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RESEARCH ARTICLE

Community Resilience Assessment: Implementation of a Novel Resilience Framework in Four Different European Case Study Areas

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Abstract

Global warming and population density increase in urban areas under natural risks highlight the need for better quantifying and measuring community resilience. A new resilience framework was developed in the course of the European project C2IMPRESS, proposing an innovative way to assess community resilience through a multifaceted lens focused on 5 dimensions: a) social, b) governmental/institutional, c) economic, d) infrastructural, and e) environmental. The framework was tested in the four Case Study Areas (CSAs) of the C2IMPRESS project; Egaleo in Greece, Mallorca in Spain, Ordu in Turkey, and Centro in Portugal. Here, we exhibit the methodology process for the framework's development (literature review, identification of resilience indicators, feedback from the CSAs) and its operationalisation, including a presentation of the data collection process and the scoring techniques used. Although there are alterations between the CSA' resilience scores, all areas have showcased fundamental deficiencies in disaster management planning and preparedness. There were also important deficiencies in their protective infrastructure and healthcare systems. On the other hand, high scores were observed in educational attainment, digital connectivity, and average life expectancy capacities of the communities.

Keywords: Community resilience • Resilience assessment • Municipality • Society • Governance • Economy • Infrastructure • Environment

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Worldwide, a shift in various climate variables has been observed (EPA 2016). Although climate change affects the vast majority of the global population, proposed modifications to policymaking, entrepreneurial activity, and citizens' conduct have not yet produced any considerable impact that counteracts this troubling phenomenon (Einecker & Kirby, 2020). The C2IMPRESS project aims to address this problem by adding to disaster and hazard research and innovation by adopting a novel "place and people" centred approach, which focuses on identifying community-specific challenges and empowers citizens and local authorities to act on them.

During recent years, there has been a notable increase in scientific publications related to the conceptualisation and the proposal of different computational resilience methods. More specifically, various attempts have been made to investigate the levels of adaptation and resistance of different systems against natural and artificial hazards (De Iuliis et al., 2023). For example, Marasco et al. (2022) developed a tool to measure resilience that incorporates risk analysis variables (hazard, exposure and vulnerability) into the fundamental resilience capacities of a community.

Consequently, in this article, we focus more on an approach that views community resilience as a constructive adaptive response, in which both citizens and institutional bodies make best use of their social, political, economic, infrastructural, and environmental assets to mitigate natural disaster effects and successfully adapt to and recover from them (Wilson, 2012). It is evident that a community cannot anticipate and regulate all possible emergencies that may affect it. Nevertheless, through the study and in-depth examination of their anticipated impacts, a community can be provided with the opportunity to plan ahead and implement strategies that can counteract or mitigate those threats or find a suitable way to adapt to them (Einecker & Kirby, 2020). As a result, it is possible for community members to study resilience capacities by comprehending its strengths and weaknesses and by taking proper action to enhance the former and eliminate the latter (Berkes & Ross, 2012).

Purpose

To effectively measure community resilience in a multi-hazard context, the C2IMPRESS project developed a novel framework, including a set of 41 indicators. The main aims of this framework are to a) measure and assess the resilience levels of a municipality by quantifying its resilience characteristics, b) provide accurate, up-to-date data to the Case Study Areas (CSAs) stakeholders and governors concerning their city's resilience capacities, c) be used as a tool by stakeholders, authorities, and citizens to help them identify the strongest and weakest points of their city's resilience. Consequently, this framework can be used as an instrument to help municipalities better understand their resilience competencies and therefore be able to make the necessary changes and adjustments to enhance and expand them.

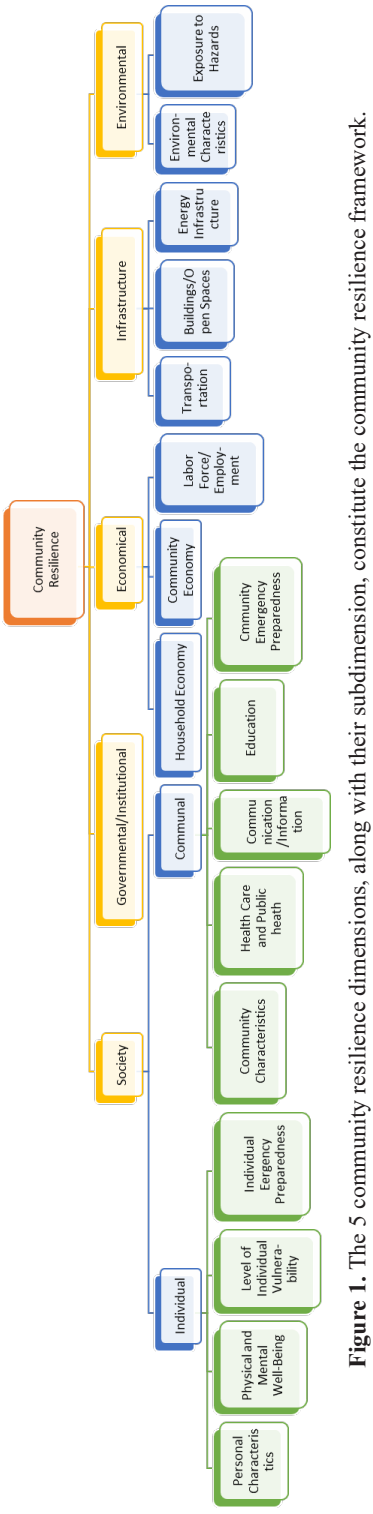

Figure 1. The 5 community resilience dimensions, along with their subdimension, constitute the community resilience framework.

Methods

Development of a Novel Community Resilience Framework

To capture the vast nature of community resilience, a literature review was conducted to identify several indicators that can be used to assess and quantify the resilience of a specific municipality. For this purpose, several open-access scientific journals were consulted, as well as a number of resilience frameworks developed either by national or European committees and organisations such as the Committee On Sustainability Assessment (COSA), the Federal Emergency Management Agency (FEMA), the World Risk Report (WRR, 2016) by the World Economic Forum, the Resilience Dashboards for the Social and Economic, Green, Digital, and Geopolitical Dimensions (2021), and the European Commission, among others.

From this literature review 5 main categories were identified, encapsulating the different dimensions of community resilience: (a) social, (b) governmental/institutional, (c) economical, (d) infrastructural, and (e) environmental. Each dimension includes subdimension comprising 131 indicators. The social dimension proportionally includes more indicators, as it consists of a large number of subdimension and also due to the special focus on the societal aspect of resilience, as there is a lack of this kind of data on the municipal scale.

The social dimension is intended to investigate personality, health, education, and emergency preparedness characteristics at both the individual and community levels. In the governmental/institutional domain, the structure, organisation and quality of the

institutional bodies of the municipalities were examined. This included the existence and status of financial and resilience plans and the efficiency and effectiveness of municipal services, as well as the accountability and transparency levels of local and national authorities. The economic characteristics were focused on financial data on both the household and municipal levels, including the labour force and employment status of the community. Infrastructure wise, the existence and quality of (energy) infrastructure were measured. Finally, in the environmental dimension, its characteristics were addressed, and the exposure levels of each CSA to various natural hazards.

After identifying the aforementioned dimensions and indicators, a short survey was conducted to investigate whether these categories fitted the project's CSA needs. In addition, the complete list of indicators was also shared with the rest of the consortium members to gather valuable feedback on the framework. Based on these findings, mandatory additions and modifications were introduced to compile the final version of the community resilience framework.

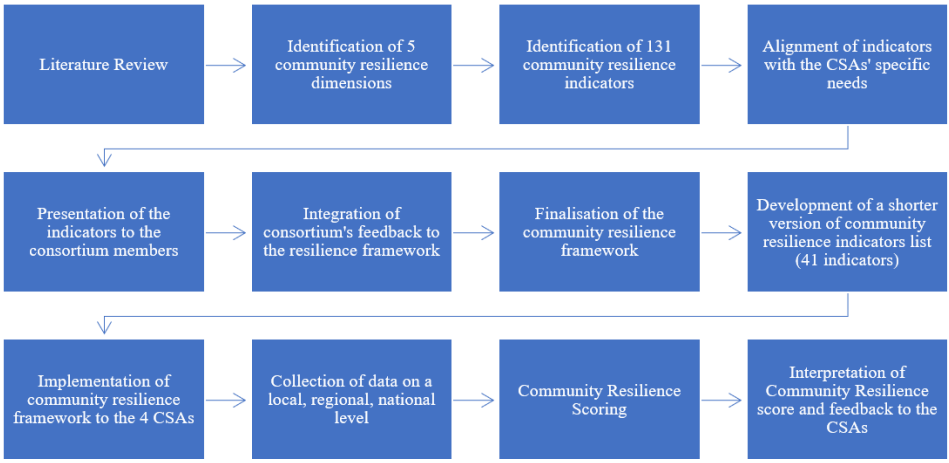

Figure 2. Flowchart demonstrating the methodology followed to construct and implement the novel resilience framework.

Data Collection Tools

As mentioned, one of the main goals of this framework is to provide a quantifiable version of municipality's resilience capacities. To achieve this, there needs to be a definite and practical metric for each indicator that allows us to measure it properly and assign appropriate values to it. Therefore, each indicator was accompanied by an example proxy, which is essentially a concrete method to assess it. The provided proxies were not exclusive; thus, if a CSA could propose an alternative way to provide accurate data that represented a certain indicator, they could select their own metric.

In addition, each indicator was accompanied by a detailed description and explanation of its connection to community resilience. The complete methodology of the framework's operationalisation has been also thoroughly reported in D3.3 – Report on (a) the risk framework, (b) resilience framework, and (c) the support tool for operationalisation v2 (Galanopoulou et al., 2024) of the C2IMPRESS project.

The original framework comprised 131 indicators. However, to make the framework more practical and user-friendly, a shorter version was developed, which only included 41 indicators. Many indicators covering similar matters or comparable proxies were conjoined. In this shorter version, there were 25 social indicators, 4 governmental/ institutional, 4 economical, 3 infrastructural and 5 environmental ones. The social dimension was proportionally larger, as previously emphasised, to contribute to municipal social cues and metrics, which are often overlooked. For a full presentation of the 41 indicators, their definitions, and their metrics, please refer to the Appendix.

