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Navigating Agricultural Risks: A Regional Analysis of Crop Insurance in Portugal

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Abstract

The low uptake of agricultural insurance in Portugal, despite the increasing climate risks, poses significant challenges to the resilience of the farming sector. This thesis analyses the factors behind this limited adoption, focusing on regional variations and social, economic, and geographic determinants. Using data from IFAP (Portuguese Institute for Financing Agriculture and Fisheries) and the 2019 Agricultural Census, this study explores the barriers and opportunities for improving insurance coverage. The findings inform policy recommendations aimed at enhancing insurance accessibility and strengthening the agricultural sector's ability to withstand climate-related risks.

Keywords: Crop Insurance, Agricultural Policy, Risk Management, Portugal, Environmental Economics

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1. Introduction

Agriculture is crucial to Portugal's economic, social, and environmental development. However, in recent decades, the sector has undergone significant structural changes. The shift towards a service-based economy made other sectors more attractive due to higher wages (Trindade and Pereira, 2023), leading to the abandonment of agriculture, particularly in small, less productive farms (Alves et al., 2003). Additionally, after Portugal joined the European Union and adopted the Common Agricultural Policy (CAP), new policies dramatically altered the Utilized Agricultural Area (UAA)[1] (Moura, 2010).

Although agriculture contributed only 2% to Portugal's Gross Domestic Product (GDP) in 2023 (World Bank Group, n.d), the sector's gross value-added grew, on average, by 4.2% annually from 2010 to 2023 (Office of Planning, Policies, and General Administration (GPP), 2024). Regionally, agriculture holds the greatest significance in Alentejo and the Azores, accounting for 8.8% and 6.8% of their respective GDPs in 2022. In contrast, agriculture represents only 0.3% of the Lisbon Metropolitan Area's (AML) GDP (Pordata, 2022).

The structural changes faced by the agricultural sector have resulted in significant economic impact over time, leading to a transformation in the social characteristics of the agricultural workforce (Alves et al., 2003). By 2019, the agricultural workforce decreased to 314 509 annual work units (AWU)2 (National Statistics Institute (INE), 2021), equivalent to 42% of the

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[1] Utilized agricultural area (UAA) - The area of the farm that includes arable land (both cleared and under forest cover), home gardens, permanent crops, and permanent pastures (INE, 2021).
[2] Annual Work Unit (AWU) - A unit of measurement representing the amount of work done by a person working full-time over a year, calculated in hours. One AWU equals 240 working days, with each day consisting of 8 hours. (INE, 2021)

workforce in 1989, according to sectorial censuses (Trindade and Pereira, 2023). Around two-thirds of this workforce is concentrated in the northern and central regions of Mainland Portugal. Also, the workforce age is relatively high, with an average age of 64 among individual producers, and has low education levels (INE, 2021).

As for the most competitive crops in Portugal, fruits, horticultural products, and flowers have consistently recorded a negative trade balance from 2010 to 2023, with both exports and imports experiencing an overall increase in volume. Cereals exhibit a similar trend, although the importance of exports in the trade balance is lower (with a variation of 477.6% throughout the studied period). Wines from fresh grapes and olives have consistently maintained a positive trade balance over most of the period. Wine exports are particularly significant, averaging 781 million euros annually. Olives have shown remarkable growth, shifting from a negative trade balance of 4 million euros in 2010 to a positive balance of 508 million euros in 2023 (GPP, 2023). In the fruit sector, especially dried fruits, almonds have also seen substantial growth, achieving a positive trade balance for the first time in 2023, valued at 40 million euros (GPP, n.d.).

The agricultural sector is heavily reliant on climate patterns and is facing challenges worldwide due to climate change. The European Union (EU) is facing altered precipitation patterns and extreme temperature fluctuations (Sharma et al., 2024). The impacts on crop production vary between Northern and Southern Europe, with potential increases in production in the North and the opposite effect in the South (Hristov et al., 2020; Shrestha et al., 2013). In Portugal, the country is already grappling with the rise in average temperatures, prolonged droughts due to extreme heat events, and variability in precipitation patterns characterized by shorter but intense periods. These climate challenges are projected to keep growing in the future (Pires et al. 2018; Miranda et al., 2018).

Strategies to effectively manage and adapt to climate risk are crucial in this sector. Irrigation and water management techniques, as well as crop diversification (in particular, among small-scale farmers), are examples of risk management tools used by farmers (Guerrero-Baena and Gómez-Limón, 2019; Ochieng et al., 2020). However, one of the most popular and important tools is crop insurance, that provides protection against financial losses due to unpredictable events. Insurance allows for faster recovery after a disaster by compensating losses, which enables farmers to keep their activity. It also helps stabilising income, as farmers may readjust their production based on previous losses, choosing crops with higher protection (Bhuiyan et al., 2022).

In Portugal, crop insurance premiums are partially subsidised by the government, playing a crucial role in supporting this sector. These subsidies significantly improve the financial accessibility of insurance for farmers by lowering the net premium costs, which encourages broader adoption of insurance. For insurance companies, subsidies are essential as they enable the offering of coverage even in high-risk regions. Additionally, the claims compensation system helps insurance companies by compensating them when claims exceed a certain threshold.

Despite these measures, insurance uptake remains unsatisfactory. Official data on crop insurance penetration in Portugal is scarce. However, Swiss Re's Crop Insurance Resilience Index (Crop I-RI) shows that Portugal's crop insurance penetration was only 6% in 2021, compared to the global average of 40.8% (Aggarwal, 2023). These figures are concerning and reveal the high vulnerability of Portuguese farmers to climate risks.

The main objective of this study is to take an initial step in addressing the significant research gap in this area, while also contributing to policymakers' understanding of the challenges within the crop insurance market. A key issue is the lack of accurate and comprehensive data on multi-peril insurance, not only within the agricultural sector but across the non-life insurance market. It is crucial to consider the location-specific social, economic, and geographic characteristics, as there is no universal solution. This study examines data on crop insurance from the Portuguese Institute for Financing Agriculture and Fisheries (IFAP) and integrates statistics from the 2019 Agricultural Census, provided by INE to offer a detailed regional analysis.

Agricultural insurance uptake in Portugal exhibits significant regional variation. Although further research is needed to evaluate disparities at the crop and regional levels, the current analysis aligns with existing literature. Regions with larger and more productive agricultural holdings, like Alentejo, show higher levels of insured capital, while areas such as the Northern Interior have lower uptake due to smaller, fragmented holdings. Other factors contributing to this disparity include risk exposure, farmer education levels, age, and the absence of coverage for severe occurrences such as droughts. These findings highlight the need for more targeted subsidies and risk management strategies in high-risk regions. Additionally, improving access to insurance and addressing low educational levels among farmers are essential for increasing insurance penetration.

The thesis begins with a literature review that contextualises agricultural insurance in Portugal, tracing its evolution and highlighting the key challenges and concerns identified in the existing research. The methodology section details the data sources and analytical techniques used to investigate regional variation in insurance uptake and the factors that influence farmers' decisions to insure their crops. The results are then presented and discussed, with an emphasis on the implications of these findings for different regions and crop types. Finally, the conclusion offers policy recommendations, outlines the limitations of this research, and suggests directions for future work to further improve the crop insurance system and its contribution to the resilience of the Portuguese agricultural sector.

2. Historical Evolution and Determinants of Crop Insurance in Portugal

Before 1980, there were already subsidised premiums in the agricultural sector. However, the system was ineffective due to the high net premiums that farmers had to bear, with the subsidised premium averaging 38% (Sampaio, 2017). The ineffectiveness was also partly due to the difficulty and even refusal of insurers to provide coverage in high-risk regions. Additionally, the lack of an adjusted compensation mechanism for loss based on the varying location-specific risk levels exacerbated the situation, as the reinsurance market was not functioning properly (Sampaio, 2017).

The inefficiency of the implemented system imposed systematic state interventions to cover losses from various risks. Consequently, farmers lacked incentives to insure their productions. Only those farmers in high-risk areas were willing to pay the very high net premiums. This adverse selection led insurers to withdraw from this line of business, as the imbalance resulted in higher overall costs for insurers, who ended up covering more high-risk individuals than anticipated (Sampaio, 2017).

Thus, in 1996, the SIPAC (Integrated System for Protection Against Climatic Uncertainties) was established. The system consisted of three different components: a crop insurance, a calamity fund, and a loss compensation. The crop insurance system offered subsidised premiums. If the insurance company's commercial rate exceeded a certain reference rate, the premium paid by farmers would be partially covered or reduced based on this reference rate. The calamity fund provided compensation to farmers for losses caused by non-insured risks. Lastly, the loss compensation program provided financial help to insurance companies in situations of excessive claims (Sampaio, 2017).

The SIPAC covered almost all crops in mainland Portugal and was exclusively funded by national funds. The maximum support level initially reached 85%, later decreasing to 70%. Four years after the establishment of SIPAC, the uptake of crop insurance increased very significantly, with 104 000 farmers participating in the program by 1999. This number represented 28% of the cultivated area with crops covered by the SIPAC being insured. The sudden increase in participation was attributed to the high level of premium support, the opportunity to receive compensation for non-covered risks (provided the farmer had an insurance contract and joined the scheme), and the new attractive conditions for insurance companies (Sampaio, 2017).

However, from 1999 onwards, we observe a decline in insurance uptake, with only 19% of the total cultivated area being insured by 2003. This decrease was attributed to several factors, including a reduction in claims (measured by the indemnity to insured capital ratio) and a decrease in the maximum subsidy level from 85% to 75% in 2000. Additionally, the calamity fund transitioned from providing direct subsidies to offering lines of credit with interest subsidies, which were less attractive to farmers and reliant on the willingness of banks to extend credit (Sampaio, 2017).

Keeping SIPAC’s loss compensation system, a new agricultural insurance system was created in 2012, initially including the Vineyard Crop Insurance (SVC) and the Fruit and Vegetable Insurance (SFH-OP). Later, in 2014, the Crop Insurance (SC) is introduced. These new insurance schemes are based on a more rational approach to the allocation of subsidies. After 2013, there was a slight increase in insurance uptake, possibly due to the features of the new insurance scheme. These features included the introduction of coverage for new risks and the prioritisation of farmers with insurance contracts (Sampaio, 2017).

According to the IFAP (2023), as of July 2023, crop insurance covered up to 70% of the insurance premium, with funding provided by the government and the European Union. Farmers are responsible for paying the net premium after the subsidy is deducted. To qualify for the subsidy, farmers must have an insurance contract, which can be either individual or collective. A valid family farming statute is required to receive the full 70% support. Young farmers are eligible for 60% support. If neither condition is met, the subsidy is reduced to 57%.

Crop insurance is divided into two categories: horizontal insurance, applicable to any region in mainland Portugal, and special insurance, which covers specific crops and regions (excluding vineyards). Each category defines coverage periods based on crop type and climatic conditions (IFAP, 2023).

As it will be detailed in the methodology section, in the event of a claim, the farmer or collective entity must notify the insurance company. If losses exceed 20% of the average annual production of the insured crop, the farmer is entitled to indemnity. For horizontal insurance, the relative deductible is 20% of the indemnity, regardless of the type of risk. In contrast, the deductible values for special insurance vary depending on the crop and associated risk (IFAP, 2023).

For vineyards, there is a specific insurance policy fully funded by the EU. This insurance covers a wider range of risks than the standard crop insurance, including persistent rain and scalds.

The insurance premium coverage can increase to 80% for group insurance contracts and 75% for individual contracts, with the proportion of the premium covered depending on the type of insurance policy contracted. Like the crop insurance system, in the event of a climate disaster, indemnity is available only for losses exceeding 20% of the insured capital (IFAP, 2023).

Lastly, the claims compensation mechanism is another type of support designed to assist insurance companies. When paid indemnities reach a certain threshold of received premiums, the state provides financial compensation to insurance companies. It is a way for insurance companies to reinsure part of the risk, given it has been hard to do it in the private sector. However, this support will cease by the end of 2024, with some specific exceptions (Confederação dos Agricultores Portugueses, 2023).

The recent announcement of the end of claim compensation has led to some historical agricultural insurance providers deciding to exit the market (Botelho, 2024). In 2023, the agricultural insurance market consisted of 5 players. According to the Portuguese Association of Insurers (APS), *Generali Tranquilidade* held the largest market share at 48%, followed by *Fidelidade* at 22.6%, and *CA Seguros* at 20.9%. *Caravela* and *UNA Seguros* were the smallest players with 5.4% and 3.0% market share, respectively (Botelho, 2024).

