Fundación AON España

Barometer of Catastrophes in Spain 2021

23rd November 2022

Index

Letter from the President of the Catastrophe Observatory

We are immersed in a context of global crisis on the verge of recession, first suffering from a pandemic and now an energy and inflationary problem aggravated by the war in Ukraine and geopolitical tensions. Likewise, we are living in an era in which natural disasters are becoming more frequent and severe. Extreme weather events cause not only serious material damage, but personal damage, with devastating and irreparable consequences in some cases. It seems that we are living in a desperate and critical situation that can make us think, as William Shakespeare said in *The Tempest*, that "hell is empty and all the devils are here."

In this scenario, at the Aon Foundation Catastrophe Observatory, we have decided, and these are our key objectives: to quantify the impacts of natural disasters, obtain and systematize criteria to prevent future events and reduce human and economic losses. This is the reason why we have prepared the Annual Barometer of Catastrophes, the first report of its kind in Spain, in which we have analyzed the 10 most relevant events based on their severity. It contains chapters on the socioeconomic impact, analysis of the human cost, assessment of the critical infrastructures affected, and resilience and vulnerability indexes. Likewise, it includes maps with the most critical location sources and recommendations to act in the event of these events appropriately, with preventive and self-protection measures.

The year 2021 has been characterized by the succession of several of the most costly natural disasters in recent history, both in Spain and globally.

As regards Spain, the total cost of extreme events amounted to approximately €3,600M (including impacts on assets, direct and indirect GDP and non-food critical infrastructure), of which €2,300M would be insured.

The insured cost, in constant euros, has been the highest in the 2016-2021 series, with an increase of 62.5% for this concept as a result of events such as the eruption of the La Palma volcano, which involved the management of more than 10,000 files, with a cost of more than €230M for the Insurance Compensation Consortium, a volcanic incident that Spanish insurance had never faced. Other disasters such as the Filomena Storm, the DANAS, the hail or the floods have contributed to swell the economic bill, especially in the last quarter of the year.

In 2020, the estimate of the insured cost was €1,331M, which makes 2021 the worst year in the last 6 years, with a marked difference of 29% higher than the next worst year in 2019, which reached €1,802M. of insured cost. However, in terms of human cost, 2021 has meant fewer human losses, with 19 people dead, the lowest figure in the 27-year series analysed.

At a global level, the panorama has not been very different from that experienced during 2021 in Spain, the $130,000M insured cost estimated by Aon in its 2021 Weather Climate and Catastrophe Insight report have represented an increase of 19.3% of the same estimated figure in 2020, leaving a year that has been the second worst in the period 2016-2021, only surpassed by 2017, in which the fires in California, the earthquakes in Mexico and the worst hurricane season in more than a century caused insured losses of $170,000M. For these purposes, Hurricane Ida, the winter storms in the United States and the floods in Europe are the three biggest events of 2021 that make up a global list of natural disasters that have returned loss results that confirm the growing trend in the incidence of these episodes.

Therefore, 2021 has meant a year for Spain in which losses as a result of natural events have reached their highest level in the last 6 years, in an amplified manner compared to the consequences observed globally.

To prepare the 2021 Barometer of Catastrophes, we have counted with a Scientific Committee made up of the Aon Spain Foundation and institutions such as the Insurance Compensation Consortium, represented by Francisco Espejo Gil, Deputy Director of Studies and International Relations; Agroseguro, represented by José Carlos Sánchez Blázquez, Director of Claims Area; the Institute of Engineering of Spain, represented by Carlos Rodríguez, General Director; the academic headquarters of our Catastrophe Chair, with Raquel Caro, from the Comillas Pontifical University, and Leire Labaka, from the Tecnun School of Engineering of the University of Navarra; Aon Reinsurance Solutions, represented by Juan Antonio Sánchez Utrilla, Director Data Analytics; and International Financial Analysts (Afi), represented by Verónica López, Diego Vizcaíno and Javier Serrano. Likewise, the analysis of the human cost by Victoria de Elizagarate, Phd in Economic and Business Sciences, and the contributions of data by Antonio Guardiola from the UNESPA have brought great value; Ángel Goya from Civil Protection; Colonel Miguel Ángel Martínez Ávila of the Military Emergency Unit (UME); and José Luis Borau of the ONCE Foundation. I would like to thank all of them for their invaluable collaboration.

Hoping that this report that we present meets the expectations and objectives that we have set, I now announce the Aon Spain Foundation's commitment to provide value and solutions in a sustainable manner to society, already immersed in the preparation of the annual Barometer of Catastrophes for 2022, a year in which to date it seems to be relatively stable in terms of major disasters and economic cost in our country. However, phenomena such as drought (Spain has joined the International Drought Resilience Alliance, presented at COP27 in Egypt), heat waves or forest fires -which have devastated 300,000 agricultural and forest hectares in the worst and toughest campaign in recent years, in which the UME had to intervene 54 times in 11 different scenarios, 30,000 people were evacuated preventively, 4 people died and 90 were injured-, have had a high social impact and human cost and will be analyzed in the next issue.

Pedro Tomey
President of the Catastrophe Observatory of the Aon Spain Foundation

Executive Summary

During the year 2021 we have witnessed natural or accidental catastrophes, which have provoked destruction and damage to property and people, causing considerable economic losses in Spain that year. Taking only those insured assets as a reference, **the costs derived from these extreme phenomena amounted to more than 2,320 million euros, with the compensation paid for this type of event being** 63% higher than in 2020 and 29% higher than in 2019 (in constant euros).

In addition, natural catastrophes caused **Spanish companies to stop earning directly around 1,500 million euros**. 99% of this turnover loss was concentrated in **agricultural and livestock** activities, by far the sector most exposed to meteorological phenomena.

In terms of GDP, the negative impact on the companies directly affected would reach 386 million euros, to which must be added the 740 million of indirect and induced impact on other companies in its value chain. Thus, the total impact on GDP of natural disasters in Spain would amount to **1,126 million euros, the equivalent of 0.1% of Spanish GDP** in 2021. This economic contraction resulted in a loss of around **23,000 jobs,** half of them in auxiliary companies of the value chain of those directly affected by the catastrophes.

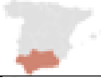
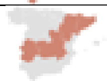
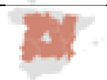
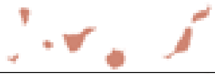
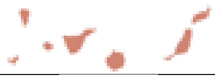
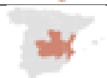
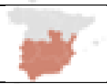
In terms of human cost, the year 2021 has fortunately been the year with the fewest human losses due to natural disasters, amounting to a total of 19, the lowest data in the series of twenty-seven years analysed. The first cause of death in 2021 has been due to causes that group deaths from landslides, avalanches, snowstorms, coinciding with the Philomena storm. The second cause of death has been heat waves. Three Autonomous Communities, Andalusia, Catalonia and Asturias, concentrate close to 70% of the total human losses caused by natural disasters in 2021.

In order to delve deeper into its impact and obtain richer and more innovative findings, the 10 most important events that occurred in our country in 2021 have been analyzed.

It has been estimated that the impact of these 10 catastrophes on critical infrastructures was more than 522 million euros, with the hail and the rains that occurred between May and June as the events that generated the greatest economic impact on critical infrastructures, followed by the frost in April. Frost and snowfall were the events whose impacts affected a greater number of critical infrastructures and caused the greatest damage during 2021.

In terms of social vulnerability, the results represent a first scientific approach to its measurement in the face of catastrophes and represent a necessary starting point through which to continue working towards the prevention of the impact of natural catastrophes.

Natural events that caused the most observable damages (indemnities paid) in Spain in 2021

Start	Duration	Event	Affected areas	Insured cost
1 January	19 days	Snowfall, frost and flood (Filomena)		505 millions €
1 January	31 days	Seismic series		18 millions €
19 March	6 days	Frost		83 millions €
12 April	8 days	Frost		20 millions €
23 May	32 days	Hailstorm and rain		120 millions €
14 August	5 days	Wind and heat wave		10 millions €
1 September	90 days	Volcanic eruption (La Palma)		233 millions €
1 September	2 days	DANA		78 millions €
13 September	13 days	DANA		99 millions €
1 December	31 days	Floods		96 millions €

Source: Afi based on Agroseguro and CCS

In short, **the total cost of the annual catastrophes in Spain would amount to around 3,600 million euros, adding the impacts on goods, direct and indirect GDP, and critical infrastructures (non-food).** Of this amount, only 2,300 million euros would be insured, so **approximately one third of the damage caused by these natural phenomena in our country would not be protected by insurance.**

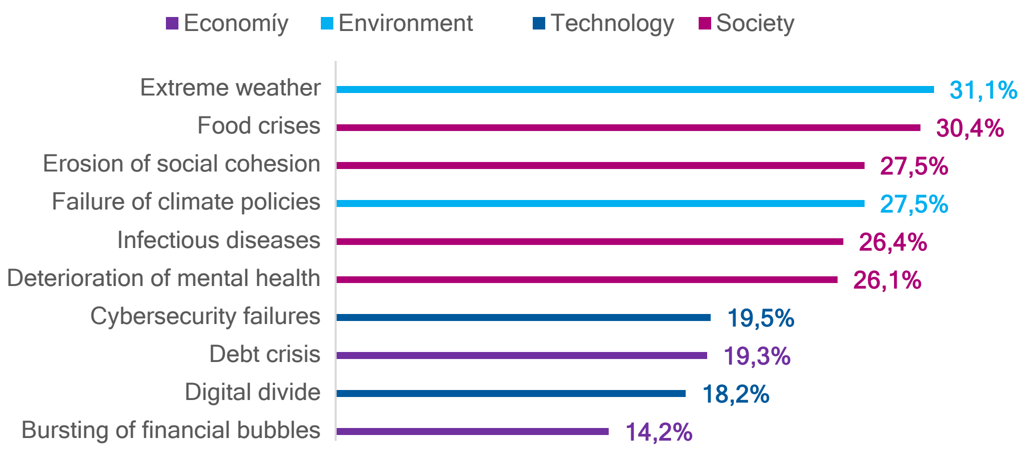
Motivation

The objective of this Barometer of Catastrophes is to analyze the impact that these events have caused on various areas of the economy and society in Spain during the year 2021. This document continues the work started last year, when the Aon Spain Foundation, within the framework of its Catastrophe Observatory, quantified the cost of these natural phenomena in Spain between 2016 and 2020.

The main novelty of this first Barometer lies in the extension of the scope of the study perimeter, since this document addresses the repercussions that natural disasters generate on another series of dimensions beyond their cost in terms of compensation. To this end, specialists in various branches of science have collaborated in order to estimate the impact of catastrophes as precisely as possible.

The analysis of the effects that natural catastrophes generate on the economy and society is of vital importance, in light of the increase in the frequency and intensity of these phenomena as a consequence of climate change. Thus, the 2022 edition of the "Global Risks" report prepared by the World Economic Forum classifies extreme weather events as one of the most imminent risks and with the most severe impacts.

Most imminent global risks (occurrence in less than 2 years)



Source: Afi, as of WEF 2022[1]

Having an accurate diagnosis, as well as a quantification of the damage caused by catastrophes in Spain, has several purposes to which this Barometer wants to contribute:

i. Have a more faithful image of the real cost of catastrophic events, combining sources of information that until now have remained isolated.
ii. Demonstrate the opportunity and urgency of intensifying prevention, mitigation and adaptation efforts in the face of the evident increase in the frequency and intensity of this type of catastrophe, many of them associated with climate change.
iii. Raise awareness among the population, companies and households of the importance of being insured.
iv. Make visible the effort made by certain public and private agents to alleviate the most immediate effects of catastrophes in Spain, in terms of insurance, compensation, repairs and reconstructions.
v. In short, for Spain to be a better prepared country to minimize the effects of natural disasters.

[1] WEF (2022) The Global Risks Report 2022: https://www3.weforum.org/docs/WEF_The_Global_Risks_Report_2022.pdf

In this context and for these purposes, this Barometer presents the following structure. In the first chapter, the cost of natural disasters in Spain in 2021 has been analyzed, following the approximation already made for the years 2016-2020, thus monitoring the incidence of these phenomena in our country. To do this, the data on the compensation paid for these phenomena and the information on certain interventions by the public emergency services have been used.

In the second chapter, International Financial Analysts has estimated the impact that natural catastrophes have on the Spanish economy in terms of GDP and employment. The repercussions on the agents directly affected by these events have been analysed, as well as the indirect effects on other companies in their value chain. The results of this chapter show the damage that catastrophes make in terms of sales, added value and jobs.

In the third chapter, the Phd in Economic and Business Sciences, Victoria de Elizagarate, has analyzed the human cost produced by natural disasters in Spain in the year 2021, based on the data provided by Civil Protection.

Although the first three chapters of this Barometer analyze the impact of all the natural catastrophes that occurred in Spain in 2021, the next two are focused on the 10 most important events that occurred in our country in those twelve months. By limiting the analysis to a smaller number of events, it is possible to delve deeper into their impact, obtaining richer and more innovative findings.

Thus, the fourth chapter of the Barometer aims to quantify the impact that natural disasters had on critical infrastructure in Spain. Prepared by the School of Engineering of the University of Navarra (Tecnun), this section tries to estimate the cost in terms of equipment, materials, repairs and loss of consumption derived from the impact of these events on transport, energy, water, health and nutrition.

The fifth chapter offers a different approach, moving away from economic repercussions, and focusing on regional vulnerability to natural disasters. In other words, this section does not intend to analyze the post-disaster impact of catastrophes, but rather the theoretical vulnerability of each territory to such events. For this, the School of Engineering of the Comillas Pontifical University (ICAI) has prepared a Social Vulnerability Index against heat waves, floods, earthquakes and snowfall in Spain, based on different criteria and weightings.

The analyses proposed in this Barometer represent a notable contribution to the knowledge of the effects of natural disasters in Spain. However, the ambition of these exercises entails certain limitations in their scope. Indeed, the estimates made in this Barometer are based on observed data in terms of compensation paid for these phenomena, as well as another series of variables linked to them.

Despite the effort made to try to estimate those unobserved effects, the results obtained have not directly taken into account the following dimensions:

- In estimating the cost of catastrophes in 2021, the costs of uninsured items have not been taken into account.
- In the field of economic impact, the opportunity costs for households and companies have not been taken into account (loss of working hours, loss of school hours, impossibility of access to the provision of services, waiting times, etc.)
- In the field of infrastructures, all the possible costs of all those repair and reconstruction works assumed by the budgets of the competent public institutions have not been taken into account.

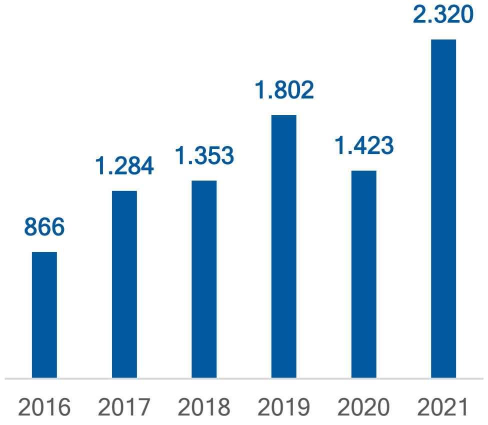
The objective of this and successive Barometers is precisely to gradually close the knowledge gap regarding the impact of natural disasters in Spain. For this, it will be key to increase the availability and accessibility to data, as well as its homogeneity and updating.

