Insuring Weather Risks in European Agriculture

Assurer les risques météorologiques dans l'agriculture européenne

Die Versicherung von Wetterrisiken in der europäischen Landwirtschaft

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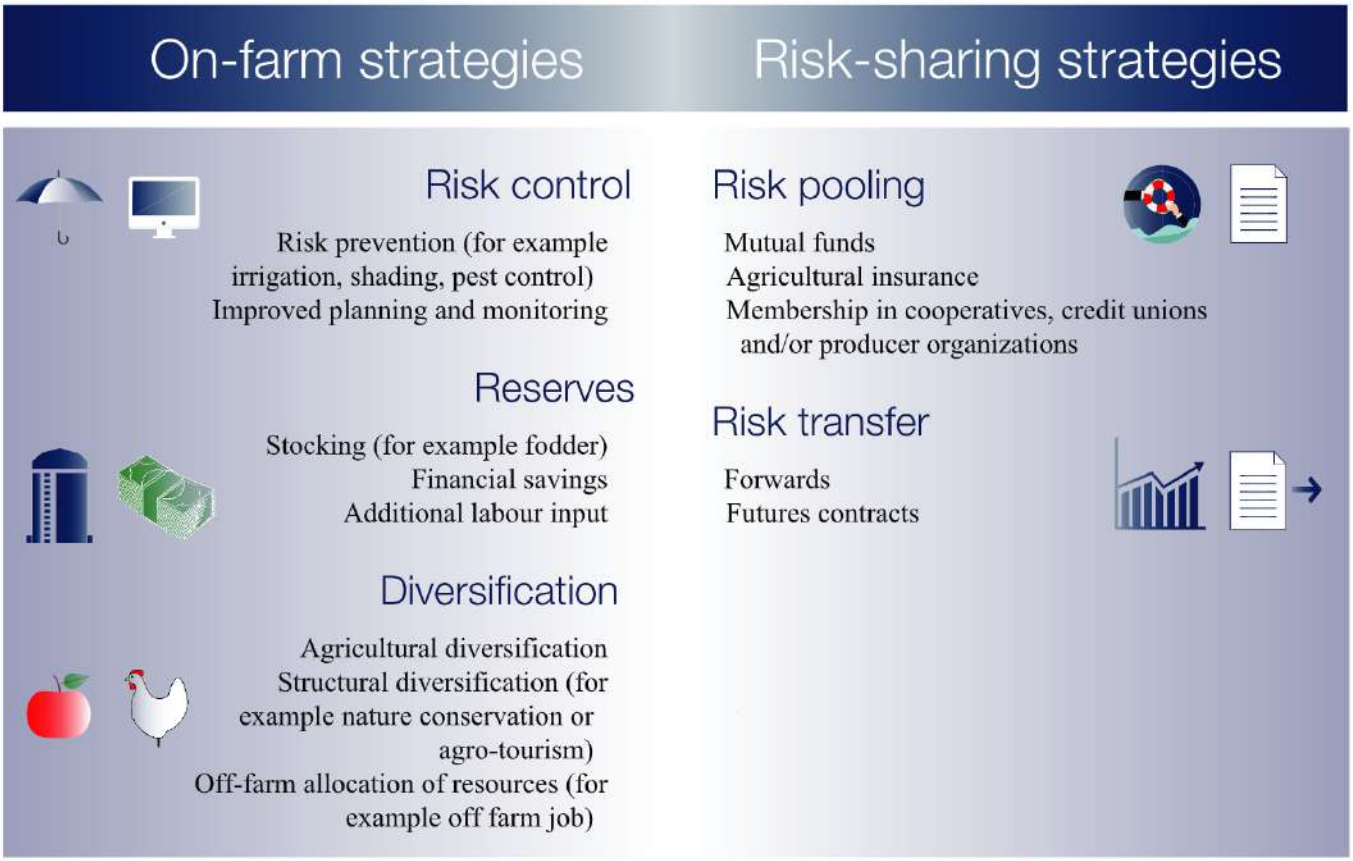
Weather risk management in agriculture

Climate change will increase the magnitude and the occurrence probability of extreme weather events (IPCC, 2014). Farms and farming systems in Europe will need to increase their resilience to these weather extreme events (see Meuwissen *et al.*, 2019 for a framework on resilience). The availability of a diverse spectrum of weather risk management strategies enhances the resilience of farming systems, because different farms, farming systems and weather risks require different solutions (Figure 1, Spiegel *et al.*, this issue).