An important aspect of the framework's operationalisation is the collection of appropriate data for each indicator. For this purpose, two different approaches were adopted, depending on the indicator. First, representatives from each CSA were contacted to retrieve data already available from the city's social services. A short survey was also prepared to be filled by the municipal authorities and provided basic information about the operation of the city's governmental and institutional bodies. On the other hand, data available online were extracted from a number of different open-data sources; i.e., "Our World in Data" (https://ourworldindata.org/grapher/share-who-trust-government), an open-access database that allows the identification and comparison of a vast amount of information per country. Other open data sources included Eurostat, the official European platform that provides high-quality data for several indicators per country, the national statistics service of each country, and others.

In this study, although the priority was to collect data representing the community at a municipal level, such information was not always available or was discarded as low-quality. In these cases, we decided to "scale-up" the data level and seek them at regional or national levels. Of course, scaling up data accuracy can occasionally decrease, and this should always be considered when interpreting evidence. Therefore, this approach was followed only when no other data were available at the municipal level.

Framework Scoring

A value from 0 to 10 was assigned for each indicator, where 0 indicates the minimum resilience and 10 the maximum. This value can include up to one decimal number (e.g. 7.4) (see the following equations at the end of this section for the explanation of this accuracy). Subsequently, the score for each dimension was extracted from the

mean average score of its indicators. The mean average scores of the five dimensions were averaged up to the overall community resilience score of the municipality. Each indicator had either a positive or negative correlation with community resilience. The positive correlation indicated that the higher the score of an indicator, the higher the score of community resilience. The negative correlation indicates that the higher the score of the indicator, the lower the overall score of community resilience.

Whether an indicator had a positive or negative correlation with community resilience depended on its operational definition. For example, the percentage of elderly people who live in a municipality exhibits a negative correlation with community resilience due to the reduced mobility of elderly people, which can be fatal during the course of emergencies and because it is more difficult for them to prepare and adapt to natural disasters. In addition, many people over the age of 70 require assistance from family, neighbours, and others, which may not be available during emergencies (Links et al., 2018).

After acquiring suitable data for each indicator, a concrete baseline score is required for these data to be compared with and assigned an appropriate value. The baseline score refers to the maximum (optimal) and minimum (insufficient) values each indicator can acquire. Consequently, these baseline scores were set by comparing the collected data with the minimum and maximum scores of each indicator that were retrieved from open-data sources or extracted from the literature. More specifically, the following formulas were used to calculate each indicator's specific score. The selection between the two equations was based on either a positive or negative correlation with the indicator that illustrates community resilience.

$$Indicator\ Score = \frac{x - Min\ x}{Max\ x - Min\ x} * 10$$

Equation 1. *Formula for the score conversion of indicators with positive correlation (Source: Eklund et al. 2023)*

$$Indicator\ Score = 10 - \frac{x - Min\ x}{Max\ x - Min\ x} * 10$$

Equation 2. *Formula for the score conversion of indicators with negative correlation (Source: Eklund et al. 2023)*

In both formulas *x* is the available data for the community/region/country that we want to convert; *Min x* is the minimum value recorded in the given data set; *Max x* is the maximum value recorded in the data set (Eklund et al., 2023).

Findings

In this section, the results from the implementation of the community resilience framework in the four CSAs that participated in the C2IMPRESS project are exhibited: Egaleo in Greece, Mallorca in Spain, Ordu in Turkey, and Centro in Portugal. Here, we present an overview of the resilience scores retrieved for each municipality, accompanied by their interpretation, as well as a demonstration of how they are associated with and interfere with community resilience, either by enhancing or reducing it.

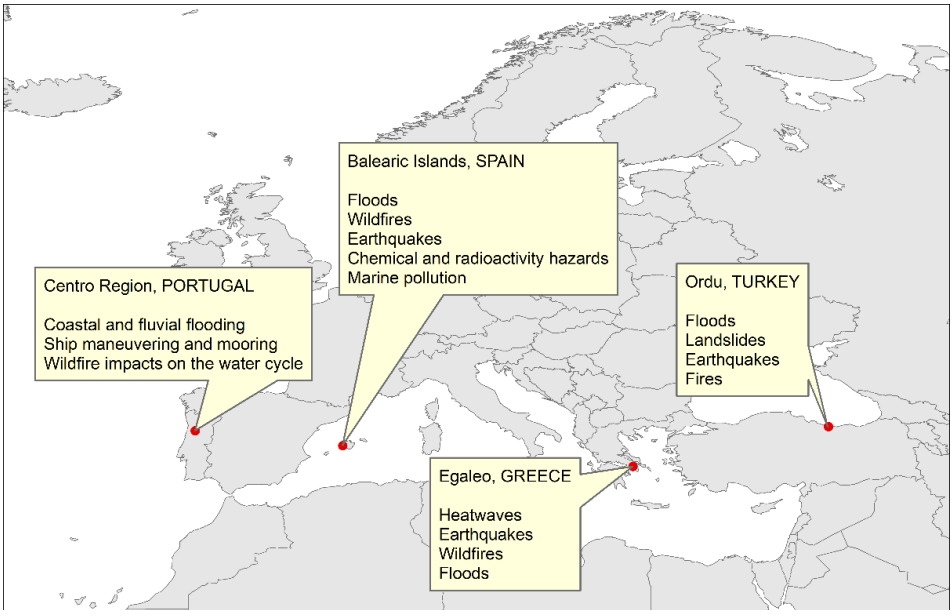

Figure 3. European map showing the locations of the 4 CSAs and the most prominent hazards in each test area.

Implementation in Egaleo, Greece

First, the resilience framework was pilot-tested in the Egaleo municipality. This CSA was chosen as a pilot project due to its spatial proximity and scientific affiliation to the National Centre for Scientific Research "Demokritos", which conducted the survey. Egaleo is a municipality in the Western Domain of Athens, Greece, with a population of 69,946 inhabitants (per the 2022 census by the Hellenic Statistical Authority). The total acreage is 6.421 km^2. One-fourth of the municipality is covered by an industrial area (Eleonas area). Other important landmarks are the University of West Attica, the "Baroutadiko" grove and mount galeo. Egaleo is also an important commercial and municipal hub, and it was once the capital of the Western domain of Athens. More than 100,000 people work or live in Egaleo on a daily basis.

Egaleo is a region prone to natural hazards, especially earthquakes, heatwaves, and floods. There is an established action plan concerning heat waves with the involvement of the Civil Protection Services, including the provision of air-conditioned spaces and the transport of vulnerable populations to these designated spaces. Municipal health clinics are also in place during heatwaves. There is also an emergency plan for earthquakes that covers accommodation, transportation, communication, and emergency equipment needs of citizens. The city's authorities have also established an Action Plan for Energy and Climate that focuses on mediating the climate change impacts and on the municipality's adjustment to climate change in general, including foreplaned decreases of its pollutant emissions. The graph below provides the overall and subdimensional resilience scores for Egaleo City.

Figure 4. Overall community resilience score for the CSA of Egaleo, along with its 5 dimensions and their respective scores.

Concerning the health resources in Egaleo, there are enough available doctors (score 7.3/10), but there is low availability for hospital beds (3/10), which can be crucial during a disaster. Moreover, a substantial proportion of the city's population are elderly (19% of citizens are older than 65 years), an age group that is more likely to require special attention and aid during a disaster due to reduced mobility or lack of knowledge about the proper emergency actions they should follow. In addition, there are mediocre levels of community participation in the decision-making process, as less than half of the city's population exercised their right to vote in the last community elections. This is crucial because it undermines the feeling of belonging to a community and the active role of citizens in the development of community policies (COSA, https://thecosa.org/resilience-indicators/).

On the other hand, Egaleo scored low on the indicators of event management and resilience plans. More specifically, there are some event management plans in place, but they do not cover the entirety of natural disasters and their different phases (pre-during-post disaster) and they are also not well coordinated among municipalities' different services. In addition, according to the city's authorities, Early Warning Systems (EWS)[1] are non-existent. Moreover, there is a collection of past data concerning the main hazards that the community faces, but there are no coordinated plans to update this information. Finally, concerning the post-event recovery plan of a city after a disaster, there are some plans and strategies, but these are not inclusive, nor have been verified and agreed upon by relevant stakeholders. There is also no available resilience plan for the city.

Nevertheless, Egaleo holds high scores on some important indicators that reflect a community's well-being and overall prosperity, namely educational attainment, Internet access, and average life expectancy. Expressly, 93.59% of the population has a high school degree, and 90.9% of households have broadband internet access. In addition, the average life expectancy in the country is 80.1 years. These indicators indicate increased well-being and overall quality of the available medical services. In addition, higher education levels can improve students' capacity to prepare for and respond to, the stress of disasters (Edgemon et al., 2018).

In the governmental and institutional domains, the pattern of existing policies that are nevertheless not well coordinated is evident. The resilience financial plan and budget are not well organised. The overall efficiency and effectiveness of the municipality holds a substandard score because the major services are scarcely reviewed. Therefore, there is no appropriate assessment of the city's services, which severely degrades their performance and impact. Moreover, on a national level, there is a score of 52/100 (where 0 perceived as very corrupt and 100 very transparent) concerning the corruption of authorities in Greece, according to the Corruptions Perceptions Index (2022) (https://www.transparency.org/en/cpi/2022). This indicator is highly interconnected with the indicator "Trust in Authorities" in which Greece scored 3.1/10. These scores are very marginal, and their measures are very important because the less citizens trust and believe in the transparency of their governing bodies, the less prone they are to follow their orders and guidelines during emergencies (Delprato et al., 2022).

The overall median household income in Greece is very low (1.9/10). However, there is a satisfactory score for income inequality (6.4/10), which corresponds to more

1 Early warning system is an adaptive measure for climate change that uses integrated communication systems to help Communities prepare for hazardous climate-related events (United Nations). https://www.un.org/en/climatechange/climate-solutions/early-warning-systems#:~:text=Early%20warning%20system%20is%20an,and%20supports%20long%2Dterm%20sustainability

just distributions of earnings across the community, in a way that boosts its overall resilience goals (Edgemon et al., 2018) and the available fundings for emergency preparedness. In addition, an unemployment rate of 12.23% exists in Egaleo (score 6.5/10), which is satisfactory overall and positively contributes to the municipality's total economic resilience.

