

Fundación

AON

España

Barometer of Catastrophes 2021

23rd November 2022

ANNEXES

Annex - Critical Infrastructures

The details of the calculations made to estimate the economic impact for each disaster are explained below.

➤ Philomena (period: 02/01/2021 – 20/01/2021)

In the case of Philomena, the most affected critical infrastructures were Energy, Water, Transport, Food and Health. Although not directly considered as a critical infrastructure, the impact of the Filomena disaster on education is also noteworthy. Several schools in the autonomous communities of Madrid, Aragón, Castilla la Mancha, Castilla y León, Valencia and Catalonia had to close and delay the start of the Christmas holidays due to travel constraints and in some cases repair work [19]-[21]. The impact on each of the critical infrastructures is analysed below:

i. Energy

Energy is one of the most important infrastructures. A failure in the energy supply affects most other infrastructures. There are several sources of energy: electricity, gas and oil. Therefore, when analysing the effects of a disaster on the energy infrastructure, it is necessary to consider the different types of energy and for each type the parts of the supply: generation, distribution and marketing.

Philomena mainly affected final distribution and consumption. Despite the severity of the storm, no significant events affected generation and transmission in general, according to Red Eléctrica de España's sources [22]. Squall Filomena directly affected final distribution lines and the consumption of different types of energy, leaving final consumers with gas and electricity outages. Therefore, in this case the economic impact is calculated only taking into account the cost of loss of consumption and it is estimated that the costs of repair or replacement of infrastructure and personnel costs for repairs are 0. Using the formula developed for the loss of consumption and the data presented in the methodology, the economic impact on energy is calculated.

For the cost of loss of electricity consumption, taking into account the effects it had in different places, it has been estimated that 45,000 homes were affected for two days [23]-[29], so the cost would be:

$$\text{Cost Electricity} = 3.80659 * 45,000 * 2 * 1.2 = 411,111.72 \text{ €}$$

For the cost of loss of gas consumption, taking into account the effects it had in different places, it has been estimated that 22,000 homes were affected for one and a half days [23]-[29], so the cost would be:

$$\text{Cost Gas} = 3.874 * 22,000 * 1.5 * 1.2 = 153,410.4 \text{ €}$$

Therefore, adding the two costs together, the total energy cost would be: 564,522.12 €.

ii. Water

The effect of Filomena on water supply was mainly secondary, as it was a consequence of the power outage that did not allow pumps to operate to deliver piped water to the homes of thousands of people [27].

Again, the economic impact will be calculated only taking into account the cost of loss of consumption and it will be estimated that the costs of repair or replacement of the infrastructure and the costs of repair personnel are 0 as there was no damage to the infrastructure.

Using the formula developed for the loss of consumption and the data presented in the methodology, the economic impact on the Water Infrastructure is calculated.

For the cost of loss of water consumption, it has been estimated that 50,000 homes were affected for three days, so the cost would be:

$$\text{Cost Water} = 0.27 * 50,000 * 3 = 40,500 \text{ €}$$

iii. Food

The Filomena effect directly affected the production of several crops and also the distribution of food. A part of the production of different crops was affected and could not be recovered. However, not all of the crop was affected and supply was able to recover when transport returned to normal operation.

Final consumption was also affected, but recovered quickly, as people replenish the stock not consumed during the days when it could not be purchased. Therefore, the cost of lost consumption will be considered negligible.

To calculate the economic impact, we will use Agroseguro data on indemnities assuming 70% insurance coverage [30]. The indemnities amounted to 41,102,716 euros. The total cost would therefore be: 58,718,165.71 €.

iv. Health

In the case of Philomena, both emergency services and hospitals for emergency patients were affected by the lack of staff who could not reach the hospital due to transport blockades. In addition, both outpatient and hospital services had to be postponed, as many of the patients could not reach the facilities.

In this case, the economic impact is calculated by taking into account the salary cost of the employees who did not carry out their work either because they could not reach their workplace or because patients could not reach the outpatient clinic or hospital.

Considering an average of 14 consultations per day and 4,000 primary care physicians in the autonomous community of Madrid [31], and considering that the condition lasted 3 days, the number of missed consultations amounts to approximately 170,000 consultations. The average gross salary of a doctor in Spain is estimated at 60,000 euros per year [32]. Regarding hospitals, there is no data on how many surgeries were postponed and whether they had any negative impact. Therefore, this cost is not included in the estimate.

$$Cost\ Health = 4,000 \left(\frac{doctors}{day} \right) * 3 (days) * \frac{60,000}{210} \left(\frac{€}{day} \right) = 3,428,571.43 €$$

v. Transport

In the case of Philomena, large amounts of snow blocked railways, roads and air transport runways. Philomena had a direct effect on transport infrastructure and this generated indirect effects on other infrastructure such as health and food.

To estimate the cost incurred by Philomena on Transport Infrastructure, we have to consider two main aspects: the loss of consumption caused by the cancellation of flights and trains and the repair cost required to release and repair the affected roads.