1. Insured cost of catastrophes

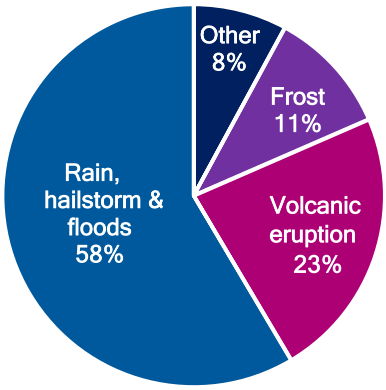
Natural catastrophes caused large economic losses in Spain during 2021. Thus, and taking only those insured assets as a reference, the costs derived from these extreme phenomena amounted to more than 2,320 million euros. The compensation paid for this type of event was 63% higher than in 2020 and 29% higher than in 2019 (in constant euros).

In general terms, it can be seen that almost half of the compensation for this type of event was paid by private insurance (925 million euros, 47%), 25% by the Insurance Compensation Consortium (570 million euros), 35% for Agroseguro (810 million euros) and 16 million for Civil Protection (1%), in constant 2022 euros.

Evolution of the insured cost of natural catastrophes in Spain, millions of constant euros of 2022



Distribution of the insured cost of natural catastrophes in Spain in 2021 by type of event



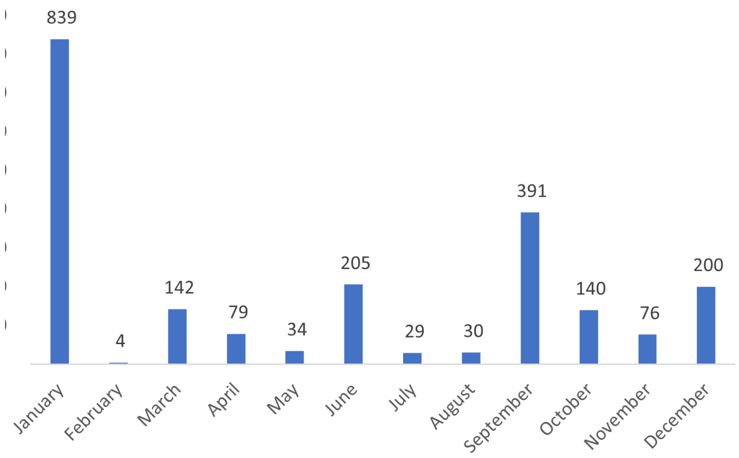
Source: Afi based on data from CCS, Agroseguro and Fundación Aon

The main increase in costs in 2021 compared to 2020 is explained by the impact of the volcanic eruption on the island of La Palma, an event that brought together close to one in four euros compensated in 2021. Despite the importance of the volcano, the extreme meteorological phenomena, such as rains, floods and hailstorms are responsible for the greatest impacts in terms of compensation, accounting for 58% of the total. Among these phenomena, the impact of the Philomena storm stands out, the other great event of the year 2021.

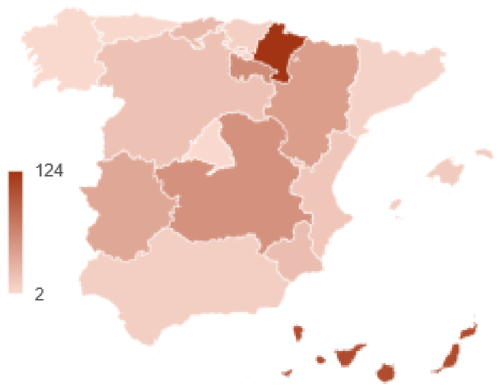
Natural disasters had a particularly virulent effect during the month of January 2021 due to the impact of the Filomena storm on the peninsula. After January, the month of September was also intense, since the eruption of the volcano on La Palma, on September 19, coincided with the havoc caused by the DANA that hit the southeast of the peninsula. Natural catastrophes also caused significant damage in the months of June (impact of hail on the field) and December (floods in the Ebro valley).

At a territorial level, 25% of the total compensation for natural catastrophes was paid in the Canary Islands (as a consequence of the volcano, but also due to heat wave) and 12% in Castilla La-Mancha. In per capita terms, however, the Autonomous Community where these events generated the greatest damage was Navarra, where the December floods generated a cost of 124 euros per inhabitant, 17% more than the impact of the volcano in the Canary Islands.

Monthly distribution of the insured cost of natural catastrophes in Spain in 2021, million euros



Insured cost per capita of natural catastrophes in Spain in 2021, euros per inhabitant



Source: Afi based on data from CCS, Agroseguro and Aon Spain Foundation

2. Impact on the productive fabric and employment

Introduction

The objective of this chapter is to quantify the economic and social impact of natural catastrophes in Spain during the year 2021. The ambition of this initiative lies in the complexity of the analysis, since natural catastrophes can have very heterogeneous repercussions on companies, workers and public institutions. It is honestly impossible to know the exact economic impact of natural catastrophes in Spain, so the exercise presented here is an estimate based on certain assumptions and subject to the information available. Throughout this chapter, the analysis strategy devised, the data used and the results obtained will be detailed.

Data

The analysis carried out in this chapter rely on two main data sources:

- Agroseguro: offers the agricultural sector technically and financially viable coverage against damage caused to production by unpredictable, uncontrollable risks and catastrophic consequences. Agricultural insurance is voluntary and producers can apply for public subsidies to pay the premium. From this source, data on the volume of compensation paid in 2021 for hail, frost, rain, wind, floods, heat waves, bad curdling and drought have been used.

- Insurance Compensation Consortium (CCS): public business entity whose objective is to indemnify insured losses derived from certain extraordinary events that occur in Spain, among others, as a result of natural catastrophes. From this source, the compensations (both for damage to property and pecuniary losses) paid in 2021 for volcanic eruptions, sea attacks, extraordinary floods, earthquakes and atypical cyclonic storms have been used.

Metodology

i. GDP Considerations

When addressing the consequences of natural catastrophes from an economic point of view, it is worth mentioning the limitations that national accounting presents to collect the effects of this type of event.

Indeed, the GDP, the main indicator of the level of economic activity, measures the value of the goods and services produced in a certain place during a certain period of time, in general, in a country during a year. Note that we are referring to the value of the production of new goods and services in that year (flow), not to the value of the goods and services that already existed in the economy (stock). This distinction, although it may seem small, is essential to understand the limitations of national accounting when it comes to quantifying the consequences of natural disasters.

Indeed, earthquakes, volcanoes or floods affect to a greater extent the stock of goods in the economy: destruction of vehicles, homes, infrastructure, commercial premises, etc. However, the GDP is not capable of collecting the negative impact derived from this destruction of physical capital, since it only includes the value of the new flows. Moreover, there is the paradox that, according to this definition, natural catastrophes could have a positive impact in terms of GDP, while reconstruction activities after the catastrophe would stimulate demand in the construction sector, the engineering, cleaning or selling new assets to replace those destroyed.

However, natural disasters can also affect the economy's ability to produce new goods and services. Frost can destroy crops, preventing farmers from earning income from the sale of their products; floods can inundate commercial premises, reducing the income of merchants; earthquakes can destroy factories, stopping industrial production. Therefore, natural catastrophes would have directly measurable consequences through GDP, since they would affect the production of new goods and services.

Furthermore, while the indirect effects of the destruction of goods would positively affect GDP (construction, cleaning, vehicle sales), the indirect effects of the contraction in production would have a negative impact on GDP. Indeed, if a flood causes the closure of a restaurant for a certain period of time, the owners of that restaurant will not only stop selling food to their customers (and therefore earning income, which directly affects GDP), rather they will stop buying raw materials, they will stop requiring cleaning, electricity, security, and logistics services, indirectly affecting other companies in their value chain.

On the other hand, if an earthquake destroys a factory, it not only affects the manufacturers (who stop producing) but stops the supply of materials (machines, components, etc.) to other industries or services, which will have difficulties to continue with their activity as the result of the absence of these intermediate inputs. All this shows that natural catastrophes can have indirect consequences on other companies located at a great distance from the event.

Until now, the direct or indirect effect that natural catastrophes can generate on the economy has been underlined, either in terms of goods or income. However, the cessation of economic activity, especially when it lasts over time, can result in the destruction of jobs. The eruption of the La Palma volcano has buried several towns and hundreds of hectares of crops under the lava, so it will be difficult for people who worked in those places to recover their jobs in the short term.

ii. Input-Output analysis for the impact on flows

To estimate the direct and indirect impact of natural catastrophes in Spain on GDP and employment, the Input-Output methodology, developed by the Russian economist Wassily Leontief (Nobel Prize in Economics in 1973), has been used. This technique, frequently used in this type of analysis, is based on the modeling of the intersectoral relations of the different branches of the economy. Specifically, the Input-Output tables allow us to know for each sector, how many inputs it needs from other sectors to produce each unit of product (drag backwards), and what proportion of its sales is destined to supply other companies (intermediate demand) or to final consumers (final demand). In Spain, the National Statistics Institute (INE) is the body in charge of providing this information.

The Input-Output tables allow us to know the way in which an exogenous shock (such as a natural catastrophe) filters through the entire economy through intersectoral relationships between the directly affected activity and the rest of the sectors of its value chain. In this sense, and based on the data provided by Agroseguro and the Insurance Compensation Consortium, the impact of the set of natural catastrophes in 2021 in our country has been simulated. Said estimation has only been made using the contraction in the turnover of the companies directly affected (flow variable) as a direct impact, leaving aside the impact on goods, since, as mentioned above, its analysis is incompatible with GDP.

iii. Degree of industrial and commercial insurance in Spain

The information provided by Agroseguro and the Insurance Compensation Consortium covers the value of the compensation paid in 2021 for certain natural events, only to those companies that were insured. However, not all Spanish companies have taken out an insurance policy, so the gross use of Agroseguro and CCS information could be underestimating the real cost of natural catastrophes on Spanish companies.

This chapter has worked in a scenario under which only 50% of companies in the agricultural sector and 40% of the rest of the economy are insured, references used in the report *The cost of natural catastrophes in Spain (2016 - 2020).*

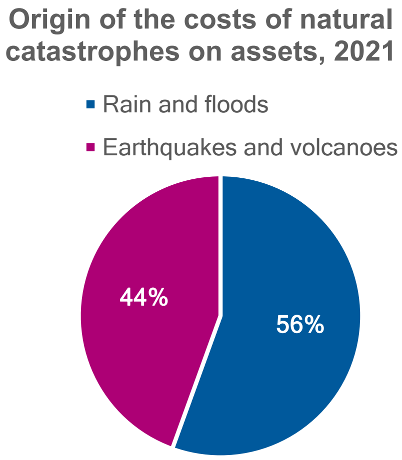
Beyond the number of companies covered, another relevant aspect is, within the insured, the volume of capital (or income) that they have insured against this type of event. Using data from the Insurance Compensation Consortium, it can be seen that all those companies indemnified for loss of profits (pecuniary losses linked to the impossibility of continuing with their activity) were indemnified with an amount strictly lower than their insured capital. From this information it can be deduced that, within the insured, no company had less compensation with respect to its real losses for having exceeded the insurance threshold.

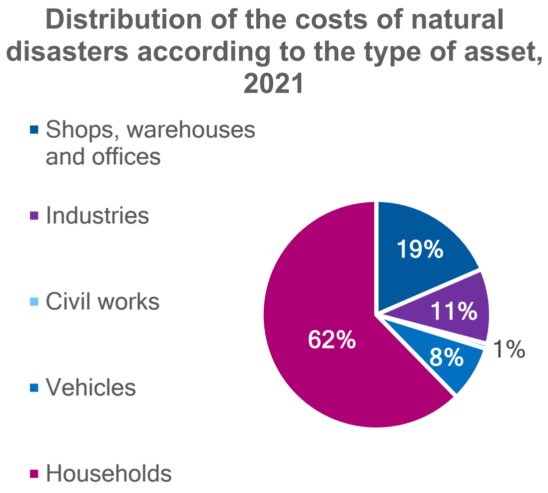
Results

i. Impact on assets

According to data from the Insurance Compensation Consortium, natural catastrophes in Spain caused in 2021 material losses worth around 1,300 million euros, of which only 41% would be insured. 84% of the losses were concentrated between the months of September and December, coinciding with the main floods and storms after the summer, as well as the consequences of the volcanic eruption on the island of La Palma. In turn, the consequences of the Filomena storm stand out, whose material damages represented around 10% of the annual total.

The material damage caused by natural catastrophes in Spain in 2021 is divided equally between those that are the result of geological phenomena (such as earthquakes or volcanoes) and those meteorological (such as those derived from rains and floods). Its consequences mainly affected homes (62% of the total damage) and businesses and warehouses (19%). Industrials (11%) and vehicles (8%) were relatively less affected in value terms.



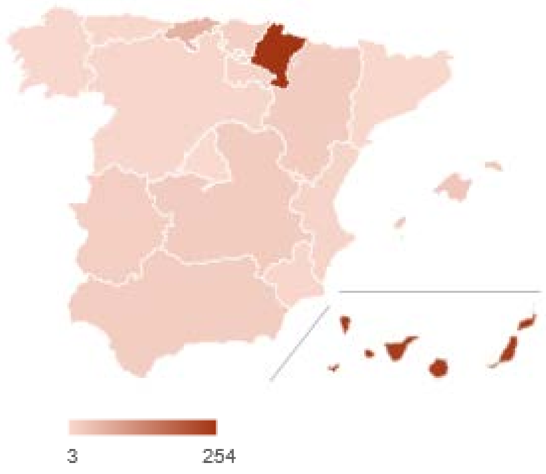


Source: Afi, based on data from CCS

At a territorial level, the Canary Islands have been, by far, the region most affected by natural disasters in Spain in 2021. The consequences of the volcanic eruption on the island of La Palma caused 41% of the material damages. Andalusia (15% of total damage) and Navarra (13%) appear as the most affected regions after the Canary Islands. In per capita terms, the situation changes slightly, while the cost of the floods in Navarra (254 euros per inhabitant) would exceed those of the volcano in the Canary Islands (240 euros per inhabitant).

Estimated total cost of natural disasters on assets in 2021, euros

Estimated per capita cost of natural disasters on assets in 2021, euros per inhabitant

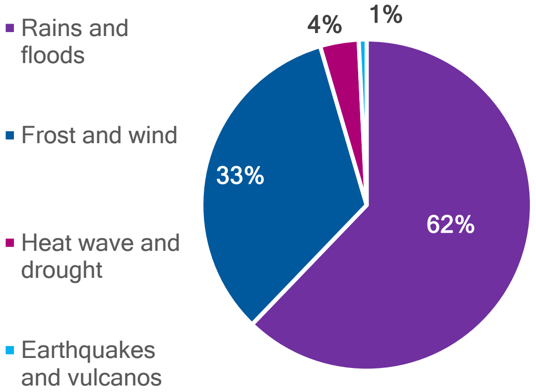


Source: Afi, based on data from CCS

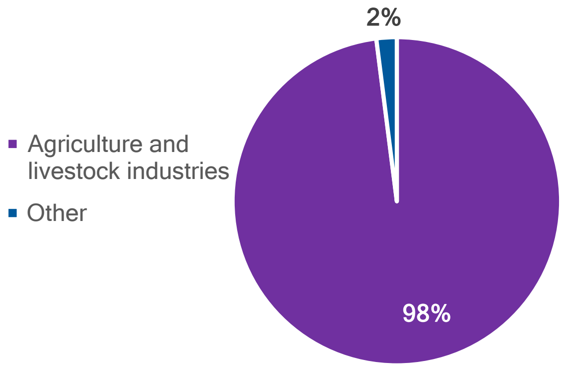
ii. Impact on rents

While the previous section has studied the impact of natural catastrophes on the stock of goods (homes, premises, vehicles, etc.), this section will analyze the impact of natural catastrophes on income (and therefore its derivative in terms of GDP and employment).

