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Assessing Greek small and medium-sized enterprises' flood resilience capacity: Index development and application

Antonis Skouloudis[1] | **Walter Leal Filho**[2] | **Panagiotis Vouros**[1] | **Konstantinos Evangelinos**[1] | **Ioannis Nikolaou**[3] | **Georgios Deligiannakis**[4] | **Thomas Tsalis**[3]

[1]Department of Environment, University of the Aegean, Lesvos, Greece

[2]Research and Transfer Centre 'Sustainability and Climate Change Management' (FTZ-NK), Hamburg University of Applied Sciences, Hamburg, Germany

[3]Department of Environmental Engineering, Democritus University of Thrace, Xanthi, Greece

[4]Department of Natural Resources Development and Agricultural Engineering, Agricultural University of Athens, Athens, Greece

Correspondence
Antonis Skouloudis, Department of Environment, University of the Aegean, University Hill, GR81132, Mytilene, Lesvos Island, Greece.
Email: skouloudis@aegean.gr

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Abstract

Floods signify one of the most common, widespread and destructive natural perils, affecting approximately 250 million people and causing billions in losses on an annual basis. Such high impact – low probability environmental perturbations can cause abrupt changes and disruption to business entities in flood-prone areas in terms of asset damages, operational interruptions and increased costs which result in loss of capital and labour, declining revenue and growth. It is therefore critical for businesses to identify such risks and, ultimately, to effectively build their resilience to such physical challenges. Small and medium-sized enterprises (SMEs) in particular are more ill-prepared to face flooding compared to large companies. Understanding the ability of SMEs to become more resilient to floods is crucial as they account for 99% of all enterprises, constitute the major employer and contributor of the total value-added of the private sector. In this study, a composite index of factors linked to the resilience capacity of SMEs to flooding is proposed and tested. A sample of Greek SMEs located in three flood-prone areas ($n = 391$) was administered a structured questionnaire pertaining to cognitive, managerial and contextual factors that affect the ability to prepare, withstand and recover from flooding events. Through the proposed index, a bottom-up, self-assessment, approach is set forth that could assist in standardising such assessments with an overarching aim of reducing the vulnerability of SMEs to floods. This is achieved by examining critical internal and external parameters affecting SMEs' resilience capacity which is particularly important taking into account the limited resources these enterprises tend to have at their disposal and that they can generate single points of failure in dense supply chain networks.

KEYWORDS

floods, Greece, index development, organisational resilience capacity, small and medium-sized enterprises

1 | INTRODUCTION

Over the last two decades, flooding has been the most frequently occurring natural disaster, accounting for up to 43% of all recorded natural disaster events in the world, and the proportion of the global population exposed to flooding today is 10 times higher than previous estimates (CRED/UNISDR, 2015; Tellman et al., 2021; UNDRR, 2020). As early century (2030) climate change projections stress that exposure to floods will increase further (Tellman et al., 2021), the organisational resilience capacity to extreme weather events (EWEs), such as floods, has sparked a growth over the past decade in scholarly and managerial attention as an essential aspect of business continuity management (Helgeson et al., 2022; OECD, 2021a, 2021b; Schaper, 2022; WEF, 2021). Supporting evidence for this claim suggests that organisational resilience capacity retains a key role in successful responses to adverse situations, crises and shocks. Small and medium-sized enterprises[1] (SMEs) are more vulnerable to face floods in comparison to their larger counterparts, so they are disproportionately affected by such EWEs (Dlugolecki, 2009). The limited resources at their disposal and the lack of time and skills all conduce to an inadequate preparedness for challenges posed by floods (Sullivan-Taylor & Branicki, 2011). SMEs tend to plan in the short-term, reacting to circumstances as they arise and focussing on their very survival (Smith & Smith, 2007). Likewise, they share less formalised structures and codified policies and they are most usually owner-managed, resulting in a command-and-control management culture (Ates et al., 2013). Such characteristics result in limited opportunities to recover from flooding and quickly turn around their operation from a loss-making to a profit-making one (Ingirige & Wedawatta, 2011; Wedawatta & Ingirige, 2012).

Scholars frame the capacity of business entities to be resilient to an EWE disturbance (such as floods) as the rate of recovery and restoration of organisational performance to pre-disturbance conditions, the amount of disturbance (i.e. threshold level) a business entity can absorb before losing structural and/or functional components that will alter or cease operations, as well as the extent to which the organisation maintains its function (i.e. impact resistance) before performance levels are driven to zero (see Linnenluecke & Griffiths, 2010). Nevertheless, while it seems to be accepted as an essential trait of firms effectively transcending uncertain conditions (e.g. Bhamra et al., 2011; Kantur & İşeri-Say, 2012; Linnenluecke & Griffiths, 2010), research deconstructing the enabling conditions and/or inhibitory factors of SMEs' resilience capacity to natural hazards is still fragmentary, sparse and mostly fuelled by anecdotal evidence or normative assumptions (Kuruppu et al., 2013; Linnenluecke, 2017; McNaughton & Gray, 2017; Verreynne et al., 2018). Table 1 presents an excerpt of relevant studies that attempt to shed light on the resilience capacity of SMEs to extreme weather with a special focus on flooding. Studies such as these offer multiple actionable insights and encapsulate implications for SME management as well as policy-design in achieving an 'EWE-resilient' sector. Focusing on the individual level of analysis, that is, the individual enterprise and its endeavours to succeed, the emergent picture from this (relatively new) research strand delineates the specification of variables, conceptual relationships or dynamic boundaries of resilience capacity components in an attempt to provide prescriptions for policy-making as well as business management (Bhamra et al., 2011; Linnenluecke, 2017; Linnenluecke & Griffiths, 2015; Mamouni Limnios et al., 2014; van der Vegt et al., 2015). By examining SMEs that have previous experience with floods, in-depth knowledge can be obtained on the effectiveness of strategies and/or practices employed to reduce the impacts and contribute to the recovery process.

Nevertheless, reflecting on the available literature, much work needs to be done to provide enabling conditions for SMEs to better prepare and successfully overcome such environmental perturbations. While several recent studies have sought to analyse impacts and factors associated with the recovery from floods and other EWEs (Frey et al., 2015; Harries, 2013; JBA Consulting, 2012; Johnson et al., 2005; Joseph et al., 2011; Royal Haskoning DHV, 2012; Twigger-Ross et al., 2014), further empirical studies are required to gain a better understanding of particular measures and actions that help SMEs to robustly address short and long-term flood impacts. Such knowledge, which can also be gained through the application

TABLE 1 An excerpt of empirical studies assessing SMEs' responses to flooding using quantitative methods drawn from Skouloudis et al. (2020) and up-to-date publications

