ± 9 Euros per hectare). This indicates adverse selection for indemnity insurance, which more likely attracts farmers who implement low natural insurance. On the other hand, the willingness to pay for drought index insurance remains constant for the different sown plant diversity levels (12 ± 16 Euros per hectare) for low diversity and (15 ± 13 Euros per hectare) for high diversity, indicating less pronounced or no adverse selection. We conclude that index insurance can be effective for farmers adopting both low and high natural insurance. Within the context of increased crop insurance subsidization in Europe, these results have important implications for both industry and public policy. They suggest that drought index insurance may have more favorable implications for natural insurance, compared to indemnity insurance.

The paper is structured the following way. First, we provide background on risk management instruments in the context of grassland farming. Second, we show the theoretical analysis describing the willingness to pay for formal insurance contingent on sown plant diversity. Third, based on the theoretical model and experimental data, we conduct numerical simulations with robustness checks. Finally, we discuss and conclude the analysis.

2 | Background and Related Literature

Grasslands (including permanent and temporary types) account for more than one third of agricultural land in Europe (Schils et al. 2022) and are mainly used to produce forage for livestock (Estel et al. 2018). Grasslands can be managed either by grazing or by mowing for hay or silage. Grasslands can include diverse plant species within the same field and are usually maintained for several years, even when classified as temporary grassland (Huyghe et al. 2014). Insurance for grassland is generally less developed than for arable crops, as yields are more difficult to measure and losses are harder to assess, although some countries offer forage- or drought-related insurance products (Vroege et al. 2019). While the use of natural insurance helps stabilize yields and income, it does not directly protect farmers against drought (Alou et al. 2026); therefore, without insurance, an extreme drought can lead to substantial losses even in high-diversity fields (Ohlert et al. 2025).

Previous ecological and economic literature has shown that increasing plant diversity in grasslands can provide two main benefits for farmers. First, it decreases the variability of yield and thus profits, thanks to ecological interactions between species and portfolio effect (Isbell et al. 2009; Koellner and Schmitz 2006; Scherzinger et al. 2024; Suter et al. 2021; Tilman et al. 1998). Second, it increases the expected biomass production and thus the expected profit for farmers, thanks to various ecological mechanisms, for example, increased use of resources through space (e.g., Binder et al. 2018; Schaub et al. 2020; Tilman et al. 1996). Also, diversity is costly, as grassland seed mixtures used to achieve greater plant diversity are more expensive (Schaub et al. 2021), and the aggregated effect on expected profits remains context specific and ambiguous. We here focus on the risk reducing property, where as a result, risk averse farmers also benefit from increased plant diversity through a reduction in variability. The increase in their expected utility from this reduction in risk is described by the insurance value of plant diversity (Baumgärtner 2008). Plant species used for grassland farming are from different functional groups, for example, grasses and legumes, and combining them in the same field can lead to greater yield increase and reduction in variability (Lüscher et al. 2022). Community species asynchrony, that is, an ecological variable based on the difference in growth of plant species, can be an indicator of complementarity between species (Loreau and de Mazancourt 2008). Furthermore, these benefits extend to ecosystem services such as food production or carbon sequestration, implying public importance (Huber et al. 2022; Paul et al. 2020). In European countries policies aim at promoting more diverse grassland, for example, through agri-environmental schemes (Baylis et al. 2008; Elmiger et al. 2023; Klaus et al. 2023; Wuepper and Huber 2022).[2]

Grasslands insurance schemes to cope with risks of extreme weather conditions are gaining momentum and are increasingly available to farmers and of increasing policy relevance (Vroege et al. 2019). In this paper, we focus on two agricultural insurance designs. Indemnity insurances are straightforward and well accepted by farmers as the payout depends directly on the loss suffered, that is, they receive payment when their yield falls below a certain threshold (Möllmann et al. 2019). In order to trigger the compensation for the insured, an objective measurement of damages needs to be made, for example, carried out via an expert or based on data (e.g., yield records). This type of insurance is most widely used for crops (e.g., Wu 1999), but it presents several drawbacks, particularly for grassland farming systems. First, asymmetric information issues such as moral hazard, that is, insured farmers may implement riskier strategies, and adverse selection behavior, that is, farmers with riskier strategies are more likely to take insurance, may be induced (Benami et al. 2021; Chambers 1989; Mieno et al. 2018). To address these behavioral drawbacks, indemnity insurance designs generally include deductibles,[3] that is, a part of the insured losses that remains the responsibility of the farmer so the risk reducing properties are diminished (e.g., European Commission 2008, see Supporting Information S.11 for an example of an insurance contract). Second, the physical damage assessment is costly and often infeasible, especially for systemic risk such as droughts that affect large areas at the same time the administrative costs for regulating losses at many farms can be high (Bucheli et al. 2023; Miranda and Glauber 1997). Third, damage assessments can be difficult to carry out when grasslands are frequently or even continuously used via grazing and cutting (Vroege et al. 2019). Insurance products can use satellite imagery to estimate farm-level grassland yield, allowing them to function similarly to indemnity insurance in practice (Lepoivre 2020; Roumiguié et al. 2015). However, challenges remain and therefore products implemented in Europe using satellite imagery to estimate yields often remain technically index insurances, and therefore still carry the associated drawbacks, most notably basis risk (Vroege et al. 2019).

Weather index insurances, which provide insurance against specific weather occurrences, are increasingly offered (Bucheli et al. 2023; Smith and Glauber 2012). The payment to the farmers is triggered when an index based on weather variables crosses a threshold. For instance, for drought insurances, the index may contain information on precipitation, drought indices or temperature (Martin et al. 2001).[4] Such insurances may be advantageous to reduce the risk of moral hazard and adverse selection since payments are not directly linked to the losses suffered by the farmers (Vroege et al. 2019) and payments can be transferred during the period of extreme weather events, potentially allowing farmers cover the cost of natural insurance strategies (e.g., plant diversity) (Bucheli et al. 2022). Previous research also identified opportunities for remote sensing technologies to enable both indemnity and index-based insurance solutions especially suited for grassland production systems, which for example are characterized by difficult yield measurement, for example, due to regular use by mowing and grazing (Vroege et al. 2021). Nonetheless, the adoption of such insurances remains limited, due to basis risk, that is, the gap between the insurance payoff and the real loss suffered by the insured individual (Clarke 2016; Jensen and Barrett 2017; Jensen et al. 2018) or insurance costs (Lichtenberg and Iglesias 2022). In Europe, weather index insurances for grassland farming systems are offered in Austria, Germany and Switzerland (Die Österreichische Hagelversicherung 2020; Schweizer Hagel 2023; Vroege et al. 2019). Overall, weather index based insurance solutions for grassland are expected to be of increasing relevance (Vroege et al. 2019).

3 | Theoretical Framework

We investigate how the incentive to adopt two different insurance schemes, that is, an indemnity insurance and a drought index insurance, depends on the farmer's adoption of natural insurance in the form of plant diversity. To do so we compute the willingness to pay for the formal insurance products varies depending on the plant diversity *sown* by farmers in their grasslands (see Figure 1). If the willingness to pay for formal insurance decreases with sown diversity, this indicates adverse selection in the adoption of formal insurance; which is not the case if the willingness to pay for formal insurance remains constant or increases with sown diversity.

In the theoretical framework we proceed in two steps. First, we describe the risk faced by farmers that can sow their fields with different productive plant species mixtures without the availability of formal insurances. Second, we design two stylized insurance schemes (indemnity insurance and drought index insurance) and compute the willingness to pay by farmers for each. We assume that the decision to adopt formal insurance comes after the decision on sown plant diversity. This is justified on the grounds that changing the grassland diversity requires sowing new mixtures, which could be more costly for farmers (Schaub et al. 2021) and therefore grasslands are likely sown for several years. In actual decision-making, the decision on plant diversity will be influenced by the anticipated decision to take formal insurance. Our theoretical model considers only the second stage of the decision-making, namely the adoption of formal insurance, contingent on the previously made decision on species diversity.

3.1 | Expected Utility

To compute the willingness to pay for formal insurance, we build on expected utility theory (Von Neumann and Morgenstern 1944). Specifically, we assume that the farmer's risk preferences are characterized by a constant relative risk aversion ($\rho > 0$) with respect to the uncertain payoff (profit π_i). This makes it possible to not only consider variance and its effect on farmers' utility, but also account for the role of downside risks (Menezes et al. 1980).

We write the expected utility of farmer i, using a power utility function, as follows:

$$EU_i = E\big(U(\pi_i)\big) = E\left(U\left(\frac{{\pi_i}^{1-\rho}}{1-\rho}\right)\right) \quad (1)$$

To express the willingness to pay in monetary terms, we use the certainty equivalent, that is, the level of certain profit that would make farmer i indifferent to his current uncertain profit:

$$CE_i = \big(EU_i \times (1-\rho)\big)^{\frac{1}{1-\rho}} \quad (2)$$

TABLE 1 | Overview of the insurance schemes.

	Indemnity insurance	Drought index insurance
Payout conditions and strike level	Payout to an insured farmer occurs when the yield of the farmer (measured in person, from yield records, or via remote sensing) falls below a certain yield level, namely the strike level. The strike level is based on the historical yield of all farmers as we assume that insurance companies do not know the level of plant diversity sown by farmers.	Payout to a farmer occurs when the drought index falls below a certain level of drought index, namely the strike level. The strike level is based on historical drought index and their connection to yield values.
Deductibles	Franchise deductibles are included for this insurance, meaning that the strike level is lower than the average yield of farmers.	Since weather index insurance are less likely to lead to behavioral drawbacks, no deductibles are included in the design of this insurance in the theoretical model. Yet, deductibles are included in the numerical simulations (see Section 4.2).
Insurance premium	The actuarial premium is calculated on the basis of all the loss amounts paid out by the insurance.	
Loading	In the main analysis, we assume a fair insurance premium without loading, meaning that no mark-up is added to the insurance premium. This is justified by the presence of insurance subsidies in most European countries, which compensate for loading. Loading is considered in Supporting Information S.1.	