Generali Tranquilidade has ceased making new insurance contracts in 2024, and *Fidelidade* has decided to retain only existing clients. However, *CA Seguros* has not announced any changes. *Caravela* and *UNA Seguros* entered the market in 2022 with the aim of addressing market gaps, indicating growth potential in the industry (Botelho, 2024).

Companies, such as *CA Seguros*, had already withdrawn from the government's claim compensation due to issues related to the application of public reinsurance, which are typically not encountered in the private sector. However, the discontinuation of this reinsurance is a concern for the market's future, as not all companies will be able to manage risks without access to reinsurance (Botelho, 2024).

From the farmers' perspective, a study by the European Commission, conducted in 2015, revealed that over 30% of young farmers in Portugal see access to insurance as challenging. Difficulty in accessing insurance creates obstacles for farmers seeking financing for projects or investments, as banks view the sector as too risky to provide funding to uninsured farmers, which ultimately eliminates opportunities in the sector (Fi-compass, 2020).

Both insurers and farmers have expressed concerns about delays in the communication of technical guidelines for the various support programs. For example, in 2024, there was a delay in applying for premium bonuses, which only opened in May after frost and hail events had already caused losses. Consequently, farmers proceeded with non-updated values from the previous year, instead of considering the new rules to be applied (Botelho, 2024).

From both demand and supply sides, the challenges in the market should be carefully studied and monitored, given the present context. Although the agricultural production value in Portugal has been increasing in recent years, insurance contracting has failed to keep pace with this trend. According to INE and IFAP, agricultural production reached 6.25 billion euros, while the insured capital value was only 423 million euros (Botelho, 2024), representing approximately 6.77% of total production. These numbers are concerning, especially when compared to the 40% insured global crop production, as estimated by the Swiss Re Institute (Swiss Re Institute, 2024).

The decision to adopt agricultural insurance is influenced by many factors, which can be broadly categorised into climatic, economic, and socio-demographic determinants. One of the most significant factors influencing farmers' decisions to purchase agricultural insurance is local climatic conditions. Studies consistently highlight weather-related risks, such as those identified in the research conducted in Kwara State, Nigeria, a primary driver of insurance adoption (Ajiboye et al., 2018). Similarly, a study on Bulgarian farmers emphasises the role of regional climatic conditions, showing that farmers' previous experiences with adverse weather increase their likelihood of adopting insurance (Lefebvre et al., 2014). The literature further underscores that risk exposure and perception are crucial factors influencing the decision to purchase insurance, particularly in agriculture, where these risks are closely tied to climatic variables.

Economic considerations also play a crucial role in the decision-making process. High premium costs often deter farmers from purchasing insurance unless they perceive an important benefit, particularly in protecting against future risks or safeguarding past gains from high yields. As discussed in the literature, premiums are expected to be negatively correlated with insurance contracting. For instance, Sihem (2017) estimated that for 23 American and European countries "a decrease of 1% in agricultural insurance premiums is associated with a 0.446% increase in agricultural insurance demand". Additionally, government subsidies on premiums can significantly enhance insurance uptake (Ajiboye et al., 2018). The importance of farm size and investment levels is further underscored in studies showing that larger farms with more assets have more resources to purchase insurance (Lefebvre et al., 2014).

Farmers' educational levels and prior experience with risk management tools also emerge as critical determinants. Most research indicates a positive correlation between higher educational attainment and the likelihood of choosing insurance, as more educated farmers are more aware of risk and may better understand the benefits of such financial products (Treerattanapun, 2011). Additionally, the age of the farmer is generally estimated to be negatively correlated with insurance uptake (Ntukamazina et al., 2017; Kaunda and Chowa, 2022). As farmers age, their willingness to pay for insurance tends to decrease, a relationship often attributed to the idea that older farmers, having accumulated more hands-on farming experience, are more inclined to take risks compared to their younger counterparts. Moreover, older farmers are often less receptive to adopting innovative technologies (Ntukamazina et al., 2017). In Portugal, most farmers rely on additional sources of income beyond agriculture. In 2019, 163 130 individuals reported pensions or retirement income as part of their earnings outside of farming (INE, 2021). However, retirement income in Portugal is generally low, leading to lower overall available income for older Portuguese farmers.[3]

The uptake of agricultural insurance differs significantly between individual producers and collective entities, with several key factors influencing these differences. Collective entities can provide more advantages in many ways, as they are able to reduce transaction costs, facilitate information dissemination and learning, and provide social networks that help internalise risks (Sibiko, Veettil & Qaim, 2018). Agricultural groups also facilitate access to public and private resources and partnerships between public authorities and associations (Gabriel, 2012). As such, they are expected to be more likely to purchase insurance (Sibiko, Veettil & Qaim, 2018). The use of other risk management strategies, such as irrigation and farm diversification, is also associated with higher insurance adoption rates, suggesting that farmers who are proactive in managing risk are more likely to use multiple tools, including insurance (Lefebvre et al., 2014).

[3] Decreased pensions may not be the only factor at play for the decrease in available income of older farmers. A study conducted in rural China found that the reduction in farm size and agricultural inputs, led to a decrease on output and labour productivity, which decreased farmers' income by 15% (Ren et al., 2023). Older farmers may have lower willingness to pay for insurance, as they rely on lower resources from agriculture.

3. Data & Methodology

The goal of this section is to carefully explain how the data was obtained and organised to prepare it for adequate treatment.

This study employs a descriptive statistical design to analyse the past and current situation of the agricultural insurance market in Portugal, in the context of increased extreme climatic events.

The primary source of data was collected from IFAP, the organisation responsible for managing and administering public financial support to the agricultural and fisheries sectors to promote their development and sustainability. IFAP provides detailed and historical data on insurance contracting and claims for most crops in the country. The database contains information from 1996 until 2022 (although the most recent year's data is not complete). The data from 1996 to 2011 was last updated in 2015, and a formatting problem made it impossible to open them. Therefore, the time-period analysed in this study is between 2012 to 2022.

For each year studied, IFAP provides information regarding insurance contracting and claims. The data is organised by programs included in the Agricultural Insurance System (SSA). For each year there is one document about the Crop Insurance (SC) and another that includes the information for the Vineyard Crop Insurance (SVC). For simplicity, the yearly documents were merged to allow for studying all crops simultaneously.

The data on insurance contracting spans from 2012 to 2022. However, for claims data, 2022 information is incomplete, only including Vineyard Crop Insurance. Therefore, only data up to 2021 was used. Additionally, the claims data for 2018 is not available in IFAP's database and was consequently excluded from this analysis. It is important to note that for both insurance contracting and claims databases, the data for 2012 and 2013 were recorded under the SIPAC, as the Crop Insurance (SC) was only established in 2014.

Ultimately, the data is organised in excel files. as follows:

Table 1: IFAP's database organised per system and years

System in place	**Years**
SIPAC + Vineyard Crop Insurance (SVC)	2012 & 2013
Crop Insurance (SC) + Vineyard Crop Insurance (SVC)	From 2014 to 2022 for the **Insurance Contracting data** From 2014 to 2021 for the **Claims data** (for 2018 there is no available data on Claims)

For the statistics on insurance contracting, the variables included presented in euros are crops by tariff region and municipality, insured capital, commercial premium, and bonus. For the statistics on claims, each file contains two sheets. The first sheet includes crops by tariff region and municipality, indemnities, reimbursement of indemnities, expenses, and reimbursement of expenses, all in euros. The second sheet also contains these variables but is organised by cause of claim (e.g., indemnities caused by frost in Borba). According to IFAP (2021) the definition of the variables are as follows:

Insured Capital (€)

The insured capital represents the potential monetary value of the insured agricultural production based on historical productivity and agreed-upon pricing within the insurance policy limits.

(1) $Insured\ Capital = Insured\ Production\ \times Insured\ Price$

where

(2) $Insured\ Production = Historical\ or\ Tabled\ Productivity\ \times Insured\ Area$

and the Insured Price is the price (up to the maximum tabulated amount) at which the production is insured.

Commercial Premium (€)

The Commercial Premium is given by the Insured Capital multiplied by the Tariff. The Tariff corresponds either to the Insurance Premium applied by the insurance company per euro of Insured Capital or to the reference Tariff set by the government, depending on which is lower. The value of the Premium is only eligible after subtracting taxes, fees, and the cost of the insurance policy (*Apólice*).

(3) $Commercial\ Premium = Insured\ Capital\ \times Tariff$

The reference Tariffs set by the State are organised by tariff region (A, B, C, D or E), by crop and by cause of disaster. For example, cereal production located in region A that suffered losses caused by a tornado may have a different reference tariff when compared to the same crop located in Region E that suffered from the same phenomena.

Bonus (€)

The bonus is the share of the commercial premium that is subsidised by the State. The percentage paid depends on the requisites which depends on where each farmer is included. As of 2023, the Ministry of Agriculture, through IFAP, subsidised up to 70% of the commercial premium. The funds are supported by the EU.

(4) $Bonus = Bonus\,\% \times Commercial\ Premium$

To obtain the value each farmer must pay, the value of the bonus is deducted from the Commercial Premium.

Indemnities (€)

The indemnities correspond to the value paid by insurance companies to the insured farmers. As of 2024, for the farmer to know if the claim is indemnifiable or not, he needs to compare the following two values:

(5) $Losses > 20\%\ of\ the\ Annual\ Average\ Production$

If the losses exceed 20% of the annual average production, the claim is eligible for indemnity. The losses correspond to the sum of production shortfalls caused by meteorological events covered by the insurance. These are calculated according to the reference unit indicated in the insurance contract for defining average productivity. The annual average production is obtained by multiplying the average productivity by the insured area.

Indemnities Reimbursement (€)

The indemnities reimbursement represents the refunds paid back to the insurance companies by the farmers. The reimbursement may be due to many causes such as a correction of payment or claim withdrawal (INE, 2014).

Expenses (€) and Expenses Reimbursement (€)

The expenses correspond to the value of the operational expenses of the insurance company. The expenses' reimbursement refers to the funds returned to the insurance company (Flora, 2022).

Cause of Claim

The cause of claim variable represents the occurrence that took place in a certain municipality and that affected a specific crop. According to IFAP (2024), the claims included in the insurance system differ, depending on the program: Horizontal insurance (crop insurance), special crop insurance or vineyard crop insurance. The table below organizes the claims covered for each insurance program:

Table 2: Crops insured per system according to IFAP

System in place	**Crops covered by the Insurance**
Crop Insurance (SC) – **Horizontal** Insurance (Any region in Mainland Portugal)	Fire, Frost, Hail, Lightning Strike, Snowfall, Tornado, Waterspout
Crop Insurance (SC) – **Special** Insurance (Specific regions and crops)	Fruit Cracking (Cherry), Fruit setting failure due to low temperatures (Rocha's Pear), Persistent Rain (Tomato)
Vineyard Crop Insurance (SVC)	Frost, Hail, Lightning Strike, Persistent Rain, Poor fruit set (in vineyards), Snowfall,

	Sunburn, Tornado, Vine pests and diseases, Waterspout

To accurately determine when each climatic event occurred, IFAP uses specific definitions of the causes behind these events. These definitions are outlined as follows:

(i) Action of Lightning Strike– atmospheric discharge between cloud and ground that causes permanent damage to insured property (IFAP, 2024);

(ii) Fire - accidental combustion with flames caused by a climatic phenomenon that can spread and cause damage to insured property (IFAP, 2024);

(iii) Frost – plant tissues freeze due to temperatures dropping below 0°C, leading to tissue damage, especially if the air is too dry for ice crystals to form (IFAP, 2024);

(iv) Hail – solid precipitation in the form of spherical ice particles (IFAP, 2024);

(v) Persistent Rain – refers to rainfall that, due to its continuous and heavy nature, saturates the soil and causes widespread damage to crops, ultimately affecting the safety of production (IFAP, 2024);

(vi) Scald or Sunburn – refers to the destruction of leaves and grape clusters caused by high temperatures, low humidity, and direct sunlight, leading to leaf and grape drying and resulting in losses of over 20% of the expected grape harvest (IFAP, 2024);

(vii) Snowfall – snowfall consists of fine ice crystals that may cluster into flakes (IFAP, 2024);

(viii) Tornado – violent rotating storm in the form of a cloud column reaching the ground, or wind speeds exceeding 80 km/h, causing destruction, or toppling of trees within a 5 km radius of the insured property (IFAP, 2024);

(ix) Waterspout – effects of rainfall equal to or greater than 10 mm in ten minutes, including flood damage caused by rain at the location (IFAP, 2024);

(x) Poor fruit set (in vineyards) - flower abortion resulting in the loss of normal grapevine production, calculated at the ripening stage, if proven to be caused by adverse weather during flowering (IFAP, 2024);

(xi) Vine pests and diseases - losses exceeding 20% of expected grape production, caused by adverse weather conditions that cannot be controlled (IFAP, 2024).