The SURE-Farm project contributes to the understanding of the potential of new insurance mechanisms. New insurance options, such as for example insurance schemes based on satellite imagery, can contribute to increasing the resilience of European farming systems to extreme weather risks, in both crop and livestock production. Drawing on findings from the SURE-Farm project, this article provides an overview of recent developments in agricultural insurance research (Bucheli *et al.*, 2020; Vroege *et al.*, 2019; Vroege *et al.*, 2020a; Vroege *et al.*, 2020b).

Farmers have several tools to reduce the impact of extreme weather. More specifically, farmers can undertake risk management strategies on their farm (on-farm risk management strategies) and share risk with others (risk-sharing strategies, Figure 1). On-farm risk management strategies include for example risk control strategies. These strategies reduce the impact of weather risks. For example, prevention measures, such as the establishment of hail nets or irrigation equipment, reduce the impact of

Figure 1: Overview of risk management strategies



Source: Adapted from Musshoff and Hirschauer (2016) and complemented with examples from Spiegel *et al.* (this issue).

DOI: 10.1111/1746-692X.12285

Grazing dairy cows – insurance solutions to address weather risk in dairy production are not well developed.

extreme weather on production. Production and income diversification are other on-farm risk management strategies, which help farmers reduce their risk exposure. Building up reserves can facilitate further on-farm risk management in the case of a shock. Yet, these strategies increase the costs of production because they either require expenditures (e.g. for an irrigation system) and/or induce opportunity costs (for example, a diverse production range does not allow for specialisation in order to realise efficiency gains). Moreover, some risks may be beyond the capacity to cope on-farm. For example, extreme weather events such as droughts and heat waves can have severe impacts on farms as these risks can affect several activities simultaneously.

Farmers can share risks with other farmers or transfer risks to markets to complement on-farm weather risk management strategies. Cooperatives and mutual funds for example facilitate risk pooling and secure farmers' incomes in difficult times. Moreover, agricultural insurance schemes pool production risks, while forward and futures contracts transfer price risks. The optimal portfolio of on-farm risk management and risk-sharing measures is farm-specific and depends on the characteristics of the farm and on the preferences of the farm manager(s) (e.g. Meraner and Finger, 2019).

Agricultural weather insurances

Agricultural insurance schemes are viable tools to manage weather risks and there are various possible insurance solutions. For example, single or multiple peril insurances cover against one or more specific causes of damage and yield insurances cover production losses against any peril. Even insurance schemes for revenues or even income levels exist (e.g. Severini *et al.*, 2019). Most common insurance schemes that cover weather-related damages are indemnity insurances. Indemnity insurances are insurance schemes that adjust losses based on physical damage observations.

The availability of insurance schemes against weather risks can contribute to the three resilience capacities, robustness, adaptability and transformability (see Meuwissen *et al.*, 2019 for a resilience framework), of farming systems in multiple ways (Spiegel *et al.*, this issue). Most obviously, weather-related insurance payoffs can increase the *robustness* of farming systems to extreme weather events. Insurance payoffs can complement on-farm risk management strategies, especially if these fall short during extreme situations. The availability of weather insurance schemes thus can increase farmers' capacity to cope with weather shocks. Moreover, weather insurances can contribute to both *the adaptability* and *transformability* of farming systems because they can allow farmers to shift time and money away from on-farm risk control to other activities. This increases farmers' flexibility as farms can then invest these resources in adaptive measures, such as diversification of agricultural production or the creation of new marketing strategies, and/or in transformative activities, such as non-agricultural activities on the farm (for example on-farm sales or agri-tourism) or off-farm work. In particular, insurance solutions that allow farmers to freely adjust their activities can enable adaptability and transformability. These can for example be insurance solutions at the level of revenues or incomes (e.g. Severini *et al.*, 2019) and insurance solutions that base payoffs on the occurrence of an adverse weather event instead of on damages (i.e. index insurances, Box 1) because insurance payoffs may not be linked to outcomes of specific farm activities.

