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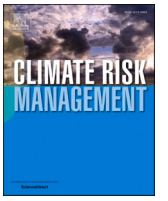

SMEs and flood insurance: Assessing the effective resilience using contextualised evidence

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ABSTRACT

Flooding is one of the biggest challenges reported by small to medium-sized businesses (SMEs) in the UK, and flood insurance is an important tool for reducing SMEs' future flood risks. Flood insurance helps small businesses manage increasing risks and, if priced and designed right, serves as a powerful incentive to better prepare for and reduce the impact of future floods. However, flood insurance uptake by SMEs is low and expensive. Insurance pricing depends on knowing an SME's risks and level of resilience with confidence. However, SMEs exhibit diverse risk profiles and levels of vulnerability due to their heterogeneous business characteristics. Such complexity makes it difficult for the insurance industry to commodify SMEs' risk and provide affordable insurance. As flood risk is on the rise, it is paramount to identify which factors influence insurers' decisions to grant insurance to SMEs or deny it. This study uses a mixed-method approach were through online surveys, semi-structured interviews, focus group discussions, and workshops with lenders, insurers, surveyors, brokers, and SMEs, pursue threefold objectives: 1) identify factors that influence SMEs resilience and insurers decision making; 2) assess SMEs' losses, flood risk mitigation strategies and insurance needs; and 3) collaborate with the insurance industry and SMEs to design and pilot a tool to unlock affordable insurance coverage. Results show that while critical, professional flood risk assessment and flood depth damages are not sufficient on their own. Well-kept descriptive and photographic evidence, along with the positive attitude associated with SMEs' behaviour, makes the evidence much more compelling and convincing when they are deciding whether to insure or lend to specific businesses. The tool also encouraged SMEs to initiate or improve resilient behaviour and to facilitate communication and knowledge exchange between SMEs and insurance providers. Overall, this research offers policy and practice recommendations that have the potential to increase mutual understanding and drive a positive behavioural change among SMEs and the insurance industry.

1. Introduction

Flooding is the UK's main climate-related threat, with more than half of small- to medium-sized businesses (SMEs) reporting that the impact of extreme flooding is their biggest concern (AVIVA, 2021). Despite this, SMEs often have limited awareness of their flood risks, limited ability to estimate potential damage, and lack knowledge of how to improve their preparedness (Bhattacharya et al., 2011; Clemo, K., 2008; Dickman et al., 2015; Mathews et al., 2021). While many SMEs acknowledge severe weather risks and some

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take action (FSB, 2015), access to flood insurance—a key risk management tool—remains limited (Sakai, P., 2020; SAKAI, P., HOLDSWORTH, A. CURRY, S., 2016).

Flood insurance can help transfer the increasing risks the SMEs are facing, and more importantly, it has the potential to motivate the adoption of resilient behaviours and reduce future risks if designed and priced correctly (Surminski and Eldridge, 2015; Kunreuther and Michel-Kerjan, 2009; Crick et al., 2018; Hudson and Botzen, 2019). However, insurers' ability to offer affordable products depends on assessing each SME's risk accurately, and moreover, whether and the extent to which an SME can be impacted and withstand a certain level of a flood event, which is hindered by limitations in data and methodology. High-risk SMEs often face unaffordable premiums or are excluded from coverage, while others may be misclassified as low risk due to location in low-risk zones or the existence of structural flood defences (Landry and Turner, 2020).

Flood risk is a function of hazard, exposure, and vulnerability (IPCC, 2023; Cardona et al., 2012). Conventionally, insurers determine the flood risk of a property using government flood risk mapping, building type and location, and then calculate the premiums based on an estimation of expected loss using probability of occurrences and costs of recovery (Seifert-Dahnn, 2018). Compared to the assessment of the probability of occurrence (hazard), the assessment of the assets/people exposed (exposure) and the capacity or the lack thereof to deal with the disaster (vulnerability) is less mature, and more challenging due to their dynamic and multifaceted nature (Koks et al., 2015, Cardona et al., 2012). Innovative tools such as Agent-Based flood risk and resilience modelling (Coates et al, 2020, Dubbelboer et al., 2015), indicator-based assessment of SMEs' flood resilience (Skouloudis et al, 2022) and knowledge sharing and information collection tools such as the "flood risk certificate" or "Property flood resilience surveyor certification scheme" (Seifert-Dähnn, 2018) are examples of efforts towards better understanding SMEs' flood risk and resilience. However, there is a persistent knowledge gap regarding how insurers perceive the flood risk as it varies across SME sectors and sizes, as well as how they perceive the effectiveness of risk-reduction strategies (Leitold et al., 2021; Sakai, P., 2020; Sakai and Yao, 2023; Surminski et al., 2018;). This uncertainty undermines insurance access and affordability for SMEs (Surminski and Eldridge, 2015).

Vulnerability to flooding includes not only physical damage but also behavioural factors (Aerts et al., 2018; Haer et al., 2019). Unlike households or vehicles, where common assets can be insured, thereby limiting insurers' risk, SMEs are highly diverse in assets and operations, making their behaviours and responses to disasters complex and variable (Ngin et al., 2020; Federation of Small Businesses, 2015; Miklian and Hoelscher, 2022). This complexity increases uncertainty, often resulting in higher insurance prices and reduced uptake, which can also limit access to finance.

Insurers and lenders can reward resilience and risk reduction, thus creating greater awareness and a market for property-level resilience (Bonfield, 2016, Yadav, 2022), but insufficient understanding by both parties leads to a self-reinforcing cycle of under-insurance and vulnerability (see Fig. 1). While this is not a new phenomenon, and governments and insurance sectors across different countries have experimented with various schemes, this challenge persists. The challenges thus reside in two main areas. First, as climate change causes further sea level rise and more frequent extreme weather events, more SMEs will be at higher risk of flooding due to increased likelihood and exposure, which may render them uninsurable if insurance coverage is based solely on the SME's location and flood hazard assessment. Second, in the case of households that seek insurance coverage, a premium discount is possible if the household has taken up certain flood mitigation and protection measures (Hudson and Botzen, 2019), but the heterogeneity and diversity of SMEs' characteristics complicate the evaluation of the implications of such measures on risk reduction and level of resilience (EA and DEFRA, 2025).

Recent research has explored various dimensions of SME resilience, showing it is shaped by pre-disaster strategies, post-disaster responses, business size, age, ownership, sector, experience, and finances (Adekola and Clelland, 2020; Adeniyi et al., 2019; Asgary et al., 2012; Campbell et al., 2019; Halkos and Skouloudis, 2020; Kreibich et al., 2007; Marshall and Schrank, 2014; McDonald and Marshall, 2019; McEwen et al., 2018; Sarmiento et al., 2019; Webb et al., 2000). Particularly, in Coates et al (2020)'s study on the evaluation of SMEs' operational resilience, semi-structured interviews with the SMEs were employed to more accurately reflect their behaviour in the modelling process. Skouloudis et al. (2022) used a structured questionnaire to flooding from the perspectives of SME

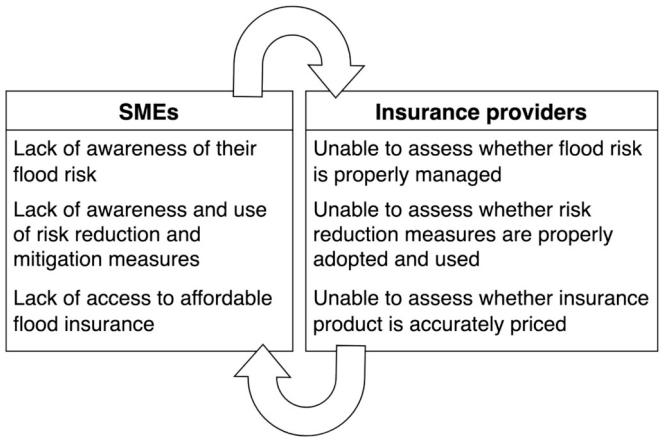

Fig. 1. A negatively reinforcing loop between the SMEs seeking flood insurance and the insurance providers.

owners or managers. But few studies incorporated the unique needs of SMEs from various sectors, and how their decision-making factors balance with the insurers' evaluative parameters.