The definitions for fruit cracking and fruit setting failure due to low temperatures are not explained on IFAP’s website, however, the definitions of the phenomena go as follows:

(xii) Fruit Cracking - the fruit absorbs water, causing cell bursts that weaken the surface layers, leading to visible cracking (Correia, 2018);

(xiii) Fruit setting failure due to low temperatures - cold temperatures can delay ripening, leading to late harvests and affecting fruit quality and flavor (Kaybee Bio, 2023).

In the IFAP’s database, the variable ‘cause of claim' categorises climatic phenomena in various ways. The original dataset combined "Fire, lightning strike, or explosion" as a single category, without detailing each individual cause. The dataset includes specific categories such as 'hail', 'frost', 'tornado', 'waterspout', 'snowfall', 'persistent rain', 'sunburn', and 'heatstroke'. Additionally, a category labelled 'others' is present, though its definition is not clarified in the methodology.

Some adjustments were necessary for consistency. For example, variations of "Fire, lightning strike, or explosion" were recorded as 'Fire, Lightning and Explosion' and 'Fire, Lightning'. To maintain consistency, only the first version was retained. Furthermore, 'heatstroke' was renamed as 'sunburn', as IFAP considers both terms synonymous.

Tariff Region

The reference tariff mentioned above changes in value according to the crop, cause of claim, and region in Mainland Portugal. The tariff regions are divided in five different groups identified by A, B, C, D, and E. On IFAP's website, as of July 2024, it can be found on the legislative documents section of the crop's insurance information area, two different documents containing the municipality allocations for each region. One of the files dates to 2014 and the most recent one is from 2018. However, the distribution of municipalities differed from one table to the other, and therefore it was decided that the most recent distribution would be used.

In addition to the five previously mentioned Tariff Regions, the organisational document included a sixth region, termed 'Northern Interior.' This region encompassed municipalities that were already part of the other five existing regions. Consequently, the data on the municipalities within the 'Northern Interior' were reassigned to their corresponding original regions to maintain accurate information tracking. This reorganisation was further justified because the tariffs for the 'Northern Interior' are only relevant for special insurance pertaining to northern interior pome fruits (Diário da República, 2018). The corresponding municipalities to each tariff region can be found in Appendix A.

For data cleaning purposes, it was also examined if there were duplicated municipalities in different tariff regions. As a matter of fact, there were, which may be due to different listing along the years, or to mistakes in the dataset. To correct this, the repeated municipalities were reorganised to be part of the tariff region assigned in the most recent table found on the IFAP's website.

The program chosen for conducting this work was the Python software. Python provides useful and powerful visualisation tools to conduct a descriptive statistics analysis. To be able to study the data in the most coherent way possible and obtain the results with quality, a process of data cleaning was conducted on all the files. It was first analysed if there was missing data on our dataset, or not. However, there were duplicated municipalities, which were written in different ways, mainly due to missing accentuation. Therefore, all the municipalities were reviewed to make sure they were all written in the same correct way.

Data on the Portuguese agricultural census 2019

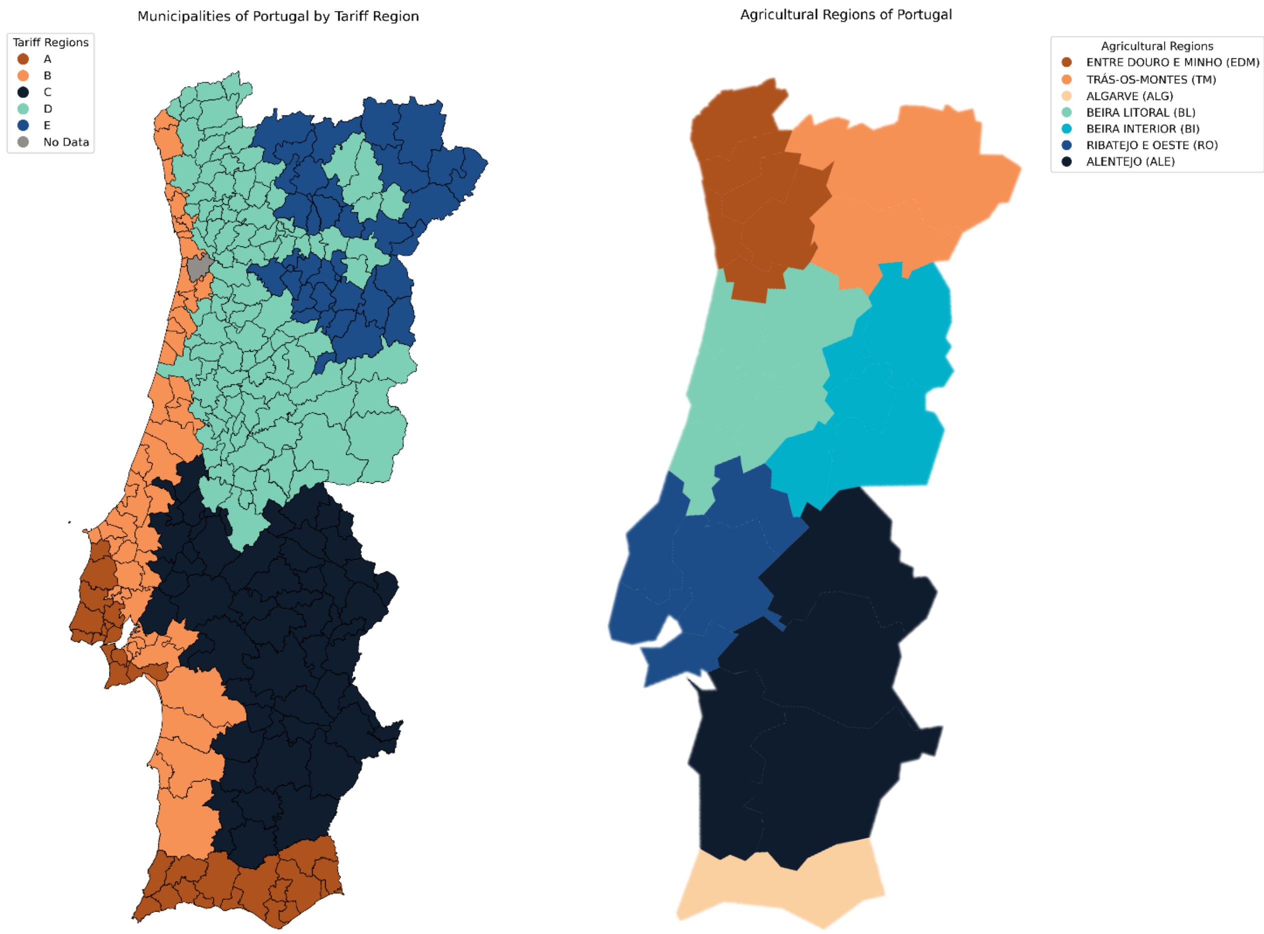
To complement the insurance data provided by IFAP, data from the 2019 agricultural census, published by INE, was utilised. This approach aimed to explore how the characteristics of the agricultural sector might inform an understanding of the Portuguese insurance market from the perspective of the insured. INE's report includes analysis on the structure of agricultural holdings, land use, irrigation, labour, and EU-level comparisons (INE, 2021). Since the statistical analysis had already been conducted by INE, its results were integrated with the insurance data to generate meaningful insights.

4. Results & Discussion

The objective of this section is to characterise the Agriculture Insurance market in Portugal, as well as understanding the main strengths and weaknesses of the underlying politics behind it.

The following map of Portugal helps visualising how the different Tariff Regions are distributed over mainland Portugal. For more detailed information on what region each municipality is included in, please consult appendix A.

Figure 1:Municipalities of Portugal per Tariff Region and the agricultural regions of Portugal

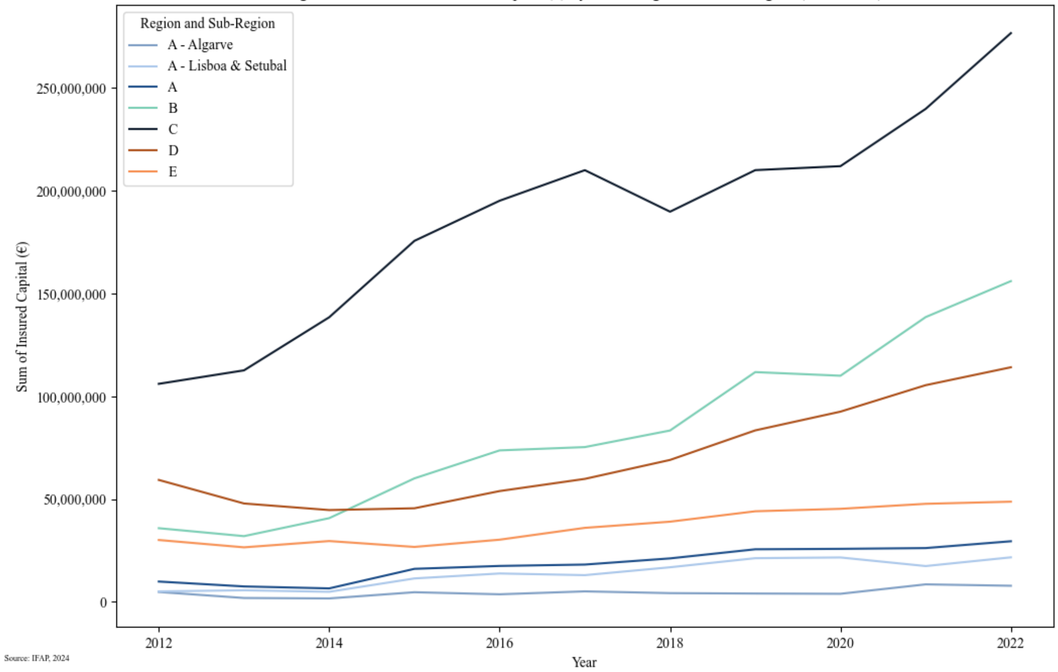


Source: IFAP, 2018

Source: Eurostat and Agroges, n.d.

During the studied period, insured capital increased across all tariff regions, though at varying rates. Region C, encompassing municipalities in inland centre and south of the country, presented the highest amount of insured capital, which exceeded 250 million euros in 2022. Region B, which includes coastal areas in the north, centre, and south, surpassed Region D around 2014. One potential explanation for this transition is the growth of coastal Alentejo, which is distinguished by intensive agricultural practices and a higher level of technological advancement, resulting in the production of a significant quantity of exported goods (Associação de Municípios do Litoral Alentejano, 2008). From 2012 to 2022, Region B experienced a 335% increase in insured capital. Despite a decline between 2012 and 2014, Region D also showed a positive linear trend, with a 92% increase in insured capital from 2012 to 2022. For both region A and E, the increases in total insured capital seemed more modest in the studied period. However, region A's total insured capital grew by 199%, with Lisbon and

Figure 2: Evolution of Insured Capital (€) by Tariff Region and Sub-Region (2012-2022)



Setúbal growing at a faster pace than the Algarve, and region E saw insured capital grow by 62.03%.

The distribution of insured capital across regions is closely linked to the structure of agricultural holdings and the utilised agricultural area (UAA). In 2019, the average UAA per holding in mainland Portugal was 14.4 hectares, with significant regional differences. The Alentejo region, which corresponds to parts of Regions B and C, had the largest average UAA per holding at 68.9 hectares, accounting for 55.9% of mainland Portugal's total UAA with 2 144 066 hectares.