Year	Author(s)	Journal/outlet	Country/-ies	Method(s)
2013	Mullins and Soetanto	*Disaster Prevention & Management*	United Kingdom	Quantitative
2013	Kuruppu, Murta, Mukheibir, Chong and Brennan	National Climate Change Adaptation Research Facility	Australia	Mixed methods
2014	Wedawatta, Ingirige and Proverbs	*Journal of Flood Risk Management*	United Kingdom	Quantitative
2015	Ingirige and Russell	UK Climate Impacts Programme, University of Oxford	United Kingdom	Qualitative
2017	Herrmann and Guenther	*Journal of Cleaner Production*	Germany	Quantitative
2017	Marks and Thomalla	*Natural Hazards*	Thailand	Mixed methods
2018	Kato and Charoenrat	*International Journal of Disaster Risk Reduction*	Thailand	Quantitative
2018	Samantha	*Procedia Engineering*	Sri Lanka	Qualitative
2018	Halkos, Skouloudis, Malesios and Evangelinos	*Business Strategy & the Environment*	Greece	Quantitative
2018	Crick, Eskander, Fankhauser and Diop	*World Development*	Kenya, Senegal	Quantitative
2020	Halkos and Skouloudis	*Climate and Development*	Greece	Quantitative
2020	Karman	*Business Strategy & the Environment*	20 European countries	Quantitative
2020	Coates, Alharbi, Li, Ahilan and Wright	*Philosophical Transactions of the Royal Society A*	United Kingdom	Mixed methods
2021	Oracion	*Climate, Disaster and Development Journal*	Philippines	Mixed methods
2021	Hashim, Ng, Talib and Tamrin	*International Journal of Disaster Risk Reduction*	Malaysia	Quantitative
2021	Neise, Garschagen and Revilla Diez	*Climate Change Research, Policy and Actions in Indonesia*	Indonesia	Mixed methods
2022	Hudson, Bubeck and Thieken	*Mitigation & Adaptation Strategies for Global Change*	Germany	Quantitative

of composite firm-level indicators assessing organisational, behavioural and contextual factors of the resilience capacity level, may serve as a basis for developing sets of actionable guidelines of good practice that can be adjusted to individual needs and adopted by SMEs to strengthen their resilience capacity. This can be achieved in collaboration with critical stakeholders in order to plan and implement agendas for action that can enhance the resilience at a community, local or regional level (UKTI, 2011).

Against this background, this study presents the development of a flood resilience capacity index (FRCI) and its application with Greek SMEs from flood-prone areas. The proposed composite metric pertains to cognitive, behavioural/managerial and contextual factors that influence a SME's ability to shape effective responses to meet flood challenges. Our aim, through the proposed indicator-based assessment, is to offer insights towards an analytical framework that could help standardise such screening tasks with the overarching aim of reducing the vulnerability of SMEs to such weather extremes. This can be achieved by identifying major internal and external parameters that affect SMEs' resilience capacity, which is essential given the intrinsic characteristics of these enterprises and that they tend to be primary sources of vulnerabilities in supply chain networks, generating costly single points of failure.

Understanding the ability of European SMEs to become more resilient to floods is crucial, as they account for 99.8% of all enterprises in the EU, contributing more than 53% of the total value added of the EU business sector while providing more than 65% of private-sector jobs in the EU Member-States. In this respect, SMEs are the backbone of the Greek economy, representing the absolute majority of domestic business activity (99.9%), accounting for 56.7% of total value-added and 83% of overall employment (EC, 2021). According to Eurostat, the majority of Greek firms are micro-enterprises (94.6%), with substantial growth (i.e. >10%) in both SME value-added and employment indicated for 2021 (EC, 2021), making the country's SME sector a unique case in the European Research Area on business resilience research.

The rest of the paper is structured as follows. The next section presents the material and methods. Section 3 presents the findings of the study. The paper concludes with managerial and policy implications and highlights possible avenues for future research.

2 | MATERIALS AND METHODS

2.1 | Area selection and sample identification

The study areas were selected by drawing on the flood risk maps issued by the Special Secretariat for Water (Ministry of Environment, Energy and Climate Change), the European Severe Weather Database of the European Severe Storms Laboratory and available literature (e.g. Diakakis et al., 2012, 2019; Diakakis, Deligiannakis, Andreadakis, et al., 2020; Kazakis et al., 2015; Kourgia et al., 2022; Kourgialas & Karatzas, 2017; Papagiannaki et al., 2015, 2017; Speis et al., 2019). In this respect, the area selection relied on criteria that directly address the study's objectives: (a) severity of flood impacts; (b) existence of SMEs which have been significantly affected by flooding, and (c) increased concern of local stakeholders regarding the future of their area expressed through their involvement in decision-making processes. Based on these criteria, the three study areas selected are: (i) the Evros river region in Thrace, (ii) the town of Mandra in the West Attica region, and (iii) the area of Kalloni Bay Lesvos Island. We opted for three diverse study areas in terms of previous experience with flooding (as evidenced by available historical data), population density, geographical characteristics and main business activities (Figure 1).

The Evros Prefecture is named after the Evros River, which is the largest river in South East Balkans, running through Bulgaria, Turkey and Greece. Evros, its tributaries and a complex network of artificial irrigation channels provide water to the vast majority of the Evros Prefecture plains (Tsantopoulos et al., 2013), making it a key factor for the regional agricultural activity and boosting the local economy. However, the Evros River has repeatedly caused extensive riverine floods, which affect close-by villages, cultivated farms and agri-business for a considerable length along its main branch (Diakakis et al., 2012). A characteristic example is the extensive flood of the spring of 2006, when more than 200 km^2 of farmland was flooded. As a result, agriculture, transport and water supply networks were severely damaged, causing the worst negative effect on economic activity over the last 50 years (Markantonis et al., 2013).

The area of Mandra is located in Attica, in Thriassion plain, which is host to extensive socio-economic activities and one of Greece's most important industrial centres and logistic hubs (Diakakis, Boufidis, Salanova Grau, et al., 2020). Mandra has a unique flood history, with several events in the last decades (Diakakis et al., 2012). On 15 November 2017, an extreme flash flood event caused extensive damage to the city of Mandra. The flood was triggered by a high-intensity storm that produced a total rainfall amount of nearly 300 mm in 13 h, with the majority of the rainfall falling within 6 h. Apart from the extensive damages to buildings, infrastructure and transportation networks, the flood resulted in 24 tragic deaths, making it the deadliest flood in Greece over the past 40 years (Diakakis et al., 2019; Diakakis, Deligiannakis, Antoniadis, et al., 2020).

The Kalloni river basin drains the broader area of the Kalloni town, which is the second-largest commercial hub of Lesvos Island. The area has a Mediterranean climate, and the land is predominantly covered by agriculture (olive groves), grassland, and brushland habitats (Tzoraki, 2020). The main economic activities in the area are agriculture, livestock production, and retail, as well as small tourism and hospitality enterprises (Koutsovili et al., 2021). Over the last decades, sudden precipitations of high intensity and short duration have caused large volumes of water to end up in the urban fabric. At the same time, the reduced cross-section of the riverbed at this point leads to river overflows, with hazardous effects on the local infrastructure and the community. As a result, Kalloni experienced significant flash floods in 1986, 2005, 2011 and 2016 (Diakakis et al., 2012; Koutsovili et al., 2021; Matrai & Tzoraki, 2018; Tzoraki, 2020).

During the first half of 2021, a sample of 391 SME owners/managers from three flood-prone areas were administered a structured questionnaire on factors that influence the ability to shape effective responses to flooding. The sample was selected following a two-stage sampling technique. In the first stage, specific area blocks were selected, relying on historical evidence of the severity of flood impacts on local businesses. In the second stage, a snowball sampling approach was employed (Bell et al., 2019; Venter et al., 2005) in order to make sure that those SMEs significantly affected from previous years' floods were included. Out of these 391 enterprises, 74% pertain to the service/retail sector, 17% are manufacturing firms and 8% are SMEs operating in the primary sector. The majority of the sample firms (82%) are micro-enterprises (i.e. employing <10 persons and having an annual turnover of no more than EUR 2m) and small business entities (i.e. firms that employ no more than 10–50 persons and whose annual turnover does not exceed