From previous studies, we perceive that the decision on whether an SME is offered accessible and affordable flood insurance relies in part on the negotiation and balance between the SMEs' perception of their own risk and the insurers' perception of the SMEs' risks. Building on these studies, this research adopts a participatory approach to address the knowledge gaps that hinder SME flood insurance uptake.

This study advances the evaluation of SME flood resilience and insurance access and derive policy and practice recommendations for the insurance industry and SMEs by addressing the following research questions: 1) Which are the factors that influence insurers' confidence on the flood resilience of an SME, and 2) can a tool to assess SME flood resilience, produced in a participatory way, increase the understanding of insurers and unlock SME flood insurance?. The objectives are:

1) to identify factors that influence SMEs resilience and insurers decision making;

2) to assess SMEs' losses, flood risk mitigation strategies and insurance needs;

3) to co-produce a tool with members of the insurance industry and SMEs to unlock affordable insurance coverage.

Ultimately, bridging the gap between SME self-assessment and insurers' risk evaluation is essential for improving insurance access (EA and DEFRA, 2025). The participatory approach here engages both researchers and stakeholders to ensure the resulting assessment tool meets the needs of both SMEs and insurers. The study's findings describe the tool's components and show how it addresses the identified knowledge gaps, enabling better decision-making on SME flood risk and insurance opportunities.

2. Methodology

As noted in the introduction, few frameworks are tailored to a comprehensive evaluation of flood risk and resilience of SMEs. Traditionally, insurers evaluate SMEs based on their geographical placement within designated "flood zones." If an SME falls within such a zone, insurance options may range from being uninsurable to being offered at high prices, depending on the specific risk profile of that area. This study aimed to investigate whether enhanced information regarding an SME's flood resilience could facilitate access to more affordable insurance. The hypothesis posited that insurers would exhibit a greater willingness to extend competitive insurance options to SMEs if equipped with a comprehensive tool for flood risk assessment that includes indicators of SME resilience.

The appraisal of an SME's resilience entails a myriad of aspects. Resilience is defined as "the capacity of social, economic, and ecosystems to cope with a hazardous event or trend or disturbance, responding or reorganising in ways that maintain their essential function, identity and structure while also maintaining the capacity for adaptation, learning and transformation" (IPCC, 2023; Cardona et al., 2012). Consequently, SME flood resilience extends beyond simple physical vulnerabilities; it becomes a management challenge. Relying solely on the risk delineated by "flood zones" fails to capture the comprehensive impact of flooding events on SMEs. Factors such as organisational, social, economic, and institutional structures significantly influence an SME's response to flooding (Wang et al., 2025; Berkhout, 2012). Therefore, resilience encompasses the ability to prepare before a flood event, cope effectively during its occurrence, and adapt, learn, and transform afterwards.

This study is grounded in the literature on climate change resilience and vulnerability, as well as organisational change and learning (Sakai, P., 2020; Hernandez Montes de Oca, 2013). Proxy variables were meticulously selected to operationalise the conceptual model that underpins the flood resilience of an SME (See Fig. 2).

After identifying the factors that contribute to the resilience of SMEs in the literature (as outlined in the supplementary material), the study focused on determining which of these factors are relevant to LIS-B. The goal was to develop a tool to test the hypothesis that

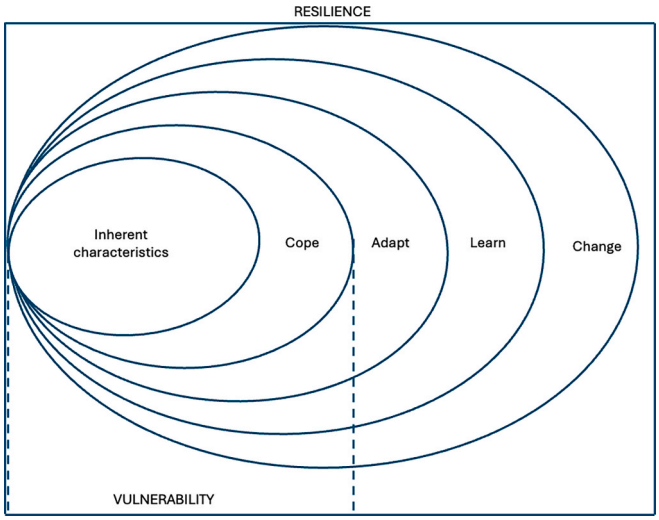

Fig. 2. Components of SME flood resilience (Sakai, P., 2020; Hernandez, 2013).

bridging the information gap between insurers and SMEs could unlock accessibility and affordability in the insurance sector. Improving SME flood insurance access requires more accurate and transparent ways to assess and communicate both risk and resilience—ideally with agreement between insurers and SME owners (EA and Defra, 2025; LSE, 2017). To be effective, any assessment tool must be adaptable rather than prescriptive.

Participatory research was employed as it is recognised as crucial in the field of flood risk management and vulnerability assessment (Ingirige and Wedawatta, 2018; Mahardhika and Pamungkas, 2024). This approach not only enables more accurate modelling of flood risks and response behaviour but can also bridge the gap between modelled and perceived flood risks (Bullen and Miles, 2024). There are four modes of participation (Cornwall and Jewkes, 1995), and this research required the researchers and stakeholders to adopt a collegiate mode of participation, fostering a partnership aimed at achieving mutual learning.

Preparatory work for this project began in the spring of 2018, during which relationships with LIS-B stakeholders and SME owners were established and nurtured to create a trusting environment for collaboration. Data was collected following a sequential explanatory design consisting of two phases: quantitative, followed by qualitative. This explanatory design is the easiest to execute among all mixed-method strategies since data collection occurs one type at a time (Creswell and Plano, 2007). Research methods employed included online surveys (N=26), open-ended interviews (N=12), semi-structured interviews (N=18), focus group discussions (N=5), and a reaction workshop (N=23). Table 1 describes the stages of the TAER co-development, from the initial contact with stakeholders to tool evaluation.

2.1. Tool development

2.1.1. Survey

The survey was conducted online via Qualtrics Survey Software and descriptive statistics are produced using IBM SPSS and Microsoft Excel. The survey contained two main sections. The first section aimed to identify the information needs of LIS-B regarding SMEs and their flooding impacts. In this section of the survey, we asked the participants to identify their information needs regarding SMEs' flood risks, SMEs' response and recovery strategies from a flooding event, and SMEs' flood insurance situations. The second section aimed to explore their user preferences for the tool and to lay the foundation for the co-creation process of the tool that was used to assess the effective resilience of SMEs. To ensure the alignment of the tool users' interpretation of resilience with what the tool is measuring, we asked the respondents about the attributes a flood-resilient SME should possess and the output the tool TAER should produce.

Table 1
Stages of TAER Co-development.

Steps	Project Stage	Actors involved	Research instrument	Purposes
1	Tool development: conceptualisation	2 Project partners (LIS-B)	Literature review, Informal interviews	To identify the aspects that determine SMEs flood resilience To identify and refine research areas, priorities and strategies
2	Tool development: building	2 insurers 4 surveyors 8 brokers 6 other relevant professions	Survey	To understand LIS-B's information needs and preferences regarding SMEs flood risks and resilience
3	Tool development: building	3 lenders 8 insurers 3 surveyors 2 brokers 2 other relevant professions	Semi-structured interviews	To further identify their requirements for the resilience assessment tool
4	Tool development: Design modification	5 LIS-B stakeholders	Focus group	to critique the structure, function, and features of the tool based on the conceptual framework, specifically in three areas: data and evidence collection reporting and evaluation distribution and development
5	Tool pre-piloting	8 SME owners or owner representatives 4 Surveyors	Open-ended interviews	To test and improve on the usability of the tool before piloting the tool
6	Tool piloting	6 SME owners or owner representatives 4 Surveyors	SMEs self-assessment survey, Professional f ield s urvey, and interviews	To pilot test the tools on 6 SME cases with 4 professional surveyors
7	Tool evaluation	23 LIS-B' stakeholders	Online workshop	To review the 6 case studies using the tool and assess based on the information provided that: The resilient works SMEs implement are effective; The SME's flood risk is properly managed; The information is useful for offering more accurate insurance pricing.