Conversely, regions such as Beira Litoral (2.9 hectares), Entre Douro e Minho (4.8 hectares), and Trás-os-Montes (6.9 hectares) had the smallest average UAA per holding. In 2019, two-thirds of land holdings and the agricultural workforce were concentrated in the north and centre of the country (INE, 2021, 14). This is aligned with what we know about how land property is allocated in the country. In the Alentejo region, large properties have a high share of regular salaried labour, accounting for 40.4% of the sector's workers in 2019, whereas in the North, small properties are typically worked by their owners, with only 12.3% of farmers receiving regular salaries in Entre Douro e Minho and just 8.8% in Trás-os-Montes (INE, 2021, 135). Despite the low percentage of salaried workers in these northern regions, the agricultural production in the Douro region plays a significant role in supporting these numbers. These regional differences in the size and structure of holdings are influenced by environmental, soil, and socio-economic factors.

Alentejo stands out as the region where farmers have the greatest incentive to protect their holdings, as it has the highest average Total Standard Production Value (TSPV)[4] per holding in the country at 59 858€. Ribatejo e Oeste follow with an average TSPV per holding of 44 825€, despite having a smaller UAA than Trás-os-Montes, which has a larger area but a lower TSPV. On the lower end, Beira Interior, Entre Douro e Minho, and Trás-os-Montes have the lowest TSPV values in mainland Portugal, with average holdings generating 11 241€, 16 312€, and 8981€, respectively (INE, 2021, 25).

[4] Total standard production value (TSPV) - The production value is calculated by adding the standard production values (SPV) for each activity, multiplying the unit SPVs by the number of area units or livestock in that activity on the farm (INE, 2011)

The size of agricultural holdings also varies depending on ownership. In 2019, 94.5% of agricultural holdings were owned by individual producers, many of whom managed very small holdings, with 71% generating less than 8000€ in Standard Production Value (SPV)[5]. Conversely, collective entities, though fewer in number, typically manage larger holdings with higher production levels. The average holding size for collective entities was 99.7 hectares of UAA, compared to just 8.5 hectares for individual producers. Collective entities are concentrated in the regions of Alentejo and Ribatejo e Oeste, where they account for 50.6% of all collective holdings (INE, 2021).

The regional variations in insured capital reflect the differences in land size, ownership, and production value. Regions with larger, more productive holdings, such as Alentejo, have higher levels of insured capital, as the economic stakes are greater. The corporatisation of the agricultural sector, with more collective entities managing large UAAs, contributed to the observed trends in insured capital across Portugal. This shift has been particularly significant in Alentejo which has undergone deep changes in recent decades, making it one of the regions with the highest level of insured capital. The Alqueva Multipurpose Project was a key factor in this transformation. The Alqueva Dam transformed the region's agriculture, shifting from primarily dry farming cereals to a more diverse range of crops, including vegetables (Borralho, 2017). Despite the overall increase in agricultural area from 2009 to 2019, which reversed the decline of the previous two decades, only 4% of agricultural lands are classified as large-scale, with a standard production value of 100 000€ or more (INE, 2021, 25).

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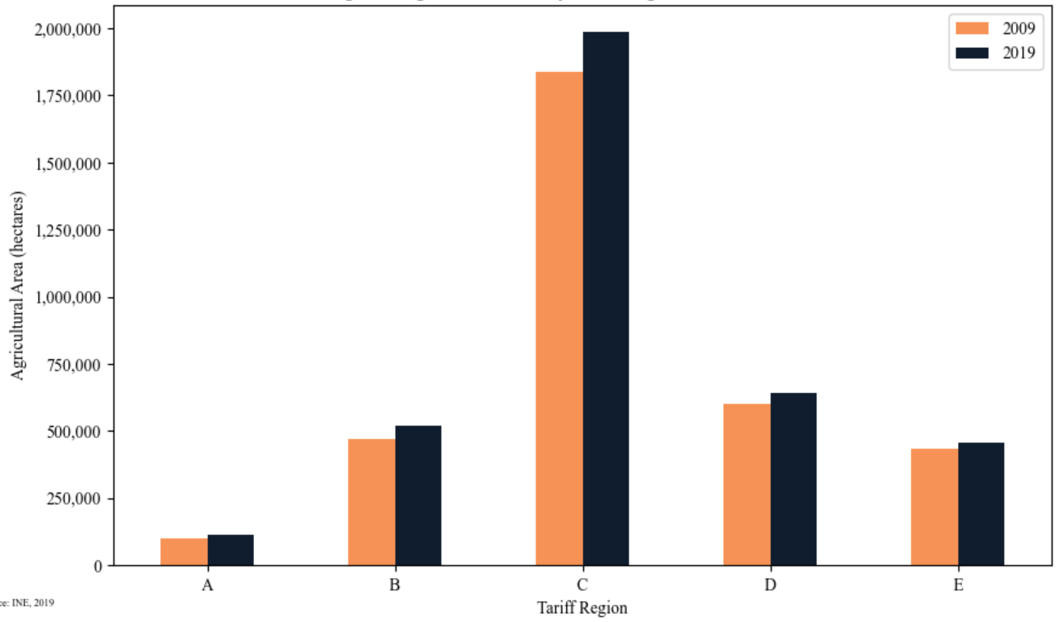
[5] Standard Production Value (SPV) - Average gross production value calculated over a five-year period for each region and agricultural activity, whether in animal or plant production (INE, 2011).

Additionally, the agricultural Census data indicates that from 2009 to 2019, the agricultural area expanded across all tariff regions, helping explain the overall increase in insured capital. For example, Region C has the largest agricultural area, growing from 1 835 787 hectares in 2009 to 1 986 631 hectares in 2019, which also proportionally contributes for its level of insured capital. The modest expansion of agricultural areas, coupled with a slight increase in the number of agricultural lands (UAA), but decrease in workforce, highlights the complex dynamics of the sector, where smaller and medium-sized holdings continue to dominate despite an increase in larger, corporately managed lands.

Figure 3:Agricultural Area by Tariff Region for 2009 and 2019



Source: INE, 2019

The increase of value in exports, that increased 8.9% between 2010 and 2023 (GPP 2024), may also influence insurance uptake in certain regions, since insurance contracting offers protection against price and production volatility, increased for crops in international markets. This may be the case for cultures such as raspberries, for example, mainly produced in coastal Alentejo and Algarve, Fundão and Guimarães (Associação dos Jovens Agricultores de Portugal, 2017), which has been increasingly exported in the last decade (GPP, n.d.). In summary, the trends in insured capital across regions in Portugal are closely tied to regional differences in agricultural holdings, ownership structures, and production value. The evolving landscape of the agricultural sector, driven by factors such as the corporatisation of farming and shifts in land use, is reshaping the insurance market and influencing the decisions of both individual producers and collective entities.

The regional distribution of insured capital is closely linked to factors such as the size of agricultural areas, economic characteristics of farming operations, and regional climate risks. However, to fully understand the dynamics at play, it is also essential to consider the human dimension of the agricultural sector—specifically, the demographic and educational profiles of the farmers themselves. The age and education levels of agricultural producers can significantly influence their decision-making processes, including their approach to risk management and insurance uptake.

In 2019, the average age of agricultural producers in mainland Portugal was 64 years, with 53% of total workers aged 65 and above. The aging of the farming population is particularly notable when considering that younger age groups, specifically those aged 15–24 years, saw a 68.3% decline in full-time agricultural workforce between 1989 and 2019. Similarly, the number of full-time workers aged 25–34 years decreased by 33.2% in the same period (INE, 2021, 137-138).

In mainland Portugal, the region presenting the lowest average age of agricultural producers has consistently been Entre Douro e Minho (2009, and 2019). However, in 2019, Alentejo had the highest percentage of workers under 45 years old, at 13.3%. On the other hand, Algarve had the highest percentage of producers aged 65 and above, reaching 63.2%. Beira Interior also had a great proportion of elderly producers, with 60.3% of producers aged 65 or older (INE, 2021, 139).

Education among agricultural producers remained low, with 70% possessing only basic education and 11% having no formal education. However, there was a substantial increase in the proportion of producers with higher education, rising by 299.5% reaching 9% of total farmers by 2019. Beira Interior stands out, with 13.2% of singular producers having no formal schooling. Algarve and Entre Douro e Minho also had significant shares of farmers without any education, respectively 12.9% and 12.3%. The region with the greatest percentage of producers with higher education (whether in agriculture or other fields) was Alentejo, with 16.2%, followed by Trás-os-Montes, with 10.3% (INE, 2021, 137-138). The results for Alentejo might be correlated to the Alqueva Multipurpose Project, that was able to attract a large amount of foreign investment (Peralta, 2021) which may have increased the share of highly educated producers in the region.

Education is widely recognised as a significant factor influencing insurance uptake. The data suggest that farmers in Portugal may be more hesitant towards insurance uptake partly due to their generally low levels of education, which is also influenced by the sector's aging workforce. Thus, it is plausible that age and education are correlated. Younger farmers, who tend to have higher levels of education, and therefore, financial literacy, may also have higher insurance uptake. Conversely, older farmers, who typically have lower levels of education, may show lower percentages of insurance uptake.

The 2019 Census also highlighted that 85% of agricultural producers derived their household income from non-agricultural sources. Only 15.4% of producers relied on their agricultural holdings as their primary income source in 2019, a sharp drop from 1989, when 39% of farmers depended mainly on agricultural income. For younger producers, the primary motivation for keeping the agricultural activity was to complement household income, while older producers, particularly those over 64 years of age, were primarily driven by an emotional attachment to the land that belongs to them. Additionally, 44% of singular producers identified pensions and retirement as their main source of income (INE, 2021, 137-138).

Economic viability was a concern for 21% of producers under 45 years old, contrasting with older producers who did not cite this as a significant factor in their continued involvement in agriculture (INE, 2021, 137-138). This is due, most likely, to the lack of alternatives given their age and education level. These trends underscore the challenges facing the agricultural sector in Portugal, particularly the aging workforce and the decreasing reliance on farming as a primary source of income.

The Census' data underscores a clear correlation between age, education, and economic motivation for remaining in the agricultural industry. If economic viability and household income are significant concerns for younger producers, it makes sense that they are more likely to protect their crops against risks through insurance.

As highlighted in the literature review, insurance premiums are expected to negatively correlate with the likelihood of insurance uptake. To better understand these dynamics at a regional level, we analysed the evolution of commercial premium values across different regions in Portugal.

The evolution of commercial premiums in the studied period reveals interesting trends, particularly in Region D. This region, where farmers pay the highest premiums, experienced a sharp decrease in premiums between 2012 and 2014, coinciding with a decline in insurance demand. From 2014 onwards, premiums in Region D increased in line with rising insured capital. Region E, with the second-highest premiums, saw a significant increase starting in

2015. Regions C and B follow in terms of premium values, while Region A consistently recorded the lowest commercial premiums. These trends provide insight into how risk is perceived across different regions, with Regions D and E facing the highest perceived risks, as reflected in their premium costs.