Therefore, insurances that base payoffs on the presence of adverse events or on farm revenues or income are generally more resilience-enabling than single-crop indemnity insurances. Despite these

Box 1: Index insurances

Payoffs of index insurances are based on an index that is related to production, such as for example rainfall measured at a specific weather station in a specific time period. An index insurance pays off when the underlying index is below or above a certain threshold. For example, when rainfall within a specific month, measured at a nearby weather station, is below a pre-defined threshold. The level of the payoff index insurances to farmers depends on the realised level of the index, for example, the level of (missing) rainfall.

resilience-enhancing potentials of weather insurance schemes, the SURE-Farm focus groups (see Spiegel *et al.* and Buitenhuis *et al.* in this issue) showed that many stakeholders believe insurances' contribution to robustness can hinder adaptability and transformability if they create a sense of complacency, crowd out necessary adaptive activities – including climate change adaptation – and limit farmers' willingness to innovate. However, to what extent insurance schemes contribute to the different resilience capacities depends largely on the insured peril and the insurance conditions. Thus, some insurance schemes may enable multiple resilience capacities while others may only enable robustness. Most commonly used indemnity insurances might not be the most resilience-enhancing insurance option in all situations.

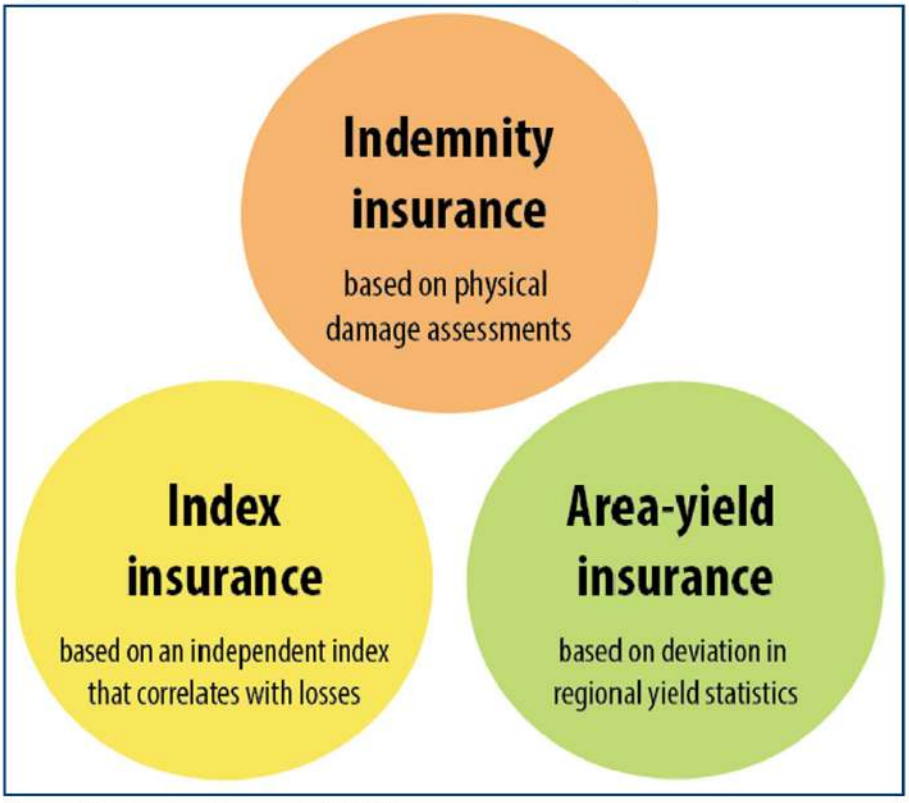
Moreover, indemnity insurances have further drawbacks. Firstly, farmers with higher risk exposure have more incentives to buy an indemnity insurance contract (adverse selection) and insured farmers might shift to riskier practices (moral hazard). Because farmers know more about their risks and cultivation measures, indemnity insurance schemes need contract provisions such as deductibles to address this information asymmetry. Secondly, if physical damage assessments are the basis for insurance payoffs, indemnifications come with high transaction costs and temporal delays. Thirdly, some activities may not be insurable because the identification of weather-related damages is difficult. For example, identifying drought damages in meadows and pastures is often impossible because of grazing and mowing activities. As a result, some risks (like droughts) and activities (like grassland production) are incompletely covered in current insurance schemes. Here, complementary solutions to indemnity insurances are urgently needed.