Distribution of the impact of natural catastrophes by type of event



Sectoral distribution of the impact of natural catastrophes on income



Source: Afi based on data from CCS and Agroseguro

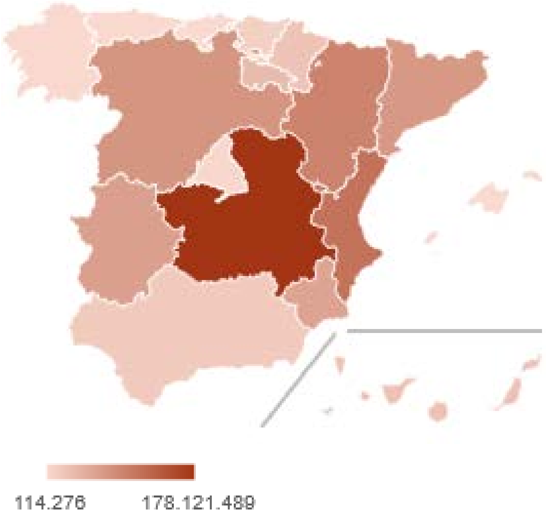
Natural catastrophes in 2021 caused Spanish companies to stop directly earning around 1,492 million euros. 99% of this turnover loss was concentrated in agricultural and livestock activities, by far the sector most exposed to meteorological phenomena.

Although natural disasters can affect other activities, their consequences are more limited in time, and businesses or industries can recover relatively quickly after an event of these characteristics. However, the loss of crops after an extreme event generates more lasting consequences, since an event of a few days generates an impact that extends throughout an entire agricultural cycle, since the farmer must wait until the next harvest to obtain income again.

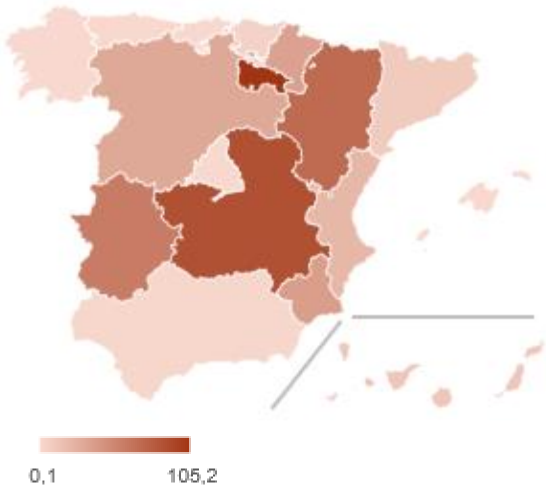
On the other hand, the data places rain and floods as the origin of most of the losses (62%), followed by frost and wind (33%). Heat waves, drought, earthquakes and volcanoes had a minor impact in relative terms, in the area of economic activity.

Around half of the loss of economic activity as a consequence of natural catastrophes in 2021 was concentrated in Castilla-La Mancha (23%), the Valencian Community (15%) and Aragon (12%). In per capita terms, the most affected territory was La Rioja, where the floods suffered in autumn caused business losses of 70 euros per inhabitant.

Estimated total cost of natural catastrophes on income, euros



Estimated per capita cost of natural catastrophes on income, euros per inhabitant



Source: Afi based on data from Agroseguro and CCS

In 2021, natural catastrophes caused a drop in the turnover of the directly affected companies of around 1,492 million euros (direct impact). At the same time, the companies that supplied products to the former saw their sales contract by 1,243 million euros (indirect impact). Both impacts (direct and indirect) ultimately had an impact on wages and consumption in the economy as a whole, which translated into a new contraction of 478 million euros (induced impact) on a whole series of companies that were not seen directly or indirectly affected.

In aggregate terms, therefore, the natural catastrophes in 2021 generated a drop in total turnover of close to 3,200 million euros (sum of the direct, indirect and induced impact). However, an important part of these losses was compensated by the Insurance Compensation Consortium and Agroseguro. Specifically, both institutions compensated approximately half of the losses to the companies directly affected.

Economic and social impact of natural disasters in 2021, million euros

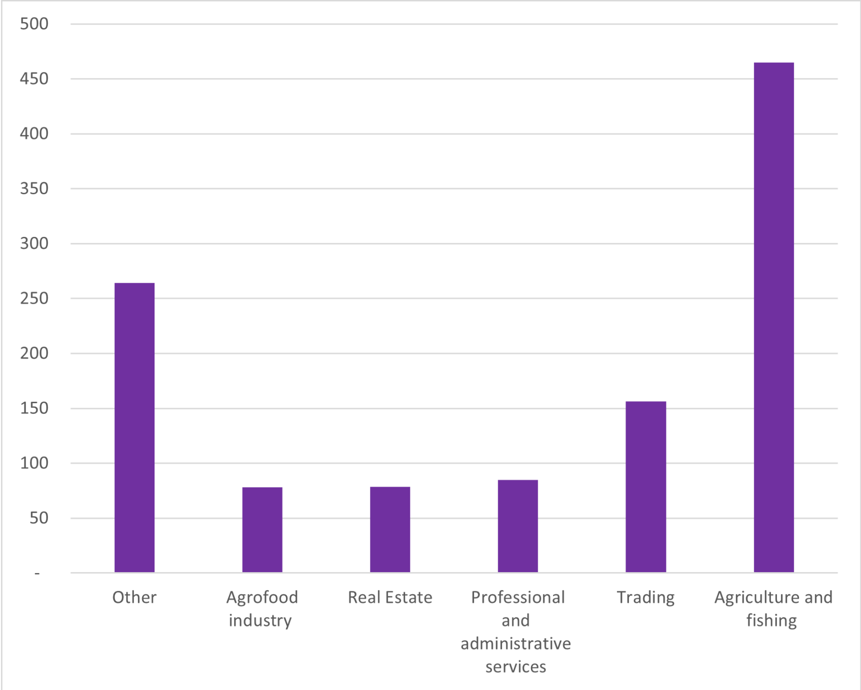
	Direct	Indirect	Induced	Total
Billing	1.492	1.243	478	**3.213**
Insurance coverage	51%	0%	0%	
Indemnities	766			
GDP	386	497	243	**1.126**
Employment	9.500	9.800	3.900	**23.200**

Source: Afi based on data from Agroseguro and CCS

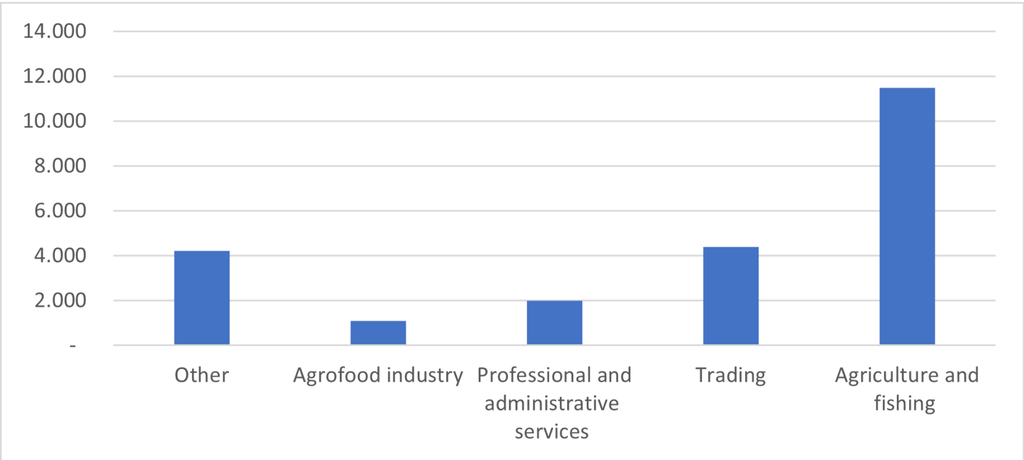
In this sense, the negative impact in terms of GDP on the companies directly affected would be reduced to 386 million euros, to which must be added the 497 million of indirect impact and 243 million of induced impact, amounting to 1,126 million euros of uncovered impact, the equivalent of 0.1% of Spanish GDP in 2021.

The economic contraction of 1,126 million euros translated into a loss of around 23,000 jobs, half of them in auxiliary companies in the value chain of those directly affected by the catastrophes.

Sectors most affected by the indirect impact of natural disasters, million €, 2021



Sectors most affected by the indirect impact of natural disasters, jobs, 2021



Source: Afi based on data from CCS and Agroseguro

The greatest impacts in terms of GDP and employment occurred in companies linked to the primary sector value chain: agriculture and livestock; food industry; wholesale and retail. After them appear another series of auxiliary services, common throughout the economy: real estate activities or professional services.

3. Human cost of natural disasters

Introduction

The human cost produced by natural disasters in Spain in the year 2021 has been analyzed with the data provided by Civil Protection in the year 2022. The study by the Aon Spain Foundation published in 2021 included the data series from 1995 to the year 2020. The individualized study of 2021 is carried out in order to know the characteristics of this year in relation to the causes that have produced the human losses and offer the 2021 Barometer information in this regard.

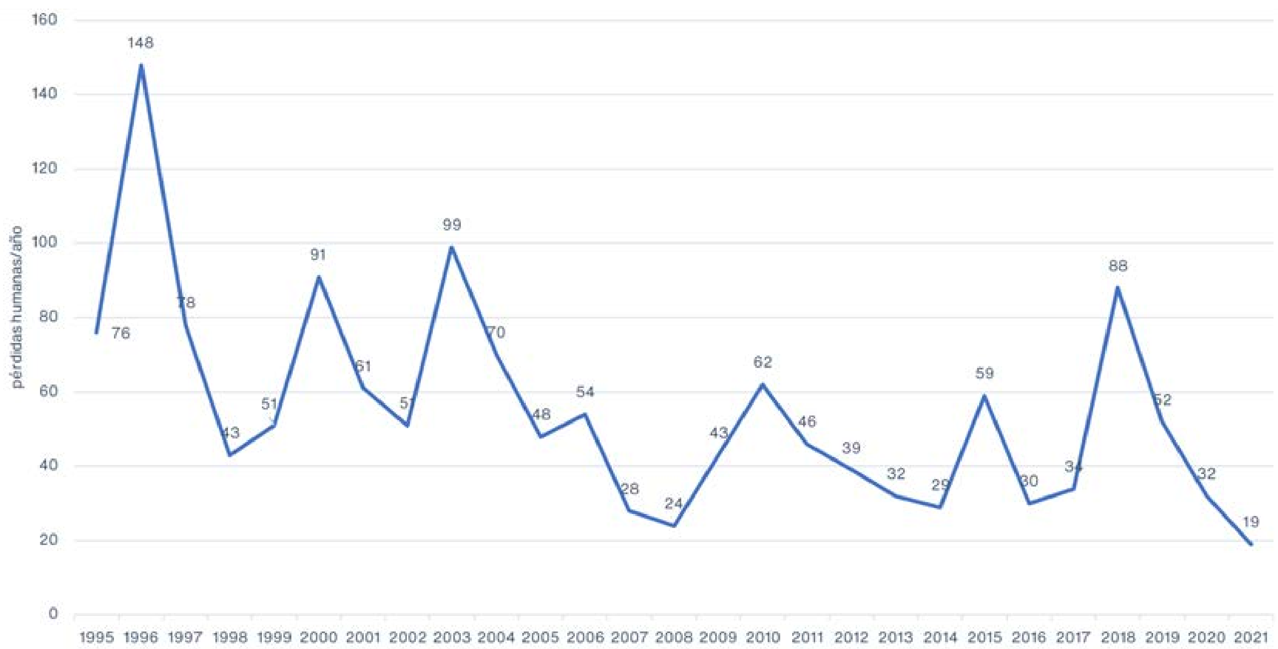
Objectives and methodology

The objective of the study developed below is to find out the human losses due to natural disasters that have occurred in Spain in 2021, thus completing the study of the twenty-seven-year series, but in this case carrying out an individual analysis of what happened in the last year of the series. The graphical representations of the data are analyzed, both in linear functions and in logarithmic functions, to explain the main causes of deaths. The graphs in this chapter are based on data from Civil Protection 2021.

Analysis of the total amount of human losses due to natural disasters in Spain in 2021

Based on the report *The cost of natural catastrophes in Spain (2016-2020)* carried out by the Aon Spain Foundation, which exposes the number of human losses caused by natural disasters during the period 1995-2020, the investigation has continued by in order to know that in 2021 this amount amounts to 19 deaths and 67 people injured or sick. As the graph shows, the number of deaths has been the lowest in the 26-year series analyzed and presents 0 deaths due to wind and 1 death due to fires.

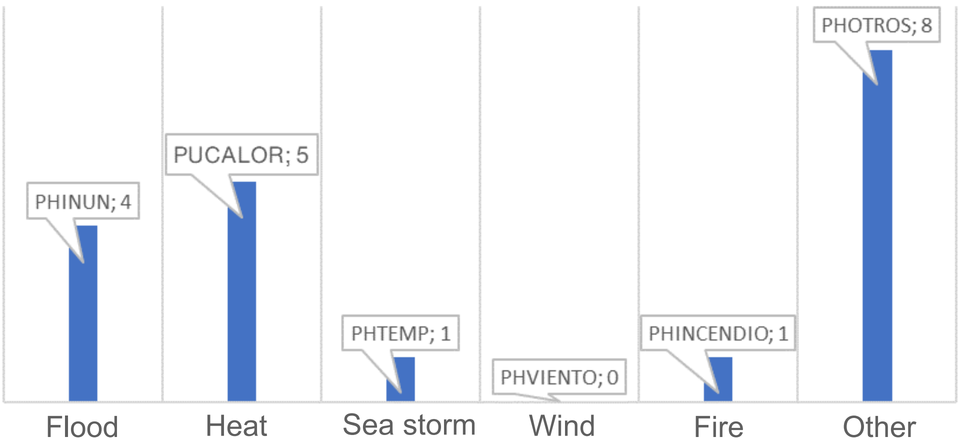
Total amount of human losses. Year 2021



Analysis of human losses due to natural disasters in Spain in 2021 by type of natural disaster

The following graph shows the different human losses that have been caused by different natural disasters.