2.1.2. Semi-structured and open-ended interviews

Semi-structured and open-ended interviews were conducted at various points of the project, in both one-on-one and focus group formats. Each one-on-one interview was scheduled for one hour, and the focus group interview was scheduled for one and a half hours, via an online video conference platform (Zoom or Microsoft Teams) to abide by social distancing requirements. With participants' permission, the conversations in all the formal interviews were recorded and transcribed, and then coded and analysed using qualitative analysis software (NVivo), the interview protocol is available in the supplementary material. The interviews conducted to clarify and facilitate the pre-piloting and piloting of the tool were not recorded or transcribed.

2.2. Tool piloting

2.2.1. Case selection

The cases for tool pre-piloting and piloting were selected from the list of SMEs who expressed interest in the previous survey and indicated their willingness to participate further. To have the greatest representation of SMEs, we narrowed down the list of interested SMEs based on their perception of flood risk, their geographical location, their sectors, and their experience with flood insurance (if they had no access to insurance or if the quotes/premiums were very high), their size, age, flood experience, flood preparedness levels and on whether they were renting/owning their premises. Table 2 presents information on the 6 selected cases. A full description of the cases is in the supplementary material.

2.2.2. Piloting procedure

The piloting testing of the tool was a two-step process. Pre-piloting of the tool was conducted with 8 SMEs (two expressed interest in further participation at this stage). We tested the updated tool framework with several SMEs as well as professional surveyors. We gathered their user experience via interviews and collected their feedback and suggestions on whether the platform is easy to operate, the questions are easy to understand, the instructions are clear to follow, etc. An interview with the surveyors allowed us to make further changes to details such as the order, type, and wording of the questions. Their opinions were incorporated to update the tool modules further. After the tool was updated and improved, it was sent to the SMEs and surveyors from our partners in Sedgwick to complete testing, while Ambiental (professional surveyors) produced a flood-risk and hazards assessment report for each SME.

2.3. Tool evaluation workshop

The SMEs' evaluation of the tool was collected immediately after their use of the tool. For each case, all the data collected by the SMEs and the surveyors are collated into a report. An online participatory workshop was conducted with LIS-B stakeholders to evaluate the tool. The stakeholders were divided into 3 groups, each reviewing 2 case reports. There were three feedback checkpoints for each case being reviewed. At the checkpoint, each participant was asked, on a scale of 1 to 7, how confident they feel that: 1) the resilient works SMEs implemented are effective, 2) the SME's flood risk is properly managed, and 3) the information is useful for providing more accurate insurance pricing. The participants were asked to provide overall feedback on each SME based on the information provided by the tool, and respond to the 4 open-ended questions: 1) whether the SME has a better chance of getting flood insurance, 2) would they consider cancelling the SME's existing policy if it had one in place, 3) does the information provided change their perspectives on the SME, and 4) what information and feedback the SME needs to increase its chance of getting flood insurance?

3. Results

3.1. Information needs and function preferences for tool development

The survey results indicated that the overall impression of a resilient SME is someone who can prepare for and respond to a natural

Table 2
Description of SME cases ().

Case #	Location*	Size (# of employees)*	Estimated annual turnover*	Flood insurance history**
1	York/Selby	1	£50,000	Did not seek flood insurance due to business location next to a river and the history of flooding
2	Calderdale	21	£5,900,000	Could not access flood insurance due to business location on a flood plain. However, they have had access to contingency funding.
3	Calderdale	1	£50,000	Could not access flood insurance due to high premiums or contingency funding
4	Wakefield	3	£315,000	Could not access flood insurance after 2015 due to high premiums and excess, and the pricing did not consider the adoption of PFR measures
5	Leeds/ Bradford	4	£305,000	Could not access flood insurance due to high pricing that did not consider the use of flood prevention measures already in place
6	East Riding	1	£350,000	Did not have flood insurance but a flood plan was developed

Note: primary data reported by the SMEs through *survey, **interviews.
Source: interview with SMEs

disaster, such as flooding, and who can cope, adapt, renew, and learn to become more resilient after a disaster. The respondents would like a deeper understanding of SMEs' experience with flooding and recovery, and their motivation for obtaining flood insurance. The top 3 outputs respondents would like the tool to produce are information on the effectiveness of installed property-level protection, a list of flood-resistance measures SMEs have installed, and a list of recovery measures and strategies installed.

From the interviews with lenders, insurers and brokers, several themes emerged. Firstly, there is a demand for a tool that can provide more nuanced, specific information for each SME seeking flood insurance. A key message that emerged from the interviews is the urgent need to change the status quo, as the flood map insurance companies use cannot provide more specific information beyond the postcode level. With climate change causing more frequent and extreme flooding, more SMEs will become uninsurable.

Secondly, the tool should facilitate communication between SMEs and insurers, and drive behavioural change in both parties. For example, insurers believe that the more detailed SMEs are in describing each step they take, the more confident they are in SMEs' ability to understand their own risks. By completing the self-evaluation, SMEs can become more resilient by using trusted sources of information and links to learning materials. The tool can help insurers and businesses be more proactive and facilitate communication and knowledge transfer between brokers and insurers, as well as between insurers and lenders.

Thirdly, the tool should enable more accurate premise-level evaluation and help provide a clear audit trail for each SME. The interviewed stakeholders suggested that having PFR measures installed alone can no longer give them confidence in an SME's ability to demonstrate its resilience. In addition to the list of PFR measures used on the property, SMEs need to confirm that the measures are properly selected and installed in accordance with professional standards, and to provide evidence that they have made serious efforts to maintain or increase their resilience. Furthermore, the tool should enable the SMEs to demonstrate their ability to recover quickly post-flooding by having in place measures such as a flood emergency response strategy and a business continuity plan.

During the focus group discussion, participants were shown an outline of the tool based on survey and interview data, and asked to critique its structure, function, and features. First, while a well-informed SME or property owner can capture detailed business-related information and straightforward flood risk and resilience information, the flood risk assessment and on-site survey of building resilience should be carried out by professional surveyors. In addition to asking about whether certain PFR measures are installed or whether there is a business continuity plan or flood plan, SMEs should upload documents, photographs, videos, and narratives of examples as supporting evidence. It is also important that the tool asks whether an SME has been flooded before, how it was impacted, and how it recovered. Finally, it is important for an SME leasing its business property to communicate with and work with the landlord to build a partnership.