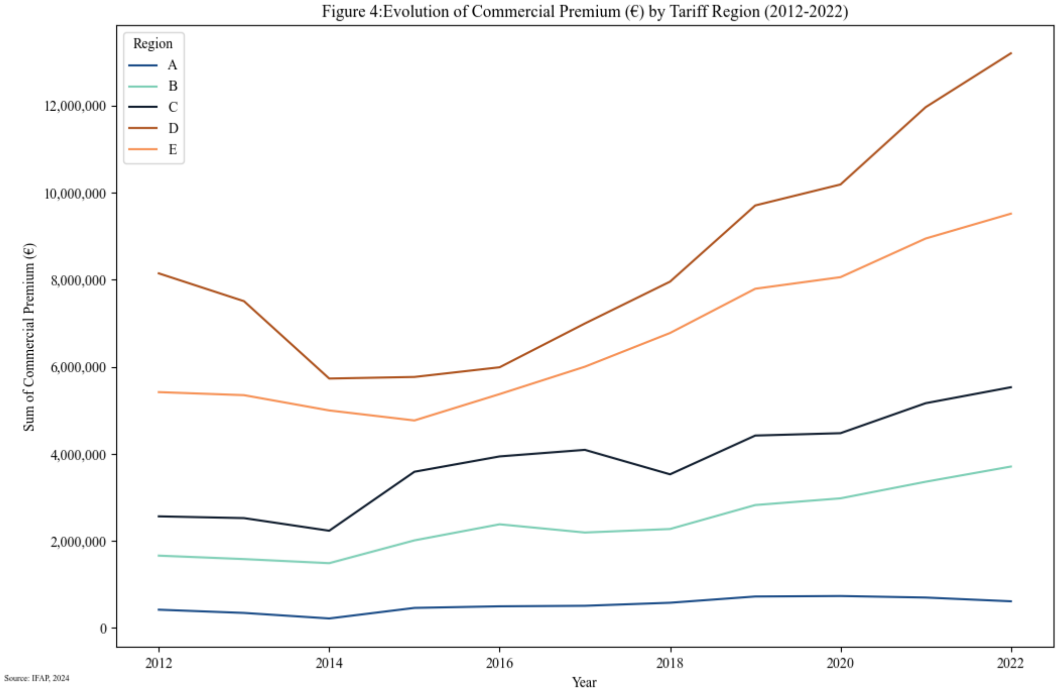
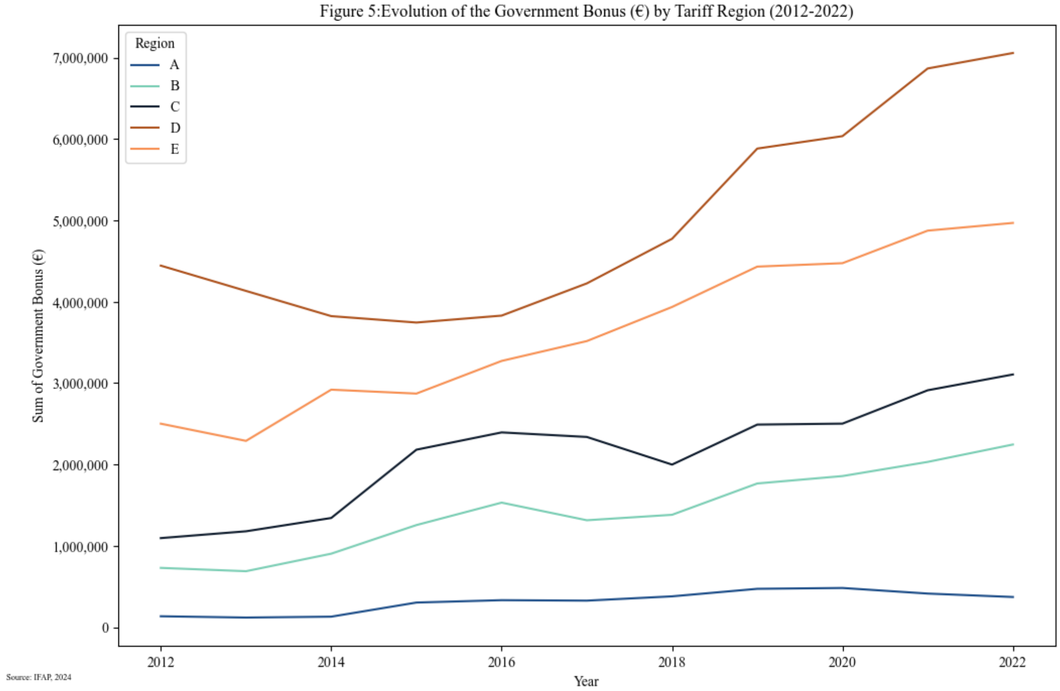


Figure 4:Evolution of Commercial Premium (€) by Tariff Region (2012-2022)

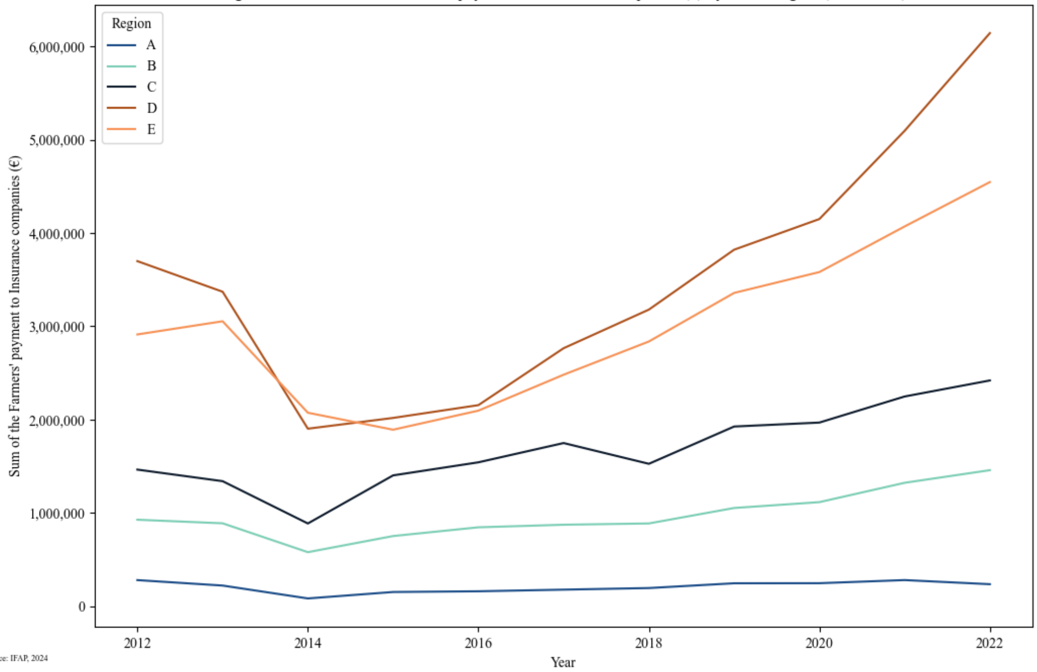
Since the government directly subsidises a portion of the premiums, the critical factor for farmers is not only the full premium price, but the amount they must bear after the subsidy is deducted. Premium subsidies have been shown to significantly and positively influence insurance contracting (Sihem, 2017). Consequently, government bonuses' values follow a similar pattern to commercial premiums, as the total government subsidy corresponds to the product of the bonus each farmer is entitled to and the commercial premium. Thus, as the commercial premium increases, the government subsidy rises proportionally, leading to an overall increase in government expenditure on crop insurance over time.

Figure 5:Evolution of the Government Bonus (€) by Tariff Region (2012-2022)



Farmer's payments—calculated as the difference between the commercial premium and the government subsidy— have been rising over time. This increase is particularly noticeable in Regions D and E, where the burden on farmers has grown more sharply than in other regions. For instance, in Region D, there was a sharp decline in farmer payments between 2013 and 2014, which was not mirrored by a comparable change in government bonuses during the same period. This suggests that factors beyond the simple reduction in commercial premiums may be at play. The dates coincide with the introduction of the new insurance system, which may have influenced how the data was processed. A similar pattern was observed in Region E and, to a lesser extent, in other regions.

Figure 6:Evolution of the Farmers' payment to Insurance companies (€) by Tariff Region (2012-2022)



Source: IFAP, 2024

These trends should be closely monitored, as the decision to purchase insurance hinges on farmers' perceptions that the benefits of insurance outweigh the costs. If premiums continue to rise, even with subsidies, farmers may become less prone to invest in insurance, potentially leaving them more vulnerable to climate-related risk.

By examining the data on claims, particularly the indemnities paid by insurance companies per tariff region, key trends are found. Region D paid for the highest indemnities for most of the studied period, indicating recurring events in this region. The trend in Region D closely parallels that of Region E, which surpassed Region D in 2012 and 2015. However, from 2016 onwards, indemnities in both regions began to diverge in quantity, although their overall trends remained similar. Notably, in 2014, both Regions B and C surpassed Regions D and E in indemnity values, suggesting a significant event that most likely has affected both regions similarly. In fact, when studying the data, it is seen that in 2014 persistent rain and waterspout created the highest indemnities in the regions, affecting tomatoes (events occurred in Vila Franca de Xira, Benavente, Azambuja, Évora and Elvas). Region A consistently shows the lowest indemnity values, recording zero indemnities in some years.

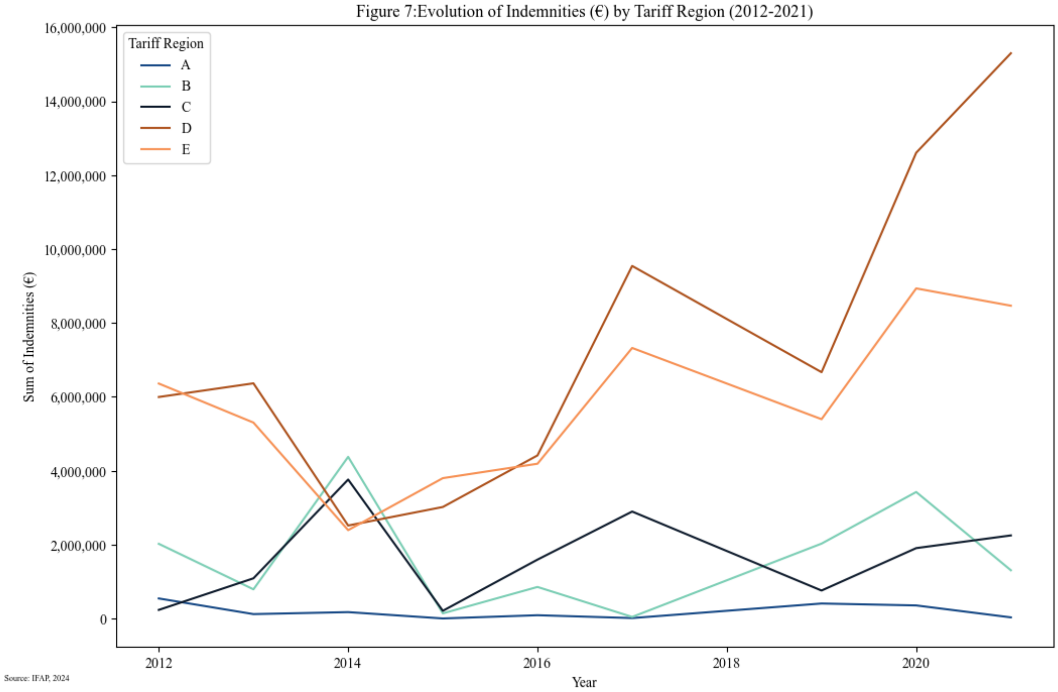
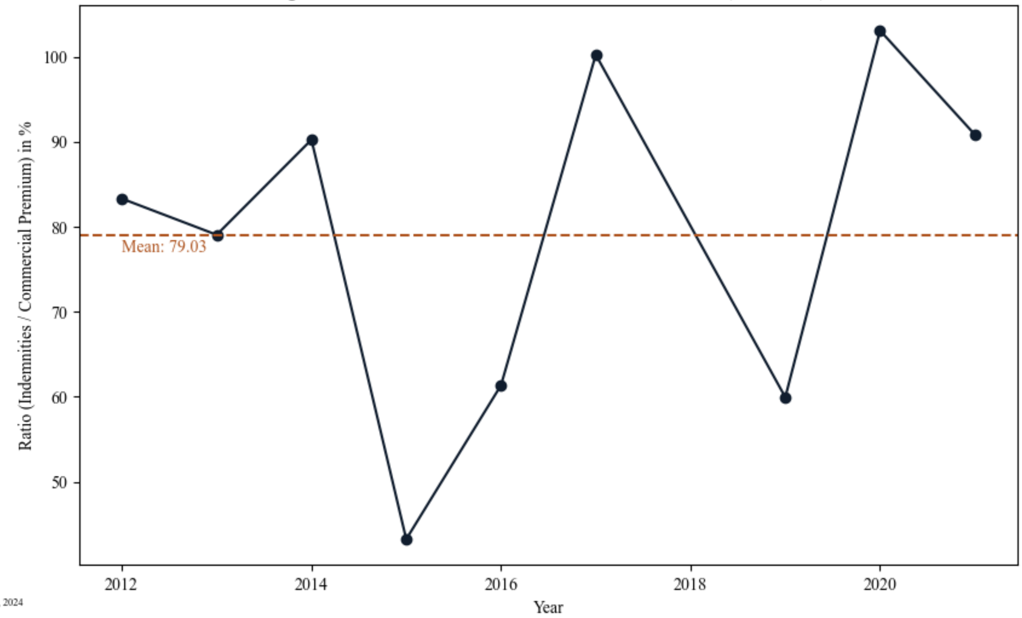


Figure 7:Evolution of Indemnities (€) by Tariff Region (2012-2021)

A valuable metric to examine is the ratio between indemnities and the commercial premium, as it indicates how closely the premium paid aligns with indemnities. Sampaio (2017) analysis of this ratio from 1997 to 2015 reveals a trend of increasing ratios in recent years. This trend is attributed to a sharper decrease in average premium values compared to indemnities, suggesting a convergence of premiums towards indemnity values. A significant drop in the ratio occurred in 2015, driven by a substantial decrease in indemnities, followed by notable increases until 2017, corresponding with rising indemnities. Another decline was observed in 2019, and a spike in 2020 when indemnities surpassed the commercial premium. The increase in indemnities across most regions may have led to higher premiums in the subsequent year, thereby reducing the ratio.