Human losses due to different causes of natural disasters. Year 2021

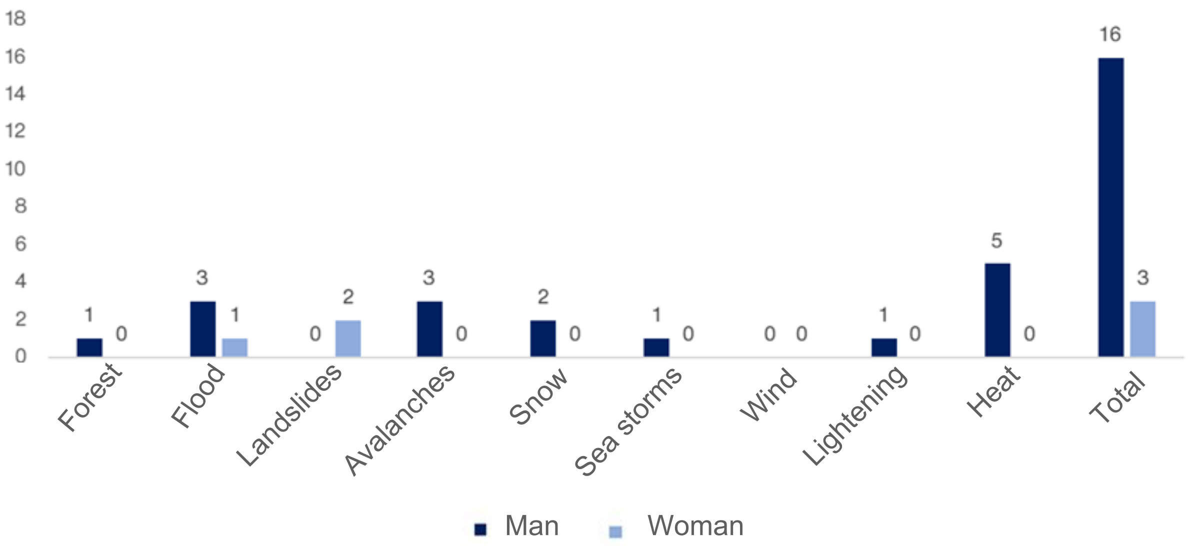


As the graph shows, the greatest human losses have occurred in the "other causes" section with 8 deaths, which are broken down into: human losses due to landslides with 2 deaths, due to avalanches with 3 deaths, due to snow with 2 deaths and by lightning with 1 death. The second cause of human losses is due to heat waves with a total of 5 deaths, followed by floods with 4 deaths. Both the sea storm and the fires have caused 1 death, while there have been no human losses due to wind.

Analysis of human losses due to natural disasters in Spain by gender. Year 2021

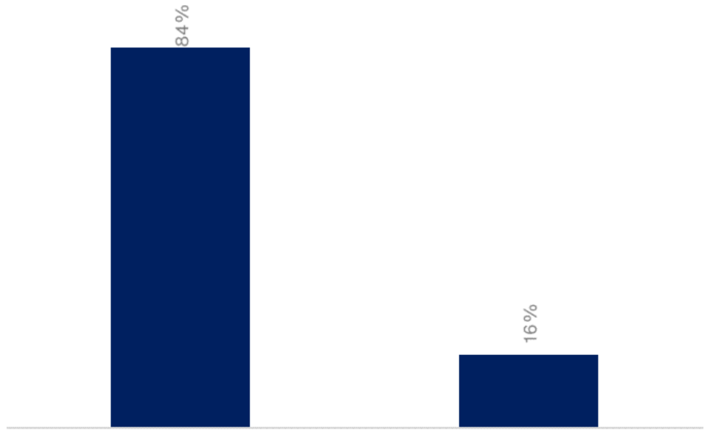
The analysis of human losses due to natural disasters in 2021 presents differences by gender in absolute value.

Human losses by gender. Absolute values. Year 2021



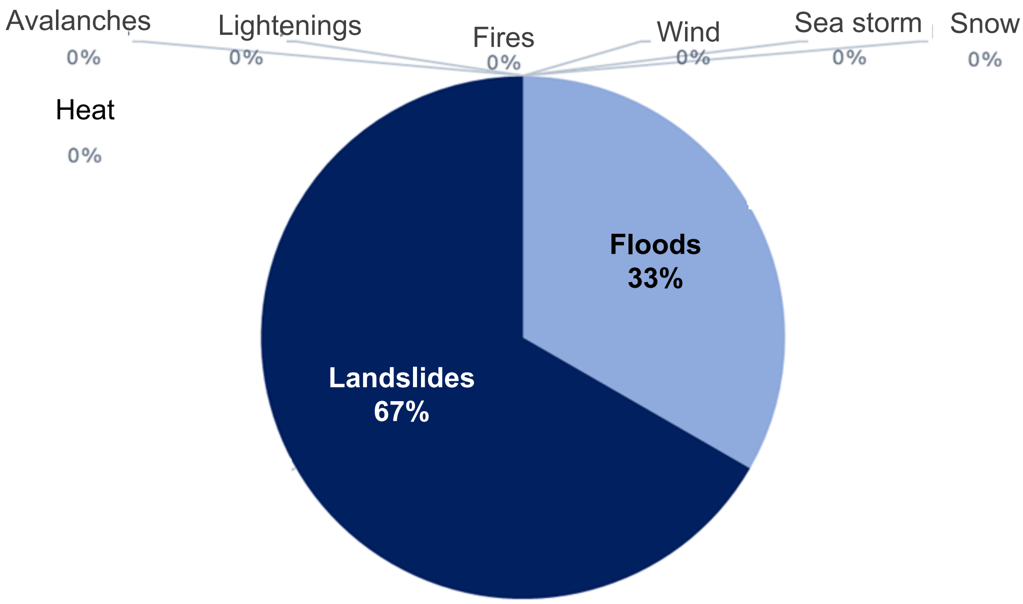
The analysis also shows a difference in relation to deceased men (86%) compared to deceased women (16%).

Human losses by gender in percentage. Year 2021

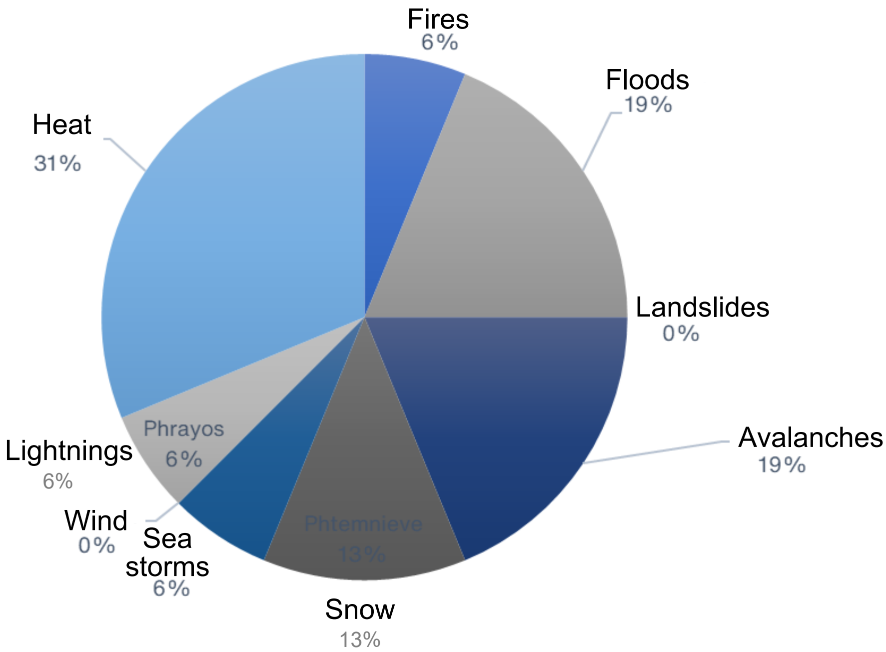


The percentage differences in the different causes of natural disasters that have produced human losses by gender are analyzed below. The graph below shows the different natural disasters that have caused the death of women. The greatest human losses in women are caused by landslides that represent 67% of the total deaths and the second cause is human losses due to floods that represent 33%. There are no human losses of women due to other causes.

Human losses due to different causes. Women



Human losses due to different causes. Men



The greatest human losses due to natural disasters in men have been caused by heat waves (31% of deaths), the first cause; the second, by avalanches (19%) and floods (19%); the third, by snow storms (13%). The remaining causes in order of importance are deaths by sea storms (6%), by lightning strikes (6%) and by fires (6%).

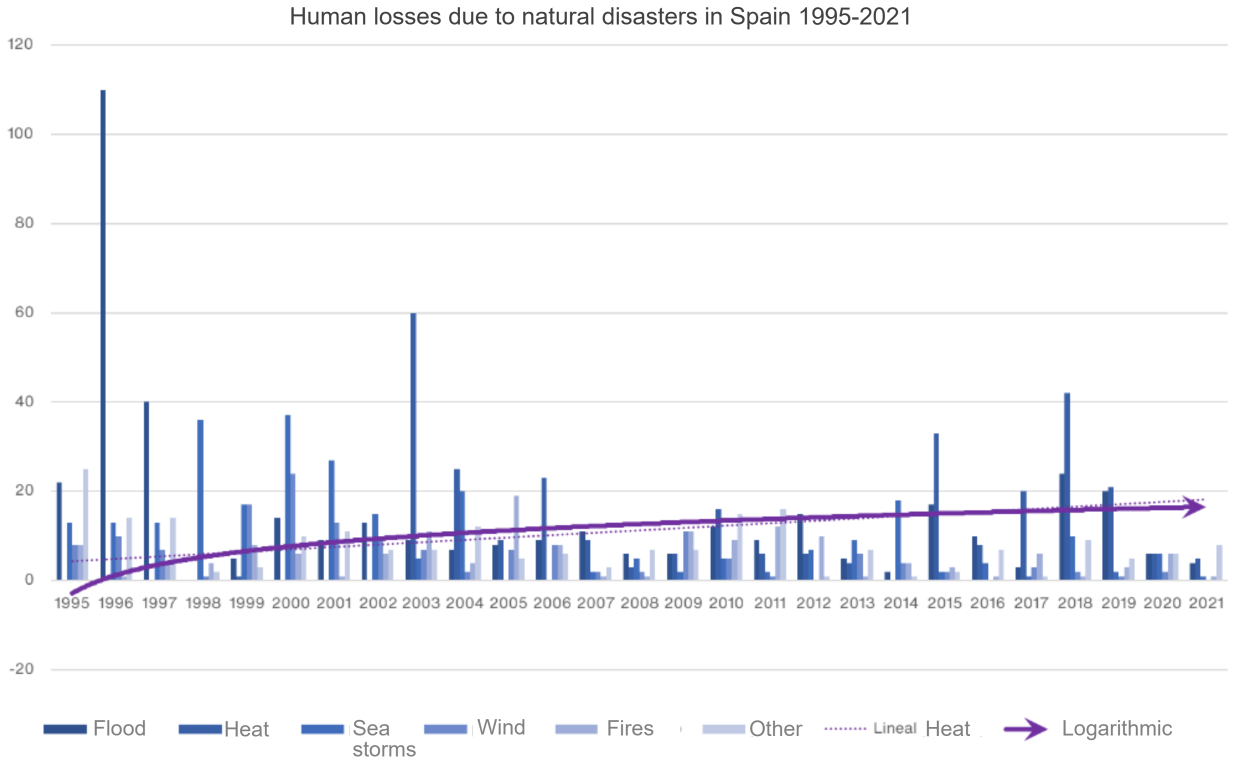
<u>Analysis of the evolution of human losses due to heat waves in the 1995-2021 series</u>

The following graph shows the evolution of human losses due to heat waves in the data series up to the year 2021. The graph represents the evolution of heat deaths on a logarithmic scale, since for long-term periods it shows more clarity for analysis than linear functions. The logarithmic function measures the percentage variations (%) of human losses due to heat waves on the ordinate axis, unlike what happens with a linear graphic representation that represents absolute values in ordinates, thus allowing to correctly analyze the evolution of human heat losses in a long-term series. In addition, the graph shows the logistic function of human losses due to heat waves, allowing us to see the periods in which exponential growth occurs, which does not always occur throughout the entire function represented.

The logarithmic function of human losses due to heat is represented by a continuous arrow (purple color) and shows that, in the years 1995, 1996, 1997 and 1998, the growth of human losses due to heat (on the ordinate axis) runs along below the linear function of human heat losses (black dotted line). This analysis coincides with groups 1 and 3 generated by the "Cluster Analysis". That is, there was no strong percentage growth in human heat losses. However, between 1998 and 2015 the logarithmic function runs above the linear function, which indicates on the ordinate axis that there has been a greater growth in percentage than in absolute values of human losses due to heat.

From 2015 to 2018 both logistic and linear functions coincide, these years being in group 2 called "the years of embarrassment" and showing that growth has continued, although slightly lower than previous years. Between 2018 and 2021, the logistic function coincides with the linear function, although there is a slight decrease that places it in 2021 below the linear function. The logistic function of human losses due to heat shows periods of strong expansion, but a function of these characteristics allows checking other periods where there are no situations of exponential growth.

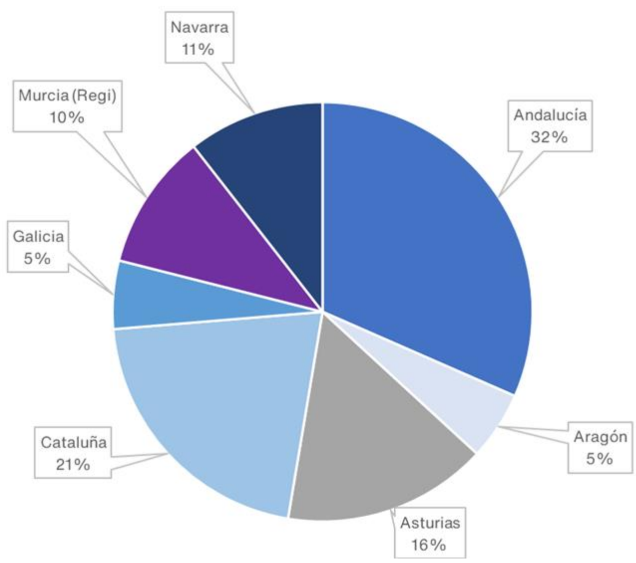
Evolution of human losses due to heat 1995-2021



The Autonomous Communities that have been affected by human losses as a consequence of natural disasters in 2021

The distribution of human losses due to natural disasters according to the Autonomous Community where the disaster occurred shows the geographical regions that have been most affected in 2021, with a total of 19 deaths distributed in seven Autonomous Communities: Andalusia, Aragon, Asturias, Catalonia, Galicia, Region of Murcia and Navarra. The highest percentage of deaths corresponds to Andalusia (32%), Catalonia in second place (21%), Asturias in third place (16%), Navarra in fourth place (11%), and the Region of Murcia in fifth place (10%), and tied in sixth place, the Autonomous Communities of Galicia and Aragon (5%).