Note: Description of the main elements in the design of the indemnity insurance and drought index insurance.

Finally, to quantify the monetary implications of the risk faced by farmers, we use the risk premium of farmers, that is, the difference between their expected profit their certainty equivalent (Pratt 1964):

$$RP_i = E(\pi_{i,t}) - CE_i \tag{3}$$

3.2 | Baseline Model

In our baseline model without insurance schemes, we consider farmers that produce hay at a stochastic level $\hat{y}_{i,t}(d_{i,t}, n_{i,t}, x_{i,t})$. We assume that they generate profit out of grass production, for example, by using it on the farm or selling it. We here assume that the produced grassland yield is valued at price[5] p. The production of grass is affected by drought $d_{i,t}$ (frequency and intensity), by the level of plant diversity $n_{i,t}$ (controlled by sowing) and by other environmental and management factors[6] represented by $x_{i,t}$. n is assumed to be a continuous variable and could be represented by the Shannon index[7] that considers both abundance and evenness of species. Using p_{ij} to denote the relative abundance of grass species j on field i, the Shannon index is defined as (Shannon 1948):

$$S_i = -\sum p_{ij} ln(p_{ij}) \tag{4}$$

Additionally, the management decision of farmers leads to cost $c_{i,t}(d_{i,t}, n_{i,t}, x_{i,t})$ also affected by drought, plant diversity and other environmental and management factors. The profit of farmer i in realization t is given by:

$$\pi^B_{i,t} = p \times \hat{y}_{i,t}(d_{i,t}, n_{i,t}, x_{i,t}) - c_{i,t}(d_{i,t}, n_{i,t}, x_{i,t}) \tag{5}$$

The certainty equivalent and the risk premium of farmer i in the baseline scenarios are denoted by CE^B_i and RP^B_i. Following the conceptual and empirical ecological literature, we assume that plant diversity reduces the production risk faced by farmers such that $\frac{\partial RP^B_i}{\partial n_i} < 0$ (e.g., Schaub et al. 2020; Suter et al. 2021).

3.3 | Insurance Models

In the following subsection, we describe farmers covered by either indemnity insurance or drought index insurance. Table 1 provides an overview of the main elements of the insurance design. In what follows we describe how the insurances are designed in more detail.

3.3.1 | Indemnity Insurance

We assume an indemnity insurance that covers all perils, similar to insurances based on Actual Production History crop insurance program in the US[8] (Mieno et al. 2018). In practice, for European grasslands, this could be based, for example, on remote sensing or other yield quantification (e.g., Vroege et al. 2019, 2021). Moreover, we assume that insurance companies observe the current yield of farmers (measured in person, from yield records, or via remote sensing) and they observe the management practices of each individual farmer (e.g., mowing regime and fertilizer levels). However, they cannot observe the specific choice of sown plant diversity of each individual farmer, as this is the only "hidden" action of farmers in our model.[9] We justify this assumption on the grounds that this variable is not generally observed in practice by insurance companies and that monitoring it might prove too costly due to the temporal character of productive grassland and the regular resowing. To reflect this hidden action, we specify that the insurer designs the strike level and the insurance premium based on the historical yield average of all farmers and plots. To illustrate this, in realization t, farmer i receives the payment:

$$\varphi_{i,t}^{M} = a_M \times p \times (\bar{y} - \hat{y}_{i,t})A \quad (6)$$

where a_M is the insurance coverage such that: $0 \leq a_M \leq 1$. This means that $1 - a_M$ represents a relative deductible.[10] The insurance company values grassland yield at price p. $(\bar{y} - \hat{y}_i)$ is the difference between mean yield (calculated using historical data of various farms) and realized yield by farmer i in realization t. A is a binary variable that ensures that payments only occurs when the profit of farmers fall below the yield threshold, $A = \begin{cases} 0 if \hat{y}_{i,t} \geq \bar{y} \\ 1 if \hat{y}_{i,t} < \bar{y} \end{cases}$.

For the main specification, we assume that the insurance premium is fair (see Supporting Information S.1 for a premium with loading), that is, equal to the expected payment received by the farmers.[11] The premium is given by:

$$\delta^{M} = E\left(\varphi_{i,t}^{M}\right) \quad (7)$$

The expectation is taken over the probability distribution of yield.

With indemnity insurance, the profit of farmer i in realization t is then given by:

$$\pi_{i,t}^{M} = p \times \hat{y}_{i,t} - c_{i,t} + \varphi_{i,t}^{M} - \delta^{M} \quad (8)$$

The certainty equivalent and the risk premium of farmer i in the indemnity insurance scenario are denoted by CE_i^M and RP_i^M. We assume that with indemnity insurance coverage farmers reduce their production risk and increase their expected utility (Vroege et al. 2019), $CE_i^M > CE_i^B$ and $RP_i^M < RP_i^B$.

3.3.2 | Drought Index Insurance

Identically to the indemnity insurance, we assume a stylized drought index insurance based on limited information of individual farmers' practices (individual historical yield and sown plant diversity are not observed). By using a stochastic drought index $\hat{I}(d)$ (e.g., cumulative precipitation index) (Martin et al. 2001), the insurance stabilizes farmers' profit against drought risk. To illustrate this, in realization t, farmer i receives the payment:

$$\varphi_{i,t}^{I} = p \times \left(\bar{I} - \hat{I}_{i,t}\right) D \times z \quad (9)$$

where the insurance company values grassland yield at price p. $\left(\bar{I} - \hat{I}_i\right)$ is the difference between mean drought index (calculated using historical data from the location of the farm, e.g., 15 years) and the actual drought index. D is a binary variable that ensures that payments only occurs when the drought index fall below the index threshold, $D = \begin{cases} 0 if \hat{I}_{i,t} \geq \bar{I} \\ 1 if \hat{I}_{i,t} < \bar{I} \end{cases}$. z is the tick size that links the index to farmers' yields (Perondi et al. 2023). Contrastingly to the indemnity insurance, we assume that there are no deductibles for the drought index insurance, meaning that all the risk resulting from the index variation is covered. This is justified because indemnity insurances usually include deductibles to deal with moral hazard and adverse selection, whereas index insurances do not necessarily include those deductibles (e.g., Barnett et al. 2008).[12] Additionally, the indemnity insurance covers multiple perils as opposed to the drought index insurance, which only covers drought, meaning that for equal coverage the indemnity insurance reduces the risk of farmers to a greater extent. Therefore, the inclusion of deductibles for the indemnity insurance ($a_M < 1$) allows to make the two insurances comparable.

We assume a fair insurance premium given by:

$$\delta^{I} = E\left(\varphi_{i}^{I}\right) \quad (10)$$

With drought index insurance, the profit of farmer i in realization t is then given by:

$$\pi_{i,t}^{I} = p \times \hat{y}_{i,t} - c_{i,t} + \varphi_{i,t}^{I} - \delta^{I} \quad (11)$$

The certainty equivalent and the risk premium of farmer i in the drought index insurance scenario are denoted by CE_i^I and RP_i^I. We assume that with drought index insurance coverage farmers reduce their production risk and increase their expected utility (Barnett and Mahul 2007; Leblois et al. 2014; Norton et al. 2012), $CE_i^I > CE_i^I$ and $RP_i^I < RP_i^I$.

3.4 | Willingness to Pay for Insurance Schemes

In the following subsection, we investigate the change in willingness to pay for the two different insurance schemes contingent on sown plant diversity. This allows us to assess whether or not plant diversity and these insurance schemes function as complementary strategies for farmers.

The willingness to pay for insurance is defined as the difference between the certainty equivalent in one of the insurance scenarios and the certainty equivalent in the baseline scenario:

$$WTP^{M,I} = CE^{M,I} - CE^{B} \quad (12)$$

To assess the substitutability between plant diversity and the different insurances, we consider changes in the willingness to pay as plant diversity increases. In mathematical terms, we compute the derivative of the willingness to pay with respect to sown plant diversity. A positive value would indicate that farmers are more likely to take out the insurance with higher diversity, that is, a complementary relationship, while a negative value would indicate that farmers are less likely to take out the insurance with higher diversity, that is, a substitutive relationship.

We expect the relationship between formal insurance and sown plant diversity to depend on the insurance type. On the one hand, sown plant diversity affects the yield of individual farmers, which is reflected in the indemnity insurance payments, potentially leading to moral hazard and adverse selection behavior (Baumgärtner 2008; Chambers 1989). Therefore, we expect the willingness to pay for indemnity insurance to decrease when sown plant diversity increases:

$$\frac{\partial WTP^{M}}{\partial n} < 0 \quad (13)$$

On the other hand, the drought index insurance payments are triggered exclusively on the basis of weather variables that are not affected by sown plant diversity. Therefore, we expect that the willingness to pay for the drought index insurance decreases less than the willingness to pay for indemnity insurance when sown plant diversity increases:

$$\frac{1}{WTP^I}\frac{\partial WTP^I}{\partial n} > \frac{1}{WTP^M}\frac{\partial WTP^M}{\partial n} \tag{14}$$

Whether the willingness to pay for index insurance decreases further with sown plant diversity is unknown and depends on the overlap of risk reduction. If the natural insurance properties of plant diversity mitigate drought risk, the willingness to pay for the insurance will decrease. If the natural insurance properties do not mitigate drought risk, the willingness to pay for the insurance will remain constant.