Infrastructure wise, Egaleo received an excellent score of 10/10 in water access, as 100% of households had potable water and 97.4% of households were connected to public sewage. This is important because complete access to clean water and sanitation systems indicates more resilient societies with the capacity to recover faster after disaster (Delprato et al., 2022). However, in terms of building infrastructure, Egaleo has some building codes and standards, but these are not applied, enforced, nor verified (score 2.5/10). Also, there is some protective infrastructure in places, but a lot of strategic areas are not protected, and defensive design and management is not consistent with best practises, according to the municipality's authorities (3.3/10). It is worth mentioning here that protective infrastructure is set to shield critical community infrastructure against natural or other hazards, and its absence increases the exposure of critical assets, affecting both human lives and material properties (Cardoso et al., 2020; Delprato et al., 2022).

Finally, on the environmental dimension, Egaleo faces some important challenges because it is a high-risk area prone to several natural hazards. As mentioned, Egaleo is exposed to major heat waves, especially during summer. Approximately 31% of summer days had temperatures equal to or greater than 35°C in 2023. Considering these extreme temperatures, exposure to forest fires is also high due to the existence of the "Baroutadiko grove", which covers almost 134,000 m² of the municipality. In addition, Egaleo is similarly prone to earthquakes as the whole of the Attica region. More specifically, according to https://thinkhazard.org/en/report/16680-greece-attiki-attikis/EQ, the risk of an earthquake is high, meaning that there is more than a 20% chance of a potentially-damaging earthquake happening in the next 50 years in the area. Also, there is a high risk of flooding, especially in the neighbourhoods with close proximity to Kifissos highway, under which there is a rubbled river that occasionally overflows following heavy rainfalls. Finally, no Natura 2000 protected areas in Egaleo could counteract the effects of climate change by mitigating the risks and impacts of extreme natural events (European Commission Directorate - General for Environment, 2014).

Implementation in Mallorca, Spain

Mallorca is a Mediterranean flood-prone insular region with a population of 914,564 as of 2022 (source: IBESTAT). It is historically affected by flash floods and wildfires. In Palma, the capital city of the island, a catastrophic flood caused approximately 5,000 deaths in 1403 (20% of its population), making floods the main natural hazards affecting

this city. Floods are allocated over an alluvial fan, filling a subsided depression. (Petrus, Ruiz, Estrany, 2018). In the rest of the island, the historical distribution patterns of human settlements were related to fluvial systems, leading to numerous urban settlements potentially affected by flash floods.

In the second part of the 20th century, urban expansion became exponential, with the addition of many urban and tourist settlements, often in flood-hazard areas or nearby forest areas, and thus, growing at the wild-urban interface, which generated new significant wildfire risk areas. Nevertheless, this urban expansion and the expansion of tourist mobility implies higher risks not only related to floods and fires but also with any other natural risk hazards such as earthquakes or meteorological hazards, and because of the proximity of more population to chemical and radioactivity hazards, marine pollution, and dangerous goods transportation hazards.

Figure 5. Overall community resilience score for the CSA of Mallorca, Spain, along with its 5 dimensions and their respective scores.

In Spain, due to no data being available on a municipal level, there is a 19% percentage of disabled persons (score 7.3/10). The proportion of minors was 15.6% (score 7.6/10), whereas the proportion of elders was 16.8% (score 4.7/10) of the population. The average life expectancy is 83 years (score 9.4/10), which is beyond satisfactory and reflects an overall good quality of life for the residents. Concerning medical resources, according to the government of the Balearic Islands[2], there are 3.03 beds per 1,000 people and 3.43 medical doctors per 1,000 people (score 2.1/10 and 3.5/10 respectively). Public school capacity is low and decreases the community's ability to restore educational services after the occurrence of a disaster and to use these spaces as evacuation or temporary refuge centres.

2 https://www.caib.es/sites/atencioespecialitzada/ca/presentacio-78950/

According to Our World in Data (https://ourworldindata.org/grapher/share-who-trust-government), there is also comparatively low trust in authorities in Spain, as only 48.2% of the population state that they trust their government (score 4.1/10), which aligns with a moderate degree of overall governmental transparency (score 60/100, where 0 is considered very corrupted governance and 100 very transparent) (Source: https://transparencia.pt/indice-de-percecao-da-corrupcao-2022/). This could demonstrate a moderate disbelief and suspicion towards governmental policies, which can sabotage a community's emergency preparedness policies and its overall resistance to natural disasters. On the other hand, 81.1% of the population of Spain stated that they trust others in their neighbourhood (https://ourworldindata.org/grapher/share-people-trust-neighborhood), which is the highest score for this indicator among the other CSAs and is correlated with higher and more mindful participation in community activities.

During an emergency on the island of Mallorca, a shortage of communication is very likely, even in the most probable natural disaster scenario. Concerning the island's risk management policies at the regional level, comprehensive plans cover disaster management, preparedness, emergency, and city mitigation, preparedness, and response to local emergencies. These plans are subject to review, updating, and continuous improvement; however, this process is often delayed due to slow administrative procedures and a lack of resources. In addition, on a municipal level, many communities lack specific emergency plans, mostly due to a lack of economic resources, especially in regions with low populations, according to the Emergency Management Service of the Balearic Islands (score 6.6/10). Also, concerning citizens'' emergency training, some training modules for civil protection volunteers do exist, but their coverage needs to be significantly improved (score 3.3/10). Thus, authorities should focus on gathering more detailed information to record and address these emergency preparedness shortcomings by identifying the most prominent risk management gaps.

On the other hand, Mallorca has already accommodated for the supply of emergency food and basic relief items because they exceed the anticipated needs, even in the most severe scenario (score 10/10). This shows that the community is well-prepared to cover the first basic needs of its citizens post-disaster, which can accelerate the rhythm of its recovery (United Nations Office for Disaster Risk Reduction [UNDRR], 2017). Also, the main hazards that threaten the island are studied and understood, but there are no agreed plans for updating this information (score 6.6/10). Additionally, the EWSs of the CSA are currently under construction and are expected to reach among 50 and 75% of the population (score 3.3/10). However, with the implementation of ES-Alert (Emergency Alert System) all citizens who possess a smartphone can be reached and informed about upcoming emergencies. Furthermore, Mallorca has developed a strategy/process for post-event recovery and reconstruction, including

economic reboot, which is also well-understood by relevant stakeholders; however, it needs to be more comprehensive and re-assessed at appropriate intervals (score 6.6/10).

In the governmental/institutional domain, the region has a financial plan and an upheld budget destined for resilience capacities, but these efforts are not coordinated between different agencies and organisations (score 3.3/10). This is crucial because every community needs to not only have available funds for resilience planning, but this budget should also be "ring fenced" and used specifically for disaster management purposes. (Cardoso et al. 2020). In Spain, however, strict administrative processes and detailed reporting can enhance the protection of allocated budgets and ensure that they are only used for their designated purposes. Also, Mallorca can capture and disseminate some lessons regarding hazards, but not in a thorough or systematic way (score 3.3/10).

These learning loops involve failure analysis, as well as the documentation of important steps that help readjust existing disaster risk reduction (DRR) plans; however, they should be approached in a more thorough manner. This could provide the CSA with important data and information to cope with upcoming disasters by learning from past mistakes and miscalculations (UNDRR, 2017). In addition, the performance of the community's major services and functions was reviewed, but this review excludes any impact assessment (score 7.5/10). This indicates that the Balearic Islands' authorities pay considerable attention to evaluating their services by monitoring their performance and interchanging best practises. However, it is important that this effort is enhanced through a thorough impact assessment, which will provide greater detail about the influence of the services on the strategies that are being implemented on the island.

Economically speaking, the comparatively low median household income in Mallorca (32,404 € per household or 12,451 € per capita/per year), combined with a medium income inequality (0.329, where 0 is perceived as complete equality and 1 as complete inequality) and 26% of the population at risk of poverty or exclusion point to restricted financial means available to the country's population. On a local level, although the unemployment rate differs per month because the island is a highly touristic location, a mean 11% of the labour force is unemployed on average per year in Mallorca, which is considered satisfactory (score 6.8/10).

In the infrastructural domain, zoning rules exist, are widely applied, are properly enforced, and are verified (score 10/10). This means that local and regional authorities pay significant attention to not only maintaining zoning and land use regulations but also imposing these rules, as well as validating their implementation. The existing protective infrastructure in Mallorca, on the other hand, is present in some cases, but some strategic protective infrastructure is missing, and the overall design and management may not be consistent with best practise score (3.3/10). Defensive infrastructure is therefore only partially implemented and exposes essential buildings

and assets to natural hazards. Additionally, there is no available data on water and public sewage access at the local level; however, at the national level, 86.93% of Spain's population is connected to at least secondary wastewater treatment (score 8.6/10).

Environmentally, the Natura 2000 network covers a significant terrestrial portion of Mallorca, essentially 29% of its land, (score 3/10). This is important because areas that belong to the Natura 2000 network can be strong indicators of well-maintained biodiversity and ecosystem functions that can help counteract climate change effects and increase the overall wellbeing of local residents (European Commission Directorate - General for Environment, 2014). In addition, the island has a major exposure to heatwaves. Approximately 42% of summer days in 2023 showcased temperatures that exceeded 35°C. This fact, in combination with the existence of 44.3% forested land around the island, upsurges its exposure to forest fires (score 5.6/10). Last but not least, Mallorca is at a very high risk of coastal floods (score 2/10), but it comparatively has little exposure to earthquakes (score 9/10).

Implementation in Ordu, Turkey

The Ordu case study area is located in northern Turkey, in the western part of the Eastern Black Sea region. The Eastern Black Sea Region is an area with the highest average annual precipitation in Turkey. In addition, there are 36 large and small rivers and streams in Ordu. Consequently, the area is very prone to floods, which can also lead to severe landslides, which are enhanced by the fact that many forest areas have been converted to urban areas. The combination of these two hazards has caused significant loss of human lives and property in the area in the past. Also, because of the floods, the city's streets, along with some workplaces and homes, are frequently overflowing. There can also be a collapse of local bridges, which consequently renders the highway out of service due to heavy traffic.