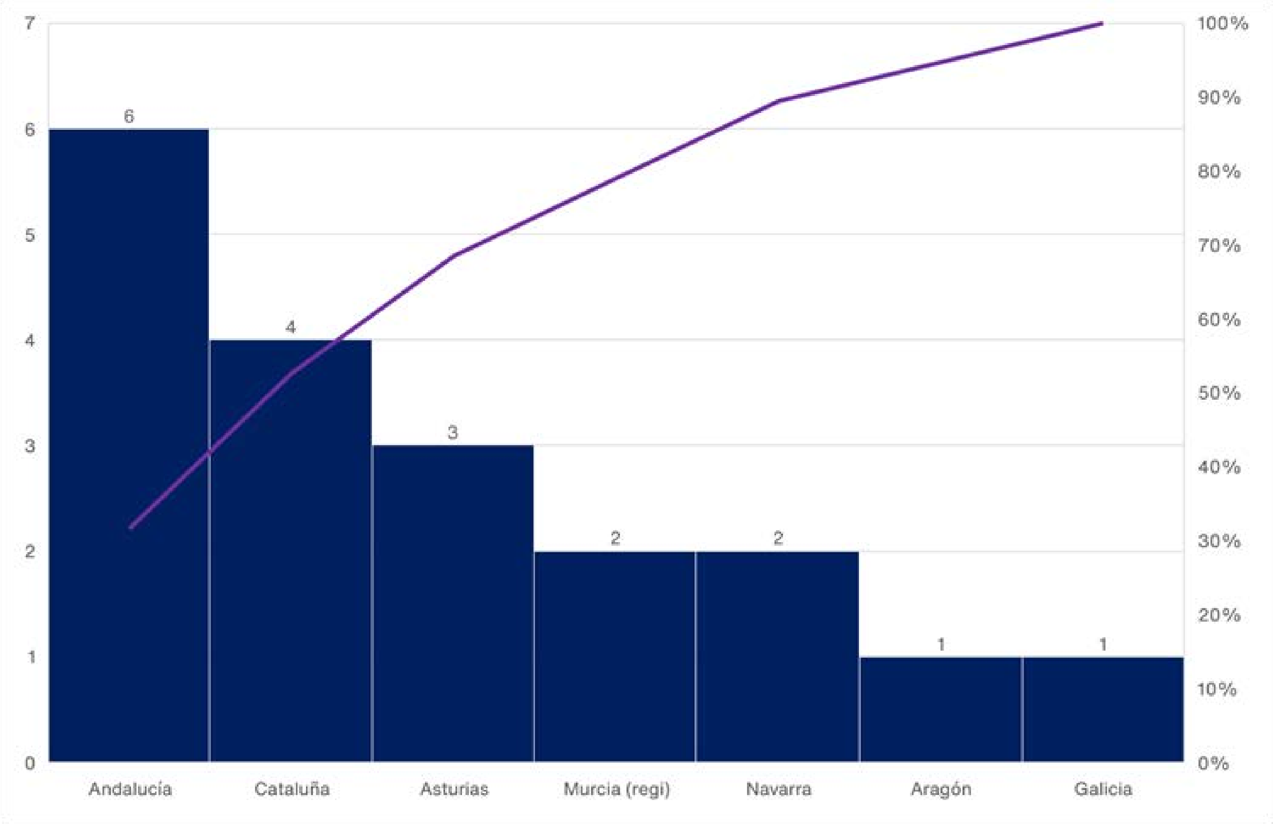
Human losses due to natural disasters by Autonomous Communities (2021)



Analysis of the concentration (%) by Autonomous Communities. Pareto chart

By means of a Pareto diagram, the seven Autonomous Communities are exposed in order of the number of human losses caused by natural disasters, how they have affected by their different magnitude. The absolute values of human losses are shown and represented by a purple line the cumulative percentage of human losses. It is verified by means of the curve that Andalusia, Catalonia and Asturias concentrate close to 70% of the total human losses caused by natural disasters in 2021. The remaining 30%, up to 100%, is reached in the Region of Murcia, Navarra, Aragon and Galicia.

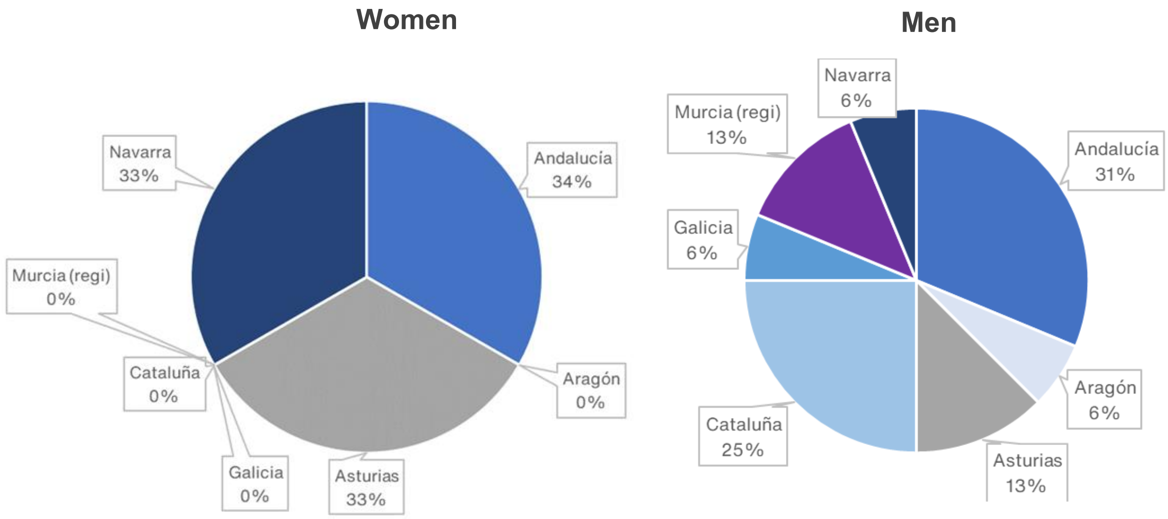
Pareto chart. Concentration (%) of human losses by Autonomous Communities (2021)



Analysis of human losses by gender and A.C.

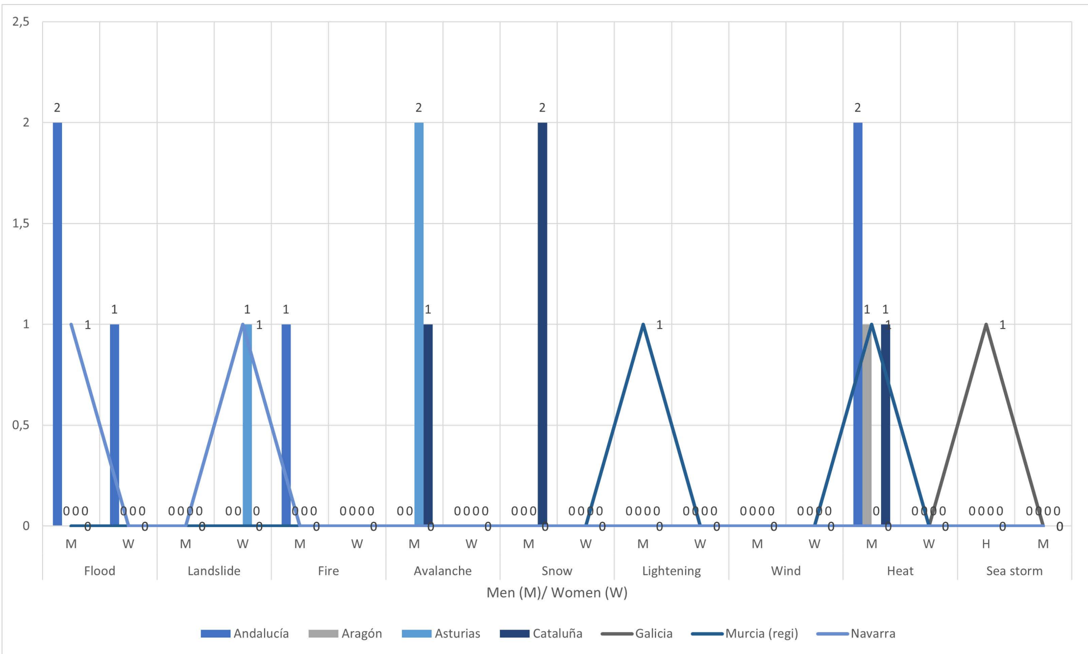
The human losses by gender according to the Autonomous Communities where the natural disasters have been located in 2021 shows how in Aragon, Catalonia, Galicia and the Region of Murcia there have been no human losses in women. However, Andalusia has 34% of human losses in women, and Navarra and Asturias, 33%.

Human losses by gender and Autonomous Communities (2021)



Human losses due to natural disasters have affected 31% of men in Andalusia, and in second place, 25% of men in Catalonia. The region of Murcia and Asturias with 13% of human losses (men) and finally Galicia, Aragon and Navarra with 6%.

Maximum human losses due to natural disaster by gender and CCAA. (2021)



The maximum human losses due to disasters are shown according to gender (Men/Women) and the Autonomous Community where the event occurred. The highest points correspond to human losses due to natural disasters (Man) with 2 deaths. There are two highest points of deaths (Men) that are caused by floods and heat, and that correspond to Andalusia. The remaining maximum deaths (Men) correspond to Asturias and Catalonia with human losses due to avalanches and snow, respectively.

Conclusions

Of the series of 27 years analyzed, 2021 with 19 deaths is the one with the lowest number of human losses due to natural disasters.

Landslides, avalanches and snowstorms (Filomena) have been the first cause of death in 2021, with no human losses due to winds.

The second cause of death has been due to heat waves. There are gender differences, with 84% of the deceased men compared to 16% women. The differences are also found by the type of cause. The highest percentage of deaths in men are from heat, while in women they are from landslides. The difference is that the human losses in women are concentrated in two causes, landslides and floods, while in the case of men deaths occur in a greater number of natural disasters.

Three Autonomous Communities, Andalusia, Catalonia and Asturias, concentrate close to 70% of the total human losses caused by natural disasters in 2021.

4. Impact on critical infrastructures

Introduction

The objective of this chapter is to quantify the economic impact of natural disasters on Spanish critical infrastructures during the year 2021. Critical infrastructures are essential for the social and economic well-being of a country, and their disturbance or destruction aggravates the effects of disasters significantly affecting the ordinary functioning of society.

There are few studies that analyze the economic impact of catastrophes on critical infrastructures [1], mainly due to the difficulty of finding data, to the fact that most critical infrastructures are managed by private entities and to the lack of a holistic methodology to estimate not only the direct damage to the physical infrastructure, but also the impact of the lack of supply.

This study firstly presents the methodology that has been developed to estimate the economic impact of a natural disaster on critical infrastructures and, secondly, estimates the economic impact for the case of Spain subject to the information and data available.

Critical infrastructures

Every day we use electricity, drink water, use public transport, make payments with bank cards, make phone calls, connect to the internet or carry out procedures with public administrations. All these essential activities depend on certain infrastructures, which are of critical importance for the proper development of society [2].

The European Directive 2008/114/CE of December 8, 2008 [3] establishes that a critical infrastructure is: "The element, system or part of it located in the Member States that is essential for the maintenance of vital social functions, the health, physical integrity, security, and social and economic well-being of the population, the disturbance or destruction of which would seriously affect a Member State by not being able to maintain these functions”. At the level of Spain, Law 8/2011 establishes an official definition of what in Spain must be considered as critical infrastructure: "Strategic infrastructures (that is, those that provide essential services) whose operation is essential and does not allow alternative solutions, Therefore, its disturbance or destruction would have a serious impact on essential services” [4]. It should be noted that many times when we talk about critical infrastructures we are not only talking about the physical infrastructures that provide the service, such as power lines or transformers in the case of energy. We refer to guaranteeing the service of critical goods to ensure the well-being of society.

Below is the list of infrastructures or services that the European Union considers critical for the well-being of society [3]:

- Water: rivers, reservoirs, water treatment, reservoirs, and distribution networks.
- Transport: airports, ports, highways, railways, public transport networks, etc.
- Energy: electricity, gas, oil (generation, transmission and distribution).
- Food: production, storage and distribution.
- Health: emergencies and ambulatory.
- Communication networks: telephone, Internet, TV, radio, etc.
- Financial and Tax System: operation and taxes.
- Government: Administration.
- Security: State Security Corps and Forces.
- Information: media, messaging systems, etc.

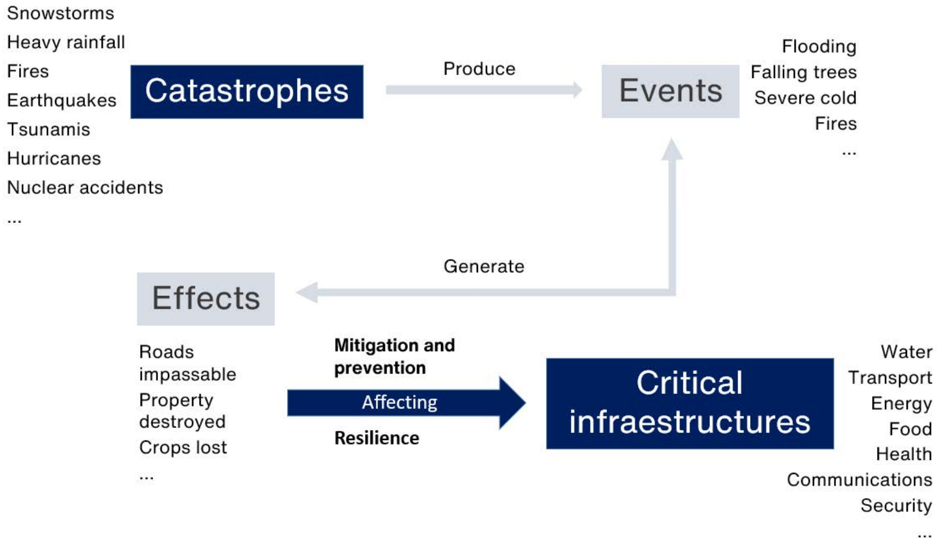
Metodology

The main source of information to design the conceptual framework in which catastrophes affect critical infrastructures is the scientific literature [1] on catastrophes and critical infrastructures, as well as reports from some organizations such as LISA Institute [2] and UNISDR [5].

The conceptual framework defines the relationship between catastrophes and critical infrastructures through the events that occur and the effects they generate. The working hypothesis is that this relationship is not direct and is determined through the effects produced by the events of the catastrophe.

In the concept map, on the left side we can see the types of disasters and on the right side, the list of critical infrastructures that may be affected. For some infrastructures we subdivide into two or three levels in order to better estimate the economic impact. For each relationship between the type of disaster and the critical infrastructures affected, three elements are considered: the cause of the effect (interruption or breakage), the duration and what was affected (production, distribution or use).

Reference framework on the effects of catastrophes on critical infrastructures



Source: Tecnun University of Navarra

On the other hand, we know that critical infrastructures are increasingly interrelated [6], causing cascading effects when one of them fails [7], [8]. These interrelationships between effects fall into three basic categories:

i. **Primary direct effect:** that of immediate consequence of the disaster. For example, a snow storm immediately makes roads impassable.

ii. **Secondary indirect effect:** that generated as a consequence of the direct effect, due to problems in an infrastructure that was directly affected by the disaster. For example, continuing with the previous example, the indirect or secondary effect would be the collapse of the alternative roads due to the fact that there are roads that are impassable.

iii. **Tertiary indirect effect:** that caused by the secondary effect, such as problems in the food supply due to the interruption in transport.

In this study we focus on the direct effects of catastrophes on critical infrastructure to define the economic impact. For each disaster, it has been studied which critical infrastructures, of those mentioned above, were affected and the economic impact on each of them has been estimated.

We have defined a 3-dimensional methodology to estimate the economic impact of disasters on critical infrastructures:

- Cost of damaged or affected equipment or infrastructure: Examples: cost of a broken transformer or cable, materials to repair a destroyed bridge or damaged road.