4 | Quantitative Analysis

4.1 | Data

To economically quantify our theoretical results, we use openly available yield data from a coordinated European grassland experiment (Kirwan et al. 2014). From this experiment, we use the sites sown with the Mid European seed mixture type, which has been carried out on 15 sites across 11 countries for durations ranging from 1 to 4 years. At each site, the main experiment consisted of 30 fields sown with different plant species mixtures. In Lithuania and Poland, the experiments were conducted in close proximity three and two times, respectively. Therefore, we consider them as a single site per country. In our main analysis, we compare the *monocultures* with the *dominant mixtures* that were sown with the following proportions of four different species (*Lolium perenne*, *Dactylis glomerata*, *Trifolium pratense* and *Trifolium repens*): *monocultures* (proportions: 1; 0; 0; 0) and *dominant mixtures* (proportions: 0.7; 0.1; 0.1; 0.1).[13] The fields were managed intensively according to local management practices (see Kirwan et al. 2014 for supporting information).

Additionally, we design a cumulative precipitation index (CPI) (Martin et al. 2001). To do so, we use the cumulative summer precipitation connected to each site (provided by Kirwan et al. 2014).[14] We use weather variations that occurred during the growing season, that is, during summer months (June, July, August) (Craine et al. 2012; Gilgen and Buchmann 2009). Furthermore, based on the variations of precipitation, we proceed to a further selection of sites. In our main analysis, we only consider sites for which a positive relationship is found between the precipitation index and yield, as other sites would not realistically participate in such an insurance scheme (12 sites and 280 field observations for the CPI) (see Figure 2 for site locations). It is also important to note that, in practice, yield might not always have a direct relationship with rainfall (e.g., Blakeley et al. 2020); see Supporting Information S.4, where we consider all sites.

To design a convincing insurance analysis despite the limited number of years per site (maximum 4) and therefore the limited variation in weather conditions and yield, we use different realizations of yield over time to estimate the distribution of next year's payoff. To this end, we combine plots with the same plant diversity on different sites to create two "hypothetical" farmers with respectively low plant diversity (1 species) and high plant diversity (4 species). To ensure that yields between sites are comparable, we adjust the yield data of each site using site fixed effects in our regression, that is, we create hypothetical adjusted yield for each field as if they were all located in the same site (see Supporting Information S.2 for more details). Additionally, we consider in our estimation that precipitation effects differ between biogeographical regions (Atlantic, Boreal and Continental). We chose Ireland as our reference site because it has the highest fixed effect coefficient and, as a result, the other sites are adjusted upwards, thus avoiding negative adjusted yield values. To derive revenues for each field, we use constant prices from Ireland, that is, 100 euros per ton of grass (Carty 2021).

4.2 | Design of Simulations

Based on the theoretical framework, we derive three revenue[15] scenarios for each field by using the adjusted yield and constant price data: (i) with no insurance, (ii) with indemnity insurance, and (iii) with drought index insurance.[16] Then based on this, we analyze the willingness to pay for the two insurance schemes for two different sown plant diversity levels (see Figure 1).

In the no insurance scenario, we calculate the revenues (Equation 5) for each field, and the certainty equivalent and risk premium (Equations 2 and 3) for both "hypothetical" farmers. In the main model, we assume risk averse farmers with a coefficient of relative risk aversion of 2 (e.g., Szpiro 1986; Chavas 2004). We also consider farmers who are less risk averse (0.5) and more risk averse (3) in a sensitivity analysis (see Section 5.2 for more details).

In the indemnity insurance scenario, we design an insurance that pays farmers (according to Equation 6) and costs a fair premium (according to Equation 7). In contrast to the theoretical analysis, we consider franchise deductibles instead of relative deductibles, which implies that the insurance covers all losses at a lower strike level (80% of mean production in this case). Then, we calculate the revenues (Equation 8) for each field, and the certainty equivalent and risk premium (Equations 2 and 3) for both "hypothetical" farmers.

In the index insurance scenarios, we design an insurance (based on CPI) that pays farmers (according to Equation 9) and costs a fair premium (according to Equation 10). In contrast to the theoretical analysis, we consider franchise deductibles instead of no deductibles, which implies a lower strike level (90% of mean production in this case). We do so to reduce the insurance premium, which would otherwise be prohibitive, and make it more realistic and comparable to indemnity insurance. This also implies that the deductible is lower for index insurance than for indemnity insurance, at 10% and 20%, respectively. We use these values for three reasons. First, in practice, although deductibles can also be used for index

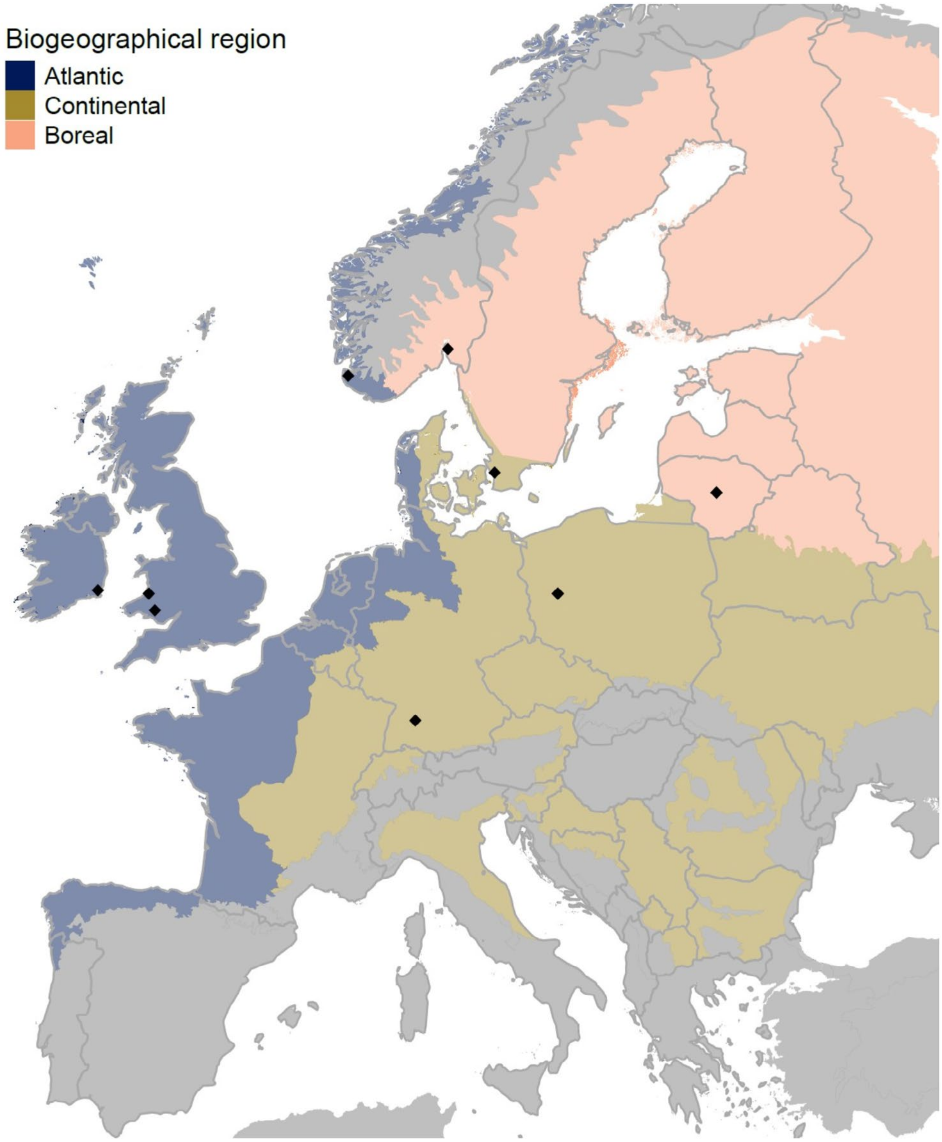

FIGURE 2 | Locations of the grassland experiments. We only show the sites sown with the Mid European seed mixture type and exhibiting a positive relationship between yield and cumulative summer precipitation. The sites come from the following countries: 1 site from Germany, 1 site from Ireland, 1 site from Lithuania, 2 sites from Norway, 1 site from Poland, 1 site from Sweden, and 2 sites from Wales. See Kirwan et al. (2014) for more information and the locations of the sites. See Cervellini et al. (2020) for more information on biogeographical regions.

insurance to reduce the frequency of payouts and, therefore, insurance premiums, they are not required to address behavioral drawbacks. Second, this choice ensures consistency with the theoretical framework, in which indemnity insurance features higher deductibles. Third, within our model, an index insurance contract with a 20% deductible would result in almost no payouts due to the limited weather variation (see Supporting Information S.9 for the case of index insurance with a 20% deductible). We calculate the effect of precipitation on yield (tick size) by using a 20% quantile regression to minimize the basis risk of insurances (Bucheli et al. 2021). Then, we calculate the revenues (Equation 11) for each field, and the certainty equivalent and risk premium (Equations 2 and 3) for both "hypothetical" farmers.

Finally, we calculate the willingness to pay for natural insurance and change in willingness to pay when plant diversity increases (Equations 12–14).