Alternative insurance tools that address these limitations are area-yield and index insurance schemes (Figure 2). With these types of insurance schemes, farmers receive insurance payoffs if the yield in a region (area-yield insurance) or an independent index, such as rainfall in a specific time period (index insurance), undercuts or exceeds a predetermined threshold, called the strike level (e.g. Miranda, 1991; Vedenov and Barnett, 2004). In these insurance schemes, payoffs are based on reference data that are monitored and published by independent institutions or official authorities, which avoids the information asymmetry as farmers and insurers have the same knowledge on the risk. Moreover, the use of such data sources as insurance underlying (i.e. as basis to specify payoffs) also avoids resource-demanding loss assessments in the field. Additionally, area-yield and index insurances create additional incentives to keep up production, as payoffs do not depend on individual farmers' production practices. There is thus no moral hazard. For example, in case of a drought, farmers with an area-yield or index insurance have more incentives to irrigate as they can gain profits from insurance payoffs and, if they avoid losses, also from markets, while farmers who are insured against their individual losses (indemnity-insured farmers) cannot cumulate benefits.

> “Pour renforcer la résilience des systèmes agricoles européens, un choix d'assurances plus varié et un environnement d'action publique permettant des innovations dans l'assurance sont nécessaires.”

A major problem with index and area-yield insurance solutions is, however, that there is a possible deviation between the measured value and a farmer's loss. This is referred to as basis risk. Basis risk may for example occur because the

Figure 2: Overview of weather insurance schemes in agriculture



Source: Adjusted from Vroege *et al.* (2019).

relationship between the area-yield or the (e.g. weather) index and a farmers' individual yield loss is not perfect, i.e. not perfectly correlated. Due to basis risk, it is possible that a farmer paid an insurance premium but does not receive a loss adjustment, even though there was damage at her/his farm. Highly risk averse farmers may not buy such insurance contracts (Clarke, 2016).

> "Um die Widerstandsfähigkeit der europäischen Agrarsysteme zu stärken, ist eine größere Vielfalt an Versicherungsoptionen und ein politisches Umfeld erforderlich, das Versicherungsinnovationen ermöglicht."

Better insurance designs and better indices can reduce basis risk and make these insurance solutions more attractive to farmers. For example, tailoring insurances to the individual farm can decrease basis risk of index insurances. This can be supported by spatially and temporally more detailed data, for example provided by satellite observations. We here summarise contributions from the SURE-Farm project that aim to support increasing resilience of Europe's farming systems by developing and evaluating new weather insurance options.