At Madrid airport alone, an estimated 700 flights were cancelled [33]. In rail transport, 183,000 passengers were affected [34]. To free up the train lines and respond to the incidents, around 5,700 professionals were mobilised for 3 days and RENFE mobilised around 2,000 professionals from different areas for two days. Filomena affected 657 roads, 133 of which were closed. 13,000 trucks interrupted freight transport and were gradually released over the 3 days. 3,000 employees and contract staff were mobilised to remove snow from 100,000 km of roads and preventive treatments were carried out on 632 km [35].

To estimate the economic impact, the cost of lost consumption due to cancelled flights and trains has been calculated.

Estimated cost of cancelled flights: to calculate this cost, it has been taken into account that if a flight is cancelled due to natural causes, then there is no compensation and only the cost of the ticket is refunded to the user. Let us assume that the average cost of a plane ticket is 200 euros and that the average capacity of a plane is 180 people [36]. Taking into account that 700 flights were cancelled, assuming a flight occupancy of 90%, the total cost would be:

$$Total\ cost\ in\ the\ aviation\ sector = 700 * 200 * 180 * 0.9 = 22,680,000 €$$

Estimated cost of cancelled trains: to calculate this cost it has been assumed that the average cost of a train ticket is 10 euros per passenger. Taking into account that Filomena affected 183,000 passengers then, the total cost would be:

$$Total\ cost\ in\ the\ railway\ sector = 183,000 * 10 = 1,830,000 €$$

Estimated cost of clearing and repairing affected roads: the Ministry of Transport, Mobility and Urban Agenda estimates the daily cost of winter viability at 370,000 euros [16]. If we take into account that the storm lasted 3 days and that it affected the whole country to a greater or lesser extent, we can estimate the cost of clearing roads. To this we have to add the preventive maintenance that was carried out. Taking into account that the annual maintenance cost per km is 80.000 euros [17], then:

$$\begin{aligned} \text{Cost of road cleaning} &= 370,000 * 3 = 1,110,000 \text{ €} \\ \text{Cost of preventive maintenance} &= 632 * \frac{80,000}{365} * 3 = 415,561.64 \text{ €} \end{aligned}$$

This brings the total cost in the transport sector to 26,035,561.64 euros.

➤ March frosts and poor fruit set (period: 19/03/2021 – 24/03/2021)

The frosts in March affected the autonomous communities of Catalonia, Aragon, Castilla la Mancha and Extremadura. In the case of these autonomous communities, the only critical infrastructure affected was food.

The main agricultural productions affected were fruit trees (apricot, peach, nectarine, flat peach and cherry), almond trees, vines and vegetables [37], [38].

To calculate the economic impact, we used Agroseguro data on indemnities assuming 70% insurance coverage [30]. The indemnities amounted to 77,285,120.98 euros. The total cost would therefore be: 110,407,315.7 €.

➤ Seismic series in Andalusia (period: 17/04/2021 – end of 2021)

From the beginning of April until the end of the year there was a seismic series that affected the south of the peninsula, specifically Andalusia and Melilla with epicentres in the southern area of the Alboran Sea, with a total of 3180 earthquakes, 184 of which were stronger than 2.0 on the Richter scale. The strongest earthquake of 5.1 occurred on 28 August and tectonic activity in the area increased that month. However, these earthquakes did not have any significant impact on critical infrastructure and therefore the economic impact was negligible in this dimension.

➤ Frosts in April (period: 12/04/2021 – 19/04/2021)

The April frosts mainly affected the autonomous communities of Castilla la Mancha, Castilla y León, Aragón, Comunidad Valenciana and Cataluña. As in the case of the March frosts, the critical infrastructure affected was food due to one of the worst one-off meteorological phenomena suffered by the Spanish countryside in the last 42 years.

The most important effects occurred in crops that were at very sensitive stages of growth and development. In the case of fruit trees, most of the damage corresponded to peach orchards,

but also to pear, apple, apricot and plum production. The frost also had a significant impact on almond trees, and to a lesser extent on persimmon, cherry, pea, sugar beet, rapeseed and early wine grape varieties [39].

To calculate the economic impact, we used Agroseguro data on indemnities assuming 70% insurance coverage [30]. The indemnities amounted to 18,778,121.15 euros. Therefore, the total cost would be: 26,825,887.36 €.

➤ Hailstorm and rains (period: 23/05/2021 – 23/06/2021)

The hail and rainfall in May and June mainly affected critical food, transport and health infrastructures. The most affected autonomous communities were Castilla y León, La Rioja, Castilla la Mancha, Extremadura, Aragón, Comunidad Valenciana and Comunidad de Madrid.