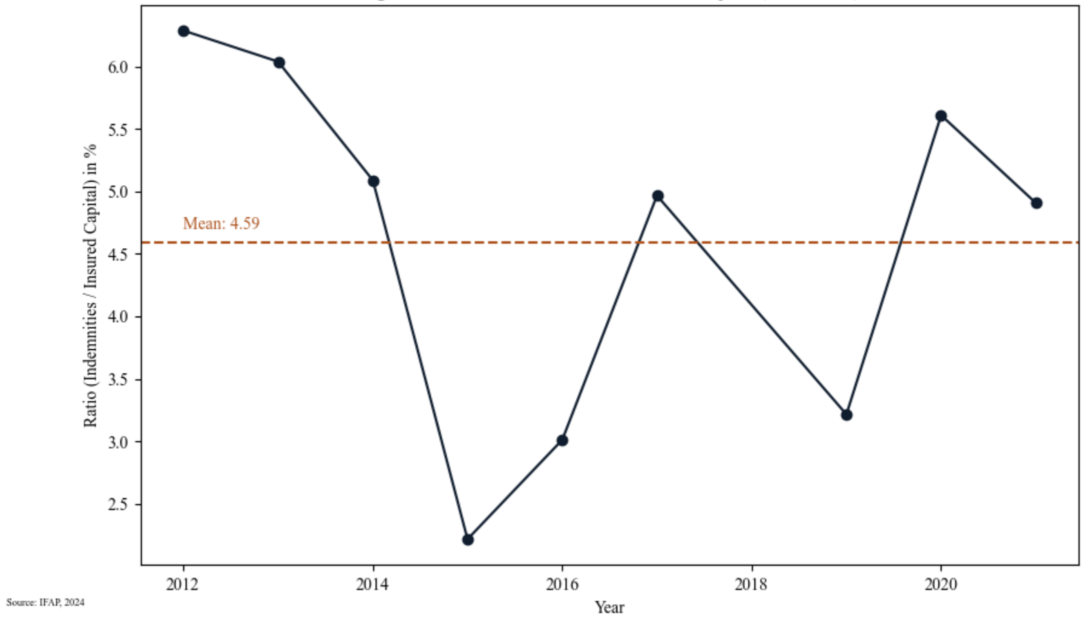
Figure 8: Ratio of Indemnities to Commercial Premium (2012-2021)



Source: IFAP, 2024

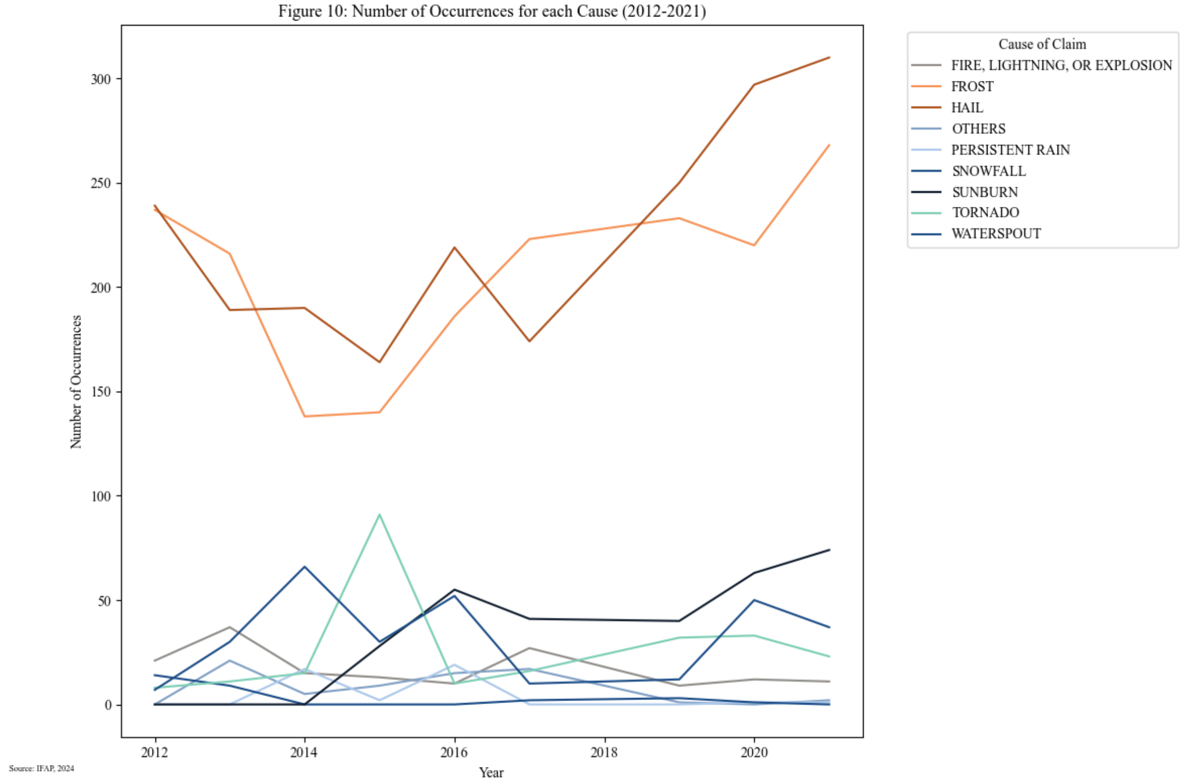
Another insightful ratio to investigate is the indemnities to insured capital value ratio. This ratio helps identifying the type of risk associated with the insured capital, depending on the behaviour of both indemnities and insured capital. A scenario where the reduction in insured capital exceeds the reduction in indemnities suggests that less risky capital is exiting the insurance pool. According to Sampaio (2017), this phenomenon contributes to an increase in adverse selection. During the studied period, the ratio seemed to be significantly influenced by fluctuations in indemnities, as the insured capital generally exhibits a more consistent, linear increase.

Figure 9: Ratio of Indemnities to Insured Capital (2012-2021)



To understand the meteorological phenomena responsible for high indemnities and their regional distributions, we first examine the frequency of occurrences recorded between 2012 and 2022. Notably, hail and frost events are predominant, reaching record values in 2021 of 310 and 268, respectively. All other causes of claims fall below 100 occurrences per year. Among these, sunburn, tornadoes, fire, lightning, and explosions are particularly relevant. The frequency of sunburn incidents exhibited an upward trend starting in 2014. Tornado occurrences peaked in 2015, with lower relevance in subsequent years. For other causes, occurrences remain below 50 per year, with some, such as persistent rain, presenting minimum impact.

Figure 10: Number of Occurrences for each Cause (2012-2021)

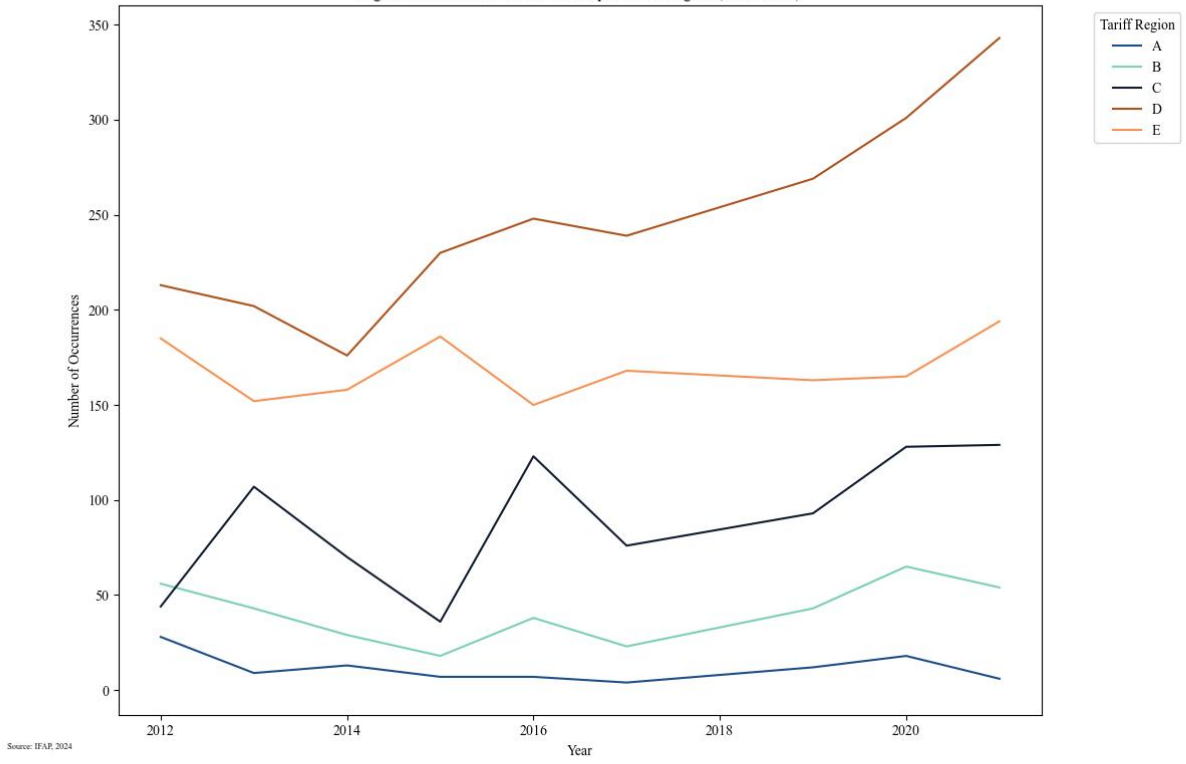


The literature highlights that risk exposure and perception are key factors influencing the decision to purchase insurance, particularly in agriculture, where these risks are closely tied to climatic variables. As Lefebvre et al. (2014) suggest, "most high-risk farms in terms of weather exposure should be more likely to take insurance".

In our dataset, the cause of claim serves as a proxy for the severity of adverse weather events across different regions in Portugal. Over the study period, Region D consistently recorded the highest number of claims, with an upward trend from 2017 to 2021. Region E follows closely, making these two regions - located in the north of the country - the most affected by weather-related incidents. Region C, ranks third in frequency. However, this may be influenced by its larger size. The distribution of disaster causes by district reveals a stark contrast between the northern and southern regions of Portugal, with some exceptions. This is largely due to the high incidence of hail and frost in the interior north, contrasting with the coastal north or the south, which are expected to decrease as temperatures rise (Portuguese Ministry of Agriculture, Sea, and Spatial Planning, 2013).

In contrast, the coastal region (Region B) typically experiences fewer than 50 occurrences per year. Despite the lower frequency, these localised events can still cause significant damage to crops. In the southern part of the country, the critical concern is water availability, with anticipated reductions in precipitation posing a significant risk (Portuguese Ministry of Agriculture, Sea, and Spatial Planning, 2013). Droughts are a frequent event in this part of the country, but as they are not covered by the insurance system in place, they are not considered in the data. If they were to be included, the figures for the south of the country would most likely show different results. For detailed information of the frequency of cause of claim per Tariff region, please consult Appendix B.