The presentation of the data should help insurers and brokers better understand SMEs' behaviour. It is appropriate to present a list of information about the building, its resilience, and the business continuity plan, along with supporting evidence, such as photographs, videos, narratives, and documents. It is also important for insurers to be able to focus on the data that are most relevant to their decision-making. Regarding a rating system, the consensus was that it would be valuable for SMEs to have a way to compare with

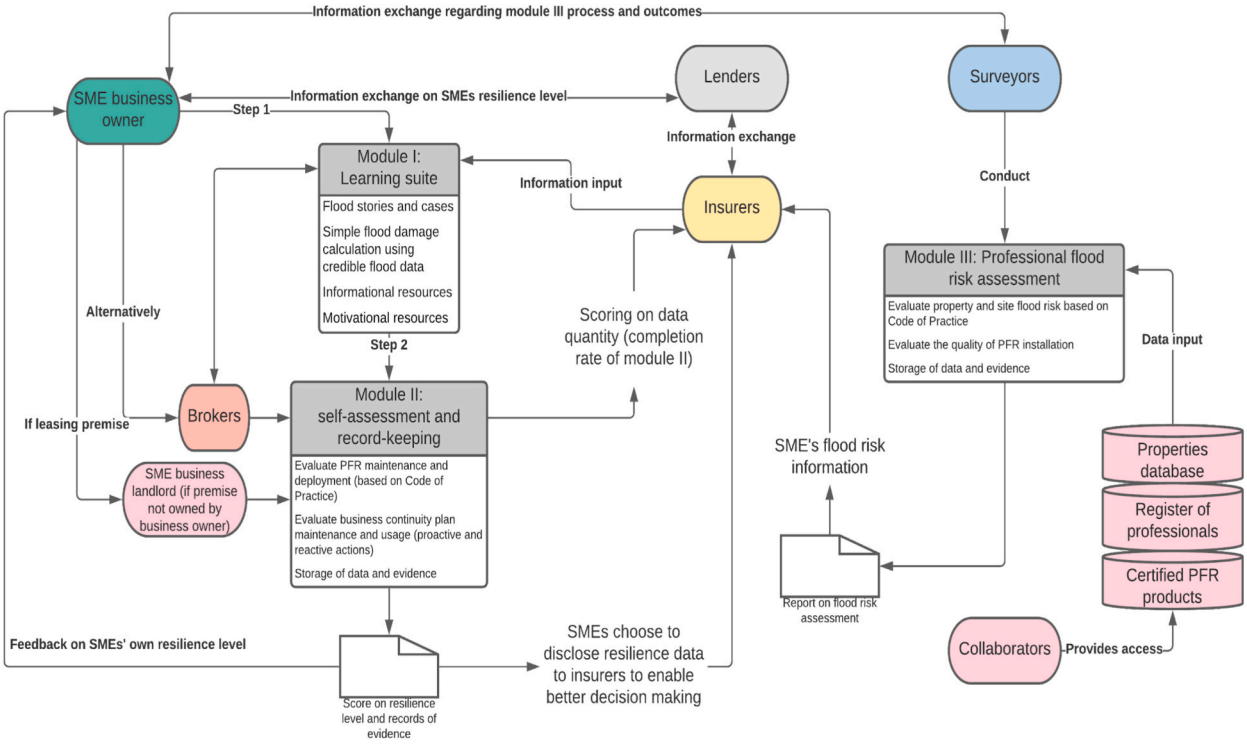

Fig. 3. Mapping of TAER presented at the focus group, consisting of the three modules and the feedback loop between the stakeholders and SMEs.

Table 3
Content description of each Module.

Module	Contents	Format	Requirements fulfilled	Input sources	Intended users
Module I: Learning Suite	Information on flood risk and climate change	Website	R7	Researchers, supporting governmental and non-gov organisations	SMEs
	Insurers' messages	Website	R7, R9	lenders, insurers, brokers	
	SMEs flood resilience toolkit Preparation and response to flooding (flood kit, flood plan, etc.) Property flood resilience measures and strategies	Website	R7	Researchers, Councils, local and national government, and NGOs	
	Flood stories	Website	R7	SMEs and local communities	
	Additional resources: Yorkshire and Humber councils provided information Code of Practice, and more	Website	R7	Councils, local and national government, specialised charters	
Module II: SME self-assessment and record-keeping	Building information	Self-assessment questionnaire	R1	SMEs (Module TAEC)	Lender, insurers, brokers, surveyors SMEs
	Flood risk information	Self-assessment questionnaire	R1		
	Flood planning: ● provide document and record of testing and maintaining when possible ● Action plan when flooding is imminent	Self-assessment questionnaire /document upload	R3, R5		
	Property Flood Resilience measures: ● photographic or video evidence of the measures ● record of testing and maintenance ● why and how the measures are installed and implemented	Self-assessment questionnaire /document upload/photo upload	R2, R5		
	Past experience with flooding: ● Duration of business closure and how much time it took to recover ● Economic losses in terms of monetary values due to flooding	Survey	R6		
	Past experience with flood protection and flood insurance	Survey	R6		
	Other business characteristics such as age, sector, etc	Survey	R1		
Module III: Building resilience survey and flood risk assessment	Building resilience and hazard assessment (with photographic or video evidence)	Questionnaire	R6, R5	Surveyors	
	Hazard assessment Pluvial screening for surface water flooding Fluvial screening for river flooding Tidal screening for storm surge flooding	Modelling	R6	Ambiental Technical Solutions Ltd.	
	Property performance and flood resilience	On-site survey/photo	R6, R2	Surveyors	
	Flood emergency plan and business continuity plan	On-site survey/photo	R6, R3	Surveyors	

similar businesses in the local area or the national average to gauge their performance. A clear challenge emerged in creating and maintaining a database due to the costs and ownership of the different data sources.

3.2. Tool composition

By incorporating feedback from the focus group, the tool evolved to include one module for SMEs' learning purposes and two modules to capture SMEs' resilience levels from the perspectives of professional surveyors and the SME owner or representative. As presented in Fig. 3, Module I (Learning Suite) and Module II (Self-assessment and record-keeping) are used by SMEs, and Module III (Professional flood risk assessment) is used by surveyors. Modules II and III will facilitate insurers' and underwriters' decision-making processes. Together with Module I and an additional actor called 'collaborator' (who contributes to products and personnel credibility), they form a feedback loop between the SMEs and LIS-B stakeholders, especially the insurers and brokers.

Module I (Learning Suite for SMEs) contains general information regarding flooding and the relationship with climate change, relevant resources, and toolkits. Module II (SME self-assessment and record-keeping) guides the SMEs through a series of questions and prompts to record and evaluate their flood protection measures and strategies. This module also involved using a tool we developed, written elsewhere, to assess the economic costs of flooding on SMEs (TAEC), which was used as part of the self-assessment questionnaire to collect data on the SMEs' past flood experience and indirect and direct damages. Module III contains the building and business resilience survey and the flood risk assessment, which should be conducted by professional surveyors. Table 3 details the contents of each Module and how each item fulfils the following information needs and functional requirements obtained from the survey, interviews, and focus group discussions:

11 Provide more nuanced and specific information**:** SME owners or property owners can use the tool to capture detailed business-related information and flood risk and resilience information.
21 Enable more accurate premise-level evaluation: demonstrate proper installation and maintenance of PFR measures.
31 Enable more accurate premise-level evaluation: demonstrate the use of strategies such as flood emergency response strategy and business continuity plan.
41 Professional surveyors should conduct the flood risk assessment and the on-site survey of building resilience.
51 Help provide a clear audit trail for each SME: SMEs should upload documents, photographs, videos, and narratives of examples as supporting evidence.
61 Provide information on SME's flood history: whether an SME has been flooded before, how they were impacted, and how they recovered.
71 SMEs should be well-informed: provide access to trusted sources of information and links to learning materials.

3.3. Tool evaluation

3.3.1. Assessment outcomes from modules II and III

First, each SME case was provided with a link to the Learning Suite website and was asked to use **Module I** to access information, resources, and recommendations regarding SME flood risk and resilience. Then, all 6 SMEs used **Module II** to self-assess the business's flood resilience and were asked to document and describe their actions on flood planning and property flood resilience. A simple traffic-light rating system at the end of the questionnaire was employed to give the SME a general appraisal of its resilience level based on the score attained.

The testing of **Module III** was conducted by surveyors from Sedgwick. First, a desk-based revision of the site was performed for each SME. Then, a flood-risk and hazards assessment model was used to perform pluvial, fluvial, and tidal screening for different types of flooding. Afterwards, the surveyors used Module III to conduct the on-site surveys, including collecting a large amount of photographic evidence.