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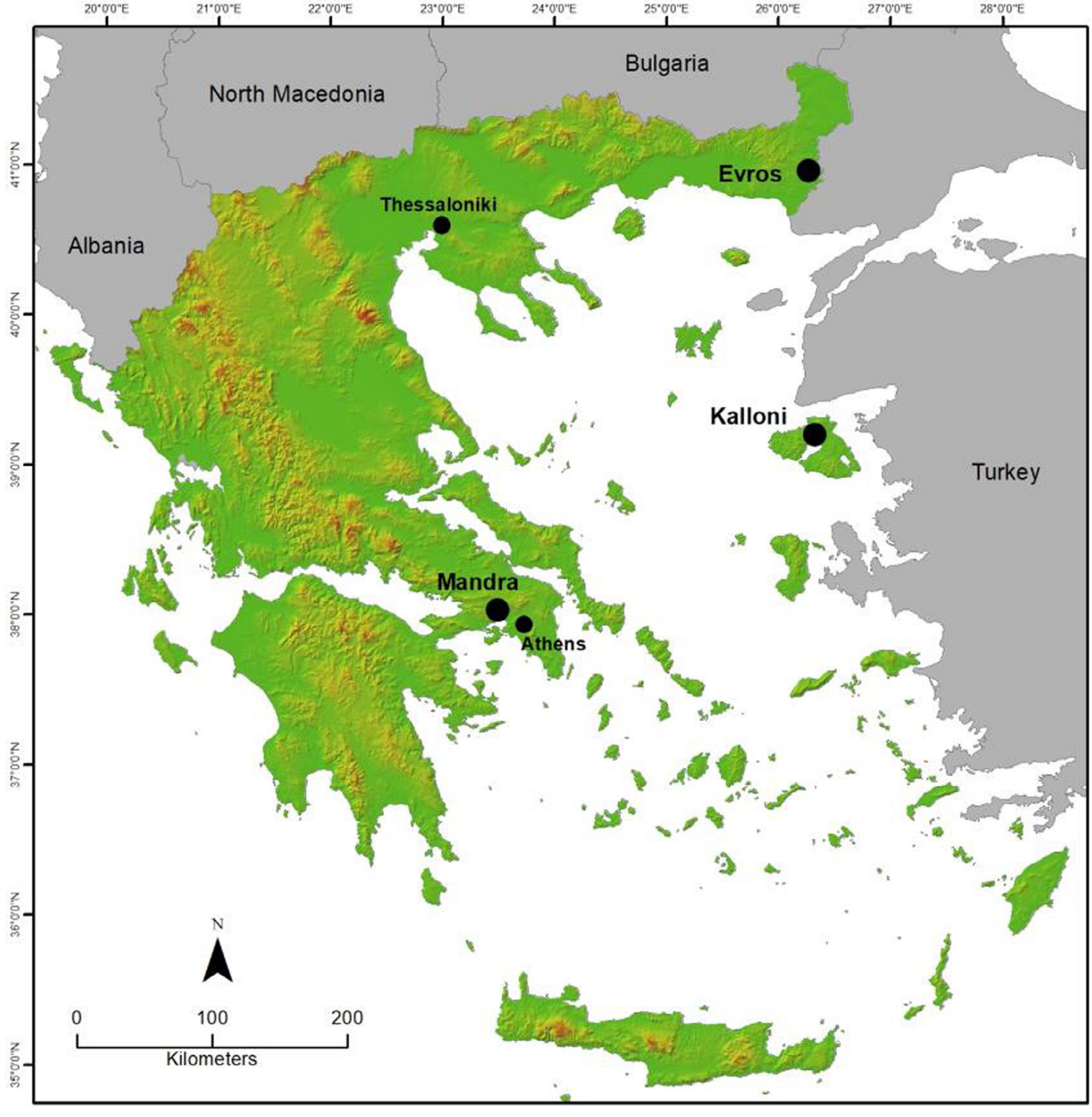

FIGURE 1 The three study area locations

EUR 10m), ranging from newly created ones (<3 years old; 6%) to SMEs founded more than 40 years ago (11%). Most SMEs had experienced flooding once in recent years (74%), while the rest had encountered two or more flooding events. In this respect, 29% of the respondents indicated that the severity of flood damages to their business was substantial.

2.2 | Model specification

A thorough literature review on variables describing the organisational resilience capacity was performed, emphasising SMEs vis-à-vis natural hazards or weather extremes and with a particular focus on floods (e.g. Herrmann & Guenther, 2017; Kuruppu et al., 2013; Linnenluecke & Griffiths, 2012; Vakilzadeh & Haase, 2021). This allowed us to identify three main groups of parameters (namely, the cognitive, behavioural/managerial and contextual factors outlined in Table 2) that influence an enterprise's ability to withstand, adapt and recover from floods. Cognitive factors pertain to attitudes and perceptions around risk awareness and proactivity as well as the level of knowledge/understanding of climate change impacts and the underlying links to extreme weather. Behavioural/managerial

TABLE 2 Resilience capacity factors, expert weights and explanatory definitions

	Factor	Factor weight	Factor definition/explanation
Cognitive factors	Knowledge/understanding (KNOW; 4 items)	0.088	Sufficient knowledge of climate change driving forces, its impacts and the underlying links to extreme weather/flooding (i.e. situation awareness; good knowledge of what climate change is, what causes climate disruptions, understanding of the low probability/high impact risk linked to extreme weather and the relative increase of such events in absolute numbers in recent years).
	Attitudes/perceptions (ATT; 7 items)	0.114	SME owners-managers have positive attitudes towards the importance of proactivity against flooding and demonstrate awareness of flood risk(s) (i.e. acknowledgement that flood protection is not merely the responsibility of the state authorities, that such extreme weather events can happen at any time during the year, that flood protection is not just good-to-have but an essential aspect in business preparedness and continuity).
Managerial factors	Leadership (LEAD; 4 items)	0.118	Leadership (behaviour) in times of adversity implies that (SMEs which are) leaders make sense of the environment in which they find themselves, and after a certain threshold in handling adversity is crossed, they initiate a new phase in the organisation's lifecycle involving new routines and/or structural patterns, embracing organisational change and new management techniques compared to other peer enterprises.
	Management culture (CULT; 3 items)	0.108	A management culture with resilient characteristics allows one to strengthen an organisation's ability to anticipate floods and to understand that adversity can strike at any time, therefore it proactively fosters risk awareness and centres on long-term survival as well as the need to involve all employees in resilience-building practices and flexible responses towards adverse conditions.
	Technological resources (TECH; 3 items)	0.111	Technological interventions within the business premises to protect from flooding and reduce the time and cost for recovery (e.g. raised level at which machinery, electrical sockets and products are located/stored, flood-resilient flooring, door guards and air brick covers, small-scale retrofits or special mechanisms to prevent damage to expensive equipment in business premises, etc.).
	Organisational planning (PLAN; 2 items)	0.104	Development of organisational plans to prepare for crises and external shocks and ensure functionality during times of adversity (as in the case of extreme/flash floods).
	Organisational learning (LEARN; 1 item)	0.095	The ability of an organisation to learn from past events and utilise such experiences to anticipate future adversity.
	Financial resources (FIN; 1 item)	0.113	Financial slack resources that provide security in effectively responding to crises, allowing the organisation to prepare for & anticipate crises before they occur and enable a quick recovery in times of crises.
Contextual factors	Relational resources (RELAT; 3 items)	0.071	Healthy, positive and strong relationships both within and outside an organisation with key stakeholder groups of the enterprise who can provide financial and/or in-kind support in case of emergency (e.g. other local enterprises and community members, business partners, suppliers, customers, friends and relatives, consultants).
	Institutional support (INST; 6 items)	0.078	Local and Central Government authorities and institutions (incl. chambers of commerce, business associations/federations, providers of capital) whose decisions and active support in the form of laws, regulations, and financial and non-financial assistance allow enterprises to successfully deal with flooding impacts.

factors refer to organisational behaviour, management culture, organisational planning and learning, and technological and financial resources, along with organisational leadership capabilities. Contextual factors encapsulate the critical role of key stakeholders (local enterprises and community members, business partners, suppliers, customers, friends and relatives, consultants, as well as business chambers and associations, providers of capital and local/central government entities) in SMEs' ability to adapt and recover from flooding.