SURE-Farm contributions

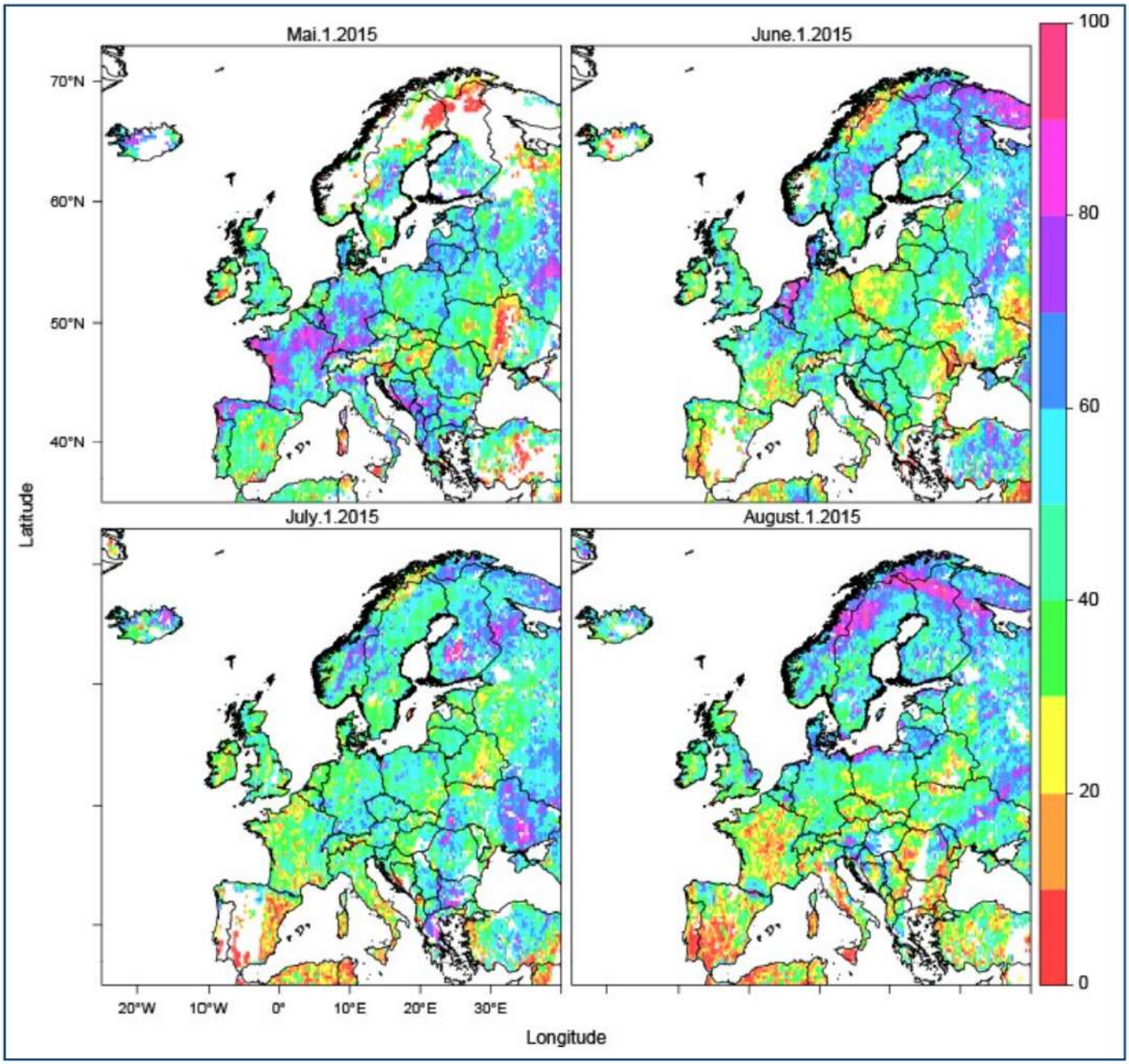
Index insurances for grasslands – A review for Europe and North America. To shed light on the diversity of index and area-yield insurance approaches which have been developed recently throughout Europe, we categorise and analyse existing index and area-yield insurance solutions for grasslands in Europe. To broaden the context, we additionally analysed insurance schemes in North America (Vroege *et al.*, 2019).[1]