We use a bootstrap sampling method with replacement to test for significance. We sample randomly 280 observations (140 from each diversity level, that is, our sample is always made up of half low-diversity fields and half high-diversity fields) from our data and calculate the payout, the insurance premium for each field, as well as the expected utility, the certainty equivalent and the willingness to pay for insurance for each level of diversity. We repeat this process 10,000 times and compute the confidence interval for the willingness to pay for the different insurances.

5 | Results

5.1 | Main Results

Concerning the economic attractiveness of indemnity insurance, we find that the willingness to pay is 28 (95% confidence interval: ±24) EUR per hectare for farmers sowing low plant diversity (1 plant species) and a negative willingness to pay of −12 (±9) EUR per hectare for farmers sowing high plant diversity (4 plant species) (see Table 2). These represent respectively 29% and 12% of the mean risk premium. Thus, only farmers sowing low plant diversity can be expected to adopt indemnity insurance. Accordingly, we find that the willingness to pay of farmers with low plant diversity is significantly higher (at the 5% level) than that of farmers with high plant diversity.[17]

For the economic attractiveness of drought index insurance, we find that the willingness to pay is 13 (±19) EUR per hectare for farmers sowing low plant diversity (1 plant species) and 15 (±16) EUR per hectare for farmers sowing high plant diversity (4 plant species) (see Table 2). These represent respectively 13% and 15% of the mean risk premium. Moreover, we find no significant difference between the willingness to pay of farmers sowing low and high plant diversity.

These results suggest that the economic attractiveness of indemnity insurance decreases when sown plant diversity is higher, while the economic attractiveness of index insurance remains constant across both diversity levels.[18]

In term of insurance specifics, we find that the indemnity insurance distributes payment unevenly between farmers sowing high and low plant diversity, while the drought index insurance distributes them equally between the two diversity levels (see Figure 3 and Supporting Information S.6 for more details). With our specific design, drought index insurance is more expensive for farmers with a premium of 62 EUR per hectare than indemnity insurance with a premium of 12 EUR per hectare (to better understand the results, we show graphically the distribution of income and payments made to farmers from the original dataset (without bootstrap sampling) in Supporting Information S.5).

5.2 | Robustness Checks

We performed various robustness checks, varying arbitrary parameters of our simulations. Notably, we explore alternative insurance designs and different risk aversion levels (see Table 3).

First, we find that a 20% loading on insurance has a small negative effect on the willingness to pay for indemnity insurance and reduces the willingness to pay for drought index insurance. Second, compared to franchise deductibles, relative deductibles with a coverage of 40% for indemnity insurance lead to an even greater willingness to pay for low diversity grasslands and an even smaller willingness to pay for high diversity grasslands. Third, we find that in our model, the willingness to pay for drought index insurance designed with SPEI index is close to zero for all diversity levels. Fourth, we find that for farmers with lower risk aversion (coefficient of relative risk aversion of 0.5), the willingness to pay for the insurances either decreases or remains constant, and for farmers with higher risk aversion (coefficient of relative risk aversion of 3), the willingness to pay for insurances either increases or remains constant. As in the main results, our robustness checks support that adverse selection occurs for indemnity insurance unlike drought index insurance.

In addition to these tests, we also checked the sensitivity of our results to the underlying data and additional policy and insurance scenarios. To do this, we ran the simulation (i) without excluding sites with no relationship between precipitation and yield, (ii) without adjusting yield, (iii) with insurance subsidies, (iv) loading on the insurance premium, and (v) higher deductibles for index insurance. Tables S2–56 present these results, supporting our main results.

6 | Discussion

In this paper, we analyze how the economic attractiveness of two insurance products varies contingent on the level of plant diversity sown by farmers. First, we find that the willingness to pay for drought index insurance does not vary with sown plant diversity. This is somewhat intriguing, as high sown plant diversity reduces income risk and thus we might expect that the need to use formal insurance goes down. However, the type of risk reduced and the exact income distribution matter, including the higher moments, and in the numerical simulations these play out such that the willingness to pay for index insurance is largely independent of the adoption of natural insurance by means of plant diversity. Second, our analysis reveals that farmers sowing low plant diversity have higher economic benefits from indemnity insurance than those sowing high plant diversity. Therefore, we confirm the occurrence of adverse selection when the indemnity insurance product attracts farmers with a riskier plant diversity strategy. The adverse selection highlights the importance for insurance companies to design products that accurately represent farmers and prevent the failure of the insurance.

TABLE 2 | Simulated willingness to pay for indemnity insurance and drought index insurance contingent on plant diversity.

	Willingness to pay for indemnity insurance		Willingness to pay for drought index insurance	
	Low diversity	High diversity	Low diversity	High diversity
Estimate	28.43	−12.45	12.69	15.42
[95% CI]	[4.57, 52.28]	[−22.84, −2.05]	[−6.76, 32.13]	[−0.56, 31.4]
(84% CI)	(11.27, 45.59)	(−19.93, −4.97)	(−1.3, 26.68)	(3.92, 26.91)

Note: Results of simulations showing the willingness to pay for indemnity insurance and drought index insurance contingent on sown plant diversity (low diversity being 1 plant species and high diversity being 4 plant species) following Section 4.2. We present the willingness to pay estimates with 95% and 84% confidence intervals (the latter is used to test for differences in willingness to pay at the 5% level (Payton et al. 2003)). These results quantify the framework described in Figure 1.

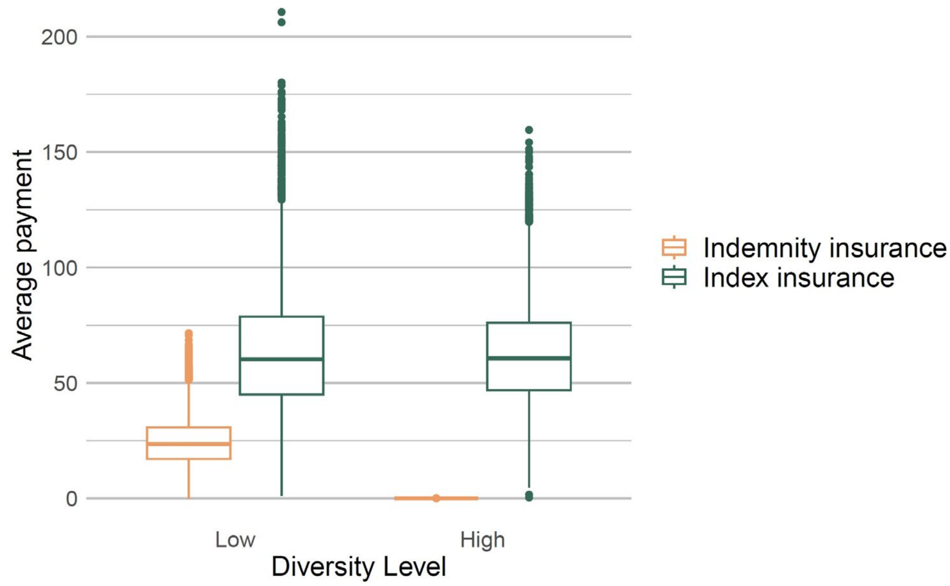

FIGURE 3 | Average payment received by farmers from insurances. This figure shows the distribution of the mean payments (from 10,000 iterations of the bootstrap sampling) to the farmers from the different insurances for high and low sown plant diversity. The central box represents the interquartile range (IQR), and the horizontal line inside represents the median. Dots are potential outliers outside the "whiskers" (extending from the quartiles to 1.5 times the IQR).

We find that farmers with high sown diversity are not expected to adopt indemnity insurance at all. This disutility results from the design of the insurance and the effects of sown diversity on yield. First, the insurance is designed uniformly for all farmers, meaning that the strike level and premium are identical for both high-diversity and low-diversity fields. Second, the difference in mean yield between high-diversity and low-diversity fields means that high-diversity fields rarely receive payments from indemnity insurance companies when they are insured (see Figure S2 and Supporting Information S.6 for more details). This shows that, in practice, differentiating between even small diversity levels might be necessary for indemnity insurance.

The presence of adverse selection with indemnity insurance, unlike drought index insurance, persists under various insurance designs. Specifically, indemnity insurance remains attractive for farmers sowing low diversity when a loading of up to 50% is added to the insurance premium, just as relative deductibles lead to an even greater difference between the economic attractiveness for high and low diversity farmers, that is, greater adverse selection. Insurance subsidies of up to 50% increase the attractiveness of both insurance types for both farmer groups; however, within our model, adverse selection persists.

Regarding drought index insurance, compared to the main analysis with a fair insurance premium, the addition of a loading reduces the economic attractiveness of the insurance, becoming negative once the loading exceeds 20%. In practice, this effect of the loading on insurance attractiveness may reflect the insurer's better access to climate data and models, creating an asymmetry of information that favors the insurer and that is not directly observable to farmers. In the main analysis, we focus on asymmetric information on the farmer side; it should be noted that in most European countries, crop insurance is subsidized, which can partially offset loadings and renders the no-loading scenario a reasonable benchmark.