The heavy storm caused heavy rainfall, which mainly affected agriculture and transport [40], [41]. It also caused trees to fall, affected roofs, leaks and flooding in some homes, and affected public order and safety [40]. However, there is no information on the cost of these consequences. Finally, due to the storm, several COVID-19 vaccination campaigns had to be suspended [40], [41]. Although this affected the health infrastructure, its cost is nil as these vaccines were dispensed later.

i. Food

According to Agroseguro, hail and heavy rains mainly affected the autonomous community of Castilla y León [42]. To estimate the economic impact on the agricultural sector, Agroseguro data on indemnities were used assuming 70% insurance coverage [30]. The indemnities amounted to 86,674,441.96 euros. The total cost would therefore be: 123,820,631.4 €.

ii. Transport

The hail and heavy rains created serious traffic disruptions throughout the country. In addition, it also affected railways according to data from the insurance compensation consortium.

To calculate the economic impact of the damage caused by this event, data from the Insurance Compensation Consortium on compensation payments were used, assuming 70% insurance coverage [30]. Compensations amounted to 720,074 euros. Therefore, the total cost would be: 1,028,677.14€.

➤ Wind and heat waves (period: 11/08/2021 – 16/08/2021)

Between 11 and 16 August, Spain and later the Canary Islands suffered a 6-day heatwave episode with record temperatures since 1975 [43]. The high temperatures mainly affect food due to crop losses, but also affect the health sector due to the number of deaths and the increasing demand on emergency services to attend to those affected.

iii. Food

The heat wave mainly affected crops in the Canary Islands between 16 and 18 August, causing the destruction of plants, leaves and fruit. Banana production in particular was affected, but also wine grapes, avocado, live plants and vegetables.

To calculate the economic impact, we used Agroseguro data on indemnities assuming 70% insurance coverage [30]. The indemnities amounted to 9,320,603.84 euros. The total cost would therefore be: 13,315,148.34 €.

iv. Health

During the entire summer of 2021, an estimated 1,298 deaths were attributable to heatwave-related excess temperatures. Of these, 54% occurred in August, and almost 90% between 11 and 20 August (during the heatwave)[44]. The economic cost of these deaths will be estimated in the socio-economic impact chapter.

Also, there was a 30% increase in hospital demand due to the extreme situation [45], [46]. However, there is no indication that this increase resulted in any extra cost, therefore, the economic impact will be considered as not significant.

➤ DANA and hailstorm (period: 30/08/2021 – 02/09/2021)

The DANA at the end of August mainly affected the Autonomous Communities of Madrid, Navarre, Valencia, Catalonia and Castilla la Mancha. The critical infrastructures that were most affected were Food, Energy and Transport.

i. Food

The DANA affected mainly grape wine cultivation (70%) and to a lesser extent autumn outdoor horticulture, nuts, olive groves and spring and summer outdoor horticulture.

To calculate the economic impact, we used Agroseguro data on indemnities assuming 70% insurance coverage [30]. The indemnities amounted to 21,274,925.36 euros. The total cost would therefore be: 30,392,750.51 €.

ii. Energy

The heavy rains left 10,000 users in the Alcanar area without electricity supply from early morning until the afternoon (12 hours) [47]-[49]. Using the formula developed for the loss of consumption and the data presented in the methodology, the economic impact on energy will be calculated. For the cost of loss of electricity consumption it has been estimated that 10,000 users were affected for 12 hours days [47], [48] so the cost would be:

$$\text{Cost Electricity} = 3.80659 * 10.000 * 12/24 * 1 = 19,032.95 \text{ €}$$

iii. Transport

The heavy rains and flooding caused traffic problems with several roads closed in different parts of the country such as Tarragona, Castellón, Navarra, Lugo, Cuenca, Segovia, and Toledo. In order to remove the mud and sludge from the roads, snow ploughs were used [48].

The railway network between Vinaròs and Castelló was also affected, but this was resolved by transferring the affected passengers by road [48], [50]. In total, 12 trains were affected and almost 200 passengers had to be transferred by road in order to reach Vinaròs.

To calculate the economic impact of the damage caused by this event on transport, data from the Consorcio de Compensación de Seguros (Insurance Compensation Consortium) on compensation payments were used, assuming 70% insurance coverage [30]. Compensations amounted to 894,342 €. Therefore, the total cost would be: 1,277,631.43 €.

➤ DANA and hailstorm (period: 15/09/2021 – 25/09/2021)

The DANA at the end of August mainly affected the Autonomous Communities of Valencia, Andalusia, the Balearic Islands, Castilla la Mancha and Extremadura. The critical infrastructures that were most affected were Food, Water and Transport.

i. Food

The September drought not only caused the usual flooding in cold drops, but was also accompanied by heavy hailstorms that aggravated the damage in the countryside [51]. This drought affected a larger geographical area than usual, including the communities of the Mediterranean arc (Valencia, Catalonia, Murcia and Andalusia) and the central and south-western communities of the peninsula such as Castilla-La Mancha, Extremadura and Castilla y León. Although education is not considered a critical infrastructure, it is worth mentioning that in the province of Huelva eight educational centres in the municipalities of Lepe, Cartaya, Ayamonte and Isla Cristina had to be evacuated as a result of the floods and some of them caused damage to their infrastructures [52], [53].