3.3.2. SMEs evaluation and feedback

All the cases selected have been flooded before, so the participants have engaged with resources before to help with their flood preparedness and post-flood recovery. Some SMEs (cases 1, 2, 6) have been actively educating themselves, communicating with local authorities and organisations, and participating in flood advocacy. They especially found the materials in the Learning Suite (Module I) not add to their existing knowledge about flood risks, protection, resilience and recovery. On the other hand, all the cases agreed that it would be a useful resource for SMEs that have not experienced flooding frequently or at all.

Feedback provided by frequently flooded SMEs was that to add value to the Learning Suite (Module I), the tool should include more information on professional flood risk assessment. Many cases suggested the tool include information on the potential costs of damage that flood can inflict on the property and business, especially since it would be more difficult to predict and adjust going forward as climate change may cause more severe flooding that would lead to larger income reduction.

After completing Module II, a participant (Case 1) commented that the tool was "very clear, easy to use and thought-provoking", and it helped them better understand their own resilience and keep a record of the measures and strategies they employed. Another participant (Case 5) thought it helped them better understand their flood resilience and keep a better record of the measures and strategies they employed. Additionally, while the questions were designed to accommodate both SMEs owning and leasing their business premises by asking different sets of questions according to their premise ownership, we learned from working with case 3 that the tool should also accommodate landlords seeking flood insurance and resilience improvement for the property they lease to SMEs.

Some participants were surprised by the rating they received as it was lower than they expected. It was a convenient way to help the participants gauge their building and business resilience, but going forward it would need further database development and integration with TAEC to give both the SMEs and the insurers a more accurate rating scheme.

Table 4
Case description of the use of each module.

Module	Contents	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Module II: SME self-assessment and record-keeping — Current information	Building information	100% completed	100% completed	100% completed	100% completed	100% completed	100% completed
	Flood risk information	100% completed	100% completed	100% completed	100% completed	100% completed	100% completed
	Flood planning: questions	21/22 completed	22/22 completed	22/22 completed with additional descriptions	17/22 completed	22/22 completed	0
	Flood planning: flood plan document	Provided	Provided	Not provided	No flood plan	Not provided	Not provided
	Action plan when flooding is imminent	11/11 completed	11/11 completed (business flood recovery plan can be provided upon request)	11/11 completed	11/11 completed	11/11 completed	0
	PFR measures: questions	12/12 completed	12/12 completed with testing dates of 6 measures provided	12/12 completed with additional descriptions	12/12 completed with testing dates of 2 measures provided	12/12 completed	0
	PFR measures: photographs or videos	12 photos with description	0	2 photos	0	2 photos	0
Module II: SME self-assessment and record-keeping — Past flood experience	Past experience with flooding	completed	completed	completed	completed	completed	completed
	Past experience with flood protection and flood insurance	completed	completed	completed	completed	completed	completed
	Other business characteristics such as age, sector, etc	completed	completed	completed	completed	completed	completed
Module III: Surveyors' building resilience survey and flood risk assessment	Building resilience and hazard assessment: questions	12/12 completed	11/12 completed	9/12 completed	12/12 completed	6/12 completed	11/12 completed
	Building resilience and hazard assessment: photos and videos	47 photos	15 photos with descriptions	9 photos	45 photos	7 photos with descriptions	55 photos
	Hazard assessment Pluvial screening for surface water flooding Fluvial screening for river flooding Tidal screening for storm surge flooding	completed	completed	completed	completed	completed	completed
	Property performance and flood resilience	completed	completed with detailed information on 1 existing resistance measure	completed with detailed information on 1 existing resistance measure	completed	completed	completed with flood protection feasibility assessment and recommendation
	Flood emergency plan and business continuity plan	60% pass	100% pass	75% pass (production of business continuity plan is in progress)	100% pass	80% pass	Inexistent

3.3.3. LIS-B evaluation and feedback

The combined outputs from Modules II and III for each SME case study were collated into a case file, which was reviewed by stakeholders who participated in the workshop "SMEs and flooding: providing tailored information on SMEs and flooding". Module II and Module III intend to provide insurers and brokers with the necessary information regarding the SME's flood resilience and inform the decision-making on whether insurance coverage can be offered or not.

3.3.3.1. Overall impression of the SME based on all modules. Case 1: the SME has made some efforts, and they understand and appreciate their risk. They seem realistic about their insurance situation and are content with not having insurance at the moment. However, although the flood risk and their personal situation were very well recorded and documented many areas are not covered (see Table 4). This SME needs to show more willingness to advance its resilience measures.

Case 2: the SME is very proactive and has a good attitude towards flood risk. They have provided great details and insight about the business and demonstrated that they are trying to take care of their business resilience. However, additional information about the recovery process and the monitoring and management of flood protection measures would be more useful.

Case 3: the SME has provided good evidence of preparation and has shown that they have taken actions such as taking up PFR measures. This evidence can allow an insurance body to make a favourable decision and provide a more balanced quote for business and property flood insurance.

Case 4: the SME has shown that they have previous flood experience and have taken measures for their own protection. Module II shows that they are willing to take action to protect their business, and the information related to the economic impact and losses is also very relevant. However, the photos show additional problems that should be addressed.

Case 5: the SME has a good understanding of the extent of their flood risk exposure, and seems to be quite confident in their measures. The flood risk assessment and building resilience survey appeared to show that the SME has a reasonably well-managed risk, and the low post-flood costs are quite reassuring. However, the SME also came off a bit complacent about their risk and should be taking more active steps to be better prepared.

Case 6: While the buildings premises are robust, the SME owner should consider seeking advice from a drainage expert as there seem to be too much run-off from the fields. An insurer would also need more in-depth knowledge to fully understand the best line of action.

3.3.3.2. Confidence rating by module. T he participants were asked to rate how confident they feel that 1) the resilient works SMEs implement are effective, 2) the SME's flood risk is properly managed, and 3) the information is useful for offering more accurate insurance pricing.

In general, the cases with more completed Module II led to higher confidence ratings, especially regarding the effectiveness of the resilient work SMEs have implemented and the proper management of the SME's flood risk (Fig. 4). In some cases, detailed documentation gave participants greater confidence in the SME's attitude and willingness to protect their business.

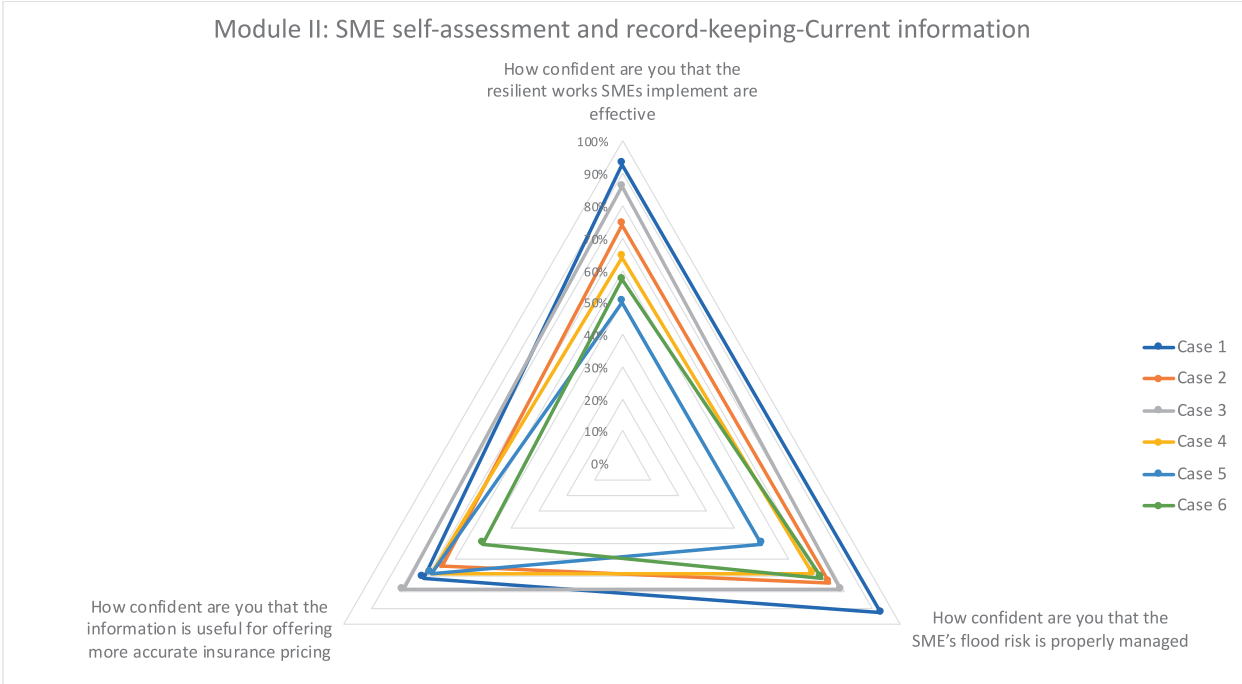

Fig. 4. Confidence rating (0–100% confidence) based on information provided by Module II-current information.