- Cost of personnel for repair and replacement work: Examples: repair of a transmission line or an insulator, construction of a new bridge or repair of damaged pavement.

- Cost of loss of consumption: refers to the loss of income of the affected critical infrastructure operator, as a result of goods not sold or services not provided. Example: loss of income from electricity companies for not supplying energy.

Thus, the total impact of disasters on each infrastructure will be determined by the sum of the cost of damaged equipment or infrastructure, the cost of personnel for repair and replacement work, and the cost derived from the loss of consumption.

For the first two types of costs (damaged equipment and infrastructure and personnel for repair and replacement), the source of information is the supply company itself or the Ministry responsible for managing the infrastructure. It should be noted that the availability of these data is very limited and in many cases it has been difficult to obtain. In most cases, they have been obtained from the data provided by Agroseguro and the Insurance Compensation Consortium and also from the media.

The cost on consumption can be estimated from the number of units (companies, homes or individuals) that have been affected. To calculate the loss of consumption we have used a formula for each type of service based on the variables described in the following equation:

$$\textit{Loss of consumption} = \textit{affection time } x \textit{ units affected } x \textit{ average consumption } x \textit{ cost } x \textit{ seasonal factor}$$

Where:

- The time affected is the time in which the critical infrastructure has not provided services or has not sold goods to its customers.
- The affected units are the people, homes or companies that have been affected by the lack of services or goods.
- The average consumption refers to the consumption of the service or that is consumed per end user and per unit of time.
- Average cost refers to the average unit cost of the service or good not provided.
- The seasonality factor refers to the variation in average consumption depending on the season in which we estimate the cost. For example, energy consumption increases by approximately 20% during the winter months compared to the average annual consumption [9]. Therefore, in case of estimating the cost of loss of energy consumption in the winter months, we would apply a seasonality factor of 1.2.

To estimate the economic impact of the disasters that occurred in 2021, this methodology is used and the three types of costs are analyzed for each disaster and infrastructure and the total cost for each infrastructure is calculated by adding the three items.

Data

The analysis presented in this study are based on data from Agroseguro and the Insurance Compensation Consortium. In addition, the following parameters have been used to estimate the cost due to loss of consumption:

- Energy: daily electricity consumption in 2021 is estimated to be 5,407.3 kWh/home [10]. Therefore, the daily consumption of electricity is estimated to be 14.81 kWh/home and day. The average price of Kwh in 2021 was €0.26/kwh [11]. Therefore, the daily cost of electricity per home is €3.81/home.

- Gas: the average gas consumption of homes with heating, hot water and cooking gas is 7,921 kwhT per year, while that of homes without heating, but with gas consumption for hot water and cooking is 2,956 kwhT [12]. Making an average between the two and dividing by the days of the year, we obtain that the average daily consumption of gas is 29.8 kWhT/home and day. We estimate the cost of kWhT to be €0.13/kWhT [13], therefore, the daily cost of gas per home and day is €3.874.

- Water: average water consumption in Spanish homes is 142 liters/home and day [14]. In turn, the average cost of 1,000 liters of water for domestic use is 1.90 euros [15]. Therefore, the average cost of water is €0.27/dwelling and day.

- Transportation: the winter viability cost for the use of snowplows to clean the roads of the entire network is 370,000 euros/day [16]. In addition, the annual cost of road maintenance is 80,000 euros/km [17].

Results

As mentioned in the methodology section, the analysis of the economic impact on critical infrastructures has been calculated for each disaster. For each of the 10 disasters analyzed, first it has been determined which infrastructures were affected and then the economic impact generated has been calculated for each infrastructure[2].

As can be seen, the event that affected the greatest number of critical infrastructures was Filomena, where five different ones were affected: energy, water, food, health and transportation. The next most severe event was the hailstorm and the rains that occurred in May which, although they only affected the food and transport sector, their cost was very high. The March frosts were the next events with the greatest economic impact on critical infrastructures (food sector). In this case, the transport sector was not significantly affected.

Critical infrastructures affected in each event

	Date	Food	Transport	Energy	Health	Water
Filomena	02/01 - 20/01	✓	✓	✓	✓	✓
Frosts	19/03 - 24/03	✓				
Frosts	12/04 - 19/04	✓				
Hailstorm and rains	23/05 - 23/06	✓				
Wind and heat wave	11/08 - 16/08	✓			✓	
DANA 1	30/08 - 02/09	✓	✓	✓		
DANA 2	15/09 - 25/09	✓	✓			✓
Volcanic eruption	19/09 - 13/12	✓	✓		✓	
Ebro river floods	10/12 - 16/12	✓	✓		✓	

Source: Tecnun University of Navarra

The next most severe events were the DANA that occurred in the second half of September and the volcanic eruption on the island of La Palma. In the first case, the DANA affected agriculture, transport and the water sector above all.

[2] Annex I, which is available in digital format, explains in detail the calculations made to estimate the economic impact of each disaster.

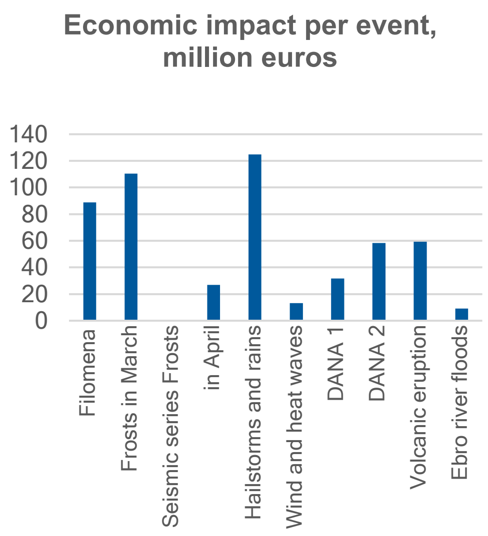
In the second case, the damage was concentrated in the food and transportation sectors. The DANA that occurred at the end of August was the next event with the greatest economic impact, followed by the frosts in April. Finally, heat waves, wind and floods due to the rise of the Ebro River were the events with the least economic impact. In total, the most significant events analyzed in this report generated an economic impact on critical infrastructures of 522,766,227 euros.

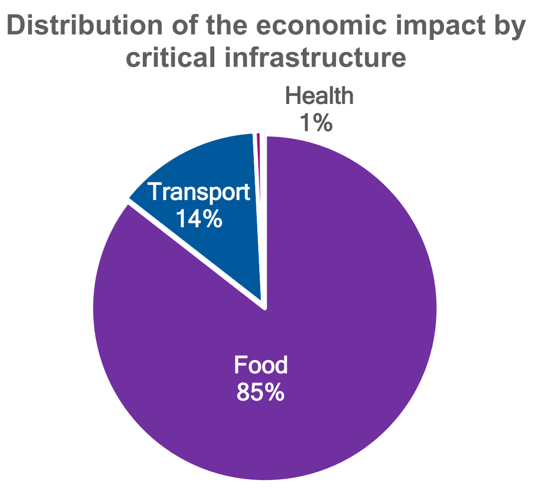
Estimation of the economic impact of the 10 events on critical infrastructures

	Food	Transport	Energy	Health	Water	**Total**
Filomena	58,718,166	26,035,562	564,522	3,428,571	40,500	**88,787,321**
Frosts in March	110,407,316	-	-	-	-	**110,407,316**
Frosts in April	26,825,887	-	-	-	-	**26,825,887**
Hailstorm and rain	123,820,631	1,028,677	-	-	-	**124,849,308**
Wind and heat wave	13,315,148	-	-	-	-	**13,315,148**
DANA 1	30,392,751	1,277,631	19,033	-	-	**31,689,415**
DANA 2	58,247,533	4,397	-	-	150,000	**58,401,931**
Volcanic eruption	18,800,000	40,500,000	-	-	-	**59,300,000**
Ebro river floods	6,547,514	2,641,244	-	1,142	-	**9,189,901**
	447,074,946	**71,487,512**	**3,429,714**	**583,555**	**190,500**	**522,766,227**

Source: Tecnun University of Navarra

The food infrastructure is the one that has suffered the most economic impact due to the disasters that occurred in 2021. This data is clearly influenced by the availability of the data, since this study has had data from Agroseguro but has not had access to data of other critical infrastructures. The calculations for the rest of the critical infrastructures have been made from the news collected and estimates made.





Source: Tecnun University of Navarra

The second most affected critical infrastructure has been transport. Frost and snow storms directly affected roads, cutting them off and requiring cleaning or repair. The hailstorms, rains and DANAS created floods, directly affecting the roads. Finally, the volcanic eruption completely disrupted air travel. Health was the third most affected critical infrastructure, mainly due to the indirect effects of other infrastructure such as transport. The transport conditions increased the inaccessibility of health personnel and patients to the hospital, which generates an economic impact. Energy was also affected, but to a lesser extent than health, due to storms that caused power and gas outages. However, the interruptions were not of long duration. The least affected infrastructure was water, where the damage was mainly due to loss of consumption and damage to critical infrastructure.

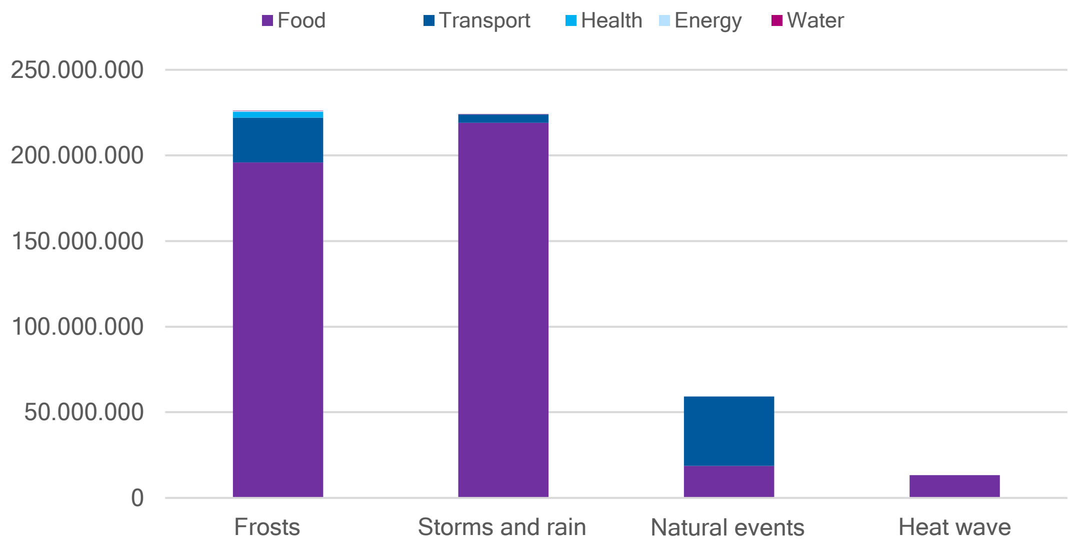
The 10 most significant events of 2021 have been grouped into the following types of event based on the Unesco categorization [18]: events related to extreme weather (cyclones, frost, storms and rain, heat waves, etc.), events related to nature (earthquakes, tsunamis, volcanic eruptions, landslides, etc.). In turn, extreme weather events have been broken down into three types according to their nature: frost, storms and rain and heat waves.

Ranking of 2021 events by type of event

Frosts	Filomena	**Natural events**	Seismic series
	Frosts in March		Volcanic eruption
	Frosts in April		
Tormentas y lluvias	Hailstorm and rain	**Heat wave**	Wind and heat waves
	DANA 1		
	DANA 2		
	Ebro river floods		

In the case of frosts, storms and rains, it is food that suffers the most damage due to the loss of crops. In the case of frost, transport was also affected, but to a lesser extent since it requires cleaning and repair work. Health, energy and water were affected, but their impact was very small since, even if the service is stopped for a few hours, the facilities are not damaged and this reduces the economic impact.

Economic impact on critical infrastructures by type of event, euros



In the case of storms and rains, in addition to food, transport is also affected, cutting roads. However, the impact is less, as traffic is diverted onto alternative roads. Costs increase if roads are damaged or require cleanup. They also increase considerably in case it affects air transport.

Regarding the disasters induced by geological phenomena such as volcanic eruption or earthquakes, the magnitude of the seismic events was relatively low, so they did not significantly affect any critical infrastructure. However, in the case of the volcanic eruption, in addition to the effects on food, air transport was interrupted, which generated a significant economic impact. This situation is very common in the case of volcanic eruptions and in the event that these eruptions occur on an island, it generates important indirect effects on other infrastructures due to the high dependence on air transport.

Finally, in heat waves, the highest impact has been registered in the food infrastructure due to the loss of various crops. Also, there has been an increase in the demand for health services, but no evidence has been found on its economic impact. It should be noted that this is the event where the highest number of deaths have been recorded.

Study limitations

One of the main limitations of this study lies in the lack of data to really estimate the economic impact that these events have generated in the different infrastructures. As explained in the methodology, the data to be able to calculate the cost of damaged equipment and infrastructures and their repair or replacement belong to the private and public companies responsible for the management of critical infrastructures. The availability of these data is very limited and this makes it difficult to estimate the economic impact of disasters.

The data provided by Agroseguro have made it easier to assess the economic impact in the food sector and for this reason it has been seen that it is the sector that has suffered the greatest impact. The data from the Insurance Compensation Consortium have also made it possible to assess the economic impact of some disasters for the transport sector, but the extent of the damage is less.

For the rest of the critical infrastructures, it has not been possible to collect information about the first two types of costs (costs of equipment and infrastructures affected and repair costs). Therefore, these results are clearly conditioned by the data available during the study and therefore the estimates that have been made are conservative.

Conclusions

It has been estimated that the economic impact on critical infrastructures of the most significant disasters in 2021 was 522,766,227 euros. It has been seen that the hail and the rains that occurred between May and June were the events that generated the greatest economic impact on critical infrastructures, followed by frost in April.

Regarding the type of critical infrastructure, food was the most affected sector according to our data, followed by transport. Finally, frost and snowfall were the events whose impacts affected a greater number of critical infrastructures and caused the greatest damage during 2021.

5. Social vulnerability to catastrophes

Introduction

Natural disasters are phenomena with serious human, environmental and economic consequences. Currently, since avoiding them is an impossible task, the best resource available to combat them is anticipation and preparation. An important part of said preparation is the task of developing knowledge that serves to design strategies aimed at reducing, as far as possible, the impact derived from the incidence of the catastrophe. Among the objectives of this long-awaited knowledge is to identify the level of vulnerability of different populations to different catastrophes, in order to respond to them in the most appropriate way. This means minimizing the consequences by optimizing the resources invested.

This chapter presents the results of the research on the phenomenon of social vulnerability and its link with catastrophes carried out by the Aon Spain Foundation Catastrophes Chair in the Comillas Pontifical University. As a result of this research, the design and construction of four indicators of social vulnerability to catastrophes related to four types of catastrophic events that devastated Spain during 2021 have been achieved. The events for which indicators are proposed are: heat waves, snowfalls, earthquakes and torrential rains.

The chapter begins by introducing the conceptual framework used for the design of the set of indicators, followed by the methodological strategy applied in the construction of the indicator, the justification of the catastrophes studied, and ends with the presentation of the results of the indicator for the case of Spain at the provincial level.