As a counteraction, the municipality of Ordu developed a Disaster Response Plan (TAMP-Ordu), which includes public, private, and civil entities (NGOs and citizens). Its goal is to clearly distribute the different roles and duties that arise in the middle of a disaster and coordinate the emergency actions that need to be taken during and after a hazard occurs. The natural hazards involved in this plan include earthquakes, floods, landslides, avalanches, and fires, industrial accidents, and mass population movements.

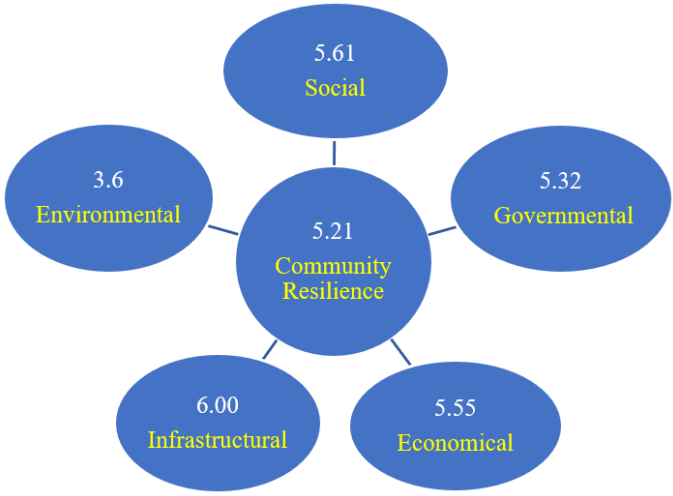

Figure 6. Overall community resilience score for the CSA of Ordu,Turkey, along with its 5 dimensions and their respective scores.

In the social domain in Turkey, almost half of the population (54.9%) stated that they trust their national government (score 4.9/10). In addition, place attachment on the national level scores was found for 62.8% of citizens who trust others in their neighbourhood (score 5.7/10). On a municipal level, Ordu has a very satisfactory score of community participation, extracted by the fact that 71.4% of its residents participated in the last local elections, which indicates a robust feeling of community belonging and an enhanced degree of participation in activities that are organised on the local level (COSA).

On a demographic spectrum, Ordu has a 26.5% of underage population (younger than 18 years old) and 9.9% population of elders (older than 65 years old). In addition, 6.9% of Ordu's population has disabilities. Whereas a bloom in the underage population is very optimistic, in terms of resilience, the youth can decrease the community's overall capacities due to reduced emergency experience and knowledge. On top of that, kids and adolescents are very likely to require guidance and assistance from adults on how to act during emergencies, which may not be available in the face of a disaster (Links et al., 2018). On the other hand, Ordu's elderly population and people who have some kind of disability are the lowest compared to the rest of the CSAs, which enhances its overall resilience because elderly people and people with special needs very often have mobility issues that can prove fatal during disasters and/or require more time and resources for their transportation during and after the crisis.

In the health sector, on a national and subsequently local level, there are only 3.01 hospital beds per 1,000 population (score 2.1/10) and 2.16 medical doctors per 5,000

population (score 2.5/10). In addition, health insurance expenditures in Ordu are only $443.08 per capita. Consequently, a severe scarcity of medical and health resources exists that can be fatal despite a disaster and undermine a community's overall well-being. This fact can also be reflected in the average life expectancy in Ordu (77.5 years), which is the lowest among the case studies, but still remains a comparatively satisfactory value when compared with the average global life expectancy levels.

In Ordu, Internet access is almost optimal (95.5% of households are connected to broadband internet), which allows citizens to be able to collect valuable information before, during, and after disasters and cross-check it using various sources (Delprato et al., 2022). However, the municipality predicts that some loss of service will be experienced even from the "most probable" disaster scenario (score 3.3/10). The knowledge of this feebleness in communication network operations should be addressed pre-disaster by the municipality to make them more robust and replace them with alternative means that will be able to function even during emergencies.

Educational attainment capacities in Turkey approach the global mean but remain comparatively low compared to the rest of the countries, since 64% of the share of people 3-5 years above the expected age of completion have completed their upper-secondary education (score 6.3/10). On the other hand, Ordu possesses 14.67 public schools per 1,000 inhabitants which over exceeds the rest of the CSA school capacity. This is important because not only can it be a predictor of quicker restoration of the schooling activities of a postdisaster community but also because school facilities can be used as safe shelter spaces for the temporary accommodation of the displaced population (Edgemon et al., 2018).

Concerning the risk preparedness practises that are present in Ordu, there is a widespread event management plan, but it contains significant gaps in coverage for mitigation, preparedness, and response to local emergencies. In addition, there are some available modules for emergency preparedness training, but their coverage and content need to be significantly improved, according to the municipality. Furthermore, more than half but less than 75% of the CSA's population is reachable by Early Warning Systems (EWS). Therefore, most citizens can be reached and informed before and during a disaster; however, a substantial part of the population is still unattainable and may be exposed during an emergency.

In addition, regarding its community emergency preparedness plan, Ordu can provide food, shelter, staple goods, and fuel supplies that would prove sufficient to cover the total estimated needs of the citizens in the "most severe" disaster scenario. This is very satisfactory, but the provisions should ideally exceed the estimated needs of the population to prevent any unanticipated requirements. In addition, concerning the existence of a comprehensive hazard assessment, the Ordu authorities are aware of

the main hazards but have no agreed plans for revising this information. This can cause significant preparation gaps in the analysis and anticipation of the key hazards of the CSA as well as in the comprehension of their possible effects on human lives and physical assets.

As far as post-event recovery planning is concerned, not only is there a post-event strategy/process in place, but it is also robust and well-understood by relevant stakeholders. Moreover, the community has well-defined processes in place to capture lessons from failures post-event (by incorporating failure analysis) and use them to improve future emergency planning strategies. However, the CSA does not yet have a holistic resilience plan, which could strengthen the community's anticipatory and absorptive capacities and accelerate recovery postdisaster. Nevertheless, a resilience plan is currently being developed and will be assisted by the C2IMPRESS project.

In the governmental/institutional domain (score 5.32/10) as far as the financial plan and budget for resilience, including contingency funds of Ordu, is concerned, there are some plans in different agencies / organisations but they are not coordinated. This means that there is not a "ring fenced" protected budget intended only for Disaster Risk Reduction (DRR) policies, and the available funds may be disseminated across different institutions. This can complicate and further delay the emergency response of municipalities due to a lack of coordination and conflict of interest among different authorities during a disaster.

In addition, some of the major services and functions of the city were reviewed at appropriate intervals, but some others were excluded. On top of that, the overall evaluation did not include any impact assessment (score 5/10). This approach leaves crucial gaps in the monitoring performance and interchange of best practises among services, which increases the vulnerability of the CSA and can negatively affect its recovery after a disaster. This is enhanced by the fact that the corruption of Turkish authorities on a national level is estimated at 36/100, where 0 indicates corruption and 100 indicates transparency (score 3/10). This score, which is the lowest for this indicator among the 4 CSAs can be alarming because obscurity and unaccountability can jeopardise effective emergency planning. Also, the less citizens believe in the transparency of their government, the less likely they are to follow their guidelines and instructions during a disaster, which can cause major dysfunctions and even prove fatal (Delprato et al., 2022).

The median household income in Turkey is very low (10,622$/per year), and in combination with the levels of income inequality, which are considerable at 0.413, create lower-income households, which have a more difficult time preparing for and dealing with disasters due to a number of factors. These include the location of most of these houses in higher-risk areas, their tendency to overlook disaster preparation

(emergency supplies, emergency equipment) in favour of other expenses that are more immediate, and the shortage of economic resources and other means to support their recovery (Links et al., 2018). In addition, high levels of income inequality point to a less equitable distribution of municipal earnings that does not support broader community goals eventually (Edgemon et al., 2018). On the other hand, Ordu has a very low unemployment rate (8.5%), a score that positively contributes to Ordu's economic capacities, although its overall economic score remains marginal.

Infrastructure wise, in Ordu, building codes and standards exist and are applied, but they are not enforced, nor verified, thereby providing Ordu. Also, in some cases, protective infrastructure is in place, but some strategic protective infrastructure is missing. Furthermore, their design and management may not be consistent with best practises (score 3.3/10). Protective infrastructures guard critical assets and human lives by counteracting or mitigating the effects of natural and man-made hazards (Delprato et al., 2022). On the other hand, there is excellent clean water/ public sewage access, since 100% of the households have access to clean water and 97.4 % of households are connected to public sewage (score 10/10).

Environmentally speaking, there are no protected areas belonging to the Natura 2000 network in the area. Medium exposure to heat is not deemed a significant threat (score 7/10). There is, however, a comparatively high risk of wildfires because 26.9% of the municipality areas are forested. There are also continuous precipitation throughout the year, and the maximum precipitation reaches high values with precipitation amounts of up to an average of 2500 mm annually in certain places. In addition, there are 36 large and small rivers and streams in Ordu. This results in a very high risk of river and urban flooding (score 2/10). Exposure to earthquakes is considered high as well (score 2/10). Given this information, Ordu is a high exposed area to natural hazards, mainly floods and earthquakes, and therefore, it scores a low total of 3.6/10 at the environmental dimension, which is the CSA's lowest dimensional score.

Implementation in the Centro Region, Portugal

This CSA is subdivided into five case study areas: i) Figueira da Foz harbour, adjacent coastal area, and downstream alluvia area of the Mondego River; ii) Aveiro harbour and adjacent coastal area, iii) Mondego River basin; iv) "Leirosa-Monte Real" groundwater body, and v) "Maciço Antigo Indiferenciado da Bacia do Mondego" groundwater body. The natural hazards that these subareas face, depending on their location, include coastal and fluvial flooding, wave overtopping, forest fires, and seawater intrusion.