An initial pool of items was devised, relying on existing knowledge/studies and developing new items/statements. Scales measuring the different aspects of SMEs' resilience capacity to floods were drawn following the systematic review of prior research and utilising expert input. This process led to a set of items comprising the resilience capacity measurement instrument (see Appendix 1). This composite research instrument was pre-tested using convenience sampling on a small group of SME representatives (Bell et al., 2019) that were easily accessible to members of the research team. Validity and reliability results for the sub-constructs (factors) comprising the specific index conceptualisation revealed acceptable metric properties, as Cronbach's alpha and the percentage of variance explained values were found to be above the acceptable threshold values (i.e. Cronbach's alpha values were above 0.8 and percentage of variance explained was in all cases above 50%). The proposed composite index is of the form:

$$\mathrm{FRCI} = \sum_{i=1}^{n} \sum_{j=1}^{3} A_{ij} \times w_{ij}^{A},$$

where A indicates the various aspects of cognitive (CG), behavioural (B) and contextual (CN) factors comprising the SMEs' FRCI; $i = 1, 2, \ldots n$, indicates each individual resilience capacity factor; $j = 1, 2, 3$ indicates the various parameters pertaining to the respective aspect A of cognitive ($j = 1 = \mathrm{CG}$), behavioural ($j = 2 = \mathrm{B}$), and contextual ($j = 3 = \mathrm{CN}$) factors and w_{ij} represents the individual weight of each resilience capacity parameter (i.e. j factor).

Factor weights were determined through an analytical hierarchy process (AHP) model of pairwise comparisons in order to allocate the relative importance of the criteria, and to achieve this, the AHP tool for decision-making processes developed by Goepel (2018) was employed. The pairwise comparison technique has been widely employed in business research to examine the relative importance of different aspects that describe complex problems in multi-criteria decision-making (Golany & Kress, 1993; van Til et al., 2014). It requires individual decision-makers to provide judgements expressed as preference ratios for pairs of criteria. These preference ratios are entered into a pairwise comparison matrix, and the weights can be derived by normalising the entries from any row or column of the matrix (Saaty, 1980). It is a heuristic decision support technique that allows one to 'translate' individual-subjective opinions (i.e. judgements) into measurable numeric relations. In this respect, using the input of a panel of 12 experts (comprised of academic scholars/researchers, sustainability management consultants and business continuity auditors), the prioritisation of resilience capacity factors was obtained. Consistency in the pairwise comparisons was measured through the consistency ratio (CR); the result was satisfactory with CR = 0.3%, that is, well below the recommended standardised threshold value (Saaty, 1990), while the aggregate expert judgements are characterised by a moderate-to-high AHP consensus (75%) in terms of overlap between the priority-setting defined by the expert group. The outcome of the weight allocation task reveals that the expert panel places more importance on the SME owners/managers' attitudes towards flood risk, their leadership capabilities, and the financial and technological resources at their disposal, rather than the contextual factors facilitating flood resilience capacity and the owner/manager's understanding of what may trigger EWEs.

Using the max–min normalisation technique, the data gathered from the sample SMEs were re-scaled to a distribution value between 0 and 1, where the minimum value for each factor is 0 and the maximum value is transformed into 1. The factor weights derived from the expert panel input were then applied to the normalised (resilience capacity) factor values in order to calculate the proposed quantitative metric of flood resilience capacity (whose sequential steps are graphically presented in Figure 2) for the sample SMEs:

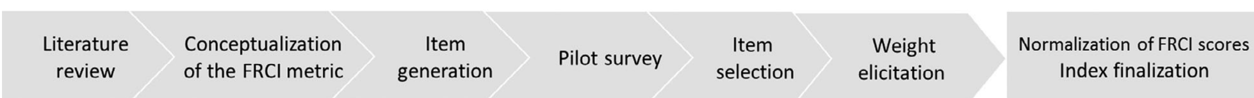

FIGURE 2 A graphical representation of the index design process

$$\begin{aligned}\mathrm{FRCI} = {} & [0.88 \times \mathrm{KNOW}] + [0.144 \times \mathrm{ATT}] + [0.118 \times \mathrm{LEAD}] \\ & + [0.108 \times \mathrm{CULT}] + [0.111 \times \mathrm{TECH}] \\ & + [0.104 \times \mathrm{PLAN}] + [0.095 \times \mathrm{LEARN}] \\ & + [0.113 \times \mathrm{FIN}] + [0.071 \times \mathrm{RELAT}] \\ & + [0.078 \times \mathrm{INST}].\end{aligned}$$

2.3 | Confidence intervals for the FRCI index based on bootstrap methodology

As sample point estimates of the average and median values of composite measures (such as the FRCI) tend to be reported as highly variable as well as dependent on the specific datasets derived from samples, confidence intervals of prediction accuracy were extracted. Specifically, the non-parametric bootstrap technique (Efron, 1982) for constructing confidence intervals for the FRCI was employed. The specific technique pertains to mathematics and probability theory and derives statistical formulas of standard errors and confidence intervals without the use of distributional assumptions, an approach that can prove to be more reliable than statistical formulas depending on distributional assumptions. The procedure of bootstrapping essentially relies on resampling from an initial sample. Specifically, one creates B bootstrap samples by sampling with replacement from the original data (Efron & Tibshirani, 1994). Once the random sample through the bootstrap resampling scheme is obtained, the various alternative confidence intervals can be produced to allow for comparisons based on statistical inference and taking into consideration the specific characteristics of the collected data. Among the advantages of this technique are (a) the requirement of fewer assumptions, especially associated with the distributional behaviour of data, since the collected data do not need to be normally distributed, (b) greater accuracy, since the method does not rely on very large samples, and (c) the generality of its use, since the same approach can be applied to a wide variety of quantitative problems. Given that the assumption of normality is usually violated for the data gathered for composite metrics such as the FRCI, the specific technique ensures the robustness of the conducted statistical analysis and the corresponding results obtained. Various alternative methods for creating the bootstrap confidence intervals for the FRCI were applied: the basic bootstrap (BB), the normal bootstrap (NB), the percentile bootstrap (PB) and the bias-corrected accelerated (BCa) bootstrap (see Davison & Hinkley, 1997). By applying these four alternative specifications we estimate reliable confidence intervals for the mean and median FRCI, and subsequently provide the means of practical value procedures in terms of making valid comparisons between the composite indices of the various areas.

2.4 | Sensitivity analysis for resilience parameters

Utilising the responses of SME owners/managers and key experts on critical parameters affecting resilience capacity, a sensitivity analysis was performed on the calculation formula used to derive the FRCI estimations. The aim of this task is to examine the robustness of the proposed FRCI and gain a better understanding of the relationships between input (cognitive, managerial and contextual factors) and output (FRCI) variables of the proposed assessment methodology. This allowed us to identify the relative magnitude of the effect from each one of the resilience capacity factors on the composite FRCI index. Sensitivity analysis is an extremely useful methodological tool (Yu et al., 1991), suitable for gaining a better understanding of how the explanatory variables contribute to the response of statistical models in a simple and efficient way. It is a quantitative technique that is commonly employed as a secondary method, subsequent to modelling (Yu et al., 1991), to determine which of the model's inputs contribute most to the variability of the dependent variable(s) (e.g. see Hamby, 1994). Conceptually, the common approach for performing sensitivity analysis in combination to regression analysis is to repeatedly vary one parameter of an explanatory variable at a time while holding the others fixed at their medium values. The main reason is to determine which of the model's inputs contribute the most to the variability of the dependent variables (in our study, being the FRCI derived from the three areas) whereas independent variables will be the various factors shaping the FRCI.