Figure 11: Number of Occurrences per Tariff Region (2012-2021)

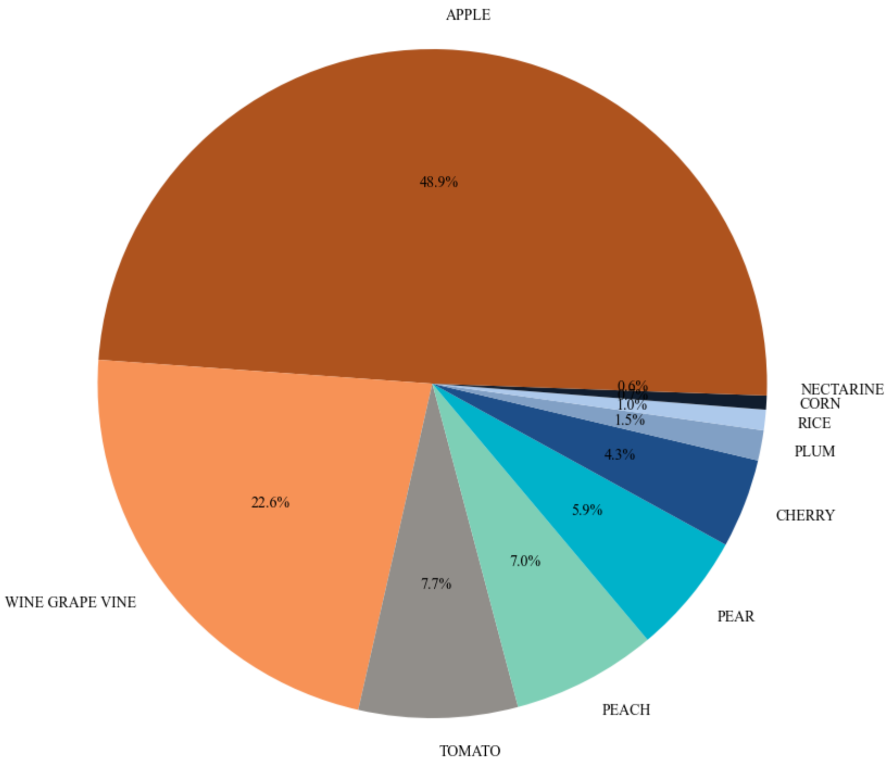


All in all, one could expect that the most likely regions to purchase insurance are the interior north and the coastal region. The interior north is driven by high event frequency, while the coastal region, though experiencing fewer events, faces higher potential costs per incident, motivating farmers to seek insurance coverage.

In general, the costliest causes of claims in terms of indemnity values are hail, persistent rain, and frost. This indicates that, despite its lower frequency in Portugal, persistent rain can lead to significant indemnities for crops. The forecasted increase in persistent rain occurrences (Santos, 2019), with flooding expected to keep having localized but high-magnitude impacts, affecting horticulture and agricultural facilities. Regarding the operational expenses of insurance companies, the most expensive causes of claims are hail, sunburn, and frost.

When analysing by crop, please note that all crop names were manually translated from Portuguese to English. Some of the crops were repeated, as the same crop had both the name of the final product and its tree (e.g.: apple and apple tree). Therefore, these were grouped into a unique name to avoid double-counting. Based on the more than 80 different crops registered in the database, this analysis' focus will lie on the top ten crops with respect to the value of indemnities paid by insurance companies, in the years studied. For the top ten crops, apple represents almost half of the indemnities paid (48.9%), followed by wine grape vine (22.6%) and tomatoes (7.7%).

Figure 15: Top 10 Indemnities Paid per Crop 2012-2021 (%)

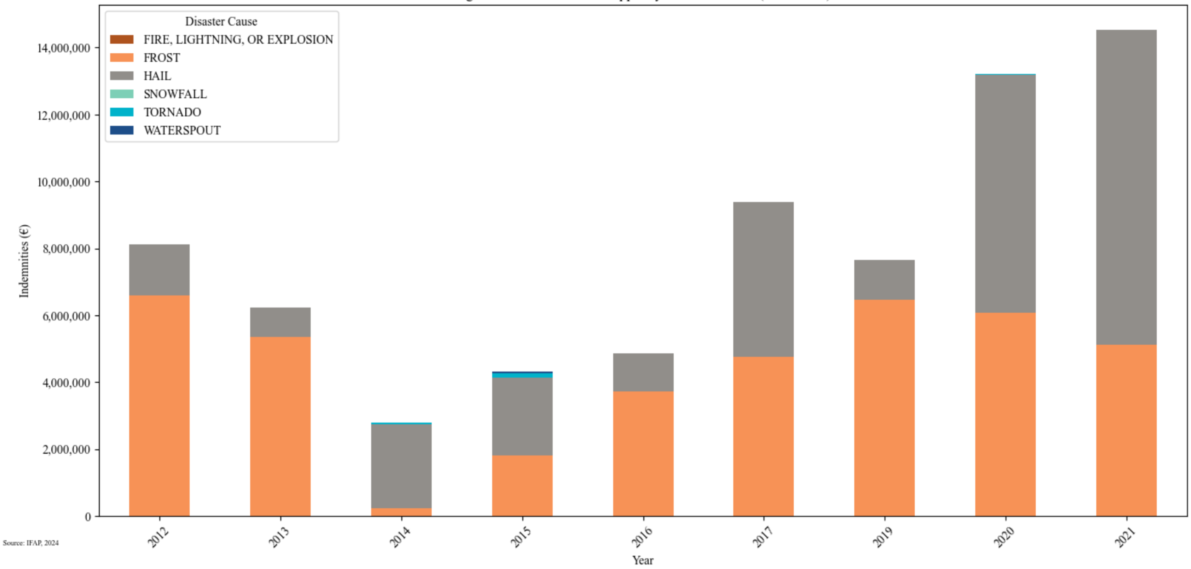


Source: IFAP, 2024

In order to determine which claims have the greatest impact on each crop, stacked plots were created for the apple and wine grape varieties. These plots highlight the indemnities by cause and year for both crops. Analysing how disasters affect each crop individually is essential for better assessing the specific risks faced by producers.

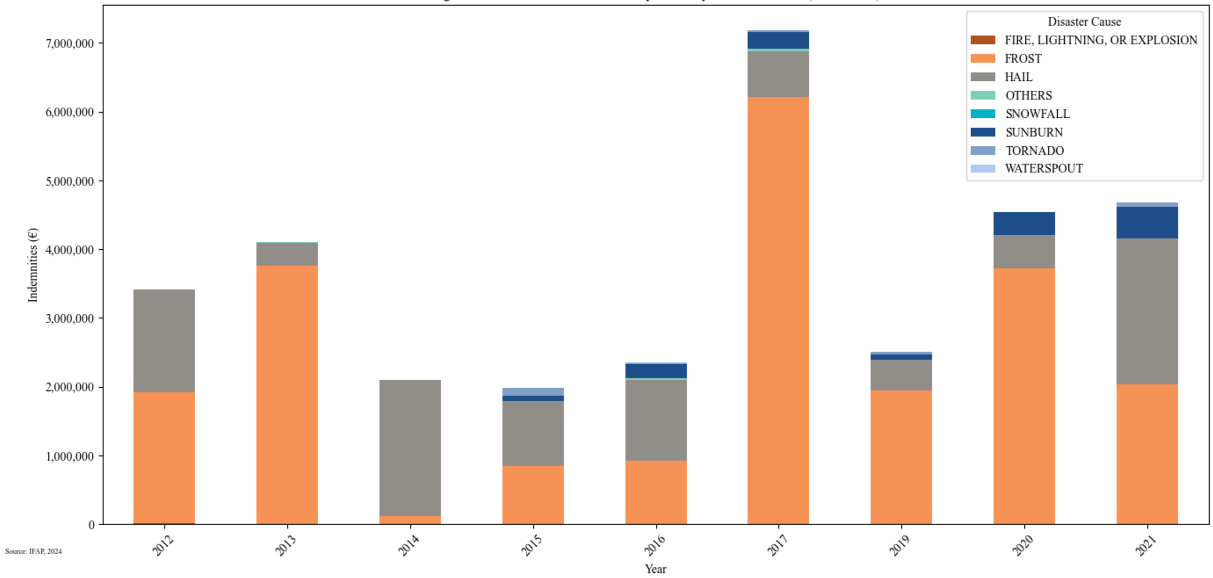
In the category of fresh fruit, apples are the most significant crop in Portugal. In 2023, they accounted for 57.8% of the Portuguese production in this category (INE, 2024), covering 31.8% of the agricultural area dedicated to fresh fruits (INE, 2024). Despite a decrease from 2012 to 2014, indemnities for this crop have shown an increasing trend overall. Throughout these years, hail and frost have been the most common causes of claims. Trás-os-Montes and Ribatejo e Oeste are the regions where most apples are produced. These regions also registered high occurrences of hail and frost. Additionally, in 2014, 2015, and 2020, notable indemnity values were caused by tornadoes.

Figure 16: Indemnities for Apple by Cause of Claim (2012-2021)



The evolution of indemnities for wine vine cultivation has been inconsistent over the years, reaching a peak in 2017 exceeding 7 million euros. Various factors have contributed to these indemnities, with frost being the most significant. Research suggests that “severe frost injury has the potential to destroy a whole vintage,” leading to substantial costs for both farmers and insurance companies (Poling, 2007). In addition to frost, hail and sunburn are also notable causes of damage that result in compensation payments to farmers. Excessively high temperatures are responsible for the hardening and partial mummification of the berries (Gambetta, 2021), leading to a decrease in wine production, as reported by the Portuguese wine producers (*Lusa*, 2018). By June 2021, the Regional Directorate of Agriculture and Fisheries of the North (DRAPN) estimated that approximately 2200 hectares of vineyards across four municipalities had been affected by hail, persistent rain, and storms, in that same year. Notably, only about 15% to 20% of wine producers in the affected area had insurance coverage at that time (*Lusa*, 2021).

Figure 17: Indemnities for Wine Grape Vine by Cause of Claim (2012-2021)



The data presented does not capture the full impact on all farmers. Some events, such as fires, can have devastating effects, especially on uninsured farmers with smaller UAAs. Every year, fires in Portugal destroy large amounts of land and property. Additionally, common disasters such as droughts and floods, which are not covered by this insurance system, are significant concerns for agricultural workers. Research on the impact of climate disasters on uninsured farmers at a national level is crucial.

The challenges and limitations that exist in the Portuguese agricultural insurance market lack adequate research focus and attention. However, some are starting to be discussed, usually by stakeholders in the market. On both the demand and the supply side, there are obstacles that undermine the uptake of insurance contracting.

The current insurance system does not sufficiently cover extreme and unpredictable climate events, which are increasing in frequency. Drought is not part of the list of events that is covered by insurance, however, similarly to other extreme events (e.g.: hail), they can cause losses to production, due to crops failure and decrease in water availability, and even propagate pests and diseases (NIDIS, 2024). This extreme event has a high probability of occurrence, which is also one of the reasons why it is not insured. Furthermore, drought is very hard to identify and evaluate in terms of impact. Frequently, drought will act in interaction with other phenomena, which makes it very hard to understand what are the individual losses that can be specifically associated to the event (Sampaio, 2017). The inclusion of drought in the crop insurance system would, as claimed by the Portuguese Insurance Association (APS), make premium prices increase, which would have significant impact on agricultural producers and on the public costs associated with the agricultural insurance system (Sousa, 2022).

Another situation that was reported in the 2018 spike in agricultural losses is that producers who have insurance are not eligible for supplementary public financial assistance. This is a measure that is implemented in the event of extreme occurrences on a large scale. This may be undermining insurance contracting, as those without insurance usually receive higher amounts of public support compared to those who receive compensation from insurance companies (Martino, 2018).

On the insurers' side, companies face regulatory constraints, as the current framework limits the development of new insurance products, hindering innovation. *CA Seguros*, for example, reported that research was already undertaken to try to understand which products would make sense to introduce in the market, but complexity in innovative solutions is huge, as there exists a lot of rules and specificities to the law (Afonso, 2024). Insurers are forced to offer non-profitable products at controlled prices, which discourages market participation. Therefore, farmers face difficulties finding suitable coverage options, which is exacerbated by the limited availability of tailored insurance products (*ECO Seguros e Lusa*, 2023). This may be aggravated soon, as the largest players exit the market. A specialist in the field, Lino Afonso, claimed this may be particularly hard for the regions of Beira Interior and Trás-os-Montes, as the smaller insurance companies may not have enough resources to support all the demand in the market (Afonso, 2024).

This highlights the need for collaborative efforts, and a structured plan for the medium and long terms, between policymakers, insurers, and agricultural stakeholders to create a more resilient and adaptive insurance system that better addresses the evolving risks faced by the agricultural sector.