We identified and analysed 12 area-yield and index insurance schemes, 5 of them in Europe (in Austria, France, Germany, Spain and Switzerland). We find different index variables and technical characteristics, ranging from index solutions that base payoffs on rainfall data towards insurance solutions based on satellite-retrieved data of the vegetation such as the NDVI (Normalized Difference Vegetation Index). The NDVI is a satellite-measured indicator that provides insights on the greenness of the vegetation, which can show anomalies due to extreme weather conditions. Additionally, we find that index insurances are developed in isolated insurance markets with little knowledge of spillovers across companies and countries. In general, we find an increasing use of satellite technology in grassland insurance schemes. We highlight that insurance products based on satellite-retrieved data are not a new insurance type *per se* but that satellite observed information is a data source that can improve different types of insurance schemes in different ways. More specifically, better, quicker and cheaper observations can reduce damage assessment costs, payment lags and reduce information asymmetry – especially for grasslands. Moreover, high spatial and temporal resolutions of satellite observations can reduce basis risk of index insurances. However, we also highlight that satellite information does not automatically provide better insurances.

The optimal drought index for designing weather index insurance. Drought risks are often systemic as they can affect large parts of countries or even continents. Thus, it is difficult and costly to insure droughts with traditional indemnity insurance schemes. As a result, there are still few drought insurance options available to farmers – even though drought is an important and increasing risk for European agriculture. We thus aimed to provide insights on how differently an optimal drought insurance contract could be designed (Bucheli *et al.*, 2020). In this contribution, we specifically address two questions. First, there are various drought indicators and we here test which is best suited in an index insurance. Second, we test whether the choice of the 'best' index can be generalised or needs to be farm specific. To this end, we compared the risk reducing potential of different drought indices. These were index insurances based on: i) a cumulative precipitation index; ii) a standardised precipitation index; iii) a standardised precipitation evapotranspiration index; iv) a soil moisture index; and

Dry soil – there are still few drought insurance options available to farmers © Pixabay

Figure 3: Illustration of satellite-retrieved soil moisture data from the European Space Agency Climate Change Soil Moisture initiative (e.g. Dorigo *et al.*, 2017): Soil moisture in % saturation for days in the year 2015



v) an evaporative stress index. We designed and compared these insurance contracts for a sample of 85 winter wheat producers in Eastern Germany. The data on drought indicators is farm specific (for example because we used gridded weather data) and accounts for drought sensitive phenology phases of wheat. In general, we found that index insurances based on any of the drought indicators can reduce financial risk exposure. However, the largest risk reduction can be achieved if the underlying index is tailored individually for each farm. This implies that insurers should offer index insurance schemes with farm-specific drought indices.

Insuring crops from space: The potential of satellite retrieved soil moisture to reduce farmers' drought risk exposure. Satellite-observed information provides high-quality drought estimates at low costs and might thus be used in drought index insurance schemes. Soil moisture is a weather-related variable crucial to crop production for which high-quality satellite-retrieved data are freely available (e.g. Dorigo *et al.*, 2017). Figure 3 illustrates soil moisture observations from this satellite-observed dataset (European Space Agency Climate Change Initiative Soil Moisture). In this study, we thus investigated whether drought insurance contracts that are based on satellite-retrieved soil moisture information could help farmers to cope with drought risk (Vroege *et al.*, 2020a). We designed index insurances for winter wheat, rapeseed and maize yields of 89 farms in Eastern Germany with the satellite-retrieved soil moisture data as index variable. To evaluate the potential of this dataset to reduce farmers' drought risk exposure, we compared farmers' risk exposure

High-resolution true colour satellite image from Brandenburg and Berlin (Germany) from the Sentinel-2 L2A Satellite on June 3, 2019 ©Copernicus data (2020).

with insurance contracts based on the satellite-observed data to their risk exposure in two other scenarios: i) where they have index insurance contracts based on interpolated soil moisture data from weather stations; and ii) where no farmer is insured. The analysis showed that offering insurance schemes based on soil moisture data can reduce farmers' financial exposure to weather risks compared to a situation where no insurance option is available, which is currently the situation for most farmers in the European Union.