"The SME fully understands and appreciates their risk." (Case 1, Participant 3)
"The information shows a good risk awareness and appreciation. Also demonstrates proactive mitigation." (Case 2, Participant 1)

Other information that changed or informed the participant's opinions on the SME includes having good information on the contingency plan or flood plan, showing that the PFR measures are implemented and effective, and demonstrating the SME's ability to cope and recover from past flooding events.

"Good information about the contingency plan they have in place. Would like to know more about the recovery process and how this could be sped up and made more effective." (Case 2, Participant 2)
"They have a clear plan in place which I think is crucial" (Case 3, Participant 3)
"They have clearly learned from previous experience and have at least taken some measures to protect stock when a warning comes. They should give some confidence to insurers that they are increasing their awareness of resilience measures." (Case 4, Participant 1)

Most participants found the additional information from TAEC very useful to better judge an SME's resilience and enable them to ask more directed questions.

"The low post flood costs are helpful and reassuring, but in general they seem to be a bit complacent about their risk and not taking as many active steps to reduce it as you'd like to see." (Case 5, Participant 3)
"Despite putting a lot of measures in, they still have high costs following flood events. Interested to know why it took longer to recover back to monthly average in the 2019/20 winter floods than the more severe 2019 incident. (Case 2, Participant 2)"

As shown in Fig. 5, cases 1 and 3 received the highest confidence ratings for the effectiveness of their resilient work and their ability to manage flood risk properly. Compared to the other cases, cases 1 and 3 provided more detailed information not only about the PFR measures they installed but also about the preventive steps they have in place to secure persons and objects. Although case 3 could not provide a copy of the flood plan in the self-assessment questionnaire as part of Module II, they described their plan of action in detail in the section on past flood experience.

It's clear they have been thinking this through, and have a generally good appreciation of the actions they need to take (Case 1, Participant 2)
The PFR measures undertaken will mitigate the risk to the insurance company (Case 3, Participant 2)
They have a clear plan in place which I think is crucial (Case 3, Participant 3)

After surveyors reviewed the information in Module III, they were asked the same set of questions. Fig. 6 shows that information from Module III gives stakeholders greater confidence in providing more accurate insurance pricing. The main feedback from the workshop participants was that it was important for insurers to have data on design depths and the levels of various types of flood risk. In case 6, this type of information allowed participants to raise their confidence in the SME's management of its flood risk, whereas it was much lower based solely on information from the Module II sections.

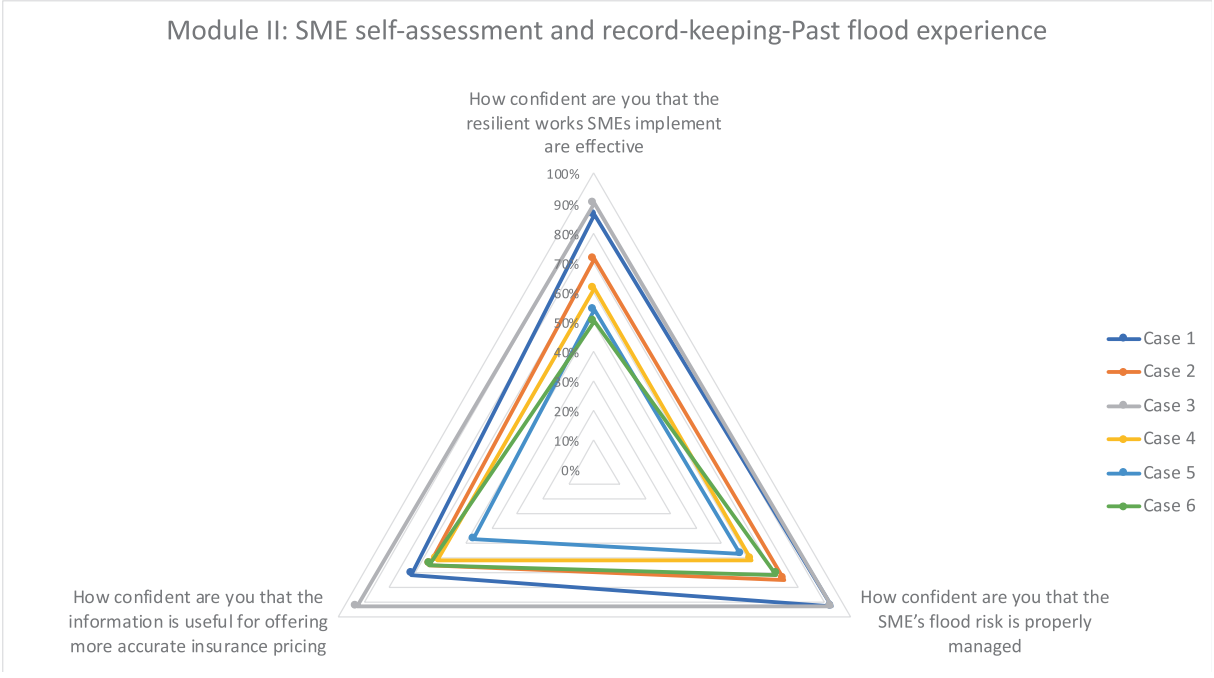

Fig. 5. Confidence rating(0–100% confidence) based on information provided by Module II-past flood experience.