The objectives for each case study sub-area are as follows: a) model coastal flooding, wave overtopping, and fluvial flooding and extend the EWS; b) model coastal flooding

and wave overtopping and extend the EWS; c) model discharge in a certain river section for a specific precipitation pattern considering the burnt area and the fire severity and to develop a new platform to predict the expected impacts for specific scenarios and deliver adaptive strategies; d) study forest fire impacts on groundwater supply wells and seawater intrusion vulnerability under climate change; e) study the impact of forest fires on groundwater body states. Also, there are River Basin Management Plans, flood risk management plans, and municipal emergency plans in place for the study areas, as well as some plans/studies regarding the overall estimation of the hazard impact in the Centro region (Lopes, 2016).

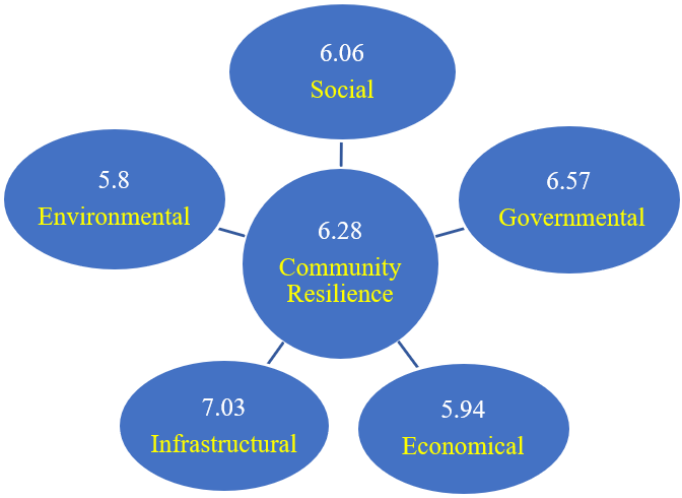

Figure 7. Overall community resilience score for the CSA of the Centro Region, Portugal, along with its 5 dimensions and their respective scores.

In Portugal, 47.7% of the population trusts their national government (score 4/10). In the Centro Region, 58% of the population exercised their right to vote in the last community elections. This score is marginally acceptable, but greater participation in the electoral process is anticipated from community members, especially those representing more marginalised groups (immigrants, youth, people with disabilities), whose needs are often overlooked. Regarding the place attachment of the CSA, there are 67.4% of people who trust others in their neighbourhoods and there is also a variation ratio of resident population of 1.91 for Portugal. The less alterations there are in a community's population, the more its citizens tend to bond and be associated with their community.

More than one-fourth of the Centro Region's population are elderly but most importantly almost 1 out of 2 citizens who present some kind of disability according to the CSA authorities. Certainly, this number is alarming since it increases the citizens' vulnerability levels due to immobility issues, reliance on others for everyday tasks and/or evacuation, lower income, etc. In the health sector, the number of hospital beds is comparatively low (3.5 beds per 1,000 habitants), but the availability of medical doctors is acceptable (5.31 medical doctors per 1,000 habitants). Furthermore, a 28% share of the population has access to public or private health insurance, and the healthcare expenditure per capita in the country reaches 2,457 € (score 5.9/10). Therefore, the values in the CSA's health sector are acceptable but nevertheless remain at a critical point. In addition, the average life expectancy of the CSA was 80.72 years old (score 8.7/10), indicating an overall good quality of life.

Education wise, 90% of the citizens in Portugal completed upper secondary education (score 9.9/10). This indicator is highly linked to better health, enhanced capacities to receive and exchange information, an overall stronger labour force and better abilities to prepare for and face disasters in general (Edgemon et al., 2018). On the other hand, the Centro Region has low public-school capacity, with only 2.7 schools per 5,000 population (score 3/10). This can interfere with the community's ability to temporarily shelter displaced populations and continue providing educational service after a disaster.

When considering a municipality's communication capacities, some loss of service is expected to be experienced by a significant proportion of the city in the most severe scenario (score 6.6/10). This means that in most mild disasters, communication means are expected to remain intact and to continue operations. However, it is crucial that only 44% of the region's population has access to the internet, according to the CSA's statistics. Therefore, municipalities should consider enhancing their citizens' web access to allow them to gain information from various and verified sources, cross-check it, and decide on the most fitting action prior to and during emergencies.

Concerning the municipality's emergency management plans, there is a complete disaster management/preparedness /ER plan outlining mitigation, preparedness, and response to local emergencies (score 10/10). The city has also provided resilience training to some sectors, but others lack the required training and engagement with resilience policies (score 6.6/10). Referring to the city's emergency services there are 3 municipal police stations and 3 fire departments (score 7/10). Additionally, the CSA authorities state that in the "most severe" scenario, the supply of emergency food and basic relief items is equal to the estimated need (score 6.6/10), which indicates a sufficient level of emergency preparedness. Furthermore, it is estimated that over 75% of the population can be reached by early warning systems. This number is satisfactory but not idyllic because no citizens should be excluded from the reach of the EWS,

which is important for receiving official and up-to-date information on upcoming disasters.

Furthermore, the community's authorities appear to understand the main hazards the area faces, and hazard data are updated at agreed intervals. This provides the CSA with the necessary information for the most prominent hazards and their anticipated impacts. However, the post-event recovery planning strategy concerning these hazards is not comprehensive or integrated or understood by the relevant stakeholders (score 3.3/10). Therefore, CSA authorities should put more effort into expanding the existing strategies to include all interested parties and to cover all of the participants' emergency response needs. It is essential to mention that Figueira da Foz Municipality, part of Portugal's Centro region, is the only CSA studied here that already has a resilience plan (score 6/10). More specifically, a Municipal Climate Change Adaptation Strategy has been in place since 2016, and the Municipal Climate Action Plan is currently in the phase of considering the results of the Public Consultation phase, which ended on December 16, 2023. This plan will continue to be formatted and evolve up to 2030 and will take into consideration climate change aspects, such as projections, scenarios, and possible impacts.

Furthermore, in the Centro Region there are some plans for allocating funds and resources for disaster risk reduction (DRR), but they are not coordinated and this budget is not protected, meaning it is not intended strictly for DRR. Also, there are mechanisms/processes incorporated by the city's institutional bodies to extract lessons from past failures. These lessons were used to update the emergency policy design of the CSA, but the mechanism that allows this needs improvement (score 6.6/10). As far as the efficiency and effectiveness of the community's authorities are concerned, reviews are planned and carried out on major services at appropriate intervals to evaluate their performance. This includes a thorough impact assessment, which permits the performance monitoring of governmental bodies, their constant evaluation, and an interchange of best practises among different services (Delprato et al., 2022). On a national level, Portugal scored 62/100 on the "Corruption of authorities" indicator (where 0=completely corrupted and 100=completely transparent), a moderately satisfactory score.

Economically speaking, Centro Region has the second lowest score in overall community resilience. The median household income in Portugal is estimated to be 24,877 $ per year, and the income inequality is 0.327, where 0 points to complete equality and 1 points to complete inequality. In Figuiera da For, 7% of the labour force is unemployed, whereas in Montemor-O-Velho, only 4 % of individuals between 15 and 54 years old are unemployed. These numbers demonstrate low unemployment percentages, which boosts the economic resilience on a local level (score 8.5/10).

Furthermore, regarding the area's Disaster Risk Financing, which refers to domestic and non-domestic insurance policies that cover natural disaster-related degames, 36.9% of domestic properties have valid insurance coverage for high-risk hazards (score 3.6/10). The more assets that are covered by similar insurance policies, the faster a community can absorb the abrupt shock of a disaster and the quicker it can recover from it (Delprato et al., 2022).

In terms of the infrastructural dimension, the CSA has the highest score (7.03/10). Building codes and zoning rules and standards exist, are applied and enforced but they are not verified (score 7.5/10). Also, regarding the existing protective infrastructure of the CSA, in most cases protective infrastructure is in place and consistent with best practise for asset design and management, based on relevant risk information, but there are some critical assets that are not disaster proofed (score 6.6/10). Consequently, some important buildings and infrastructure are left exposed, which upsurges the CSA's vulnerability to upcoming disasters and can have a negative impact on estimated damages and human losses. Finally, in Figueira da For, 95.2% of the population has access to clean water, while 48.3% of households are connected to either public or private sewage, whereas in Montemor-O-Velho, the latter is estimated at 75.4%.

Environmentally, there are several Natura 2000 protected areas in the CSA, including Porto de Aveiro and a significant area between Aveiro and Figuiera da For. The Natura 2000 network also covers most of Centro's Region coastal line. These areas increase the CSA's biodiversity and can help mitigate and absorb climate change impacts. In the last summer period (2023), there were 28/92 days when the temperature exceeded 35°C (score 7/10), indicating high heat exposure. Medium exposure to wildfires was observed, as 14.4% of the land was covered in forests (score 8/10). However, the main natural threat to the CSA however is exposure to river, coastal, and urban floods (score 2/10). Last but not least, the area has low exposure to earthquakes (score 7/10).

Discussion

As demonstrated, the community resilience framework elicited within the context of the C2IMPRESS project equipped municipal and regional authorities and stakeholders with a novel tool that permits the quantification, measurement, and assessment of their city's resilience. This framework allows the interested parties to capture a complete picture of the current resilience state of their community by identifying its strengths and weaknesses. This gives authorities the initiative to address these points either by implementing new strategies and policies to cover and strengthen its ellipses or by enhancing and mastering its strong suits. Therefore, it positively contributes to disaster risk and emergency research and innovation by facilitating decision-making strategies and planning of local institutional bodies.

Overall, concerning the resilience assessment of the four CSAs we can notice some reoccurring patterns among them. Although all CSAs have some form of event management and disaster preparedness plans, these strategies have fundamental weaknesses and lack coordination. This calls for the adaptation of a more holistic and better organised risk management design. It is also crucial that all CSAs acquire a protected budget that will be guarded and used only in emergencies. As far as municipalities' governance is concerned, there needs to be a more meticulous assessment of cities' services to improve both efficiency and transparency. The latter constitutes a crucial issue for all CSAs (with either low or medium scores) and severely undermines citizens' trust in authorities and the guidelines proposed by them, which jeopardises the community's long-term safety.

Furthermore, infrastructure wise although there are existing codes and regulations, they have not been thoroughly implemented. Also, there is an important omission in the protective infrastructure domain, as many critical buildings and assets are not safe to test and are exposed. Although in all the case studies, the domain of infrastructures registered the highest scores, it is nevertheless necessary to take into account the fact that resilience cannot be based only on regulatory aspects but, as mentioned, on effective compliance with codes and regulations, and it is considered essential to strengthen monitoring and inspection.