The main damage affected persimmon and citrus fruit production. Rice, almond trees, maize, fruit trees, wine grapes and table grapes, among others, were also affected.

To calculate the economic impact, we used Agroseguro data on indemnities assuming 70% insurance coverage [30]. The indemnities amounted to 40,773,272.7 euros. Therefore, the total cost would be: 58,247,532.5 €.

ii. Water

Due to the floods in the area of Cuevas de Campo (Granada), the Junta de Andalucía earmarked 150,000 euros to repair the damage to the supply network [52], [53].

iii. Transport

The heavy rains and flooding that occurred caused traffic problems with several roads cut off in different parts of the country [52], [54]: Balearic Islands (road between Manacor and Campos and the Levante motorway), Andalusia (Cartaya road A-5053 and road N-431, Aljaraque road A-497), Extremadura (in the municipalities of Zafra, Mérida and Almendralejo).

There was also damage to the railway network infrastructure, interrupting its service [52]. According to data from the Insurance Compensation Consortium, compensation for damage caused by this disaster in the transport sector amounted to 3,078.48 €. Assuming 70% insurance coverage [30], the total economic impact was 4,397.83 €.

➤ La Palma Volcanic Eruption (period: 19/09/2021 – 13/12/2021)

In the case of the volcanic eruption, the effect on critical infrastructure was not very severe. The two most affected infrastructures were agriculture (food) and transport. There was also some minor impact on health infrastructure, due to the demand for medical care related to ash poisoning.

Agro-industry, in particular banana and plantain production near the volcanoes, was completely destroyed. Part of the production was already affected by a heat wave during the summer of 2021.

The other infrastructure affected was air transport and road transport. Due to the ash and smoke expelled by the volcano, many flights to and from the island of Las Palmas were cancelled.

The health infrastructure was not directly affected, but the health of the population may be affected in the future by the intoxication caused by the ash gases.

i. Food

The volcano eruption directly affected banana and plantain production near the volcano. Agroseguro is not responsible for the crops affected by the volcano as this event is not covered by its policies. Therefore, these losses will be covered by the public administration and are estimated at 18.8 million euros [55], [56].

ii. Transport

The volcanic eruption mainly affected two types of transport: roads and air transport.

In total, 73.8 km of roads were affected by the volcano, namely: LP-2, LP-212, LP-213, LP-211, LP-2132 and LP-215. Therefore, the north-south communication on the west side of the island was completely interrupted, isolating the municipalities and farms of Los Llanos de Aridane, Tazacorte and El Paso.

To mitigate these effects, the Ministry of Transport, Mobility and Urban Agenda, by means of a declaration of emergency, will build a new road some 5.5 km long between Puerto Naos and Tzacorte, which will re-establish the road connection on the western side affected by the volcanic eruption. At the same time, a stretch of road not affected by the volcano will be upgraded to absorb and distribute the traffic that now travels along the western strip affected by the volcano. The investment is estimated at 38 million euros [57].

Total cost for roads = 38,000,000 euros.

Regarding the air sector, it is estimated that more than 500 flights were cancelled arriving and departing from the Canary Islands during the almost 3 months of the volcanic eruption [58]. Assuming an average of 100 passengers per flight (as many flights are inter-island), we estimate that 50,000 passengers were affected. If we estimate the average cost of a ticket to be 50 euros per person, the estimated loss is 2,500,000 euros.

Total cost in the airline industry = 2,500,000 euros.

This brings the total cost to: 40,500,000 euros.

iii. Health

This infrastructure was not directly affected as the hospitals were able to care for the people, mainly affected by gas and ash poisoning. However, there are other consequences that appear in the medium and long term. The number of deaths between September and December 2021 on La Palma was twice as high as in those same months in the Canary Islands as a whole [59].

➤ Floods in the Ebro basin (period: 10/12/2021 – 16/12/2021)

The Barra squall left heavy rains and huge amounts of precipitation, facilitating the flooding of the Ebro River. This phenomenon mainly affected three autonomous communities: Aragón, Navarra and La Rioja.

In La Rioja, the flooding of the river caused flooding of agricultural land and also affected water catchment wells for drinking water supply. Several roads were also cut off due to the event.

In Navarre, at the height of Tudela, the river overflowed its banks and flooded all the streets of the municipality. Several roads had to be closed, as well as the AP-15 motorway, the N-113 and other secondary roads as they passed through Cabanillas and Fustiña. In addition, the floods caused two deaths, one in Elizondo and the other in Sumbilla.