Conceptual framing

Vulnerability is an abstract concept and, as such, its definition and consequent measurement differ depending on the interpretive framework from which it is approached. In the study of the impact of catastrophes there is no consensus on the definition and measurement of vulnerability to catastrophes and this is demonstrated by the great diversity of methodological strategies and conceptions present in the scientific literature for their study (Baijnath-Rodino et al. ., 2021; Lam et al., 2014; Papathoma-Köhle et al., 2019, 2019; Shijin et al., 2019). Although, it is true, in recent times the definition of vulnerability proposed by the United Nations Intergovernmental Group of Experts on Climate Change (IPCC) stands out (IPCC 2001, p.995). A multitude of research works have used the scheme proposed by the IPCC for the construction of vulnerability indicators for a wide range of catastrophes and territories (Adu et al., 2018, 2018; Baijnath-Rodino et al., 2021; Flanagan et al. al., 2011; Lam et al., 2014).

According to the said organization, the vulnerability of a population in the face of an environmental catastrophe is a concept made up of three dimensions:

i. degree of exposure
ii. adaptability
iii. population sensitivity

The degree of exposure refers to the level of incidence or the probability at which a population is susceptible to suffering a certain type of catastrophic event. The greater the probability with which this occurs, the higher the risk of the population. Therefore, this is a determining element to know the extent to which a population is vulnerable to a catastrophe. However, exposure is not the only element involved when determining the impact of a catastrophe and the resulting consequences. The level of development and well-being given in society are also extremely important elements. The quality of the infrastructures, the quantity and quality of the services or the general state of health of the population, to mention a few examples, are elements that mediate the capacity of a society to cushion and rebuild itself in the face of a natural catastrophe. .

That is why the conceptual scheme proposed by the IPCC, in addition to considering the purely environmental dimension (degree of exposure to the catastrophe), also includes two dimensions of a social nature. On the one hand, it considers the ability to adapt, which is defined as the ability of a society to resist or recover from a catastrophe. And on the other hand, it also includes the dimension of sensitivity, which refers to the weaknesses that this territory presents and that will hinder or increase the consequences of the catastrophe in the short, medium and long term.

Metodology

As defined by the IPCC, vulnerability results from the interaction between the catastrophic phenomenon and the affected population, being defined based on three dimensions: exposure, adaptability and sensitivity.

Exposure is the easiest dimension to evaluate since it is derived from the measurement of the incidence of physical-environmental phenomena, elements that are especially susceptible to being measured. In addition, since these are socially relevant phenomena and are widely studied, there is a great availability of data that informs about their severity and incidence. However, the other two dimensions (adaptive capacity and sensitivity), being concepts that aspire to capture the idiosyncrasies of societies, are much more difficult to measure constructs. It must be taken into account that societies are complex systems that involve a large number of actors, entities, processes and interactions.

Variables included in the indicators by catastrophe and dimension

	Heat wave	Torrential rains	Snowfall	Earthquakes
Proportion of University students	**a**	**a**	**a**	**a**
Ambulances per 100,000 inhab.	**a**	**a**	**a**	**a**
Urban population rate	**a**			
Number of fire services	**a**	**a**	**a**	**a**
Population with Internet access	**a**	**a**	**a**	**a**
Roads (km)	**a**	**a**	**a**	**a**
Snowplows			**a**	
Flux capacity			**a**	
Urban population		**a**	**a**	**a**
Interprovincial Mobility		**s**	**s**	**s**
Inadequate Temperature			**s**	
Household Agrarian Land (Ha)			**s**	
Seniors living alone (>65 years)	**s**	**s**	**s**	**s**
Unemployment rate	**s**	**s**	**s**	**s**
Crude Birth Rate	**s**	**s**	**s**	**s**
Agricultural Land (ha)	**s**	**s**	**s**	
Dependency Ratio	**s**	**s**	**s**	**s**
Crude Mortality Rate	**s**	**s**	**s**	**s**
Days with more than 30º degrees	**e**			
Snow days in January			**e**	
Magnitude of earthquakes in 2021		**e**		
Daily precipitation > 30 mm (summer months)		**e**		

a = Variable Relative to the Adaptation Dimension
s = Variable Relative to the Sensitivity Dimension
e = Variable Relative to the Exposure Dimension

Source: ICAI Comillas Pontifical University

For this reason, in order to achieve a precise approximation of each dimension, a broad set of indicators is required to provide information on the different elements that it encompasses. However, up to now, there is no standardized agreement on the set of appropriate variables to measure each dimension. Then the selection of these has been made based on the definition of each dimension and the previous literature (Adu et al., 2018, 2018; Baijnath-Rodino et al., 2021; Flanagan et al., 2011; Lam et al. , 2014).

To assess the dimension of exposure, since it is a phenomenon of a physical nature, as mentioned before, and therefore susceptible to being measured objectively, only one variable per catastrophe has been used. While, for the dimensions of a social nature, the ability to adapt and sensitivity, as they are complex constructs, the use of a broad set of variables by catastrophe and dimension has been required.

Once the variables that make up each indicator have been selected, it is necessary to determine their relevance within the dimension. This question, together with the selection of variables, are determining elements for the construction of the indicator, since their choice will significantly condition the results (Becker et al., 2017). According to Beccari's (2016) systematic review on vulnerability indicators, in half of the research papers where an indicator of this type was constructed, all sub-indicators were weighted equally; 25% of the papers did so according to the researchers' arbitrary criteria and the last 25% based on empirical-statistical criteria.

Considering that the empirical-statistical strategy is the least arbitrary, and consequently, reliable, this has been the one selected for the construction of the indicators. Following this line, Papathoma-Köhle (2019) proposes an empirical strategy for determining the weights. In his strategy, the relative importance of each variable within its dimension is determined by its correlation with previous catastrophes, a link estimated through a statistical model. The model in question used by Papathoma-Köhle is the random forest. This technique makes it possible to predict the behavior of one variable from others, in addition to offering the predictive value of each of the explanatory variables. In this way, the importance of each variable within the dimension is the result of weighing the value of the variable, previously standardized, by the value that quantifies its predictive capacity. Then those that show a greater predictive capacity for the severity of the catastrophe will accumulate greater importance in the dimension.

The random forest technique has been applied to estimate the weights of the variables related to the dimensions: adaptability and sensitivity, of three of the four catastrophes studied. For the earthquake catastrophe, it has been decided to apply the linear regression technique instead of the random forest. A technique that, in addition to offering the value of the predictive/explanatory capacity of the variables considered, allows the inclusion of control variables. In the case of earthquakes, it is essential to consider the depth of the hypocenter, the place from which the tremor is triggered, in order to have a better adjustment of the model and consequently avoid biases and achieve more precise estimates. The exposure dimension, since it has only been represented through a variable, has not required the weighting strategy.

Once the procedure for determining the weights has been carried out, the vulnerability indicator has been estimated using the formulation proposed by Hahn et al (2009), which defines vulnerability as:

Vulnerability Index = (Exposure – Adaptability) × Sensitivity

Selection of catastrophic events

The catastrophes studied have been heat waves, snowfalls, earthquakes and torrential rains[3].

A- Index of social vulnerability to heat waves

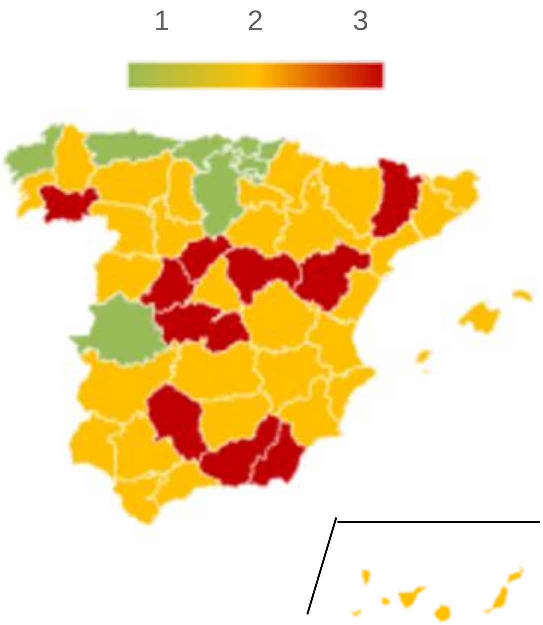
The Spanish climate stands out for being one of the warmest on the European continent, and despite the fact that this characteristic places the country as one of the favorite tourist destinations, the heat is responsible for hundreds of deaths annually. Indeed, the Mortality Monitoring program of the Carlos III Institute estimates that, during the year 2021, around 2,000 deaths in Spain would be attributable to high temperatures, mostly during the summer period. Consequently, the construction of an indicator that reports on the degree of vulnerability at the provincial level in the face of high temperatures has been considered opportune.

Heat wave

Vulnerability indicator weights

Variable	Weight
Adaptation	
Urban Population	35123
Ambulances	3369
Internet Access	21244
Roads (km)	11210
University Population	8279
No. of Fire Services	3048
Sensitivity	
Senior Living Alone	29144
Mortality	20714
Unemployment Rate	19829
Crude Birth Rate	9174
Dependency Ratio	7785
Agrarian Land (ha)	6979
Exposure	
Days with temperature >30 °C	1
Variable Weight	
No. of deaths associated with excess temperatures	

Vulnerability index



The variable used to measure exposure to heat waves has been the average number of days where temperatures exceed 30 degrees during the months of June, July and August (climatological value, reference period 1981-2010). This variable allows us to capture those territories that suffer a greater number of days subjected to intense heat during the months of June, July and August.

According to the data offered by the State Meteorological Agency, the hottest provinces are in the south of the peninsula: Córdoba with 27 days, Seville with 25 days and Granada with 24. On the contrary, the territories that are least exposed to days of intense heat during the summer months are Asturias and Cantabria with less than one day on average and A Coruña, which reports little more than one day on average.

[3] In annex II available in digital version, the calculations made to estimate the vulnerability index are explained in detail.

For its part, according to the results of the indicator derived Adaptation Capacity, the provinces that have reported the best adaptation capacity have been Cáceres, Badajoz and Burgos. In turn, the provinces with the least adaptation capacity are: Ourense, Ávila and Lugo.

As for the provinces with the highest level of sensitivity, we find Cuenca, Teruel and, at a considerable distance from the former, Lugo. While the provinces with the lowest degree of sensitivity are Madrid, followed closely by Barcelona and Alicante. The results of the general vulnerability indicator have been reflected on a map, differentiating the territories according to the three levels of vulnerability, level 1 being: low vulnerability; level 2: intermediate vulnerability and level 3: high vulnerability4.

The map shows that the provinces with a low level of vulnerability are few, specifically 8, most of them located in the north of the country. It is striking that this group belongs to the province of Cáceres, which maintains a high level of exposure (the ninth province that accumulates the most days of intense heat). However, its high adaptability and its intermediate score in the sensitivity sub-indicator give this province an advantageous position with respect to vulnerability to high temperatures.

The group of provinces with intermediate vulnerability is the largest; It is made up of a total of 32 provinces that cover practically the entire map. Of this group, the provinces of Ciudad Real, Jaén and Murcia stand out, both characterized by high exposure and intermediate levels of adaptability and sensitivity.

Regarding the last level of vulnerability, the highest, the group of provinces that make it up are a total of ten, with Toledo being the most vulnerable. The presence of Lleida, Segovia or Ávila may be surprising because they are not populations characterized by high exposure, however, they are territories with high sensitivity. Ourense, for its part, although it does not present such a high degree of sensitivity, appears as a highly vulnerable province, due to its low capacity for adaptation.

B- <u>Social vulnerability index against snowfall</u>

After a hard year 2020 marked by the COVID-19 pandemic, the year 2021 began with another major catastrophe, a storm, known as the Philomena storm, which devastated mainly the central plateau of the peninsula. The snowfall paralyzed a large part of the streets of the capital for weeks, blocking an important productive engine of the country. In addition, it produced various consequences such as damage to urban furniture, damage to public health such as a large number of traffic accidents, bruises, involuntary isolation, etc. Given its considerable impact, as it completely conditions daily life and its derived repercussions, snowfalls during the winter period have been included as another catastrophe of interest.

According to the average data, the provinces most exposed to snowfall during the month of January are the Castilian provinces of Soria, Burgos (with five days of snow), followed by Ávila and Segovia (with 4 and 3 days of snow). Significant data taking into account that a total of 32 provinces show an incidence of less than one day of snow on average between 1981 and 2010, 9 of them being provinces whose probability of snow is negligible, reporting approximately 0 days of snow in this period.

For their part, the provinces with the greatest capacity for adaptation turn out to be Burgos, Cáceres and Madrid. On the contrary, the provinces with the least ability to adapt to snowfall are Guipúzcoa, Pontevedra and Navarra. Regarding the sensitivity dimension, Guadalajara, Cuenca and Almería are the provinces with the highest sensitivity. The provinces with less sensitivity are, in turn, Asturias, León and A Coruña.

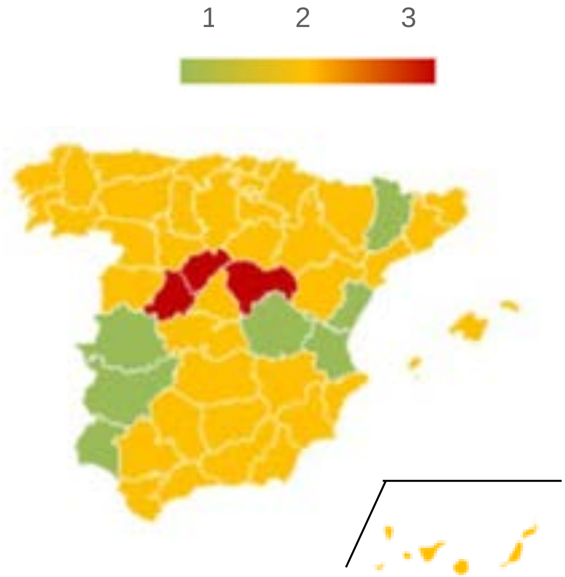
4 The groups have been defined based on their score in the general vulnerability indicator. The provinces belonging to the low vulnerability group are those that have obtained a score equal to or less than 33 points, those in the intermediate vulnerability group between 33 and 66 points and those with high vulnerability a score above 66 points..

Snowfalls

Vulnerability indicator weights

Variable	Weight
Adaptation	
Ambulances	3,42E+15
Urban Population	2,47E+15
Snowplow	2,11E+15
Internet Access	1,43E+15
Roads (km)	7,24E+14
Availability of Fluxes	6,76E+14
University Population	3,73E+14
No. of Fire Services	3,24E+14
Sensitivity	
Unemployment rate	3,17E+15
Seniors Living Alone	2,76E+15
Interprovincial Mobility	1,47E+15
Inadequate Temperature Household	8,49E+14
Agrarian Land (ha)	7,66E+14
Crude Birth Rate	7,23E+14
Dependency ratio	7,11E+14
Exposure	
Number of Snowy Days in January	1
Weight Variable	
Amount of insurance companies for damages caused by snow in Filomena	

Vulnerability index



Regarding the general vulnerability index to snowfall, there are seven provinces that are in the low vulnerability group (they yield a score of less than 33 out of 100 in the indicator). While the intermediate vulnerability group is once again the most numerous, this time even in a higher proportion than in the case of heat waves. It is made up of a total of 40 provinces. The group with the highest vulnerability, however, is made up of only three provinces, with Ávila being the most vulnerable, followed by Segovia and Guadalajara.