The choice of index is important, as within our model, farmers' willingness to pay for index insurance is much lower with the SPEI drought index than with the CPI index. Basis risk is often cited as a main limitation of index insurance and refers to the gap between payouts and farmers' realized losses (Clarke 2016; Jensen and Barrett 2017; Jensen et al. 2018). In the context of our results, since yield and weather measurement are taken at the same location, this mismatch is less likely to result from spatial basis risk (e.g., due to a mismatch in the location of the measurements) and instead reflects to challenges in temporal basis risk (e.g., when the index measurement period does not reflect the critical growth phase) or design basis risk (e.g., a not well fitting index) (Dalhaus and Finger 2016). This highlights the importance of careful index design and data selection. Recent evidence on index insurance adoption further suggests that basis risk may not always be the primary barrier to adoption. High insurance costs may play a larger role, as farmers may prefer lower premiums even if this implies higher basis risk (Lichtenberg and Iglesias 2022).

Furthermore, varying the risk aversion coefficient does not alter the adverse selection mechanism, but has an anticipated effect on the attractiveness of insurances, that is, an increase in risk aversion increases the economic benefits of insurance use, and a decrease in risk aversion reduces the economic benefits of insurance use.

Within our simulation, differences in diversity-related costs do not affect the willingness to pay for insurance, because the cost differences between insured and non-insured scenarios offset each other. However, in real-world settings, diversity costs could constrain farmers' cash flow and push them toward cheaper

TABLE 3 | Robustness checks of the willingness to pay for insurances contingent on sown plant diversity.

	Willingness to pay for indemnity insurance		Willingness to pay for drought index insurance	
	Low diversity	High diversity	Low diversity	High diversity
Insurance premium with 20% loading				
Estimate	25.86	−14.89	−0.05	2.64
[95% CI]	[4.37, 47.36]	[−27.18, −2.6]	[−15.63, 15.52]	[−13.54, 18.81]
(84% CI)	(10.4, 41.33)	(−23.73, −6.05)	(−11.26, 11.15)	(−9, 14.27)
Relative deductibles of 60% for the indemnity insurance				
Estimate	83.59	−28.69		
[95% CI]	[56.38, 110.79]	[−48.06, −9.31]		
(84% CI)	(64.02, 103.15)	(−42.62, −14.75)		
SPEI drought index				
Estimate			3.1	4.49
[95% CI]			[−7.16, 13.36]	[−6.29, 15.27]
(84% CI)			(−4.28, 10.48)	(−3.27, 12.24)
Coefficient of relative risk aversion 0.5				
Estimate	15.66	−12.27	3.48	3.32
[95% CI]	[6.4, 24.92]	[−19.51, −5.04]	[−6.69, 13.65]	[−6.15, 12.79]
(84% CI)	(2.79, 28.53)	(−22.34, −2.21)	(−10.66, 17.61)	(−9.84, 16.49)
Coefficient of relative risk aversion 3				
Estimate	39.19	−12.53	19.21	23.71
[95% CI]	[15.95, 62.43]	[−19.94, −5.13]	[1.96, 36.47]	[10.06, 37.36]
(84% CI)	(6.88, 71.49)	(−22.83, −2.24)	(−4.78, 43.2)	(4.73, 42.69)

Note: Results of simulations showing the willingness to pay for indemnity insurance and drought index insurance contingent on sown plant diversity for various insurance design and risk aversion levels: (i) with a 20% loading on insurance premium, (ii) indemnity insurance with relative deductibles equal to 60% of payout to farmers, (iii) drought index insurance with a standardized precipitation evapotranspiration index, (iv) and (v) with farmers exhibiting relative risk aversion of 1.5 and 2.5.

insurance options. For the sown diversity levels included in our simulation (1 vs. 4 species), the additional cost is approximately 15 EUR ha^{-1} for the higher-diversity mixture in Germany and Switzerland (Schaub et al. 2021). Although cost differences are observed, the cost is more than compensated by the higher expected yields of more diverse grasslands (see Figure S1 for income distributions). Nevertheless, the relationships between sown diversity, seed mixture cost, and expected yield are nonlinear: seed mixture costs increase at an increasing rate with higher diversity, while gains in expected yield show diminishing returns (e.g., Isbell et al. 2015). As a result, cash-flow constraints may become a significant factor at higher diversity levels.

These insights into the effect of plant diversity on insurance attractiveness help provide a better understanding of plant diversity as a risk management tool in grassland farming. Unlike crop or farm diversification, relatively high plant diversity for intensive management is always preferable, economically speaking, to lower plant diversity, as it results in both a lower risk premium and a higher expected production (e.g., Isbell et al. 2015; Schaub et al. 2020). In addition, these effects on production result from both the averaging of multiple assets and ecological interactions (e.g., Tilman et al. 1996). This adds complexity to the question of whether farmers would change the diversity of plants sown after taking out insurance. In fact, if we consider the overall economic gain from high plant diversity, farmers with already high plant diversity are unlikely switch to low plant diversity, even with indemnity insurance coverage. However, indemnity insurance coverage reduces the potential economic gain from switching from low to high plant diversity. Given that shifting plant diversity strategies is already costly and might require additional plowing and sowing costs (Schaub et al. 2021), farmers with low plant diversity and indemnity insurance coverage could find themselves locked into their current management practices, hindering overall beneficial change. This opens the way for further studies using controlled designs, such as randomized control trials, to assess the potential negative effects of insurance coverage in a multi-stage framework.

In this study, we focus on production risk in grasslands within the framework of expected utility theory. As we assume deterministic prices, we acknowledge that our approach simplifies the link between field yield and farmers' income. Despite this simplification, our findings hold great relevance to grassland farming confronted with risk, particularly in light of the upcoming global challenges posed by climate change and the need for environmental sustainability (Korell et al. 2024). In addition, market risks are not currently taken into account by the insurance schemes offered in Europe (Vroege et al. 2019). Nevertheless, further research could build upon our work by incorporating market risk and utilizing dynamic models to explore the implications of risk through market adaptations (Antle 1983). Additionally, our research centers on two risk management instruments—formal insurance and plant diversity—but future extensions could explore the significance of household decisions in the context of broader income diversification strategies.

Finally, our study has some limitations related to the scope of the analysis and the data used. First, the study focuses on agricultural insurance in a European context, and the conclusions may not be applicable to other markets, particularly developing countries. For example, in some regions such as Africa, it may be difficult to implement insurance products other than index insurance, for example, due to differences in production systems and institutions. Second, the temporal coverage of the data is limited, as a maximum of 4 years was observed at each site. As a result, in our model, the range of weather conditions represented in the bootstrapped distribution may be limited and it is not possible to account for effects of drought duration (Ohlert et al. 2025).

7 | Conclusion

We show how indemnity insurance, compared with index insurance, might attract farmers with low diversity and, in so doing, support such low diversity systems. Moreover, the willingness to pay for indemnity insurance decreases when diversity increases, reaching negative values for farmers sowing four plant species. The willingness to pay for the drought index insurance remains constant for different diversity levels and of important magnitude, suggesting that it can effectively function as a more complementary strategy to natural insurance.

Our results raise concerns regarding the profitability of indemnity insurances in grassland farming systems that do not take account of sown diversity. Indeed, only farmers sowing the lowest-yielding and riskiest plant mixtures will participate and, as a result, the payment conditions and insurance premiums are likely to be misaligned. This is a typical case of adverse selection behavior. Also, this interplay holds relevance in the context of increasing crop insurance subsidies in Europe. Policymakers should carefully assess which insurance premium to subsidize (e.g., drought index insurance), as this could impact the insurability of farmers, food production, and public welfare derived from ecosystem services.

Future research should focus on dynamic decision-making models including market risk analysis. Additionally, this study sets the ground for work that could consider heterogeneity in management practices and extend the analysis to a public welfare analysis including different ecosystem services. Furthermore, the analysis shall be expanded to other regions and production systems.

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Disclosure

We hereby confirm that this study is original.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are openly available in Figshare at https://doi.org/10.6084/m9.figshare.c.3307098.v1. The code used for the quantitative analysis of this paper was made with the software R and is available in the supporting information.

Endnotes

[1] It should be noted that meat and dairy production in Europe will require adjustments in the future to meet climate and other environmental targets and cope with climate risks (Springmann 2024). This highlights the need for more sustainable and resilience-enhancing production systems as addressed in this paper.

[2] It should be noted that not all intensively managed grasslands in Europe are sown as single-species swards. For example, most intensively managed grasslands in Switzerland are sown as mixture (AGFF and Agroscope 2021).

[3] Example of deductibles are a franchise deductible (farmers assume all losses under a certain amount) and a relative deductible (farmers assume a proportion of the insured losses).

[4] Bucheli et al. (2021) categorize five different indexes for drought insurances that consider some of the variables: cumulative precipitation index (CPI), standardized precipitation index (SPI), standardized precipitation evapotranspiration index (SPEI), soil moisture index (SMI), and evaporative stress index (ESI).

[5] Prices are assumed to be deterministic through, for example, contracting.

[6] Some of the most important factors include weather, soil properties, elevation, number of cuts and/or grazing animals, amount of fertilizer (Blüthgen et al. 2012; Huguenin-Elie et al. 2017).

[7] Other variables could be used to represent diversity, for example, the richness of species or the Simpson index.

[8] It can also reflect an index insurance that covers all perils based on satellite imagery functioning similarly to indemnity insurance, such as in France (Lepoivre 2020).

[9] In our model, all farmers receive the same indemnity insurance contract, since the insurer observes identical data for each of them (namely, management practices and area), but their payouts differ due to varying levels of sown diversity. This contrasts with area-yield index insurance, where payments are triggered by yield observed at the area level rather than the farm level, meaning all farmers in a given area would receive the same payment (Vroege et al. 2019).

[10] In the quantitative analysis, we consider both franchise and relative deductibles (see Section 5.2).