Effects of extreme heat on milk quantity and quality. Heat waves affect dairy production in multiple ways. When it is hot and humid, cows produce less milk, which is of a lower quality, while mortality and animal sales increase and feed production decreases. Yet, insurance solutions to address weather risk in dairy production are not well developed. This is because of these diverse responses and because quantifying weather-related damages is complicated due to the continuous, but seasonally dependent, character of dairy production. We here aimed to develop a basis for a future introduction of weather insurances for dairy production. To this end, we quantified the effect of heat on milk production losses in a study on all dairy farmers in Belgian Flanders (Vroege *et al.*, 2020b). We found that milk production decreased non-linearly with increasingly hot and humid weather. Even though farms use measures to cope with high temperature-humidity levels (for example ventilation systems), there remains damage to milk production. For instance, we estimated that dairy farms in Flanders lose €20 revenues with every hour they are exposed to temperatures of 30°C with 60 per cent humidity. Thus, heat risk is economically significant. Knowledge on the relationship between weather and yield losses is important for establishing insurance solutions for dairy farmers.

> "To strengthen the resilience of European farming systems, greater diversity of insurance options and a policy environment that enables insurance innovations are needed."

Policy implications

Our research shows that there is considerable potential for new insurance options in both crop and livestock production. However, some European governments still intervene with *ad hoc* disaster payments in times of extreme weather (European Commission, 2018), as for example the German government did during drought in

Extreme weather events can have severe impacts on farms as these risks can affect several activities simultaneously.

2018. This practice creates high costs to society and it underlines that some European farming systems lack preparedness and are currently not resilient to extreme weather. Yet, the European Union recently enlarged the possibilities to subsidise insurance premiums and European governments increasingly subsidise (France, the Netherlands, Poland), or recently decided to start subsidising (Belgium) insurance schemes that compensate weather-related losses (see for example Meuwissen *et al.*, 2018). However, the current subsidisation systems may create inadequate incentives for innovations in the insurance market (Vroege *et al.*, 2019). Although the currently existing EU regulation on support for rural development opens up possibilities for support of area-yield and index insurance (The European Parliament and the Council, 2013), it is still necessary to prove that farmers are compensated for their individual yield losses (e.g. Vroege *et al.*, 2019). As this in most cases still requires individual damage assessments, it removes the advantages of area-yield and index insurances. To strengthen the resilience of European farming systems, a larger diversity of insurance options and a policy environment that enables insurance innovations is needed. To improve the resilience of Europe's farming systems, governments should improve knowledge exchange and knowledge accessibility on new insurance options for farm communities and support the development and use of (new) data sources.

Weather-related insurance payoffs can increase the robustness of farming systems to extreme weather events.

Acknowledgements

This research was undertaken within the SURE-Farm (Towards SUstainable

and REsilient EU FARMing systems) project, funded by the European Union (EU)'s Horizon 2020 research and innovation programme under Grant Agreement No 727520 (http://surefarmproject.eu). The content of this article does not necessarily reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the authors.

For the Belgium case study, we thank Erwin Wauters for his insights and support, Dakerlia Claeys for providing the data and Tobias Dalhaus for support with data analysis. We thank Janic Bucheli, Tobias Dalhaus and Martin Hirschi for their contributions to the work in Eastern Germany. Moreover, we thank two anonymous referees and the Editor for their careful reading and constructive feedback on a previous version of the paper.

Note

1 Innovative schemes have also been established in other countries. Examples include satellite-retrieved vegetation health insurance schemes for livestock in Kenya, Ethiopia and Mongolia, satellite-retrieved rainfall insurance in Zambia and weather index insurances in India.

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Summary

Insuring Weather Risks in European Agriculture

Smart insurance designs (e.g. tailoring insurances to the individual farm) and technological progress (e.g. advances in satellite technology) enable improvements in insurance schemes. Spatially and temporally more detailed information as well as better knowledge of the relationship between weather and yields losses can reduce basis risk of insurances. However, the use of new and better data does not automatically lead to better insurance schemes. The SURE-Farm project contributes to the understanding of weather risks and new insurance mechanisms as possible tools to increase the resilience of European agriculture to weather extremes. Therefore, we aim to show how to integrate newly available data sources for different agricultural outputs, namely grassland, crop and dairy production in different European regions. In the four contributions summarised here, we evaluate currently existing index insurance schemes and provide fundamental insights for future developments of index insurances for the crop and livestock sector in Europe. We first summarise and discuss existing index-based weather insurances. Second, we investigate the drought risk reduction potential of different drought indicators in two case studies on different crops in Eastern Germany. Third, we examine the relationship between hot and humid weather and milk yield losses for dairy producers in Flanders.