3 | FINDINGS

Table 3 is a summary of the descriptive statistics for the sample SMEs, while Figure 3 presents the histogram plot of the FRCI, both from the overall sample and the three study areas. The mean FRCI for the total sample is 0.609, with considerably lower scores on aspects pertaining to contextual parameters affecting flood resilience capacity. Grouping the mean scores (%) of the FRCI factors into the three domains, it is evident that flood resilience capacity is primarily driven by cognitive factors, followed by managerial competencies, while contextual factors leave much to be desired (see Figure 4). Likewise, looking

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TABLE 3 Summary of descriptive statistics for the 10 factors describing SMEs' resilience capacity and the overall FRCI composite index as well as the three areas

	KNOW	ATT	LEAD	CULT	TECH	PLAN	LEARN	FIN	RELAT	INST	FRCI Total	FRCI Mandra	FRCI Evros	FRCI Kalloni
Min	0.022	0.012	0.015	0.000	0.009	0.000	0.000	0.000	0.000	0.000	0.286	0.286	0.297	0.398
Max	0.088	0.107	0.118	0.095	0.111	0.103	0.095	0.108	0.071	0.057	0.885	0.872	0.885	0.852
Mean	0.069	0.071	0.074	0.044	0.078	0.072	0.052	0.086	0.037	0.028	0.609	0.585	0.568	0.639
Median	0.072	0.065	0.074	0.048	0.083	0.070	0.052	0.081	0.035	0.026	0.605	0.583	0.578	0.653
First Quartile	0.061	0.053	0.059	0.032	0.065	0.056	0.026	0.081	0.029	0.020	0.530	0.516	0.484	0.562
Third Quartile	0.083	0.081	0.096	0.060	0.092	0.084	0.078	0.108	0.047	0.036	0.694	0.645	0.641	0.697

closer at the 10 factors reveals that it is knowledge/understanding, organisational learning and planning, as well as technological resources that mainly shape SMEs' resilience capacity to floods, followed by leadership capabilities and the owner/manager's attitudes towards flood risk and perceptions of proactive control measures. In contrast, findings suggest that the resilience capacity of these enterprises is to a far lesser degree built by relational resources and institutional support mechanisms or the internal culture that nurtures the anticipation of flooding (see Figure 5).

The bootstrap subsampling has been performed with the utilisation of a total sample of 10,000 iterations to construct the bootstrap subsamples. Figure 6 presents the histograms and normal probability plots for the overall FRCI and for the three regions, based upon the 10,000 bootstrap subsamples. As the graphs reveal, the bootstrap samples follow the normal distribution.

Based upon the 10,000 bootstrap subsamples, the 90% and 95% bootstrap confidence intervals were constructed to determine a reliable estimate of the range of values of the FRCI index in the population of Greek SMEs. To enhance the robustness of the obtained results, the four alternative bootstrap confidence intervals were calculated. Hence, Tables 4 and 5 present the 90% and 95% normal, basic, percentile and bias-corrected and accelerated (BCa) bootstrap confidence intervals for the FRCI, respectively.

The obtained results indicate that there are identifiable differences between the FRCI indices among the three study areas. The FRCIs in the Kalloni area are significantly higher in comparison to the FRCI indices of the Mandra and Evros areas. The confidence interval graphs (Figure 7) depict the mean FRCI and the corresponding 90% and 95% confidence intervals as calculated by the BCa method for the three flood-prone areas of the study. It is evident that the resilience capacity levels in the Kalloni region are statistically significantly higher than in the Evros area. On the other hand, the SMEs' resilience capacity levels between Mandra and Evros do not differ significantly statistically from each other. However, the FRCI figures of SMEs from Evros are the lowest among the three study areas. In this respect, the Evros FRCI values share the wider intervals when compared to the comparatively narrower intervals for the Kalloni FRCI bootstrap values.

Lastly, a deterministic sensitivity analysis is performed to provide measurable evidence with regards to the magnitude of the impact of the 10 explanatory variables of SMEs' resilience capacity on the composite FRCI metric. In Table 6, the sensitivity analysis results that were obtained from the variations of each one of the resilience capacity factors that comprise the FRCI values

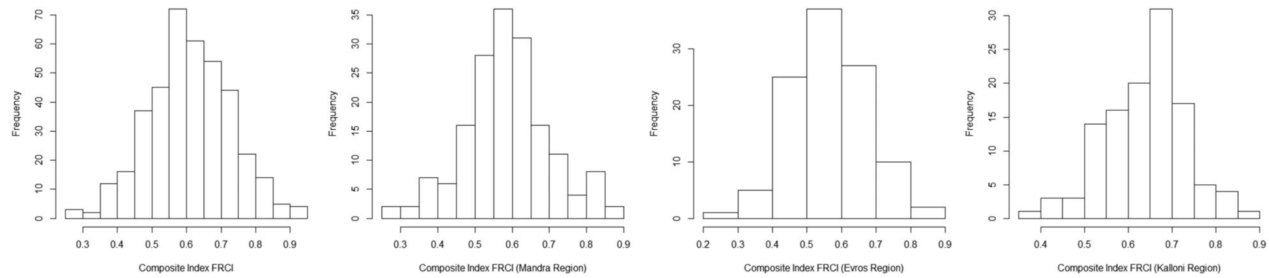

FIGURE 3 Histogram plots for the overall FRCI composite index and the three regions

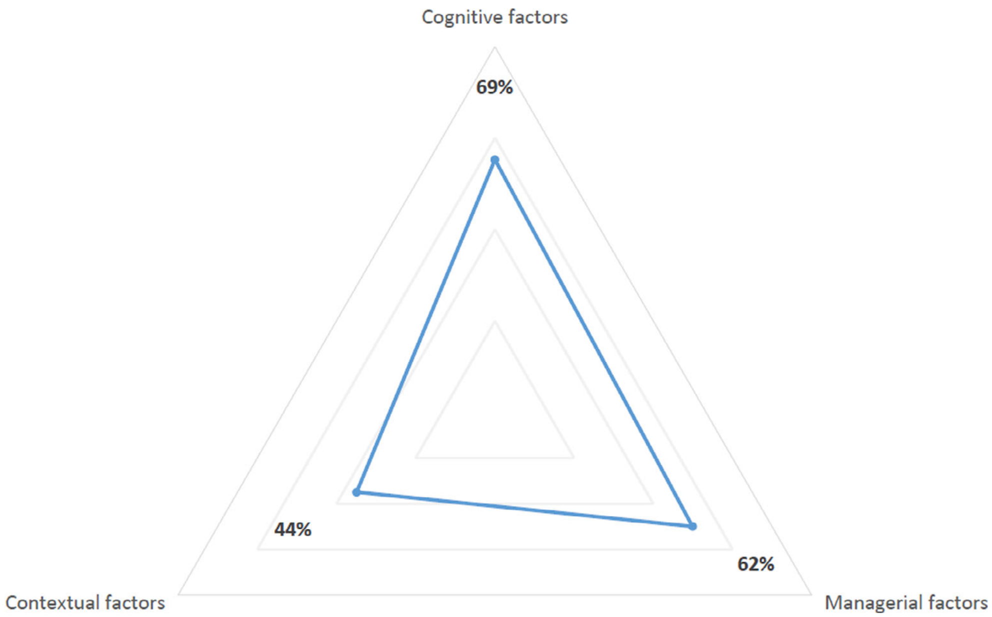

FIGURE 4 Mean scores (%) among the three domains of factors describing SME flood resilience capacity