[11] In the quantitative analysis, this assumption is relaxed as we consider a 20% loading on the insurance premium (see Section 5.2).

[12] In the quantitative analysis, this specification is relaxed as we consider index insurance with deductibles.

[13] Among the diverse fields, we select dominant mixtures because they perform better (in term of certainty equivalent) than bi-dominant mixtures, and farmers are therefore more likely to use the proportion of dominant mixtures. Despite the high certainty equivalent of the equi-proportional mixture, we excluded it to simplify the comparison and have four different monocultures and four different mixtures (see Supporting Information S.10 for the details on the four different types of mixtures).

[14] As a robustness check, we design an index insurance based on a standardized precipitation evapotranspiration index (SPEI) (Vicente-Serrano et al. 2010).

[15] As we do not observe production costs, we consider revenues rather than profit in the simulation analysis. The mean factor in the calculation of the willingness to pay for insurances is not affected, as costs between the insurance scenarios and the no insurance scenario cancel each other out. However, this affects the risk premium because we consider relative risk aversion. By omitting production costs, we consider a higher reference level for risk aversion, which translates into a lower absolute risk aversion.

[16] Compared with the theoretical model, we relax certain assumptions concerning the insurance specification (types of deductibles, insurance premiums) in order to present a range of realistic insurance designs.

[17] To test for differences in willingness to pay at the 5% level, we examine whether or not the 84% confidence interval of the willingness to pay estimates overlap (Payton et al. 2003) (see Table 2).

[18] Table S1, we show the risk premium of each farmer (low and high plant diversity) in each scenario (no insurance, indemnity insurance, drought index insurance).

References

AGFF, and Agroscope. 2021. "Standardmischungen Für Den Futterbau Revision 2021–2024." https://www.agroscope.admin.ch/agroscope/en/home/topics/plant-production/forage-grassland-grazing-systems/samenmischungen-sortenpruefung.html.

Alou, N., S. Schaub, M. Suter, A. Lüscher, and R. Finger. 2026. "Plant Diversity to Cope With Increased Drought Risk in Grasslands." *Ecological Economics* 241: 108852. https://doi.org/10.1016/j.ecolecon.2025.108852.

Antle, J. M. 1983. "Incorporating Risk in Production Analysis." *American Journal of Agricultural Economics* 65, no. 5: 1099–1106. https://doi.org/10.2307/1240428.

Barnett, B. J., C. B. Barrett, and J. R. Skees. 2008. "Poverty Traps and Index-Based Risk Transfer Products." *World Development* 36, no. 10: 1766–1785. https://doi.org/10.1016/j.worlddev.2007.10.016.

Barnett, B. J., and O. Mahul. 2007. "Weather Index Insurance for Agriculture and Rural Areas in Lower-Income Countries." *American Journal of Agricultural Economics* 89, no. 5: 1241–1247. https://doi.org/10.1111/j.1467-8276.2007.01091.x.

Baumgärtner, S. 2008. "The Insurance Value of Biodiversity in the Provision of Ecosystem Services." *Natural Resource Modeling* 20, no. 1: 87–127. https://doi.org/10.1111/j.1939-7445.2007.tb00202.x.

Baumgärtner, S., and M. F. Quaas. 2010. "Managing Increasing Environmental Risks Through Agrobiodiversity and Agrienvironmental Policies." *Agricultural Economics* 41, no. 5: 5. https://doi.org/10.1111/j.1574-0862.2010.00460.x.

Baylis, K., S. Peplow, G. Rausser, and L. Simon. 2008. "Agri-Environmental Policies in the EU and United States: A Comparison." *Ecological Economics* 65, no. 4: 753–764. https://doi.org/10.1016/j.ecolecon.2007.07.034.

Benami, E., Z. Jin, M. R. Carter, et al. 2021. "Uniting Remote Sensing, Crop Modelling and Economics for Agricultural Risk Management." *Nature Reviews Earth & Environment* 2, no. 2: 140–159. https://doi.org/10.1038/s43017-020-00122-y.

Binder, S., F. Isbell, S. Polasky, J. A. Catford, and D. Tilman. 2018. "Grassland Biodiversity Can Pay." *Proceedings of the National Academy of Sciences* 115, no. 15: 3876–3881. https://doi.org/10.1073/pnas.1712874115.

Bindi, M., and J. E. Olesen. 2011. "The Responses of Agriculture in Europe to Climate Change." *Regional Environmental Change* 11: 151–158. https://doi.org/10.1007/s10113-010-0173-x.

Blakeley, S. L., S. Sweeney, G. Husak, et al. 2020. "Identifying Precipitation and Reference Evapotranspiration Trends in West Africa to Support Drought Insurance." *Remote Sensing* 12, no. 15: 2432. https://doi.org/10.3390/rs12152432.

Blüthgen, N., C. F. Dormann, D. Prati, et al. 2012. "A Quantitative Index of Land-Use Intensity in Grasslands: Integrating Mowing, Grazing and Fertilization." *Basic and Applied Ecology* 13, no. 3: 207–220. https://doi.org/10.1016/j.baae.2012.04.001.

Bucheli, J., N. Conrad, S. Wimmer, T. Dalhaus, and R. Finger. 2023. "Weather Insurance in European Crop and Horticulture Production." *Climate Risk Management* 41: 100525. https://doi.org/10.1016/j.crm.2023.100525.

Bucheli, J., T. Dalhaus, and R. Finger. 2021. "The Optimal Drought Index for Designing Weather Index Insurance." *European Review of Agricultural Economics* 48, no. 3: 573–597. https://doi.org/10.1093/erae/jbaa014.

Bucheli, J., T. Dalhaus, and R. Finger. 2022. "Temperature Effects on Crop Yields in Heat Index Insurance." *Food Policy* 107: 102214. https://doi.org/10.1016/j.foodpol.2021.102214.

Bulte, E., and R. Lensink. 2023. "Why Agricultural Insurance May Slow Down Agricultural Development." *American Journal of Agricultural Economics* 105, no. 4: 1197–1220. https://doi.org/10.1111/ajae.12353.

Carson, J. M., K. A. McCullough, and D. M. Pooser. 2013. "Deciding Whether to Invest in Mitigation Measures: Evidence From Florida." *Journal of Risk and Insurance* 80, no. 2: 309–327. https://doi.org/10.1111/j.1539-6975.2012.01484.x.

Carty, D. 2021. "Sales of Silage and Hay Remain Relatively Low." *Irish Farmers Journal*, February 17, 2021. https://www.farmersjournal.ie/sales-of-silage-and-hay-remain-relatively-low-603387.

Cervellini, M., P. Zannini, M. Di Musciano, et al. 2020. "A Grid-Based Map for the Biogeographical Regions of Europe." *Biodiversity Data Journal* 8: e53720. https://doi.org/10.3897/BDJ.8.e53720.

Chambers, R. G. 1989. "Insurability and Moral Hazard in Agricultural Insurance Markets." *American Journal of Agricultural Economics* 71, no. 3: 604–616. https://doi.org/10.2307/1242016.

Chavas, J.-P. 2004. *Risk Analysis in Theory and Practice*. Elsevier.

Clarke, D. J. 2016. "A Theory of Rational Demand for Index Insurance." *American Economic Journal: Microeconomics* 8, no. 1: 283–306. https://doi.org/10.1257/mic.20140103.

Courbage, C. 2001. "Self-Insurance, Self-Protection and Market Insurance Within the Dual Theory of Choice." *Geneva Papers on Risk and Insurance Theory* 26: 43–56. https://doi.org/10.1023/A:1011212324117.

Craine, J. M., J. B. Nippert, A. J. Elmore, A. M. Skibbe, S. L. Hutchinson, and N. A. Brunsell. 2012. "Timing of Climate Variability and Grassland Productivity." *Proceedings of the National Academy of Sciences* 109, no. 9: 3401–3405. https://doi.org/10.1073/pnas.1118438109.

Dalhaus, T., and R. Finger. 2016. "Can Gridded Precipitation Data and Phenological Observations Reduce Basis Risk of Weather Index–Based Insurance?" *Weather, Climate, and Society* 8, no. 4: 409–419. https://doi.org/10.1175/WCAS-D-16-0020.1.

Dalhaus, T., J. Wu, and N. Möhring. 2023. "Rapidly Growing Subsidization of Crop Insurance in Europe Ignores Potential Environmental Effects." *Nature Plants* 9, no. 12: 1938–1939. https://doi.org/10.1038/s41477-023-01569-9.

Di Falco, S., and J. Chavas. 2009. "On Crop Biodiversity, Risk Exposure, and Food Security in the Highlands of Ethiopia." *American Journal of Agricultural Economics* 91, no. 3: 599–611. https://doi.org/10.1111/j.1467-8276.2009.01265.x.

Di Falco, S. D., F. Adinolfi, M. Bozzola, and F. Capitanio. 2014. "Crop Insurance as a Strategy for Adapting to Climate Change." *Journal of Agricultural Economics* 65, no. 2: 485–504. https://doi.org/10.1111/1477-9552.12053.

Die Österreichische Hagelversicherung. 2020. "Ergänzende Bedingungen Für Die Versicherung von Hagel- und Anderen Elemantarschäden 'Agrar Universal'." https://www.hagel.at/wp-content/uploads/2021/01/Bedingungen_2021_Agrar-Universal_end.pdf.

Ehrlich, I., and G. S. Becker. 1972. "Market Insurance, Self-Insurance, and Self-Protection." *Journal of Political Economy* 80, no. 4: 623–648.