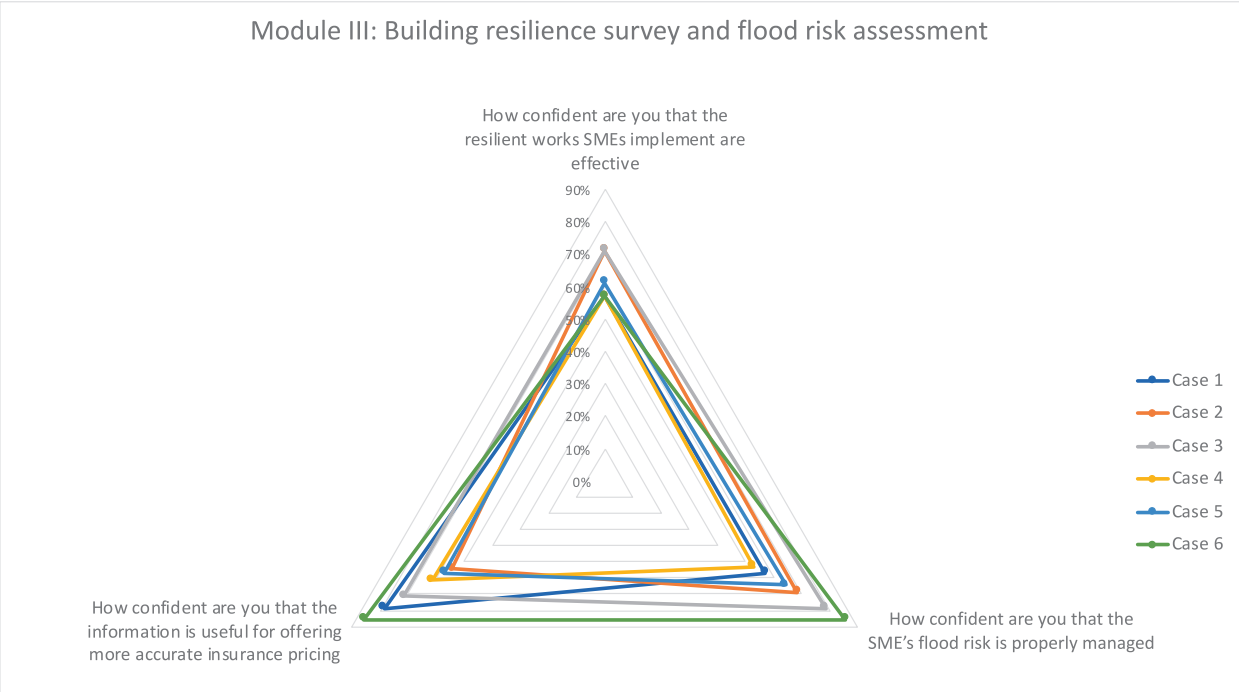

Fig. 6. Confidence rating (0–100% confidence) based on information provided by Module III-building resilience survey and flood risk assessment.

3.3.3.3. Most useful information. Most workshop participants agreed that the business's photographs were the strongest evidence, especially when paired with the written descriptions. Many reported that they were able to make an evaluation specific to the property, based on the written description of the measures and strategies paired with the pictures, and to work out the possible rationale behind the measures and estimate their performance. Based on this evidence, they can ask the SME owner specific questions for further clarification or provide specific recommendations to help the SME improve their current conditions. Other evidence that helped the participants gain more confidence in an SME's flood risk management included information regarding the business impact and economic losses after a flood event, the design depth and flood risk calculated by Ambiental's UK FloodMap^{TM}, and the evidence of a robust flood plan or contingency plan that can demonstrate that proactive actions have been taken.

4. Discussions

4.1. Academic contribution: rich and contextualised evidence for resilience assessment

The results of this study align with existing literature showing that several factors contribute to SMEs' resilience—particularly technical and technological resources, strategic planning and recovery capacity, and awareness and knowledge of risk management (Coates et al, 2020; Skouloudis et al., 2022, De Matteis, J. et al, 2023). At the same time, prior work has highlighted a key tension: although past flood experience can heighten awareness of flood risks, their impacts, and the importance of insurance (Ingirige and Wedawatta, 2018), this awareness does not necessarily result in greater protection and preparedness, particularly insurance uptake. A gap exists in the understanding of SMEs flood risk and their resilience, by the insurance industry (Sakai, P., 2020). Reasons are lack of trust, SMEs hetereogeneity and the traditional way of assessing SMEs flood risk based on 'flood zones'. This is translated into high insurance prices that do not recognise SMEs' resilience strategies. This research is intended to explore whether improved information about an SME's flood resilience might help in obtaining more affordable insurance, and thereby propose a framework for a thorough assessment of SMEs' flood risk and resilience. The findings reinforce the importance of the factors noted above and emphasise the need to recognise and bridge the gap between modelled and perceived risks from both insurers' and SMEs' perspectives, and also lend support to the need for the availability of detailed and specific risk information (Seifert-Dähnn, 2018; Thathsarani and Wijayasinghe, 2022; Bullen and Miles, 2024). In this context, the study underscores the potential of participatory, co-produced tools to enhance risk understanding, support better decision-making, and strengthen resilience.

To address this gap, we developed a tool and associated methodology that support decision-making from two main perspectives. First, they provide insurers with contextualised information on the expected size of losses at the level of individual cases. Second, they help reduce uncertainty around potential exposures by offering a more detailed understanding of the likely impacts on assets at risk. This dual function can help break the negatively reinforcing loop illustrated in Fig. 1 and contribute to a long-term, holistic, and positively reinforcing solution, as discussed in Surminski and Crick, 2013.

In current practice, when an SME applies for insurance online or through a broker, applications linked to postcodes in high-flood-

risk areas are often automatically rejected. The evidence-based information generated by our tool, when combined with postcode data, can instead trigger a conversation with an underwriter. Visual evidence and structured information about risk management efforts enable insurers to make more confident decisions and open discussions that would otherwise not take place. In particular, the insights from Modules II and III together demonstrate the extent to which an SME is actively managing its risks, increasing the likelihood that an application passes the initial screening stage.

The process can be strengthened when photos are collected from multiple angles and accompanied by clear descriptions of how risk management measures are implemented and maintained. Insurers are more confident when they have detailed information about past damages and associated costs. Our TAEC tool provides such information, and participants found it useful because it delivers a more compelling narrative of each SME being assessed. This points to the value of integrating TAER and TAEC: integration would be especially beneficial for SMEs without prior flood experience, as it helps them visualise potential damage and highlights the importance of Property Flood Resilience (PFR) measures and business continuity planning.

Modules II and III thus offer complementary information that supports a rounded assessment of an SME's flood resilience and risk management capacity. However, the resulting judgement can vary, depending on confidence ratings and direct feedback from workshop participants. For example, one participant noted that the self-assessment from Module II suggested that an SME was managing risk reasonably well, but the more detailed information on past flood experiences and the evidence collected in Module III painted a different picture.

4.2. Instrumental contribution: knowledge transfer, flood risk awareness and moral hazard

Participants stressed that the tool could strengthen communication and knowledge transfer not only between brokers and insurers but also between insurers and lenders. Taken together, the outputs of Modules II and III give underwriters a clearer view of an SME's overall risk management attitude and behaviour. As one participant emphasised, beyond putting a flood management plan and resilience measures in place, SMEs must demonstrate an ongoing commitment to managing, reassessing, readjusting, and training for flood risks.

Underwriters can also draw on flood risk and building resilience assessments conducted by surveyors to check whether SMEs have acted on identified risks. Over the course of the case studies, the tool effectively captured differences in SMEs' engagement: those investing more time and effort in communicating and sharing information with the project team received more positive and specific feedback from workshop participants.

Our findings on flood risk awareness are consistent with previous research: past flood experience can increase awareness of risks, consequences, and the value of insurance (Ingirige and Wedawatta, 2018), but does not always result in improved protection or preparedness. SMEs may still rely on the perceived adequacy of community-level protection (Wedawatta and Ingirige, 2012). In our study, participants from LIS-B aimed that the tool would support SMEs in better understanding their flood risk profiles and in identifying practical mitigation steps.

The literature has warned that insurance coverage may reduce incentives to adopt or maintain resilience measures, thus creating a moral hazard (Hudson and Thieken, 2022; Surminski and Oramas-Dorta, 2014; O'Hare et al., 2015). In our framework, moral hazard is mitigated because continued coverage and potential premium discounts depend on demonstrable actions by SME owners and employees to protect property and ensure business continuity. The presence, correct use, and maintenance of PFR measures thus become central.