Assurer les risques météorologiques dans l'agriculture européenne

La conception d'assurances intelligentes (par exemple, l'adaptation des contrats à l'exploitation individuelle) et le progrès technologique (par exemple les progrès de la technologie des satellites) permettent d'améliorer les dispositifs d'assurance. Des informations spatiales et temporelles plus détaillées ainsi qu'une meilleure connaissance de la relation entre les intempéries et les pertes de rendement peuvent réduire le risque de base des assurances. Cependant, l'utilisation de données nouvelles et améliorées ne conduit pas automatiquement à de meilleurs dispositifs d'assurance. Le projet SURE-Farm contribue à la compréhension des risques météorologiques et des nouveaux mécanismes d'assurance susceptibles d'accroître la résilience de l'agriculture européenne aux conditions météorologiques extrêmes. Par conséquent, nous visons à montrer comment intégrer les nouvelles sources de données disponibles pour différentes productions agricoles, à savoir les prairies, les cultures et la production laitière dans différentes régions européennes. Dans les quatre contributions résumées ici, nous évaluons les dispositifs d'assurance indicielle existants et apportons des informations fondamentales pour le développement d'assurances indicielles pour le secteur des cultures et de l'élevage en Europe. Nous résumons et examinons tout d'abord les assurances météorologiques indexées actuelles. Deuxièmement, nous étudions le potentiel de réduction du risque de sécheresse de différents indicateurs de sécheresse dans deux études de cas sur différentes cultures en Allemagne de l'Est. Troisièmement, nous examinons la relation entre des conditions météorologiques chaudes et humides et les pertes de rendement laitier pour les producteurs laitiers de Flandre.

Die Versicherung von Wetterrisiken in der europäischen Landwirtschaft

Intelligente Versicherungskonzepte (z. B. betriebsspezifische Versicherungen) und technologischer Fortschritt (z. B. Weiterentwicklungen in der Satellitentechnologie) machen Verbesserungen im Versicherungssystem möglich. Der Zugang zu detaillierteren räumlichen und zeitlichen Informationen sowie ein verbessertes Wissen über den Zusammenhang zwischen Wetter und Ertragsausfällen können das Basisrisiko von Versicherungen reduzieren. Dennoch führt die Nutzung von neuen und besseren Daten nicht automatisch zu besseren Versicherungssystemen. Aus diesem Grund möchte das SURE-Farm-Projekt einen Beitrag zum Verständnis von Wetterrisiken und neuen Versicherungsmechanismen als möglichen Werkzeugen leisten mit dem Ziel, die Widerstandsfähigkeit der europäischen Landwirtschaft gegen Wetterextreme zu erhöhen. Im Rahmen des Projekts wollen wir zeigen, wie neue Datenquellen für verschiedene landwirtschaftliche Produktionszweige, nämlich Grünland, Ackerbau und Milchproduktion in verschiedene europäische Regionen integriert werden können. In den vier hier zusammengefassten Beiträgen bewerten wir die derzeit bestehenden Indexversicherungen und liefern grundlegende Erkenntnisse für deren zukünftige Entwicklungen für den Ackerbau und die Tierhaltung in Europa. Wir fassen zunächst die bestehenden indexbasierten Wetterversicherungen zusammen und diskutieren sie. Anschließend untersuchen wir das Dürrerisiko-Minderungspotenzial verschiedener Dürreindikatoren in zwei Fallstudien zu verschiedenen Anbaukulturen in Ostdeutschland. Schließlich testen wir einen möglichen Zusammenhang zwischen heißem und feuchtem Wetter und Milchertragsverlusten bei flämischen Milchviehbetrieben.