Elmiger, N., R. Finger, J. Ghazoul, and S. Schaub. 2023. "Biodiversity Indicators for Result-Based Agri-Environmental Schemes–Current State and Future Prospects." *Agricultural Systems* 204: 103538. https://doi.org/10.1016/j.agsy.2022.103538.

Enjolras, G., F. Capitanio, F. Adinolfi, G. Enjolras, F. Capitanio, and F. Adinolfi. 2012. "The Demand for Crop Insurance: Combined Approaches for France and Italy." *Agricultural Economics Review* 13: 5–22. https://doi.org/10.22004/AG.ECON.253490.

Estel, S., S. Mader, C. Levers, P. H. Verburg, M. Baumann, and T. Kuemmerle. 2018. "Combining Satellite Data and Agricultural Statistics to Map Grassland Management Intensity in Europe." *Environmental Research Letters* 13, no. 7: 074020. https://doi.org/10.1088/1748-9326/aacc7a.

European Commission. 2008. "Agricultural Insurance Schemes." Joint Research Center—ISPRA. https://agriculture.ec.europa.eu/system/files/2020-02/ext-study-insurance-full-report-rev_2008_en_0.pdf.

Garcia, V., C. McCallum, and R. Finger. 2024. "Heterogeneity of European Farmers' Risk Preferences: An Individual Participant Data Meta-Analysis." *European Review of Agricultural Economics* 51, no. 3: 725–778. https://doi.org/10.1093/erae/jbae012.

Gilgen, A. K., and N. Buchmann. 2009. "Response of Temperate Grasslands at Different Altitudes to Simulated Summer Drought Differed but Scaled With Annual Precipitation." *Biogeosciences* 6, no. 11: 2525–2539. https://doi.org/10.5194/bg-6-2525-2009.

Huber, R., S. Le'Clec'h, N. Buchmann, and R. Finger. 2022. "Economic Value of Three Grassland Ecosystem Services When Managed at the Regional and Farm Scale." *Scientific Reports* 12, no. 1: 1. https://doi.org/10.1038/s41598-022-08198-w.

Huguenin-Elie, O., E. Mosimann, P. Schlegel, A. Lüscher, W. Kessler, and B. Jeangros. 2017. "9/Düngung von Grasland." *Agrarforschung Schweiz* 8, no. 6: 1–21.

Huyghe, C., A. De Vliegher, B. Van Gils, and A. Peeters. 2014. *Grasslands and Herbivore Production in Europe and Effects of Common Policies*. Éditions Quae. https://doi.org/10.35690/978-2-7592-2157-8.

Isbell, F., D. Craven, J. Connolly, et al. 2015. "Biodiversity Increases the Resistance of Ecosystem Productivity to Climate Extremes." *Nature* 526, no. 7574: 574–577. https://doi.org/10.1038/nature15374.

Isbell, F., H. W. Polley, and B. J. Wilsey. 2009. "Biodiversity, Productivity and the Temporal Stability of Productivity: Patterns and Processes." *Ecology Letters* 12, no. 5: 443–451. https://doi.org/10.1111/j.1461-0248.2009.01299.x.

Iyer, P., M. Bozzola, S. Hirsch, M. Meraner, and R. Finger. 2020. "Measuring Farmer Risk Preferences in Europe: A Systematic Review." *Journal of Agricultural Economics* 71, no. 1: 3–26. https://doi.org/10.1111/1477-9552.12325.

Jensen, N., and C. Barrett. 2017. "Agricultural Index Insurance for Development." *Applied Economic Perspectives and Policy* 39, no. 2: 199–219. https://doi.org/10.1093/aepp/ppw022.

Jensen, N. D., A. G. Mude, and C. B. Barrett. 2018. "How Basis Risk and Spatiotemporal Adverse Selection Influence Demand for Index Insurance: Evidence From Northern Kenya." *Food Policy* 74: 172–198. https://doi.org/10.1016/j.foodpol.2018.01.002.

Just, R. E., L. Calvin, and J. Quiggin. 1999. "Adverse Selection in Crop Insurance: Actuarial and Asymmetric Information Incentives." *American Journal of Agricultural Economics* 81, no. 4: 834–849. https://doi.org/10.2307/1244328.

Kirwan, L., J. Connolly, C. Brophy, et al. 2014. "The Agrodiversity Experiment: Three Years of Data From a Multisite Study in Intensively Managed Grasslands." https://doi.org/10.6084/M9.FIGSHARE.C.3307098.V1.

Klaus, V. H., A. Jehle, F. Richter, N. Buchmann, E. Knop, and G. Lüscher. 2023. "Additive Effects of Two Agri-Environmental Schemes on Plant Diversity but Not on Productivity Indicators in Permanent Grasslands in Switzerland." *Journal of Environmental Management* 348: 119416. https://doi.org/10.1016/j.jenvman.2023.119416.

Knapp, A. K., P. A. Fay, J. M. Blair, et al. 2002. "Rainfall Variability, Carbon Cycling, and Plant Species Diversity in a Mesic Grassland." *Science* 298, no. 5601: 2202–2205. https://doi.org/10.1126/science.1076347.

Knapp, L., D. Wuepper, T. Dalhaus, and R. Finger. 2021. "Revisiting the Diversification and Insurance Relationship: Differences Between on– And Off-Farm Strategies." *Climate Risk Management* 32: 100315. https://doi.org/10.1016/j.crm.2021.100315.

Koellner, T., and O. J. Schmitz. 2006. "Biodiversity, Ecosystem Function, and Investment Risk." *Bioscience* 56, no. 12: 977–985. https://doi.org/10.1641/0006-3568(2006)56[977:BEFAIR]2.0.CO;2.

Korell, L., M. Andrzejak, S. Berger, et al. 2024. "Land Use Modulates Resistance of Grasslands Against Future Climate and Inter-Annual Climate Variability in a Large Field Experiment." *Global Change Biology* 30, no. 7: e17418. https://doi.org/10.1111/gcb.17418.

Leblois, A., P. Quirion, A. Alhassane, and S. Traoré. 2014. "Weather Index Drought Insurance: An ex Ante Evaluation for Millet Growers in Niger." *Environmental and Resource Economics* 57: 527–551. https://doi.org/10.1007/s10640-013-9641-3.

Lefebvre, M., D. Nikolov, S. Gomez-y-Paloma, and M. Chopeva. 2014. "Determinants of Insurance Adoption Among Bulgarian Farmers." *Agricultural Finance Review* 74, no. 3: 326–347. https://doi.org/10.1108/AFR-05-2013-0022.

Lepoivre, B. 2020. "l'Assurance des Prairies." *Fourrages* 244: 87–92.

Lichtenberg, E., and E. Iglesias. 2022. "Index Insurance and Basis Risk: A Reconsideration." *Journal of Development Economics* 158: 102883. https://doi.org/10.1016/j.jdeveco.2022.102883.

Loreau, M., and C. de Mazancourt. 2008. "Species Synchrony and Its Drivers: Neutral and Nonneutral Community Dynamics in Fluctuating Environments." *American Naturalist* 172, no. 2: E48–E66. https://doi.org/10.1086/589746.

Lüscher, A., K. Barkaoui, J. A. Finn, D. Suter, M. Suter, and F. Volaire. 2022. "Using Plant Diversity to Reduce Vulnerability and Increase Drought Resilience of Permanent and Sown Productive Grasslands."

Grass and Forage Science 77: gfs.12578. https://doi.org/10.1111/gfs.12578.

Macholdt, J., S. Hadasch, A. Macdonald, et al. 2023. "Long-Term Trends in Yield Variance of Temperate Managed Grassland." *Agronomy for Sustainable Development* 43, no. 3: 37. https://doi.org/10.1007/s13593-023-00885-w.

Martin, S. W., B. J. Barnett, and K. H. Coble. 2001. "Developing and Pricing Precipitation Insurance." *Journal of Agricultural and Resource Economics* 26, no. 1: 261–274.

Menezes, C., C. Geiss, and J. Tressler. 1980. "Increasing Downside Risk." *American Economic Review* 70, no. 5: 921–932.

Mieno, T., C. G. Walters, and L. E. Fulginiti. 2018. "Input Use Under Crop Insurance: The Role of Actual Production History." *American Journal of Agricultural Economics* 100, no. 5: 1469–1485. https://doi.org/10.1093/ajae/aay040.

Miranda, M. J., and J. W. Glauber. 1997. "Systemic Risk, Reinsurance, and the Failure of Crop Insurance Markets." *American Journal of Agricultural Economics* 79, no. 1: 206–215. https://doi.org/10.2307/1243954.

Mishra, A. K., H. S. El-Osta, and C. L. Sandretto. 2004. "Factors Affecting Farm Enterprise Diversification." *Agricultural Finance Review* 64, no. 2: 151–166. https://doi.org/10.1108/00214660480001160.

Möllmann, J., M. Michels, and O. Musshoff. 2019. "German Farmers' Acceptance of Subsidized Insurance Associated With Reduced Direct Payments." *Agricultural Finance Review* 79, no. 3: 408–424. https://doi.org/10.1108/AFR-09-2018-0071.

Müller, B., L. Johnson, and D. Kreuer. 2017. "Maladaptive Outcomes of Climate Insurance in Agriculture." *Global Environmental Change* 46: 23–33. https://doi.org/10.1016/j.gloenvcha.2017.06.010.

Müller, B., M. F. Quaas, K. Frank, and S. Baumgärtner. 2011. "Pitfalls and Potential of Institutional Change: Rain-Index Insurance and the Sustainability of Rangeland Management." *Ecological Economics* 70, no. 11: 2137–2144.