In addition, in the health domain, fundamental shortages exist, especially in hospital beds and occasionally on available medical staff, which can lead to fatal situations amidst an emergency. On the other hand, most CSAs demonstrate high scores in areas that hold substantial weight to a community's overall well-being and enhance its capacity to quickly recover from disasters, such as educational attainment, internet access (except for Centro Region), water and sanitation systems' access, average life expectancy, and comparatively low unemployment rates. Finally, the municipal authorities in all tested areas should consider enhancing their community participation and strengthening social bonds among citizens through common activities, which can positively contribute to their overall place attachment.

As per the limitations of this study, no similar assessments were conducted on these specific municipalities for the investigators to be able to compare and cross-validate the results. This provides an open space for further investigation to verify and expand this assessment. In addition, the current study does not address the implementation of any concrete solutions that would increase communities' resilience, as this approach strands away from its original purpose. However, foreseeable research that will be conducted within the scope of the C2IMPRESS project will focus on proposing and testing such solutions, always in close collaboration with municipalities' authorities and stakeholders as well as the rest of the project partners.

Last but not least, as mentioned, due to the unavailability of some data at the local and community level, we extracted data from either the regional or national level for certain indicators, which could theoretically decrease the accuracy of resilience assessment. However, this matter was addressed, and the indicators that included scaled-up data were interpreted at their corresponding levels because there is an important correlation between nationwide and local level data, which can still provide valuable information regarding a specific area's resilience levels.

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Appendix

Indicator	Indicator Description	Why is this indicator relevant?	Example Proxies	Centro Region-PT	Egaleo, GR	Ordu, TK	Mallorca, SP
Trust in authorities (Delprato et al. 2022)	To what extent does the person trust both the local and the national authorities? Do they think their way of operating is efficient and transparent?	High level of trust is associated with citizens being more likely to follow guidelines and instructions before, during or after an emergency to keep themselves and others safe.	% of population aware of and believing in the effectiveness of local authorities in their community or area (Source: Our World in Data https://ourworldindata.org/grapher/share-who-trust-government) % of population who trust and believe in information shared by their authority	PT Use Case info: 47.7%	GR: 40.7 % (2020)	TK: 54.9% (2020)	SP: 48.2% (2020)
People with disabilities (McGlade et al., 2019)	How many people with disabilities exist within the community?	Individuals with disabilities tend to be more vulnerable to physical, social, and economic challenges.	% of citizens who have disabilities *European Union Mean Average: 25% (Source Eurostat: Population reporting long-standing disabilities, 2017)	PT Use Case info: 48% (Center, Coimbra region) 33% (Source: Population reporting long-standing disabilities, 2017)	GR: 24% (Source: Eurostat: Population reporting long-standing disabilities, 2017)	TK: 6.9%	SP: 19%

Food Waste (proposed by Portugal CSA)	The indicator is defined as the amount of food waste generated per year divided by the average population of the country.	Food waste indicates a lack of sensitivity to food shortages and, therefore, lack of sustainability practices. Waste is the opposite of conserving and allowing better management of reserves in storage	The amount of food waste generated per year divided by the average population of the country (kg per capita) https://ec.europa.eu/eurostat/databrowser/view/ENV_WASFW/default/table?lang=en ref: logotiporevista.eps (aps.pt)	PT data: 184 kg per capita	GR data: 191 Kg per capita (2020)	TK; 93 kg per capita (2020)	SP data: 90kg per capita (2020)
% of children in population <18 years old (Links et al., 2018)	How many underage people are there within the community population?	Children and teenagers have less knowledge and experience with disasters and crises and are usually in need of guidance from an older figure (parent, teacher etc.).	% of underage people within the community	PT Use Case info: 11% under 15 years old (2 munici-pali-ties) 11% center region (Coimbra)	EGL: 17% under 15 years	26.50% of % children in population <18 years old	15.6% (under 16 years old)
% of elderly people (Links et al, 2018)	How many elderly people are there in the community population?	Elderly people tend to be less mobile and they can find it more difficult to prepare for disasters and to adapt to extreme circumstances. Also, many people over 70 require assistance from family, neighbors, and others, which might not be available during a disaster.	% of elderly people in the population >65 years old	PT Use Case info: 22% > 70 years old fig da foz + montemor o velho INE - Indicador	EGL: 19% > 60 years old	9.9%	16.80%

Indicator	Indicator Description	Why is this indicator relevant?	Example Proxies	Centro Region-PT	Egaleo, GR	Ordu, TK	Mallorca, SP
Community Participation in Decision Making (COSA, Committee on Sustainability Assessment)	To what extent do the local citizens participate in the decision making regarding their communities? Is there a transparent and accessible voting process?	Participating in the electoral process and/or taking part in the decision making strengthens the feeling of belonging in a community and gives the citizens an active role in the development of the community policies.	% of people who participated in the last community elections	Resultados - formato folha de cálculo | Comissão Nacional de Eleições (cne.pt) 58% (sum fig foz and mont o velho; registered voters/voters) 42.45%	42.45% who participated in the last community elections	71.40%	56.70%
Place Attachment (Delprato et al., 2022)	To what extent are the citizens emotionally connected to their place of residence? Do they feel a sense of belonging in their local area?	Place attachment encourages citizens to invest time and energy to improve resilience of their community e.g. by engaging in resilience activities, etc. In addition the lesser the change in a community's population the greater the affective affiliation and identification with said community.	% of population with close relationships with others, such as family, friends, neighbors % of residents in the same residence for greater than 5 years % of population living in the area for 10+ years Variation ratio of resident population (2011 - 2021) (%) by Place of residence, Sex and Age group	Variation Ratio of resident population for continental Portugal: -1.91 % (2011-2021) INE - Indicador PT: 67.4% of the population trust others in their neighborhood (2020)	GR: 66.4% of the population trust others in their neighborhood (2020) (Source: https://ourworldindata.org/grapher/share-people-trust-neighborhood	TK: 62.8% of the population trust others in their neighborhood (2020)	SP: 81.1% of the population trust others in their neighborhood (2020)

Average Life Expectancy (Garschagen et al. 2016)	How many years do people live on average in the community?	The average life expectancy of a community reflects its well-being levels and the quality of its medical services.	Average life expectancy in years in the community (Source Our World in Data Life Expectancy, 2021 https://ourworldindata.org/grapher/life-expectancy?tab=map)	80,72 years (data 2019-2021)	GR: 80.1 years (2021)	TK: 76 years (2021)	SP: 83 years (2021)
Hospital Beds Capacity (Delprato et al., 2022)	How many available hospital beds are there for the community citizens?	Lack of health resources in terms of people, equipment, facilities and funding, contributes to reducing the ability of a community's health system to meet the emergency needs.	Number of hospital beds per 1,000 inhabitants in the community (Source: https://ourworldindata.org/grapher/hospital-beds-per-1000-people)	3,5 beds/1000 inhabitants Camas dos hospitais - Observatório das Desigualdades (observatorio-das-desigualdades.com) (year 2019) By municipality:AER2021_II_04.xlsx (live.com)	GR data: 4.2 hospital beds per 1000 inhabitants (2019) Source:https://ourworldindata.org/grapher/hospital-beds-per-1000-people	TK: 3.01 hospital beds per 1000 inhabitants	Balearic Islands: 3.03 hospital beds per 1000 inhabitants (Government of the Balearic Islands [https://www.caib.es/sites/atencioespecialitzada/ca/presentacio-78950/])
Medical Professional Capacity (Edgemon et al., 2020)	How many medical practitioners are available to the community?	Lack of access to physicians is related to lower levels of overall community resilience as indicated by low birth weight and premature mortality. In addition, physicians are a critical emergency resource in the response to and recovery from a disaster.	The number of health-diagnosing and treating practitioners per 1,000 population (Source: https://ourworldindata.org/grapher/physicians-per-1000-people)	PT data: 5.31 medical doctors per 1000 population (2019)	GR data: 6.23 medical doctors per 1000 population (Source: https://ourworldindata.org/grapher/physicians-per-1000-people)	TK: 2.16 medical doctors per 1000 population (2019)	- 3.43 medical doctors per 1,000 people Government of the Balearic Islands [https://www.caib.es/sites/atencioespecialitzada/ca/presentacio-78950/])

Indicator	Indicator Description	Why is this indicator relevant?	Example Proxies	Centro Region-PT	Egaleo, GR	Ordu, TK	Mallorca, SP
Health Insurance (Edgemon et al., 2020)	Do people have health insurance either public or private?	Health insurance coverage is one indication of individuals' capacity to effectively respond to and recover from a crisis, both mentally and physically.	% of people who have public or private health insurance OR/ Healthcare expenditure per capita (Source: https://ourworldindata.org/grapher/life-expectancy-vs-healthcare-expenditure?endpointsOnly=1&time=1995..2014)	8% people who have public or private health insurance, 2457€ healthcare expenditure per capita	100% of people have public health insurance $2,100.17 (Healthcare expenditure per Capita, 2021) (Source: https://ourworldindata.org/grapher/life-expectancy-vs-healthcare-expenditure?endpointsOnly=1&time=1995..2014)	443.08 $ per capita (Healthcare expenditure per Capita, 2021)	1.645 € per capita
Shortage of communication networks (Cardoso et al., 2020)	Would a significant loss of service be expected for a significant proportion of the city in the 'worst case' scenario event?	It is important for the community to be aware, prior to a disaster, of the strength and capacities of its communication services, in order to prepare alternative communication networks, in case every other system falls short.	Quantitatively expressed as: 3 – There would be no loss of service even from the "most severe" scenario. 2 – Some loss of service would be experienced from the "most severe" scenario. 1 – Some loss of service would be experienced from the "most probable" scenario. 0 – Significant loss of service would be experienced from the "most probable" scenario.	PT: 2	EGL: 2	TK: 1	SP: 1