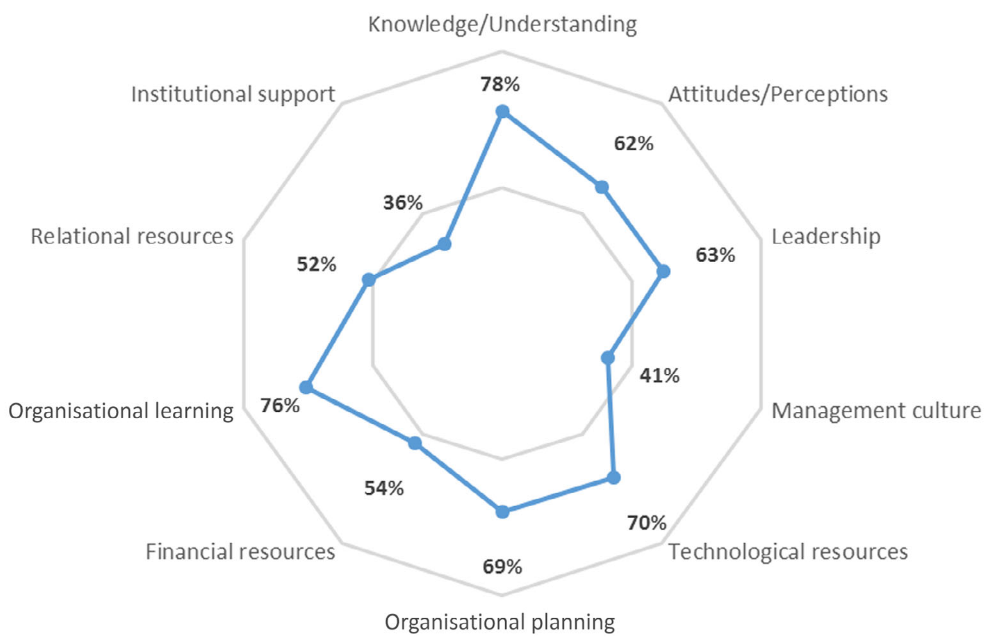

FIGURE 5 Mean scores (%) among the 10 factors comprising the SME flood resilience capacity index

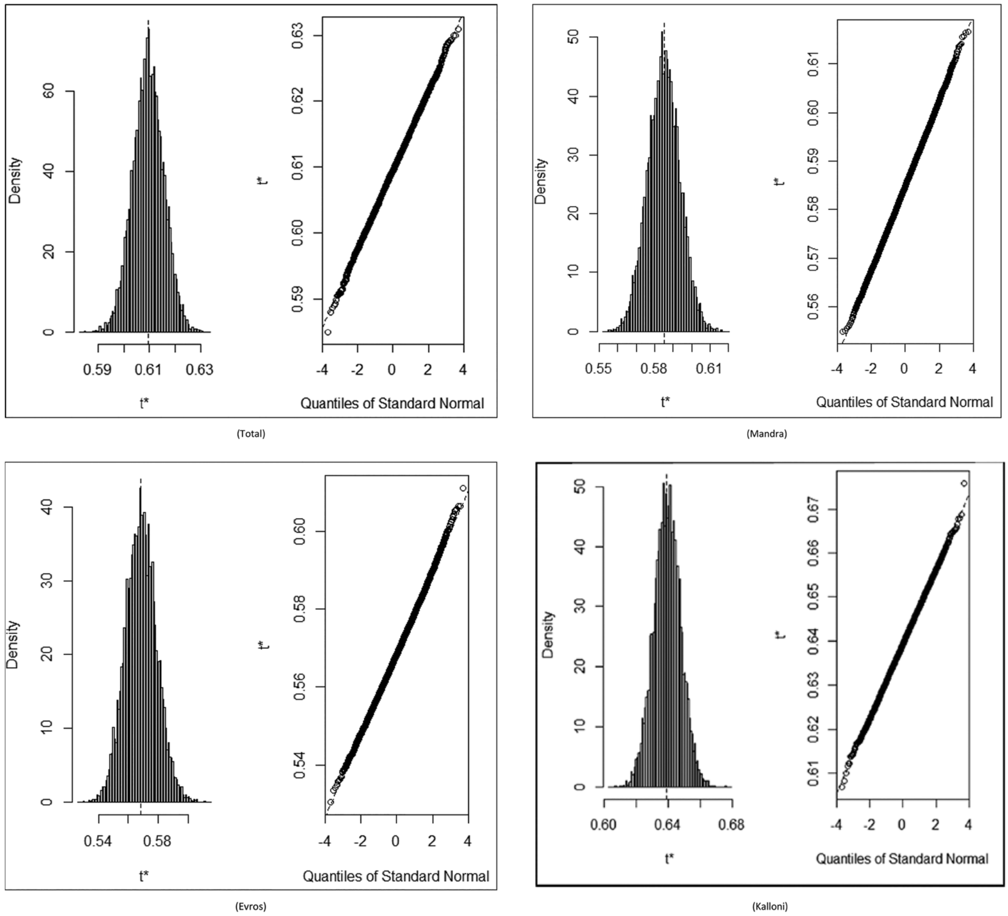

FIGURE 6 Histogram and normal probability plots for the bootstrap samples

TABLE 4 90% bootstrap confidence intervals for the FRCI based on 10,000 bootstrap replicates

Bootstrap CI	FRCI total	FRCI (Mandra)	FRCI (Evros)	FRCI (Kalloni)
Normal	0.5873–0.6056	0.5706–0.5993	0.5510–0.5862	0.5873–0.6056
Basic	0.5873–0.6055	0.5707–0.5992	0.5507–0.5858	0.5873–0.6055
Percentile	0.5874–0.6055	0.5708–0.5993	0.5511–0.5863	0.5874–0.6055
BCa	0.5875–0.6056	0.5708–0.5993	0.5518–0.5870	0.5875–0.6056

TABLE 5 95% bootstrap confidence intervals for the FRCI based on 10,000 bootstrap replicates

Bootstrap CI	FRCI total	FRCI (Mandra)	FRCI (Evros)	FRCI (Kalloni)
Normal	0.5855–0.6074	0.5679–0.6021	0.5476–0.5896	0.5855–0.6074
Basic	0.5854–0.6072	0.5678–0.6020	0.5475–0.5894	0.5854–0.6072
Percentile	0.5857–0.6074	0.5680–0.6022	0.5476–0.5894	0.5857–0.6074
BCa	0.5857–0.6075	0.5680–0.6022	0.5484–0.5902	0.5857–0.6075

are presented. The obtained FRCI values were calculated for the minimum, 25th percentile, median, 75th percentile, and the maximum values of each factor, as they were determined by the distribution of their weighted scores. In the last two rows of the table, the range between minimum and maximum as well as the standard deviation of the FRCI values are reported for a better understanding of the overall variation in index scores caused by the resilience capacity factors.