In Aragón, it mainly affected rural areas, significantly affecting agriculture in that area.

i. Transport

Due to the floods caused by the rise of the Ebro, several roads were cut off. In Navarre, the overflowing of the river Arga left streets and garages flooded and roads closed in the Pamplona region [60]. The AP-15 and the N-113 were closed at several points in the Castejón area [60]. In the town of Miranda (Burgos), several streets were also closed [60]. In the Basque Country, in the Deba basin, the overflowing of the river Kilimon caused the road and access to the Mendaro Hospital to be cut off, and the fire brigade provided assistance in moving staff and material to the health centre [60]. In Aragon, the flooding also caused cuts on provincial roads CP-002 in Novillas, CP-003 in Pradilla de Ebro, and in Gallur [61].

To calculate the economic impact of the damage caused by this event on transport, data from the Insurance Compensation Consortium on compensation payments were used, assuming 70% insurance coverage [30]. Compensations amounted to 1,848,871 euros. Therefore, the total cost would be: 2,641,244.29 €.

ii. Health

Due to the overflowing of the river Kilimon, the access roads to Mendaro Hospital were cut off. Due to this, endocrinology, otorhinolaryngology, cardiology stress tests and rheumatology consultations were cancelled [62]. In this case, the economic impact will be calculated taking into account the cost of losses of services (consultations or surgeries) not provided or performed. Considering an average of 14 consultations per day and one doctor per speciality (4 in total), and considering that the condition lasted 1 day, the number of consultations not performed was 56. The average gross salary of a doctor in Spain is estimated to be 60,000 euros per year [32]. Therefore, the cost of cancelling these consultations had an economic impact of:

$$Cost\ Health = 4 \frac{Doctors}{day} * 1 (day) * \frac{60,000}{210} \left(\frac{€}{day} \right) = 1,142.86€$$

In addition, in order to be able to respond to the demand, the staff at the Eibar PAC was reinforced and increased due to the inaccessibility of the Mendaro hospital [62]. However, there is no data on how much these reinforcements were.

iii. Food

The floods affected the following crops in Navarra: broccoli, cauliflower, cornfields, winter cereals, alfalfa, artichoke, asparagus and cardoon [63]. It also caused damage to fruit trees, vineyards, olive groves and nuts [63]. In addition to this damage to agricultural crops, there was also damage to agricultural infrastructures, estimated at around 2,000 hectares affected [63].

To calculate the economic impact, we used Agroseguro data on indemnities assuming 70% insurance cover [30]. The indemnities amounted to 4,583,259.84 €. The total cost would therefore be 6,547,514.06 €.