Internet Access (Delprato et al., 2022)	How many citizens have mobile connection access and/or can access internet services through their phone?	Broadband internet access allows citizens to receive information from various sources and cross-check it in order to take proper action. In addition, stable and fast internet connection can be an indicator of economic development of a society.	Fixed broadband Internet accesses per 100 inhabitants (No.)	44%	90.9% of households in Attica have fixed broadband internet access (Source ELSTAT, Census, 2021)	95.5%	96.4 % (Spain)
Educational Attainment (Edgemon et al., 2020)	How many citizens hold a high-school diploma?	Higher levels of education are associated with health, as well as an improved ability to communicate and comprehend information. They are also a characteristic of a strong labor force and the individuals' ability to access community resources. In addition higher levels of education can improve the capacity to prepare for, and respond to, the stress of disasters.	% of people with high-school diploma (Source: https://ourworldindata.org/grapher/completion-rate-of-lower-secondary-education)	90%	93.59%	64%	76%
Public School Capacity (Edgemon et al, 2020)	Does the community have an adequate number of schools to accommodate its pupils?	Public schools are a measure of response and recovery capacity, as they represent the community's ability to provide safe shelter for individuals and facilitate evacuations. In addition, more availability of schools can increase the ability to maintain schooling after a disaster.	The number of public schools per 5,000 population	2.7 public schools per 5,000 population	1.5 public schools per 5,000 population	14.67 public schools per 1,000 habitants	2.72 schools per 5,000 population (Balearic Islands)

Indicator	Indicator Description	Why is this indicator relevant?	Example Proxies	Centro Region-PT	Egaleo, GR	Ordu, TK	Mallorca, SP
Event Management Plans (Cardoso et al., 2020)	Is there a disaster management/ preparedness/ emergency response plan outlining city mitigation, preparedness and response to local emergencies?	Event Management Plans should be pre-determined and include the several distinct levels of a community in order to address all the possible needs that may rise due to the hazards' impact.	Quantitatively expressed as: 3 – There is a disaster management / preparedness / emergency response plan outlining mitigation, preparedness and response to local emergencies. 2 – A comprehensive plan exists but it contains significant gaps in coverage for mitigation, preparedness and response to local emergencies. 1 – Some plans exist, but they are not comprehensive or joined up. 0- No known plan.	3	1	2	2

Emergency Preparedness Training (Delprato et al., 2022)	Are both the locals and the authorities properly trained in order to take action in the face of various hazards? Is the training up to date and repeated in adequate time frames?	The knowledge and experience that people in a community possess in emergency preparedness (derived from previous disaster experiences as well), constitutes relevant factors towards the development of appropriate behavior and is beneficial for mitigation of local hazards and related risks.	% of people in the community who have passed a drill on emergency evacuation in the past 3 years. Also qualitatively expressed as: 3 – There are training courses covering risk, resilience and disaster response offered across all sectors of the city including government, business, NGO's and community 2 – The city has a track record of delivering resilience training to some sectors, but other sectors lack training and engagement. 1 – Some training modules are available. Coverage and content needs to be significantly improved. 0 – Little or no relevant training exists that is tailored for the city.	2	1	1	1
Emergency meeting stations (Delprato et al., 2022)	Are there enough and adequate predetermined emergency meeting stations where the local citizens are expected to meet in case of an emergency?	Every community should have pre-determined emergency meeting stations. Those places should be safe and prepared to meet the needs of the citizens (e.g. food deposits, flashlights etc.) It is very important that all community members are informed about the exact location and the capacity of these meeting stations. They should also be accessible to everyone and within reasonable distance even from the most remote locations of the community.	% of community members who know about facilities/services/skills available pre-, during and post-emergency, and how to access them	No data	No data	No data	No data

Indicator	Indicator Description	Why is this indicator relevant?	Example Proxies	Centro Region-PT	Egaleo, GR	Ordu, TK	Mallorca, SP
Food, shelter, staple goods and fuel supply (United Nations Office for Disaster Risk Reduction (UNDRR), 2017)	Would the city be able to continue to feed and shelter its population post-event?	It is important for the community to assess its citizens' basic needs prior to a disaster happening so that it can organize its supplies and avoid shortages of any kind.	Quantitatively expressed as: 3 – In "most severe" scenario, supply of emergency food and basic relief items exceeds estimated need. 2 – In "most severe" scenario, supply of emergency food and basic relief items is equal to estimated need. 1 – In "most severe" scenario, supply of emergency food and basic relief items is less than estimated need by 2% or more. 0 – In "most severe" scenario, supply of emergency food and basic relief items is less than estimated need by 5% or more / food gap exceeds 24 hours.	2	2	2	3
Emergency experience (Delprato et al., 2022)	Level of knowledge based on previous experience of community members with local hazards, emergency preparedness and mitigation strategies (emergency plans) and disaster response.	The knowledge and experience that people in a community possess in emergency preparedness (derived from previous disaster experiences as well), constitutes relevant factors towards the development of appropriate behavior and is beneficial for mitigation of local hazards and related risks.	% of people who have previous experience with disasters (estimated based on the duration of residence of a specific household in a hazard-exposed area)	No data	No data	No data	No data

Early Warning Systems (EWS) and Reach of Warning (Delprato et al., 2022)	What is the prevalence of EWS in the community? How many people are within the EWS reach and are they familiar with their use?	To reduce the impact of possible hazards on the population of a community, the use and efficiency of early warning systems (population covered and effective understanding by the public) and other forms of communication and information dissemination are important factors to assess.	Existence of Early Warning System for monitoring, forecasting and making predictions on hazards (including climate change-related events) / % of community members who can recognize warning signal(s) (e.g., emergency sirens) and know how to act when they receive them. Reach of warning quantitatively expressed as: 3 – Estimated that over 90% of the population is reachable by early warning system. 2 – Estimated that over 75% of the population is reachable by early warning system. 1 – Estimated that more than half of the population is reachable by early warning system. 0 – Less than half of the population is reachable by early warning system.	2	0	1	1
Hazard Assessment (Delprato et al., 2022)	Existence of hazard assessment(s) (knowledge of key hazards that the city community faces, including likelihood of occurrence)	Each community should have prior knowledge of the possible hazards that may occur within its reach and their possible impact. Knowing how vulnerable a community is and to which specific hazards, can help the authorities devise a more adequate plan against disasters and thus help increase the overall resilience of the community.	Existence or absence of scenarios setting out community-wide exposure and vulnerability from each hazard level. Measured quantitatively as follows: 3 – Community understands the main hazards. Hazards data is updated at agreed intervals. 2 – Community understands the main hazards, but there are no agreed plans for updating this information. 1 – Data exists on most of the main hazards. 0 – Hazards are not well understood. (UNDRR)	3	1	2	2

Indicator	Indicator Description	Why is this indicator relevant?	Example Proxies	Centro Region-PT	Egaleo, GR	Ordu, TK	Mallorca, SP
Post event recovery planning—(decided pre event) (Cardoso et al, 2020)	Is there a strategy or process in place for post-event recovery and reconstruction, including economic reboot, societal aspects etc.?	A community that has a predecided plan of action for post event recovery is more likely to act and recover faster from a disaster. Quick and efficient response can also mitigate the hazards' effects and possibly prevent further impact of the disaster.	Qualitatively expressed as: 3 – There is a strategy / process in place. It is robust and well-understood by relevant stakeholders. 2 – There is a strategy / process in place. It is well-understood by relevant stakeholders but has known weaknesses. 1 – Some plans / strategies exist but they are not comprehensive or joined up or understood by relevant stakeholders. 0 – No known plans.	1	1	3	2
Plan for resilience (Cardoso et al, 2020)	Does the city community have a municipally approved resilience plan (strategy or action plan)? And what is its timeframe?	Since community resilience can be measured and assessed, it is suggested that cities conduct their own resilience plan that addresses the regions and the citizens' specified needs.	Is there a municipally approved resilience plan (strategy or action plan)? And what is its timeframe? Does the resilience plan consider climate change (projection, scenarios, impacts, etc.)?	YES (for Figueira da Foz Municipality at least)	No	No (in the development phase)	No

Emergency services (Delprato et al., 2022)	What are the available emergency services of the community?	Lack of adequately trained resources and services, capable of effectively dealing with disaster-related risks, limits a community's ability to cope with the consequences of a disaster.	N. of local fire and police departments	(Figueira da Foz and Montemor-oVelhomunicipalities: Municipal police departments: 3 Fire departments: 3	1 police department / 1 fire department / 1 municipal police department	1 police station, 1 fire depart 1 municipality police station	No data
Financial plan and budget for resilience, including contingency funds (Cardoso et al, 2020)	The budget, resources and funds that are reserved for Disaster Risk Reduction (DRR). Does the city have in place a specific "ring fenced" protected budget, the necessary resources and contingency funds arrangements for local disaster risk reduction (DRR) (mitigation, prevention, response and recovery)?	Both preparing for as well as dealing with a disaster always require a certain budget in order to cover all the financial and practical needs that may arise. Each community should have a predisposed budget for resilience and/or know where and how to look for emergency funds during a disaster.	Qualitatively expressed as: 3 –The city financial plan is comprehensive in relation to DRR, budgets are ring fenced and contingency plans are in place. 2 – The city financial plan allows for DRR activities, budgets are ring fenced. 1 – There are some plans in different agencies / organizations but they are not coordinated. It is key to assess here both the presence and size of the budget, and the protection for these funds that stops them being diverted to other uses. 0 – No clear plan.	1	1	1	1

Indicator	Indicator Description	Why is this indicator relevant?	Example Proxies	Centro Region-PT	Egaleo, GR	Ordu, TK	Mallorca, SP
Corruption of Authorities (Proposed by Portugal CSA)	Are the outputs and outcomes of the emergency governance transparent? Do the local institutions follow the rules of best practice?	Transparency and accountability, as well as the absence of conflicts of interest, are key in delivering effective emergency plans.	The Corruption Perception Index (CPI) is the oldest and most comprehensive corruption measurement tool in the world, analyzing the levels of corruption in the public sector of 180 countries and territories, scoring them from 0 (perceived as very corrupt) to 100 (very transparent).	62/100 0 (perceived as very corrupt) to 100 (very transparent)	52/100 0 (perceived as very corrupt) to 100 (very transparent).	36/100 0 (perceived as very corrupt) to 100 (very transparent).	60/100 0 (perceived as very corrupt) to 100 (very transparent).
Lessons learnt /learning loops (Delprato et al., 2022 & Cardoso et al, 2020)	Do post-event assessment processes incorporate failure analyses and the ability to capture lessons learned that then feed into the design and delivery of rebuilding projects?	It is important for a community to learn from past disasters by assessing and reviewing both its successes and its failures in order to design better policies for future events.	Qualitatively expressed as: 3 – Clear processes are in place to capture lessons from failures post-event. There are clear and effective mechanisms / processes to feed these lessons into design and delivery of rebuilding projects. 2 – Clear processes are in place to capture lessons from failures post event, mechanisms / processes to feed these lessons into design and delivery of re- building projects require improvement. 1 – Some lessons are captured and disseminated but not in a thorough or systematic way. 0 – Lessons learnt are unplanned / ad-hoc and rely on individuals.	2	1	3	1