Comparing to other flood risk assessment tools, TAER has the added function to raise awareness of both insurers and SMEs. First, as noted by SMEs in the case studies, Module I is especially valuable for firms without direct flood experience or prior investment in understanding their risks. Second, Module II uses information on past flood experiences to quantify historical and potential costs of flood damage to property and business continuity, tailored to each SME's characteristics. This helps SMEs contextualise potential losses and evaluate their risk reduction efforts. Third, the tool facilitates communication and knowledge exchange among SMEs, insurers, and

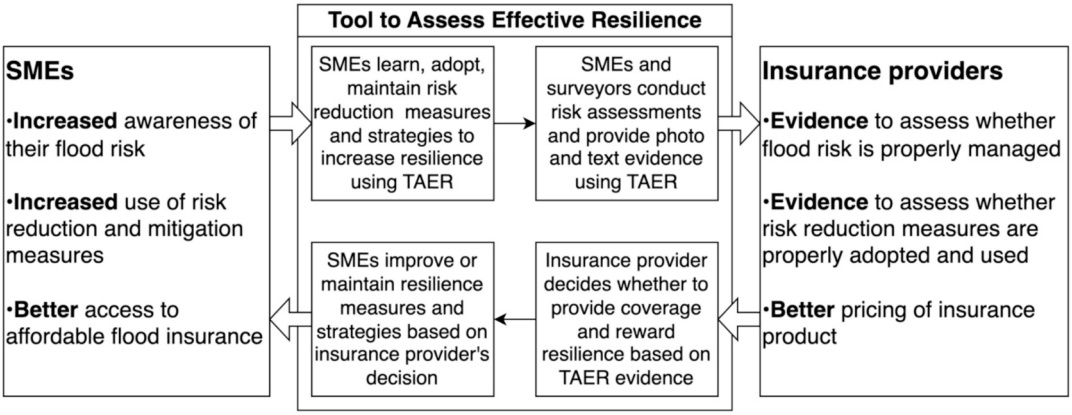

Fig. 7. A more balanced feedback loop between the SMEs seeking flood insurance and the insurance providers with the aid of TAER.

property landlords, which is crucial for addressing moral hazard.

Effectively managing SMEs' flood risks and securing flood insurance that provides a meaningful financial buffer are mutually reinforcing processes (EA and DEFRA, 2025). By enhancing resilience and actively managing flood risk, SMEs are better positioned to obtain and retain insurance coverage, while insurance itself supports recovery and further investment in resilience, creating a positive feedback loop (Fig. 7).

4.3. Limitations and future work

This study was conducted at the height of the COVID-19 pandemic (March 2020-March 2021); as a result, SMEs were either closed or struggling to survive. Business Development teams were overstretched, providing grants to recover from flood incidents, as well as managing the pandemic furloughs. Going forward, several improvements should be made to fully functionalise and integrate the tool in the SME resilience assessment and insurance decision-making processes. First, it is essential to actively engage the brokers, who can play a major role in explaining, elaborating, and clarifying to the insurers the information SMEs provided using the tool, while helping the SMEs bring clarity and context to their information. The team was not able to fully engage with the lenders during the piloting process, nor could they reach a large number of insurance underwriters to test the tool on a larger scale.

Secondly, a scenario overlooked was when an SME is a landlord working on leasing their property to other SMEs, or when the landlord wants to improve the building and the tenant's flood resilience. It is recommended to incorporate the tool with the necessary guidance steps in the self-assessment questionnaire and tailor the questions to the leasing landlords.

Thirdly, as revealed in the workshop feedback, the modelling outputs are an important set of evidence for proving the insurability of an SME, so the tool should be used in conjunction with catastrophe modelling when available to provide a more contextualised and individualised risk profile of the SME seeking flood insurance. Similarly, future efforts should focus on incorporating flood damage curves that provide SMEs with a gauge of what the costs of damages would be.

Fourth, to create real conversations with lenders and insurers beyond the flood map, the tool needs further development in scoring, reporting, as well as comparison between SMEs, which was not attainable given the time and resources available. While some SME cases found the simple traffic-light resilience rating system useful, there was not the capacity to fully develop a system for SMEs to compare locally with others of similar characteristics, or for LIS-B actors to easily access and digest the information gathered using both Modules II and III.

Finally, a limitation of this study is the uncertainty regarding the actual adoption of this model by SMEs and LIS-Bs. However, this tool was co-created by independent researchers, SMEs and insurers, providing meaningful advantages. The co-creation approach improved the relevance, accuracy, and legitimacy of the tool by integrating experiential SME knowledge, actuarial insights from insurers, and methodological rigour from independent researchers. It focused on enhancing trust, usability, and adoption likelihood while supporting innovation in insurance products and offering a playing field to share understanding between stakeholders. This approach increases the tool's real-world impact by embedding it within existing decision-making processes and strengthening pathways for dissemination and implementation.

5. Conclusion remarks and policy implications

SMEs are the cornerstone of communities at flood risk. Current weather and future climate impacts, such as flooding, ask that SMEs need to be prepared. This study contributes to the literature by identifying a set of factors that are relevant for insurance decisions. It also contributes to policy and practice as these represent entry points for future interventions that can advance flood protection assisting SMEs to obtain insurance. Despite this, there is a knowledge gap regarding SMEs flood resilience. To bridge this knowledge gap, we worked with our partners from the insurance industry to disentangle the information they needed to increase the trust that SMEs are engaged in self-protection and open up insurance market opportunities for SMEs. Through constant engagement and feedback with SMEs, lenders, insurers, surveyors and brokers for over a year, we have produced TAER (Tool to Assess the Effectiveness of Resilience Measures on SMEs). TAER seeks to broaden LIS-B's understanding of SMEs' flood risk management strategies, including property resilience measures. This will allow them to make more informed decisions based on a wider understanding of SMEs' risks.

When SMEs are affected by flood incidents, the impact can be widespread, and both our local authorities and insurer partners indicated that, as entities that are constantly managing flood risk, the degree of awareness that SMEs have of their own flood risk and their resilience is an important decision-making factor. It is understood that many SMEs don't have flood insurance because they are not aware whether flood insurance is included in their business insurance (DEFRA, 2022), underestimate their exposure to flood risks, and overestimate the effectiveness of flood protection measures installed privately and publicly (DEFRA, 2022, OECD, 2016). To encourage learning and awareness increase in SMEs, this study suggests the use of Module I as a source of information and a guide for action. It can help SMEs better understand the rationale behind the increasing risks of flooding due to climate change, and measures and strategies that they can employ to reduce their risks and increase their resilience.

Measuring resilience has always been complex. Resilience needs to be embedded into SMEs' business culture because it is a dynamic process. The essential aspect is increasing the capacity to cope in the short term. PFR measures, along with professional standards and proper validation and audit trails are a great first line of defence for SMEs in flood-risk areas. SMEs undertake strategies to better protect their premises from flooding, and many feel that their businesses are better equipped for another flood event, yet their efforts are not considered when it comes to insurance. Among SMEs seeking flood cover, affordability or availability remains the primary challenge, and the most commonly cited reason is that the business is complex or niche (DEFRA, 2022). The interaction between the case studies and LIS-Bs was a valuable assessment of SME risks. Returning LIS-Bs' feedback to the SMEs enables greater interaction

with the results, which can create a feedback loop, helping SMEs further increase their resilience.

The UK government and the insurance industry have advance introducing stronger incentives for property flood resilience to make resilient properties more routine across the country, and have often worked with SMEs (EA and DEFRA, 2025). The results contributed to the development of a flood resilience app co-created by DEFRA, the Chartered Institution of Water and Environmental Management, and Flood Re. While this marks a positive and necessary shift toward long-term climate preparedness, new regulations makes the landscape concerning for SMEs. Financial institutions are now required to consider their clients' climate risks when making lending decisions (Bank of England, 2025), making effective flood risk management, including flood insurance, increasingly vital for SMEs. Moreover, the FloodReady review itself highlights that business owners, including SMEs, are expected to adopt PFR -without receiving dedicated, tailored support. This gap is concerning because stakeholders have specifically noted that navigating PFR standards and certification processes remains difficult for SMEs, yet no SME-specific assistance is being put in place to address these barriers. Further research is needed on how Local Authorities, SMEs, and the insurance sector can build a system that fosters trust and enables learning loops on long-term flood risk management strategies, thereby increasing flood protection in the face of climate change.

CRediT authorship contribution statement

Zeyu Yao: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Conceptualization. **Paola Sakai:** Funding acquisition, Conceptualisation, Methodology, Investigation, Supervision, Writing – original draft, Writing – review & editing, Project administration. **Cecilia De Ita:** Investigation, Writing – review & editing. **Marco Sakai:** Funding acquisition, Supervision, Resources, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.crm.2026.100801.

Data availability

Data will be made available on request.

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