From the sensitivity analysis findings, it is clear that the higher levels of sensitivity of the FRCI are due to the resilience capacity factors of organisational planning, organisational learning, financial resources, attitudes/perceptions, leadership and technological resources. In contrast, the FRCI is less sensitive to factors pertaining to knowledge/understanding, relational resources and institutional support. These results are further confirmed in Figure 8, which is a visual representation of the

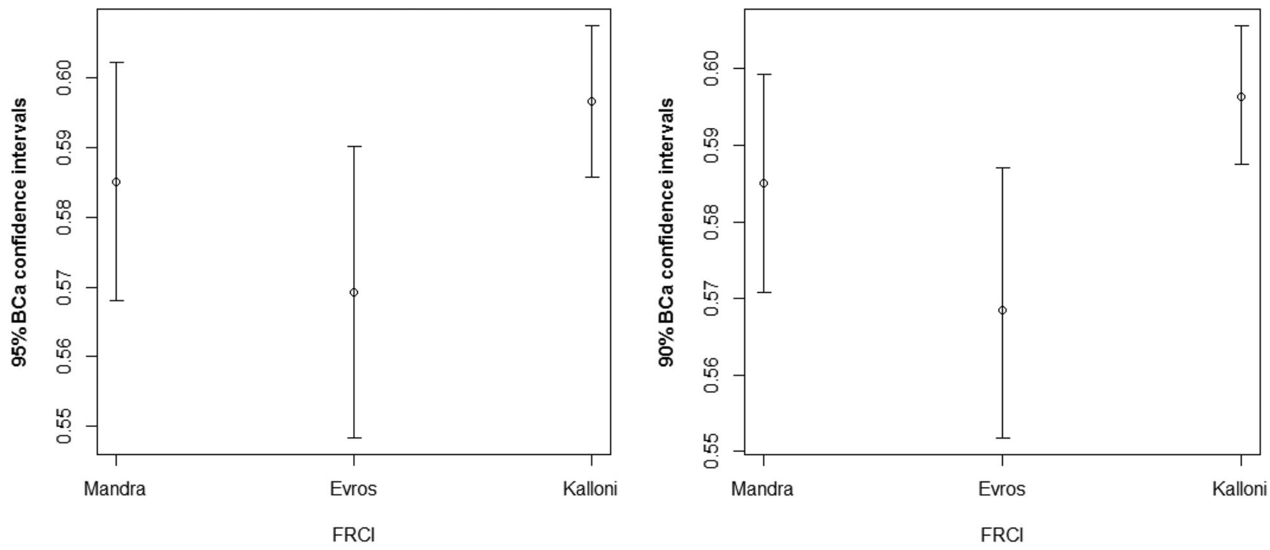

FIGURE 7 90% (left) and 95% (right) BCa bootstrap confidence intervals for the three regions

TABLE 6 Sensitivity analysis results on the magnitude of the effect of the resilience capacity factors on the FRCI

	Resilience capacity factors									
	KNOW	ATT	LEAD	CULT	TECH	PLAN	FIN	LEARN	RELAT	INST
Min	0.552	0.553	0.543	0.554	0.528	0.532	0.550	0.521	0.567	0.576
25th percentile	0.591	0.586	0.587	0.586	0.584	0.588	0.576	0.602	0.596	0.596
Median	0.602	0.602	0.602	0.602	0.602	0.602	0.602	0.602	0.602	0.602
75th percentile	0.613	0.610	0.624	0.618	0.611	0.616	0.628	0.629	0.614	0.612
Max	0.619	0.655	0.646	0.650	0.630	0.644	0.654	0.629	0.637	0.635
Range	0.066	0.102	0.103	0.095	0.102	0.113	0.104	0.108	0.071	0.059
SD	0.026	0.037	0.039	0.036	0.039	0.042	0.041	0.045	0.026	0.022

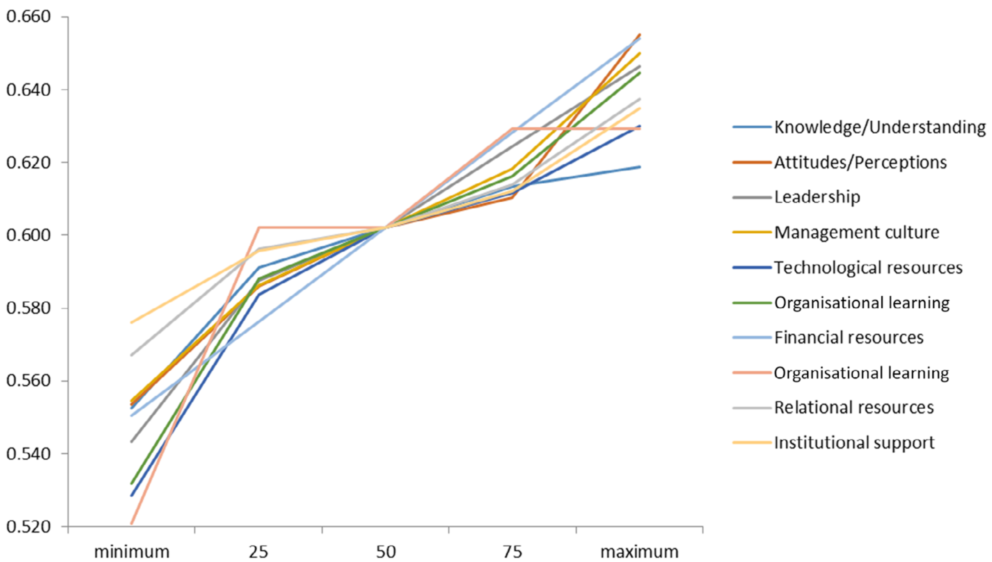

FIGURE 8 Sensitivity analysis results of the overall FRCI derived from the explanatory factors

sensitivity analysis results, with steeper curves indicating a higher degree of sensitivity to deviations from the original estimates. It is clear from the figure that the FRCI is primarily more sensitive to the increase of financial resources and SME owner's attitudes/perceptions. Likewise, FRCI is found to be sensitive to reduced values of organisational learning, technological resources and organisational planning.

4 | DISCUSSION AND CONCLUDING REMARKS ON MANAGERIAL, RESEARCH AND POLICY IMPLICATIONS

Our findings lend support to insights drawn from Kuruppu et al. (2013), Marks and Thomalla (2017), Crick et al. (2018), Kato and Charoenrat (2018), in that contextual factors in terms of institutional support interventions are essential to nurturing the resilience and anticipatory prevention of SMEs. It also adds weight to the case for assessed SMEs' owners to work towards a management culture that proactively fosters flood risk awareness and the need to involve all employees in resilience-building practices and flexible responses to such adverse conditions (Hashim et al., 2021; Karman, 2020; Kato & Charoenrat, 2018; Wedawatta et al., 2014). The low levels of organisational planning activities and attitudes to flood hazards identified in the study are in line with findings from other national settings (e.g. Hudson et al., 2022; Kato & Charoenrat, 2018; Neise et al., 2021; Neise & Diez, 2019; Oracion, 2016). Crucially, the financial constraints and the overall limited capacity for business continuity, as reported by sample SMEs, corroborate the critical support needs well-established in the literature (Neise et al., 2021; Oracion, 2016; Samantha, 2018) and win–win opportunities stemming from bottom-up initiatives for the active engagement of SMEs in flood risk management and governance (Bott & Braun, 2019).

Through the proposed indicator-based approach, an analytical framework is set forth that helps to standardise such assessments with an overarching aim of reducing the vulnerability of SMEs to flooding. This is achieved by identifying major internal and external attributes that explain resilience capacity, which is particularly important given the limited resources these enterprises have at their disposal and that they tend to be primary sources of vulnerabilities in supply chain networks, generating single points of failure. In this respect, our study makes three contributions to the extant literature. First, a composite metric is developed to assess determinants of SMEs' resilience capacity, offering insights on how various parameters affect the organisational ability to confront flooding. Second, we provide evidence from Greek small- and medium-sized enterprises for the first time, shedding light on facilitating factors and (underlying) barriers. Third, a replicable assessment method for examining SMEs' resilience capacity characteristics is proposed, contributing to the domains of regional studies, business sustainability and continuity research, as well as to the theorisation of organisational resilience to EWEs (Linnenluecke et al., 2012; Winn et al., 2011).