Efficiency and Effectiveness (Delprato et al., 2022)	Evaluation of the community's level of effectiveness and efficiency, measured through the implementation of practices aimed at monitoring performance and interchange of best practices.	The efficiency and effectiveness evaluation of a community, is a useful factor for the overall improvement of a community's vulnerability; understood in terms of willingness to constantly review and evaluate services provided and establishment of policies to improve performance by implementing new practices.	All major services and functions are regularly reviewed at appropriate intervals, to evaluate their performance and impact. (qualitatively expressed as: 0 - no reviewing scheduled; 0.25 – reviews are carried out irregularly; 0.50 – reviews are planned and carried out on some services and functions; 0.75 - reviews are planned and carried out on major services and functions performances and with no impact assessment; 1 - reviews are planned and carried out on major services and functions performances and impact assessment)	1	0.25	0.50	0.75
Median Household Income (Links et al, 2018)	What is the average median household income in the community?	Low-income households are at greater risk because they tend to live in lower-quality housing situated in higher risk areas, are less likely to have prepared for a disaster, and have fewer resources to support recovery.	Average annual household income combined from all family members divided per number of family members (per capita income) Source: (https://ourworldindata.org/grapher/share-of-household-consumption-in-gdp-vs-gdp-per-capita?country=~GRC)	24,877 $ per year	20791 $ a year	10,622 $ per year	32,404 € per household / 12,451 € per capita
Disaster Risk Financing (Delprato et al., 2022)	Accessibility and strength of household and non-domestic insurance in the community for damage and losses suffered as a result of natural disasters	High levels of insurance cover and resilience incentives cover means that a community is more likely to recover from a disaster more quickly. Insurance can help withstand the immediate shock of a disaster, while resilience incentivisation can help ensure that businesses/households are fiscally prepared.	% of domestic properties with insurance coverage for high-risk hazards % of business properties with insurance coverage for high risk hazards % of public infrastructure that is insured for high-risk hazards	36.9% of domestic properties with insurance coverage for high-risk hazards	No data	No data	No data

Indicator	Indicator Description	Why is this indicator relevant?	Example Proxies	Centro Region-PT	Egaleo, GR	Ordu, TK	Mallorca, SP
Income Inequality (Pfeiffer, 2019)	Income inequality shows how unevenly income is distributed throughout a population. The less equal the distribution, the higher income inequality is.	The economic environment is a major factor in a community's resilience; and when income inequality is present, earnings tend to be distributed in a way that does not support broader community goals. In addition, a skewed distribution of economic resources may negatively affect the cohesiveness of the residents' response to a disaster.	Gini Index Coefficient (Source: OECD Data, Available on: https://data.oecd.org/inequality/income-inequality.htm) Measured as: 0: Complete Equality 1: Complete Inequality	0.327	0.320	0.415	0.329
Unemployment Rate (McGlade et al., 2019 & Pfeiffer, 2019)	How many people are unemployed at the moment?	High levels of employment contribute to a healthy community economy, which supports community resilience. Employment also provides residents with financial resources that contribute to their livelihoods. In addition unemployed persons do not have the employee benefit plans that provide income and health cost assistance in the event of injury or death.	% of labor forced unemployed https://ourworldindata.org/grapher/unemployment-rate	Figueira da Foz: 7%, Montemor-O-Velho: 4 % *individuals 15-54 years old that are unemployed	12.23% of labour force unemployed (EGL)	TK: 8.5 % unepmloyed	T1: 18 % T2: 9.3 % T3: 5.8 % T4: 10.9 % MEAN:11%

Building codes and standards (Delprato et al., 2022 & Cardoso et al., 2020)	Do building codes or standards exist, and do they address specific known hazards and risks for the city? Are these standards regularly updated?	The availability of zoning and land use regulations, as well as the existence of building standards, is potentially an important parameter in addressing natural hazards and reducing impacts on the environment and urban structure. However, the extent to which these rules and codes are enforced is equally relevant, as their non-application or limited application could result in a failure or partial achievement of the purposes behind them.	Are zoning rules, building codes and standards widely applied, properly enforced and verified?(qualitatively expressed as: 0 - no zoning rules; 0.25 - existing zoning rules and building codes; 0.50 - existing and applied; 0.75 - existing, applied and enforced; 1 - existing, applied, enforced and verified)	0.75	0.25	0.50	1
Existing protective infrastructure (Delprato et al., 2022 & Cardoso et al., 2020)	Is existing protective infrastructure designed and built according to risk information? Does it reduce potential damage to people and goods from natural and man-made hazards?	The existence of adequate, effective and well-maintained protective infrastructures designed to protect against specific or multiple hazards, reduces the vulnerability of exposed value (people and assets).	Quantitatively expressed as: 3 – In all cases protective infrastructure is in place and consistent with best practice for asset design and management, based on relevant risk information. 2 – In most cases protective infrastructure is in place and consistent with best practice for asset design and management, based on relevant risk information. 1 – In some cases protective infrastructure is in place but some strategic protective infrastructure is missing. Design and management may not be consistent with best practice. 0 – Significant parts of the city community are unprotected from known risks / hazards.	2	1	1	1

Indicator	Indicator Description	Why is this indicator relevant?	Example Proxies	Centro Region-PT	Egaleo, GR	Ordu, TK	Mallorca, SP
Water Access (Delprato et al., 2022)	This indicator shows how well the water infrastructure system covers the population living in a given community, irrespective of community and energy grid specificities. The indicator includes access to public potable water (incl. purified water), private potable water and sewage.	A community with higher access to water and sanitation is more resilient during hazardous events and faster in the recovery phase.	% of people in the community who have access to public potable water sources (Source: https://ourworldindata.org/sdgs/clean-water-sanitation) % of people in the community who have their own potable water sources (tanks, wells, etc.) % of people in the community who have access to public sewage % of people in the community who have access to private sewage / Community water storage volume (cubic meters)	clean water: 95.2% public/ private sewage Figueira da Foz: 48.3%	100% of households have water access 97.4 % of households connected to public sewage	99.6% access to drinking water 91.1% access to sewage	86.93% of population connected to at least secondary wastewater treatment
Natura 2000 protected areas (Resilience Dashboards for the Social and Economic, Green, Digital, and Geopolitical Dimensions, 2021)	Natura 2000 is a network of protected areas covering Europe's most valuable and threatened species and habitats.	Natura 2000 protected areas can help mitigate the effects of climate change by providing natural storage capacity for carbon, by increasing capture of carbon dioxide in natural ecosystems, by reducing the risks of and impacts from extreme events and by reducing impacts of sea level rise, thus contributing to the overall resilience of the community (European Commission Directorate - General for Environment, 2014)	Is there one or multiple Natura 2000 protected areas within the community?	Yes	No	No	No

Exposure to heat (Delprato et al., 2022)	The degree to which the population and natural environment are exposed to the negative effects of heat wave events and heat-related health impacts.	The strong increases of heat stress has a high impact namely in public health and in mortality indicator in central and partly northern Europe and, on a lower level, in eastern Europe as well (Lung, Lavalle, Hiederer, Dosio, and Bouwer, 2013)	Number of summer days with temperature that exceeds the 35 degrees Celsius in summer period (June, July, August)	28/92 days with temp > or equal to 35 degrees C	29/92 days with temp > or equal to 35 degrees C	No data	39 days in summer 2023 when at least one metorological station exceeded 35 degrees C
Exposure to landslides and avalanches (Delprato et al., 2022)	Landslides and avalanches are external geologic processes called "mass wasting."	Landslides not only kill people but also have an extremely serious impact in terms of hindering rescue operations and the supply of aid and can cause long-term damage to communication and electricity networks.	% of population in areas that are at risk from landslides % of not slide area	No data	No data	No data	No data
Exposure to flooding and area of operational floodplain (Delprato et al., 2022)	The area of the operational floodplain is a good indicator for several resilience characteristics. It is an indicator of ecosystem structure and function. A growth in this indicator should be interpreted as a rise in resilience.	This can raise awareness of the risks of depleting natural capital assets in own and neighboring communities can have on community resilience. A functioning floodplain is important for regulating flood risk, but it also contributes to other services such as silt deposition, soil formation and providing a diverse ecosystem structure.	% of land area does not prone to liquefaction % of flooded area, magnitude of a 100-year event flood / Mean water depth [in m] of flooded area, magnitude of a 100-year event flood / Flood duration (month) / Population density within areas (%)	High exposure to river, coastal, urban flood	High risk of flooding	High risk of River flood and Urban Flood	High risk for coastal flood

Indicator	Indicator Description	Why is this indicator relevant?	Example Proxies	Centro Region-PT	Egaleo, GR	Ordu, TK	Mallorca, SP
Exposure to forest fire (Delprato et al., 2022)	The degree to which the natural environment is exposed to the negative effects of forest fires or wildfire events.	Forest fire seasons are becoming more and more frequent worldwide, and large wildfires are having unusual impacts on people and property, in spite of several investments to support social–ecological resilience to wildfires.	% forested land cover / Greatest number of consecutive days per year with daily precipitation < 1 mm / Mean of daily mean summer temperature (June, July, August) / Summer precipitation (June, July, August)	High risk of wildfire 14.4% forested land covered	Baroutadiko grove", covers almost 134,000 m² of the municipality (high exposure)	29.6% (High risk of wildfire)	44.3 % of forested land cover (high risk)