C- Index of social vulnerability to earthquakes

With the fateful memory of the Lorca earthquake still in mind, which demonstrated the devastating power of seismic movements, earthquakes are an undeniable catastrophe to consider. In Spain during the year 2021 there were a total of 5,560 seismic movements affecting 36 of the 52 provinces of the national territory, although it is worth mentioning that only 6% exceeded magnitude three on the Richter scale. The most intense ones occurred in Granada in January and December of the same year, and although their presence was felt by the population, the damage caused was slight without actually causing structural damage.

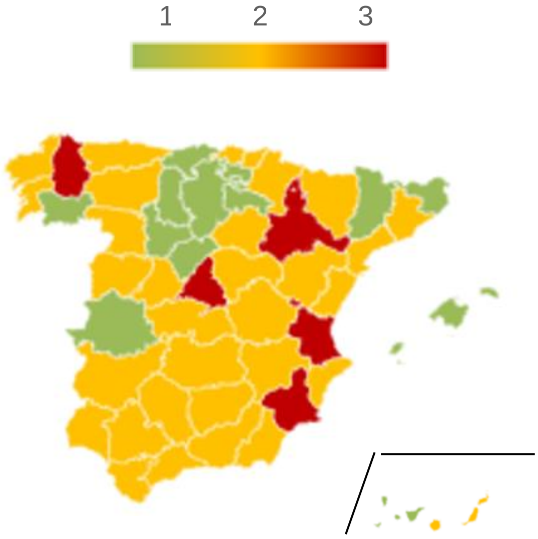
The variable used to evaluate the exposure to earthquakes has been the average seismic magnitude during the year 2021. According to the data of the National Geographic Institute, most of the Spanish provinces witnessed some tremor, a total of 36 compared to the 52 that make up the total of the territory. The province that had a higher average magnitude was Zamora with 2.23 on the Richter scale. This data suggests that the earthquakes have hardly been felt by the Spanish population during the 2021 academic year. Despite this, and given that a tremor of greater magnitude could occur at any time, as has occurred on previous occasions, we must not abandon the work in prevention studying the vulnerability that each province reports.

Earthquakes

Vulnerability indicator weights

Variable	Weight
Adaptation	
Internet Access	0,17
Ambulances	0,04
No. of Fire Services	0,02
University Population	0,02
Urban Population	0,02
Roads (km)	0,00
Sensitivity	
Dependency Ratio	0,37
Unemployment Rate	0,16
Mortality	0,14
Interprovincial Mobility	0,11
Crude Birth Rate	0,05
Senior Living Alone	0,03
Exposure	
Average Seismic Magnitude (2021)	1
Variable Weight	
Seismic Intensity (2017-2021)	

Vulnerability index



According to the adaptation capacity sub-indicator, the provinces with the greatest adaptation capacity are Burgos, Cáceres and Cuenca. While those with the least adaptation capacity are Asturias, Murcia and Guipúzcoa. Regarding sensitivity, Madrid, together with the Catalan provinces Lleida, Girona and Barcelona, are the most sensitive. On the contrary, as less sensitive are Jaén, Huelva and Asturias.

Finally, Madrid appears as the most vulnerable province, largely due to its high degree of sensitivity, followed by Valencia and Murcia. Lugo and Zaragoza complete the group of high vulnerability provinces according to their score on the indicator. As usual, most of the provinces are found in the intermediate group of medium vulnerability. While now the least vulnerable group is significantly more numerous than for previous catastrophes, being made up of a total of 13 provinces. Among them, Segovia, Lleida and the Balearic Islands stand out due to their low score in the indicator.

D- <u>Index of social vulnerability to torrential rains</u>

Summer storms and convective precipitation, associated or not with a DANA, are the last catastrophe analysed. It is included because of its great damage both at a health and economic level, as well as because it is one of the most frequent catastrophic episodes that devastate the Spanish territory.

The variable collected to assess the degree of provincial exposure is the number of days with very heavy rainfall (>30mm). This variable allows us to know which are the provinces most susceptible to suffering this type of episodes, however, it reports a weakness. By working with the frequency of days where the event occurred (instead of a variable that reports their intensity), areas where it rains for a few days, but disproportionately intense (as usually happens on the Mediterranean coast) will enjoy a hidden role at the exhibition level. Taking this limitation into account, the indicator has been built, in the absence of a more precise variable that avoids said bias. Consequently, the provinces that suffer from very heavy rains on a greater number of days as a climatological value, are Pontevedra, Guipúzcoa, A Coruña and Girona. While the least are Las Palmas, La Rioja and Soria.

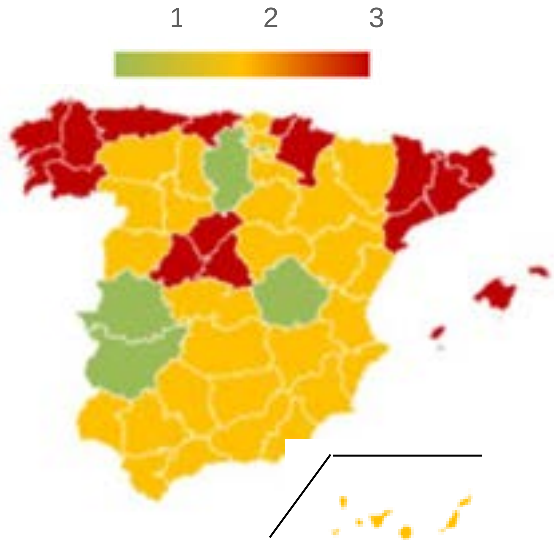
At the level of adaptability, Cáceres ranks as the best prepared province, then Badajoz appears at a reasonable distance and Burgos considerably below the first. The least adapted are Ourense, the Balearic Islands and Ávila.

Very heavy rain

Vulnerability indicator weights

Variable	Peso
Adaptation	
Ambulance Rate	4,04E+12
Urban Population Ratio	3,64E+12
Internet Access	1,68E+12
Road (km)	9,24E+11
University Population No. of Fire	9,05E+11
Services	5,62E+11
Sensitivity	
Crude Mortality Rate	3,18E+12
Older Population Living Alone	2,53E+12
Dependency Rate	1,80E+12
Unemployment Rate	1,77E+12
Interprovincial Mobility	1,65E+12
Gross Birth Rate	5,36E+11
Agrarian Land (ha)	4,06E+11
Exposition	
Very Heavy Rainy Days	1
Exposition variable	
Amount of insurers for damages caused by rain in Filomena	

Vulnerability index



Lugo heads the list of territories with the greatest sensitivity, followed by Cuenca and Zamora. Madrid, along with Las Palmas and Barcelona are the provinces that appear to be less sensitive to very heavy rains.

Regarding the index of vulnerability to very heavy rains, the group of provinces with low vulnerability is scarce, made up of Cuenca, Cáceres, Burgos and Badajoz. The medium vulnerability group is again the most numerous group with a total of 30 provinces. While the high vulnerability is made up of a total of 16, placing this catastrophe as the one that reports the largest number of provinces with a high vulnerability index. Most of them are located in the northern region of the country, with the four Galician provinces being the most vulnerable, and a few in the center of the peninsula (Madrid, Soria and Segovia).

Conclusions

This is the first scientific approach to measuring social vulnerability to catastrophes carried out in the national territory. It is worth mentioning that the scope of the results, in terms of their precision, is constrained by limitations of a methodological nature that have to do with the availability of precise data at the territorial level. With data with a higher level of disaggregation and more empirical studies, which support the selection and suitability of variables for each subdimension of the vulnerability indicator, estimates with a higher degree of precision could be obtained. In any case, the present investigation offers relevant results for the well-being of the Spanish population, in addition to assuming a necessary starting point through which to continue paving the way towards preventing the impact of natural catastrophes. A task that becomes even more necessary in a context of climate change where extreme weather events are expected to increase in number and intensity.

Conclusions y recommendations

In 2021 we have witnessed natural or accidental catastrophes that have caused destruction to property and people, causing significant economic losses in Spain that year. Taking only those insured assets as a reference, the costs derived from these extreme phenomena amounted to more than 2,320 million euros, with the compensation paid for this type of event being 63% higher than in 2020 and 29% higher than in 2019 (in constant euros).

In terms of the direct and indirect economic impact of natural catastrophes in Spain on GDP and employment, the Input-Output methodology, developed by the Russian economist Wassily Leontief (Nobel Prize in Economics in 1973), has been used. Natural catastrophes in Spain caused in 2021 material losses worth around 1,300 million euros, of which only 41% would be insured. 84% of the losses were concentrated between the months of September and December, coinciding with the main floods and storms after the summer, as well as the consequences of the volcanic eruption on the island of La Palma. In turn, the consequences of the Filomena storm stand out, whose material damages represented around 10% of the annual total. The impact on income of natural catastrophes in 2021 caused Spanish companies to stop directly entering around 1,492 million euros (51% covered and 49% uncovered). 99% of this turnover loss was concentrated in agricultural and livestock activities, by far the sector most exposed to meteorological phenomena.

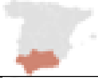
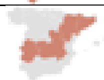
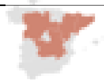
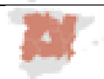
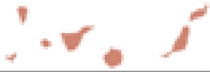
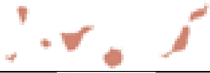
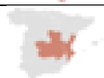
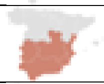
In terms of human cost, the year 2021 has fortunately been the year with the fewest human losses due to natural disasters, amounting to a total of 19, the lowest data in the series of twenty-seven years analysed. The first cause of death in 2021 has been due to landslides, avalanches and snow storms, coinciding with the Philomena storm. The second cause of death has been due to heat waves. Three Autonomous Communities, Andalusia, Catalonia and Asturias, concentrate close to 70% of the total human losses caused by natural disasters in 2021.

In terms of impact on critical infrastructures, three dimensions can be distinguished: costs of equipment and infrastructures affected by the disaster; personnel costs for repair or replacement of damage; and finally, costs of loss of consumption due to the lack of income because of the unavailability of the service or good not provided. It has been estimated that the impact of these ten catastrophes on critical infrastructures was more than 522 million euros, with the hail and rains that occurred between May and June having the greatest impact, followed by frost in April. Frost and snowfall were the events whose impacts affected a greater number of critical infrastructures and caused the greatest damage during 2021.

In terms of social vulnerability, the results constitute a first scientific approach to its measurement in the face of catastrophes and represent a necessary starting point through which to continue working towards preventing the impact of natural catastrophes.

In short, the total cost of the annual catastrophes in Spain would amount to around 3,600 million euros, adding the impacts on goods, direct and indirect GDP and critical infrastructures (non-food). Of this amount, only 2,300 million euros would be insured, so approximately one third of the damage caused by these natural phenomena in our country would not be protected by insurance.

Natural events that caused the most observable damages (indemnities paid) in Spain in 2021

Start	Duration	Event	Affected areas	Insured cost
1 January	19 days	Frost, snowfall and floods (Filomena)		505 million €
1 January	31 days	Seismic series		18 million €
19 March	6 days	Frost		83 million €
12 April	8 days	Frost		20 million €
23 May	32 days	Hailstorm and rain		120 million €
14 August	5 days	Wind and heat wave		10 million €
1 September	90 days	Volcanic eruption (La Palma)		233 million €
1 September	2 days	DANA		78 million €
13 September	13 days	DANA		99 million €
1 December	31 days	Flood		96 million €

Source: Afi based on Agroseguro and CCS

Reflections

The research team and the members of the Scientific Committee who have advised and guided the elaboration of this Barometer are aware that the ideal cost estimate, the one that comes closest to reality, should systematically consider, in addition to the data already considered from the amounts of compensation disbursed and the economic costs of emergency interventions, those associated with the following dimensions:

- The cost of all those assets and activities affected that are not insured.
- The cost of all those repair and reconstruction works assumed by the public budgets of the different competent ministries, Autonomous Communities and local corporations such as, for example (and these are only examples), those associated with the repairs of the damage caused by DANAS in the Maritime Terrestrial Public Domain (DMPT) by the Ministry of Ecological Transition and Demographic Challenge (MITECO), or the costs of repairing roads by the Ministry of Transport, Mobility and Urban Agenda (MITMA).
- The costs of all those repair and reconstruction works assumed in their budgets by the entities owning the infrastructures, such as, for example, those assumed by Adif for the repair of damage to railway infrastructures caused by natural disasters.
- The costs faced by families and businesses in terms of opportunity cost: loss of working hours, loss of schooling hours, inability to access service provision, waiting times, etc.
- Other effects that may materialise in the short, medium or long term and that are not visible or identifiable in the immediate aftermath of the disaster event.

However, being aware of the above, this work has attempted, through five complementary methodological approaches, to make progress in closing the knowledge gap and to point out the limitations identified so that subsequent exercises can broaden the scope and depth of the analysis. This is an essential task in a context of climate change where extreme weather events are expected to increase in number and intensity.

Recommendations

It is essential **to improve data availability in terms of quantity, granularity, diversity and timeliness.** To this end, it will be ideal to broaden the sources of available information and aspire to have a single point of information and data (avoiding data silos) to which the different agents responsible for its generation, capture, storage and analysis contribute, including public administrations and companies managing, for example, critical infrastructures. Establishing collaboration frameworks with all those agents likely to collaborate in this purpose is a basic recommendation emanating from this Barometer.

It is also indispensable **to seize the opportunity and recognise the urgency of intensifying prevention, mitigation and adaptation efforts in the face of the evident increase in the frequency and intensity of this type of catastrophes**, many of which are associated with climate change. These efforts include raising awareness among the population, businesses and households of the importance of being insured, and incorporating climate risks into decision-making.

It is also important **to make visible the efforts made by public and private agents to alleviate the most immediate effects of catastrophes in Spain,** in terms of insurance, compensation, repairs and reconstruction.

It is also very important **to remember the basic recommendations of the Directorate General for Civil Protection and Emergencies**, which, as a governing body whose aims include promoting preventive actions and extending the culture of self-protection, provides information on how to be better prepared for an emergency situation, as well as how to act in these situations. Let us remember that emergency situations are sudden and occur without warning.

1. At home, have a kit of basic survival items ready. Don't forget the specific needs of certain family members, such as people with disabilities, babies and the elderly.

2. When travelling, check weather forecasts, road conditions and public transport.

3. If it is essential to take the car, plan your journey, equip yourself and drive with caution.

4. As a precaution, if you are in an enclosed area, check the emergency routes and exits.

5. If an emergency situation arises, call the single emergency number 112 and follow the instructions given by the operator. Communicate clearly and concisely what is happening. Once the call has been made, do not use the telephone to avoid overloading the lines.

6. In the event of an evacuation, leave the building immediately and don't linger around picking up personal belongings. Walk quickly, but do not run, and never use the lift.

7. If an emergency occurs in an industrial establishment near your home, stay indoors or take shelter in the nearest closed premises by closing doors and windows.

8. In the event of an emergency, remain calm and act calmly and quickly.

9. Avoid spreading and listening to rumours that generate confusion. Get information from official sources and remain attentive to their recommendations.

10. Pay attention to the forecasts and updated news that the media are giving about the emergency. Act prudently and follow the guidelines of the authorities so as not to hinder the work of the emergency teams.

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