Naumann, G., C. Cammalleri, L. Mentaschi, and L. Feyen. 2021. "Increased Economic Drought Impacts in Europe With Anthropogenic Warming." *Nature Climate Change* 11, no. 6: 485–491. https://doi.org/10.1038/s41558-021-01044-3.

Norton, M. T., C. Turvey, and D. Osgood. 2012. "Quantifying Spatial Basis Risk for Weather Index Insurance." *Journal of Risk Finance* 14, no. 1: 20–34. https://doi.org/10.1108/15265941311288086.

O'Donoghue, E. J., M. J. Roberts, and N. Key. 2009. "Did the Federal Crop Insurance Reform Act Alter Farm Enterprise Diversification?" *Journal of Agricultural Economics* 60, no. 1: 80–104. https://doi.org/10.1111/j.1477-9552.2008.00166.x.

Ohlert, T., M. D. Smith, S. L. Collins, et al. 2025. "Drought Intensity and Duration Interact to Magnify Losses in Primary Productivity." *Science* 390, no. 6770: 284–289. https://doi.org/10.1126/science.ads8144.

Ortiz-Bobea, A., T. R. Ault, C. M. Carrillo, R. G. Chambers, and D. B. Lobell. 2021. "Anthropogenic Climate Change Has Slowed Global Agricultural Productivity Growth." *Nature Climate Change* 11, no. 4: 306–312. https://doi.org/10.1038/s41558-021-01000-1.

Pannequin, F., A. Corcos, and C. Montmarquette. 2020. "Are Insurance and Self-Insurance Substitutes? An Experimental Approach." *Journal of Economic Behavior & Organization* 180: 797–811. https://doi.org/10.1016/j.jebo.2019.05.018.

Paul, C., N. Hanley, S. T. Meyer, C. Fürst, W. W. Weisser, and T. Knoke. 2020. "On the Functional Relationship Between Biodiversity and Economic Value." *Science Advances* 6, no. 5: eaax7712. https://doi.org/10.1126/sciadv.aax7712.

Payton, M. E., M. H. Greenstone, and N. Schenker. 2003. "Overlapping Confidence Intervals or Standard Error Intervals: What Do They Mean in Terms of Statistical Significance?" *Journal of Insect Science* 3, no. 1: 34. https://doi.org/10.1093/jis/3.1.34.

Perondi, D., C. W. Fraisse, J. A. Watson, K. J. Boote, L. Zotarelli, and R. G. Huffaker. 2023. "Assessing the Impact of Sowing Dates and ENSO in a Drought Index-Based Insurance for Soybean." *Climate Risk Management* 41: 100544. https://doi.org/10.1016/j.crm.2023.100544.

Pratt, J. W. 1964. "Risk Aversion in the Small and in the Large." *Econometrica* 32, no. 1/2: 122–136. https://doi.org/10.2307/1913738.

Roumiguié, A., A. Jacquin, G. Sigel, H. Poilvé, B. Lepoivre, and O. Hagolle. 2015. "Development of an Index-Based Insurance Product: Validation of a Forage Production Index Derived From Medium Spatial Resolution fCover Time Series." *GIScience & Remote Sensing* 52, no. 1: 94–113. https://doi.org/10.1080/15481603.2014.993010.

Schaub, S., N. Buchmann, A. Lüscher, and R. Finger. 2020. "Economic Benefits From Plant Species Diversity in Intensively Managed Grasslands." *Ecological Economics* 168: 106488. https://doi.org/10.1016/j.ecolecon.2019.106488.

Schaub, S., R. Finger, N. Buchmann, V. Steiner, and V. H. Klaus. 2021. "The Costs of Diversity: Higher Prices for More Diverse Grassland Seed Mixtures." *Environmental Research Letters* 16, no. 9: 9. https://doi.org/10.1088/1748-9326/ac1a9c.

Scherzinger, F., M. Schädler, T. Reitz, et al. 2024. "Sustainable Land Management Enhances Ecological and Economic Multifunctionality Under Ambient and Future Climate." *Nature Communications* 15, no. 1: 4930. https://doi.org/10.1038/s41467-024-48830-z.

Schils, R. L., C. Bufe, C. M. Rhymer, et al. 2022. "Permanent Grasslands in Europe: Land Use Change and Intensification Decrease Their Multifunctionality." *Agriculture, Ecosystems & Environment* 330: 107891.

Schweizer Hagel. 2023. "Graslandversicherung." https://www.hagel.ch/de/versicherungen/grasland/.

Shannon, C. E. 1948. "A Mathematical Theory of Communication." *Bell System Technical Journal* 27, no. 3: 379–423. https://doi.org/10.1002/j.1538-7305.1948.tb01338.x.

Smith, V. H., and J. W. Glauber. 2012. "Agricultural Insurance in Developed Countries: Where Have we Been and Where Are we Going?" *Applied Economic Perspectives and Policy* 34, no. 3: 363–390. https://doi.org/10.1093/aepp/pps029.

Soussana, J.-F., and A. Lüscher. 2007. "Temperate Grasslands and Global Atmospheric Change: A Review." *Grass and Forage Science* 62, no. 2: 127–134. https://doi.org/10.1111/j.1365-2494.2007.00577.x.

Springmann, M. 2024. "A Multicriteria Analysis of Meat and Milk Alternatives From Nutritional, Health, Environmental, and Cost Perspectives." *Proceedings of the National Academy of Sciences* 121, no. 50: e2319010121. https://doi.org/10.1073/pnas.2319010121.

Suter, M., O. Huguenin-Elie, and A. Lüscher. 2021. "Multispecies for Multifunctions: Combining Four Complementary Species Enhances Multifunctionality of Sown Grassland." *Scientific Reports* 11, no. 1: 3835. https://doi.org/10.1038/s41598-021-82162-y.

Szpiro, G. G. 1986. "Measuring Risk Aversion: An Alternative Approach." *Review of Economics and Statistics* 68: 156–159.

Tilman, D., C. L. Lehman, and C. E. Bristow. 1998. "Diversity-Stability Relationships: Statistical Inevitability or Ecological Consequence?" *American Naturalist* 151, no. 3: 277–282. https://doi.org/10.1086/286118.

Tilman, D., D. Wedin, and J. Knops. 1996. "Productivity and Sustainability Influenced by Biodiversity in Grassland Ecosystems." *Nature* 379, no. 6567: 6567. https://doi.org/10.1038/379718a0.

Vicente-Serrano, S. M., S. Beguería, and J. I. López-Moreno. 2010. "A Multiscalar Drought Index Sensitive to Global Warming: The Standardized Precipitation Evapotranspiration Index." *Journal of Climate* 23, no. 7: 1696–1718. https://doi.org/10.1175/2009JCLI2909.1.

Von Neumann, J., and O. Morgenstern. 1944. *Theory of Games and Economic Behavior*. Princeton University Press.

Vroege, W., T. Dalhaus, and R. Finger. 2019. "Index Insurances for Grasslands—A Review for Europe and North-America." *Agricultural Systems* 168: 101–111. https://doi.org/10.1016/j.agsy.2018.10.009.

Vroege, W., and R. Finger. 2020. "Insuring Weather Risks in European Agriculture." *EuroChoices* 19, no. 2: 54–62. https://doi.org/10.1111/1746-692X.12285.

Vroege, W., A. Vrieling, and R. Finger. 2021. "Satellite Support to Insure Farmers Against Extreme Droughts." *Nature Food* 2, no. 4: 215–217. https://doi.org/10.1038/s43016-021-00244-6.

Webber, H., F. Ewert, J. E. Olesen, et al. 2018. "Diverging Importance of Drought Stress for Maize and Winter Wheat in Europe." *Nature Communications* 9, no. 1: 4249. https://doi.org/10.1038/s41467-018-06525-2.

Wu, J. 1999. "Crop Insurance, Acreage Decisions, and Nonpoint-Source Pollution." *American Journal of Agricultural Economics* 81, no. 2: 305–320. https://doi.org/10.2307/1244583.

Wuepper, D., and R. Huber. 2022. "Comparing Effectiveness and Return on Investment of Action- and Results-Based Agri-Environmental Payments in Switzerland." *American Journal of Agricultural Economics* 104, no. 5: 1585–1604. https://doi.org/10.1111/ajae.12284.

WWF, and Deloitte. 2023. "Underwriting Our Planet: How Insurers Can Help Address the Crises in Climate and Biodiversity." https://wwfint.awsassets.panda.org/downloads/wwf-deloitte-insurance-biodiversity-climate-2023-full--report.pdf.

Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Data S1:** aepp70081-sup-0001-Supinfo1.zip. **Table S1:** Risk premium of farmers in the different scenarios. **Table S2:** Simulated willingness to pay for indemnity insurance and drought index insurance contingent on plant diversity: non-adjusted yield. **Table S3:** Simulated willingness to pay for indemnity insurance and drought index insurance contingent on plant diversity: all sites. **Figure S1:** Distribution of farmers' income. **Figure S2:** Distribution of payments received by farmers from insurances. **Table S4:** Simulated willingness to pay for indemnity insurance and drought index insurance contingent on plant diversity: insurance subsidies. **Table S5:** Simulated willingness to pay for indemnity insurance and drought index insurance contingent on plant diversity: loading on the insurance premium. **Table S6:** Simulated willingness to pay for indemnity insurance and drought index insurance contingent on plant diversity: 20% deductible for index insurance. **Figure S3:** "Assurance des prairies" contract example.