The proposed FRCI adds to the emerging field of climate services and the considerably under-researched topic of organisational resilience to extreme weather and natural disasters. In line with UN's Sustainable Development Goal (SDG) 1 – Target 1.5 (i.e. 'by 2030, build the resilience of (…) those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters'), it is an attempt to provide a quantification of business resilience capacity to floods and to link such information to SMEs' assistance needs. This is particularly important, taking into account that economic damages from EWEs have reached record-breaking levels over the past decade and that the frequency of such natural disasters is escalating (e.g. Munich Re, 2017, 2021), indicating that the ability to cope with flooding has become a sheer necessity.

The application of the FRCI in a certain study area can highlight 'best-performers' among local SMEs, which can serve as industry and/or regional 'champions' and allow for a reproducible assessment, the insights of which can cater to both private- and public-sector decision-making. It can be a useful benchmarking tool that local social actors and stakeholders can employ to identify the ability of (local) enterprises to withstand and recover from such environmental disruptions. This bottom-up approach and (self-) assessment tool for SMEs to diagnose their resilience status against flooding can be scaled up to other vulnerable flood-prone areas across Europe and beyond, for a better understanding by governmental bodies of which assistance needs and/or policy interventions will increase SMEs' resilience status under the scope of internal and external factors found to be critical (Wedawatta et al., 2014). The findings derived from the FRCI application can assist local governance structures in understanding how to incentivise SMEs to proactively prepare for such natural hazards in terms of financial and/or other means of support, as well as by facilitating the coordination of multi-stakeholder partnerships for mobilising actions through the dissemination of best practices and screening tools (such as the proposed, self-assessment, indicator-based tool). It can also feed into high-quality, actionable and practical guidelines, manuals and/or management standards on business preparedness to EWEs, towards an enabling regulatory environment, coupled with capacity-building support measures that ensure SMEs are: (a) sufficiently informed of flood threats, (b) incentivised to invest in adaptation-resilience measures, and (c) not stifled by suboptimal or even restrictive policies.

As the proposed FRCI may assist SMEs in preparing for and bouncing back from flood disasters in a strengthened and more resourceful way, it also encapsulates a moderating effect on performance, reputation and, ultimately, on competitiveness and sustainability trajectories (APEC, 2014). In this regard, it paves the way for these enterprises to contribute to the community in terms of leadership, acting as hubs that promote good practice on flood preparedness. Being interconnected with a wide range of stakeholders (e.g., employees, business partners, customers) in the areas where they operate, flood-resilient SMEs can reduce exposure to such EWEs and enhance the recovery of local communities to their adverse impacts, thus contributing to a more resilient society (Neise et al., 2021). Primary findings from the FRCI application provide a fruitful platform for employee development schemes on business continuity planning through options such as web-based or short training interventions (also stressed in Kato & Charoenrat, 2018, Neise et al., 2021 and Hashim et al., 2021). Ultimately, they can provide fertile ground for SME owners-managers to actively engage and promote educational programmes in the form of internal awareness-raising, training material, and exercises among employees to increase knowledge, expertise, preparedness and know-how of critical resilience capacity interventions in the enterprise.

The FRCI also reflects a SME scanning process that offers a mechanism of cross-comparing disaster experts' analysis of flood impacts with survey evidence (like those derived from our study) as an input for prioritising necessary interventions. Hence, it facilitates the development of customised flood preparedness toolkits for SMEs to increase their resilience status – this will also allow them to specify essential external support needs. Crucially, the FRCI can be a useful tool for business consulting services and networks that support and guide SMEs on continuity management where the prioritisation of measures in terms of appropriateness and financial viability is essential. As the implementation of climate adaptation gap assessments and the certification of climate risk assessments are pressing matters for the private sector, the FRCI's structure and rationale can assist in devising formal certification-auditing systems for both individual enterprises and/or SME consultancies. Lastly, the FRCI may inform providers of disaster risk insurance through the refinement of balanced scorecards or screening criteria, which can assist in determining premiums of micro-insurance products (Kato & Charoenrat, 2018) aimed at SMEs towards the endorsement of a 'flood-proof' SME sector (Surminski & Eldridge, 2017).

Using the FRCI's structure and rationale, future research can prove our study's observations using larger and stratified samples from diverse national settings and regions for a better understanding of the underlying drivers and barriers of flood resilience through cross-country or regional comparisons. The proposed metric can be further refined and expanded by drawing from other weighting techniques or a larger pool of experts for weight elicitation and by considering additional aspects (i.e. factors) that describe SMEs' flood resilience capacity, which can also be examined through structural equation modelling. Based on the FRCI estimations and proper weighting of each resilience capacity factor, researchers can further explore deterministic and multivariate probabilistic sensitivity analyses schemes for deriving the inference for alternative scenarios associated with the relative effects of the various explanatory variables on the FRCI. In this respect, there is fertile ground to draw inferences with such a proposed scheme of probabilistic sensitivity analysis by employing Markov chain Monte Carlo (McMC) simulations. Lastly, ethnographic research, focusing on key stakeholders and SME owners-managers, can provide supporting evidence to explain variations in the FRCI scores among the study areas of our paper as well as in other flood-prone areas where the composite metric is to be applied. Indeed, while macro-oriented studies of SMEs' resilience capacity allow for valuable insights, flood resilience researchers should emphasise the documentation of the critical importance of a micro-level mapping of SMEs' owners/managers decision-making and strategic thinking. This can be achieved through longitudinal and action research studies to better capture – in temporal terms – trajectories in resilience capacity-building and how essential capabilities are shaped. As there is growing pressure placed on the global community from changing disaster patterns due to extreme weather, there is a window of opportunity as well as an obligation for key stakeholders to actively engage in anticipatory prevention and resilience mechanisms. Among these stakeholder groups, we strongly believe that SMEs represent the segment of the economy with a largely untapped potential in terms of contribution to flood resilience across various scales.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ORCID

Antonis Skouloudis https://orcid.org/0000-0002-3363-6692
Walter Leal Filho https://orcid.org/0000-0002-1241-5225
Ioannis Nikolaou https://orcid.org/0000-0002-2607-3545
Georgios Deligiannakis https://orcid.org/0000-0002-3620-6153
Thomas Tsalis https://orcid.org/0000-0002-9705-4747

ENDNOTE

[1] According to the European Commission, small enterprises are business entities that employ no more than 50 persons and whose annual turnover or annual balance sheet total does not exceed €10m. Likewise, a medium-sized enterprise is company that has fewer than 250 employees and an annual turnover that does not exceed €50m.

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APPENDIX 1

AN EXCERPT OF STATEMENTS INCLUDED IN THE STUDY'S QUESTIONNAIRE (TRANSLATED FROM GREEK)

Cognitive aspects

- Inadequate preparatory tasks and insufficient infrastructure are the main causes of flood impacts.
- Flood protection is an important issue to consider but only during the winter months. (*)
- Flood risk management and protection are responsibilities that solely lie with the pertinent governmental authorities. (*)
- Floods may incur significant damages and losses but they are very rare phenomena. (*)

Managerial aspects

- We have an emergency plan in place in case of flood occurrence.
- We keep a backup of critical documents for our business stored offsite in a safe and secure location.
- If the enterprise is forced to close down for an extended period of time due to unforeseen circumstances and/or damages, we have sufficient funds to cover the relevant reopening costs.
- We do not have the time to engage in flood protection measures. (*)

Contextual aspects

- The current legislative framework is too complex and strict, leaving us little room to engage in flood protection interventions within the enterprise (e.g. in fear of sanctions from the urban planning commission/authority).
- We can rely on members of the local community (friends and relatives, neighbours and/or other local enterprises) for financial support or other forms of assistance in case of emergency situations.
- Business continuity consultants may provide useful services to our enterprise but the cost of consulting in business continuity management is particularly high. (*)
- The local Chamber of Commerce provides us with sufficient guidance and support towards the prevention of and intervention against floods.

(*) Reversed scored items.