5. Final Remarks & Conclusions

First and foremost, one of the recommendations that stands out from conducting this work, is the pressing need for scientific research in the area. Understanding which are the tailored solutions that can work in the market, for both producers and insurance companies, requires careful evaluation and study. There should be a rigorous risk definition, which clearly establishes the connection between the occurrence of an extreme event and its impact on crops (Sampaio, 2017). Studies should also analyse long-term statistical data on the frequency and intensity of the different weather phenomena (Sampaio, 2017). A proposed approach could be to create a government workgroup, involving policymakers, producers, and insurers, that is, all relevant stakeholders that specifically work in developing insurance system solutions (Afonso, 2024).

Research into new solutions for the market could foster the creation of new special insurance programs that serves the needs for specified crops conditional on the regional contexts. Special insurance redistributes risk between the insurer and the producer. Specifically, "absolute deductibles," could be used, where the farmer takes on more risk. This can lead to a decrease in insurance premiums, which might encourage participation, even though the farmer must agree to cover more of the potential loss (Sampaio, 2017).

For risks that are difficult to insure, comprehensive production insurance covering all risks—meteorological, pests, and diseases—is recommended. Studies suggest that such a model, initially tested on wheat and barley for collective entities, could be adapted to other crops (Sampaio, 2017). Another growing area of research is index-based insurance, which relies on predefined indices that trigger payouts when thresholds are met. This method eliminates adverse selection and moral hazard issues, as payouts are tied to external indices beyond the control of both farmers and insurers. The absence of on-site loss assessments also helps keeping premiums low (Koprivica et al., 2024). Research indicates that indices like the Standardized Precipitation Index (SPI)[6] strongly correlate with crop yields and are effective for both floods and droughts. Swiss Re developed a Soil Moisture Deficit indicator, which is already in use in Kazakhstan (Swiss Re, n.d.).

With the scheduled end of the claim compensation system by late 2024, the government must consider alternatives if insurers are unable to secure reinsurance solely through the private sector (Sampaio, 2017; Afonso, 2024). One proposed solution is transforming the current system into a hazard compensation fund, financed annually by insurers and the government. This would ensure that unspent public funds remain in the fund (Sampaio, 2017). Private reinsurance could cover claims up to a certain amount, with government intervention only in catastrophic situations (Afonso, 2024). This approach could enhance credibility to the private reinsurance market. A similar Excess of Loss (EXL) partnership between the Beijing Municipal government and Swiss Re has diversified risk and reduced the burden on individual entities (Xing and Lu, 2010). How

[6] SPI - refers to the deviation of precipitation from the average for a specific time-period, divided by the standard deviation of that period (IPMA, n.d.).

to adapt those potential alternative solutions to the Portuguese case will be left for future research.

The main objective of this study is to serve as an initial step towards addressing the substantial need for research in this area. The results highlight significant regional disparities in the uptake of agricultural insurance across Portugal. Regions like Alentejo, benefiting from larger and more productive agricultural holdings partly due to the Alqueva Multipurpose Project, show higher levels of insured capital. In contrast, regions such as the northern interior exhibit lower insurance uptake, driven by smaller and fragmented holdings. Additionally, factors like climatic risk exposure, farmer education levels, age, and the lack of coverage for severe events such as droughts and flooding further contribute to these disparities.

A few challenges were faced in the course of this work. Firstly, data limitations constraint the analysis. Specifically, the data used from IFAP had missing claims data for 2018 and incomplete data for 2022. Additionally, historical data could not be reached, limiting the analysis to the years 2012-2022. The studied data is focused only on insured farmers, which is important to understand part of the low insurance uptake problem. However, it is insufficient. It would be important to measure the impacts of certain climatic disasters to get an overall picture on losses. It would also be interesting to make a survey at a national level to understand how Portuguese farmers perceive insurance, and their reasons for contracting it or not.

While this study highlights significant regional disparities, it also underscores the need for more detailed research at the crop-specific level. The variability in insurance coverage across different regions and crops could not be fully explored due to data limitations and the broad scope of the analysis. Additionally, identifying complementary risk management strategies alongside insurance would be valuable. The Alqueva Dam project in Alentejo is a prime example, having structurally transformed the agricultural sector and helped mitigate the effects of decreased precipitation and increased drought occurrences in the region.

The study underscores the need for targeted policy interventions to enhance insurance adoption, particularly in high-risk regions. Improving access to insurance, addressing educational gaps, and developing new risk management strategies are critical steps towards increasing insurance penetration in the sector. These findings align with the broader literature and suggest a pathway for future research and policy development to strengthen the resilience of Portugal's agricultural sector.

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Appendix

A Tariff Regions

Table 1: Tariff regions per municipality, according to IFAP[7]

Região	Distrito	Concelho
A	Faro	Albufeira; Alcoutim; Aljezur; Castro Marim; Faro; Lagoa; Lagos; Loulé; Monchique; Olhão; Portimão; São Brás de Alportel; Silves; Tavira; Vila do Bispo; Vila Real de Santo António.
	Lisboa	Amadora; Cascais; Lisboa; Loures; Lourinhã; Mafra; Odivelas; Oeiras; Sintra; Torres Vedras.
	Setúbal	Almada; Seixal; Sesimbra; Setúbal.
B	Aveiro	Aveiro; Espinho; Estarreja; Feira; Ílhavo; Murtosa; Oliveira de Azeméis; Ovar; São João da Madeira; Vagos.
	Beja	Odemira.
	Braga	Esposende.
	Coimbra	Figueira da Foz; Mira; Montemor-o-Velho; Soure.
	Leiria	Alcobaça; Bombarral; Caldas da Rainha; Leiria; Marinha Grande; Nazaré; Óbidos; Peniche; Pombal; Porto de Mós.
	Lisboa	Alenquer; Arruda dos Vinhos; Azambuja; Cadaval; Sobral de Monte Agraço; Vila Franca de Xira.
	Porto	Maia; Matosinhos; Porto; Póvoa de Varzim; Vila do Conde; Vila Nova de Gaia.
	Santarém	Rio Maior.
	Setúbal	Alcácer do Sal; Alcochete; Barreiro; Grândola; Moita; Montijo; Palmela; Santiago do Cacém; Sines.
	Viana do Castelo	Caminha; Viana do Castelo.
C	Beja	Aljustrel; Almodôvar; Alvito; Barrancos; Beja; Castro Verde; Cuba; Ferreira do Alentejo; Mértola; Moura; Ourique; Serpa; Vidigueira.
	Évora	Alandroal; Arraiolos; Borba; Estremoz; Évora; Montemor-o-Novo; Mora; Mourão; Portel; Redondo; Reguengos de Monsaraz; Vendas Novas; Viana do Alentejo; Vila Viçosa.
	Leiria	Batalha.
	Portalegre	Alter do Chão; Arronches; Avis; Campo Maior; Castelo de Vide; Crato; Elvas; Fronteira; Gavião; Marvão; Monforte; Nisa; Ponte de Sor; Portalegre; Sousel.
	Santarém	Alcanena; Almeirim; Alpiarça; Benavente; Cartaxo; Chamusca; Constância; Coruche; Entroncamento; Golegã; Ourém; Salvaterra de Magos; Santarém; Torres Novas; Vila Nova da Barquinha.
D	Aveiro	Albergaria-a-Velha; Anadia; Arouca; Águeda; Castelo de Paiva; Mealhada; Oliveira do Bairro; Sever do Vouga; Vale de Cambra.
	Braga	Amares; Barcelos; Braga; Cabeceiras de Basto; Celorico de Basto; Fafe; Guimarães; Póvoa de Lanhoso; Terras de Bouro; Vieira do Minho; Vila Nova de Famalicão; Vila Verde; Vizela.
	Bragança	Alfândega da Fé; Mirandela; Vila Flor.
	Castelo Branco	Belmonte; Castelo Branco; Covilhã; Fundão; Idanha-a-Nova; Oleiros; Penamacor; Proença-a-Nova; Sertã; Vila de Rei; Vila Velha de Ródão.
	Coimbra	Arganil; Cantanhede; Coimbra; Condeixa-a-Nova; Góis; Lousã; Miranda do Corvo; Oliveira do Hospital; Pampilhosa da Serra; Penacova; Penela; Tábua; Vila Nova de Poiares.
	Guarda	Gouveia; Meda; Sabugal; Seia; Vila Nova de Foz Côa.
	Leiria	Alvaiázere; Ansião; Castanheira de Pêra; Figueiró dos Vinhos; Pedrógão Grande.
	Porto	Amarante; Baião; Felgueiras; Gondomar; Lousada; Marco de Canaveses; Paços de Ferreira; Paredes; Penafiel; Santo Tirso; Trofa; Valongo.
	Santarém	Abrantes; Ferreira do Zêzere; Mação; Sardoal; Tomar.
	Viana do Castelo	Arcos de Valdevez; Melgaço; Monção; Paredes de Coura; Ponte da Barca; Ponte de Lima; Valença; Vila Nova de Cerveira.
	Vila Real	Mesão Frio; Mondim de Basto; Peso da Régua; Santa Marta de Penaguião; Valpaços.
	Viseu	Armamar; Carregal do Sal; Cinfães; Lamego; Mangualde; Mortágua; Nelas; Oliveira de Frades; Resende; Santa Comba Dão; São João da Pesqueira; São Pedro do Sul; Tabuaço; Tondela; Viseu; Vouzela.
E	Bragança	Bragança; Carrazeda de Ansiães; Freixo de Espada à Cinta; Macedo de Cavaleiros; Miranda do Douro; Mogadouro; Torre de Moncorvo; Vimioso; Vinhais.
	Guarda	Aguiar da Beira; Almeida; Celorico da Beira; Figueira de Castelo Rodrigo; Fornos de Algodres; Guarda; Manteigas; Pinhel; Trancoso.
	Vila Real	Alijó; Boticas; Chaves; Montalegre; Murça; Ribeira de Pena; Sabrosa; Vila Pouca de Aguiar; Vila Real.
	Viseu	Castro Daire; Moimenta da Beira; Penalva do Castelo; Penedono; Sátão; Sernancelhe; Tarouca; Vila Nova de Paiva.
Interior Norte	Bragança	Carrazeda de Ansiães; Vila Flor.
	Castelo Branco	Belmonte; Covilhã; Fundão.
	Coimbra	Oliveira do Hospital.
	Guarda	Aguiar da Beira; Almeida; Celorico da Beira; Fornos de Algodres; Gouveia; Guarda; Meda; Pinhel; Sabugal; Seia; Trancoso.
	Vila Real	Alijó; Chaves; Murça; Sabrosa; Valpaços; Vila Real.
	Viseu	Armamar; Carregal do Sal; Castro Daire; Lamego; Mangualde; Moimenta da Beira; Nelas; Penalva do Castelo; Penedono; Resende; Santa Comba Dão; Sátão; São João da Pesqueira; São Pedro do Sul; Sernancelhe; Tabuaço; Tarouca; Tondela; Vila Nova de Paiva; Viseu; Vouzela.

Source: Diário da República, 2018

[7] As mentioned in the Data & Methodology section, the data on the municipalities within the 'Northern Interior' were reassigned to their corresponding original regions to maintain accurate information tracking.

B Frequency of causes of claim

Table 2: Frequency of causes of claims by tariff region

Tariff Region	Cause of Claim	Number of Ocurrences
A	FIRE, LIGHTNING, OR EXPLOSION	1
A	FROST	20
A	HAIL	67
A	PERSISTENT RAIN	2
A	SUNBURN	4
A	TORNADO	7
A	WATERSPOUT	3
B	FIRE, LIGHTNING, OR EXPLOSION	2
B	FROST	54
B	HAIL	208
B	OTHERS	1
B	PERSISTENT RAIN	8
B	SUNBURN	21
B	TORNADO	23
B	WATERSPOUT	52
C	FIRE, LIGHTNING, OR EXPLOSION	95
C	FROST	175
C	HAIL	261
C	OTHERS	3
C	PERSISTENT RAIN	29
C	SNOWFALL	2
C	SUNBURN	67
C	TORNADO	34
C	WATERSPOUT	140
D	FIRE, LIGHTNING, OR EXPLOSION	36
D	FROST	932
D	HAIL	876
D	OTHERS	53
D	PERSISTENT RAIN	1
D	SNOWFALL	5
D	SUNBURN	145
D	TORNADO	113
D	WATERSPOUT	60
E	FIRE, LIGHTNING, OR EXPLOSION	21
E	FROST	680
E	HAIL	620
E	OTHERS	13
E	SNOWFALL	22
E	SUNBURN	64
E	TORNADO	62
E	WATERSPOUT	39

Source: IFAP, 2024