Annex - Social vulnerability

Figure. Heat wave Catastrophe Indicator and Subdimensions Score

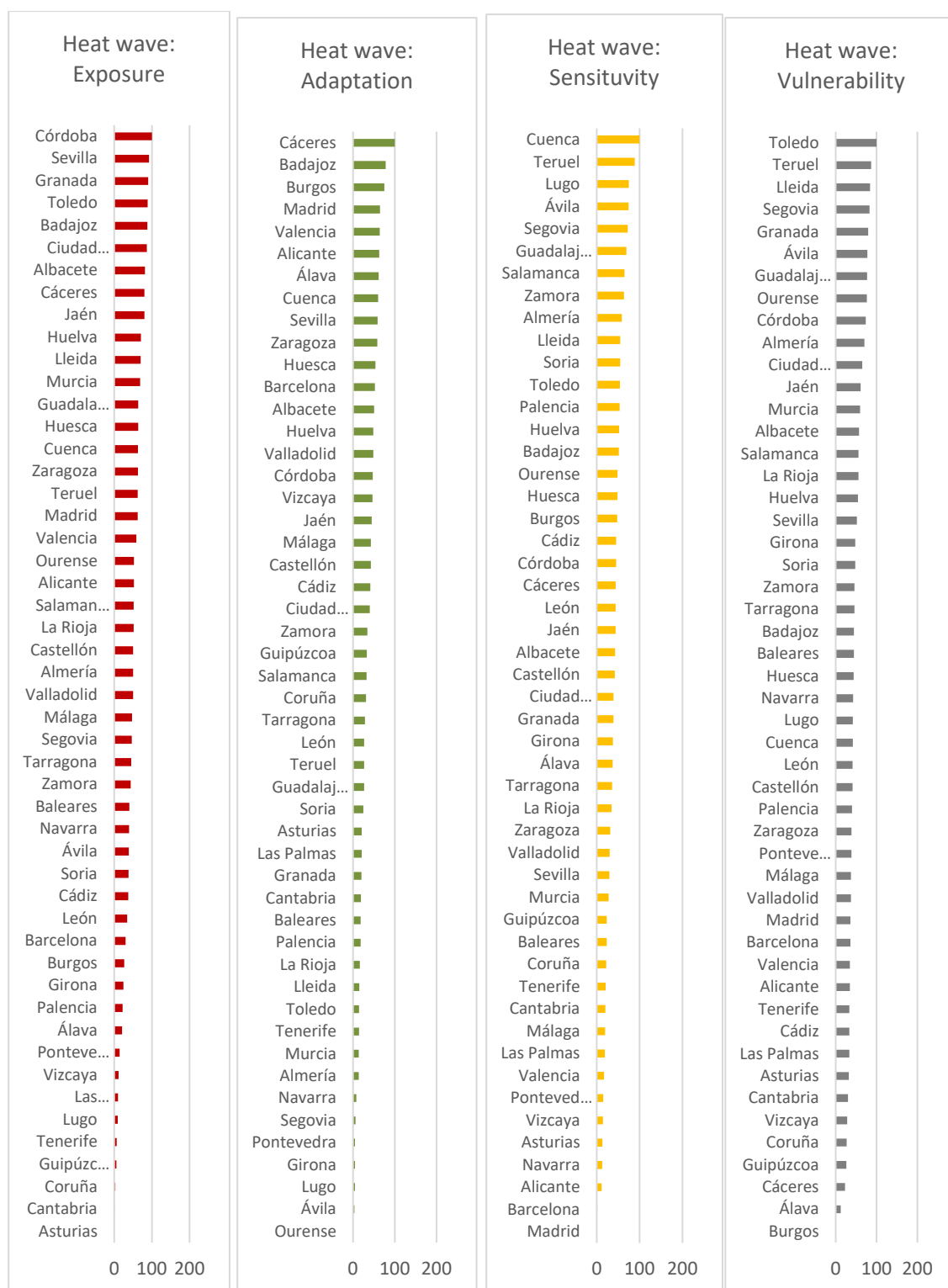


Figure. Indicator Score and Sub-Dimensions Related to the Snowfall Disaster

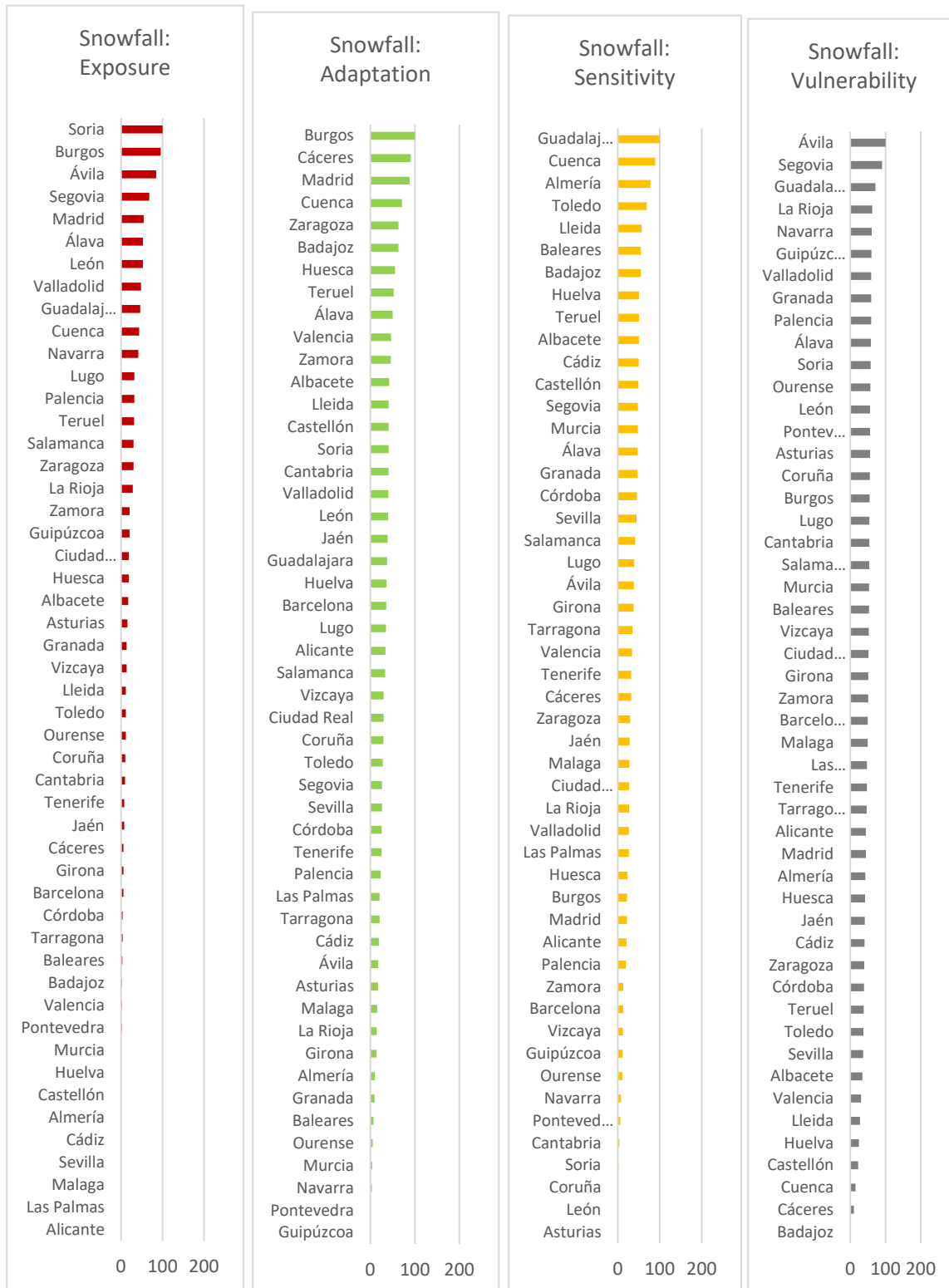


Figure. Indicator Score and Subdimensions Related to Disaster Earthquakes

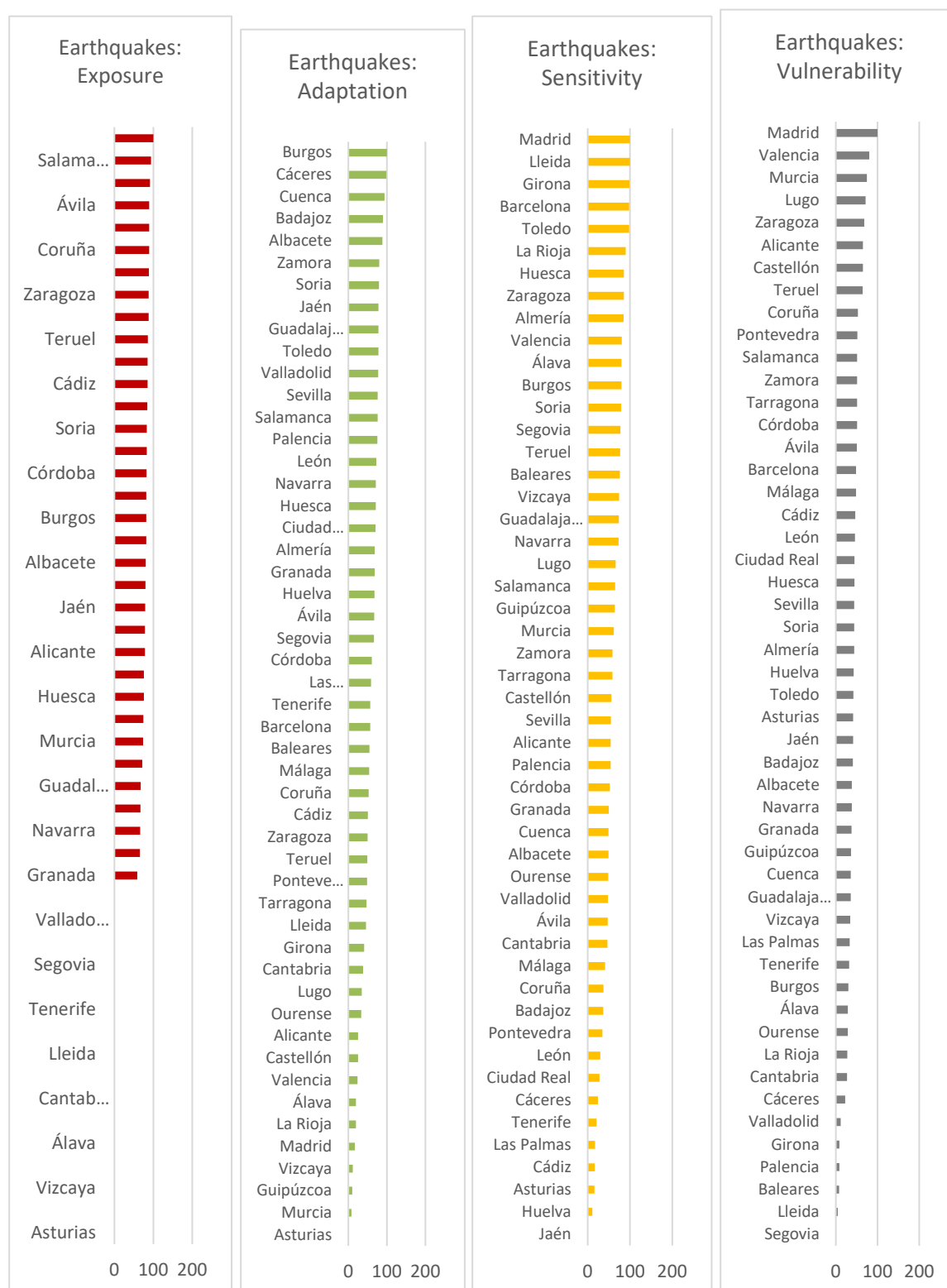


Figure. Disaster Related Indicator Score and Subdimensions Very Heavy Rainfall

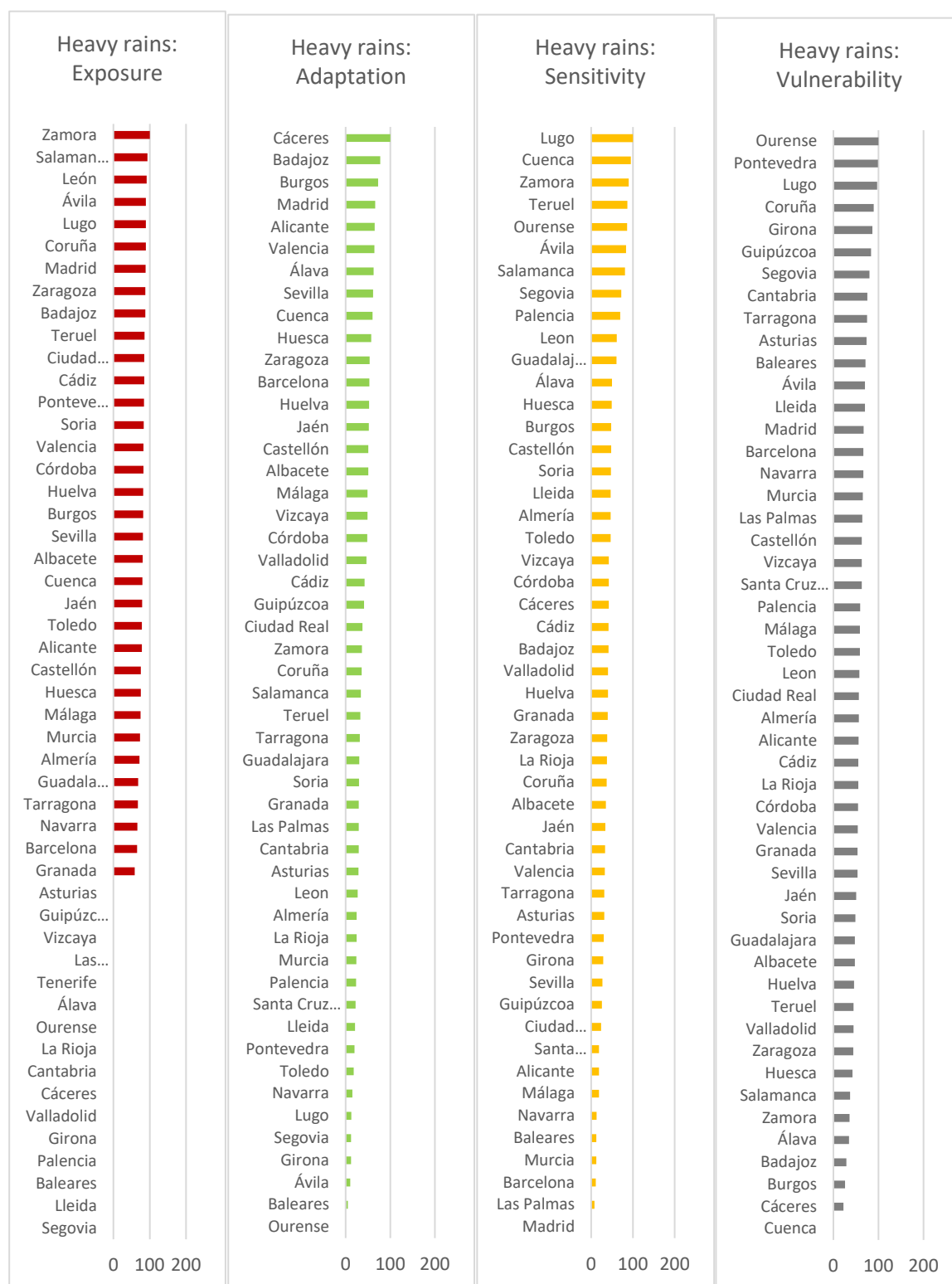


Table. Data sources

Variable	Source
Proportion of university graduates	INE
Unemployment rate	INE
Ambulances per 100,000 Inhabitants	Ministerio de Sanidad
Snowploughs	Ministerio de Movilidad Transportes y Agenda Urbana
Total availability of snow melting equipment	Ministerio de Movilidad Transportes y Agenda Urbana
Interprovincial Mobility	INE
Roads (km)	Ministerio de Movilidad Transportes y Agenda Urbana
Crude Mortality Rate	INE
Inadequate Household Temperature	Ministerio para la Transición Ecológica y el Reto Demográfico
Internet Access	INE
Elderly Living Alone	INE
Urban Population	INE
Agricultural Land	INE
Deaths associated with low temperatures	Ministerio de Ciencia e Innovación
Deaths associated with high temperatures	Ministerio de Ciencia e Innovación
Seismic Magnitude	Instituto Geográfico Nacional
Seismic Intensity	Instituto Geográfico Nacional
Number of snow days in January	AEMET
Days with maximum temperature greater than 30 degrees Celsius	AEMET
No. of days with minimum temperature less than or equal to 0 °C	AEMET
Total Multi amount due to snowfall	UNESPA
Total Multi amount due to rainfall	UNESPA