Property Flood Resilience (PFR): Exploring the experiences of commercial property owners

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Abstract

In response to more severe and frequent flooding, the latest Flood and Coastal Erosion Risk Management Strategy in the UK aims to mainstream resilience. This has encompassed a recognition of the need to improve the resilience of individual properties, through what has become known as Property Flood Resilience (PFR). However, the application and implementation of PFR has focused on residential properties and there has been a dearth of research on its application to commercial property. This research explored the views and experiences of flood affected commercial property owners towards the practice of PFR to identify the barriers and develop improved implementation strategies. The research adopted an exploratory approach using six commercial properties as case studies, examined through site visits, interviews and documentary evidence. The findings revealed that while PFR measures had thus far been sparsely implemented, there was a clear prevalence towards low-cost interventions, designed to meet particular characteristics of the property and business activities. Generally, these measures had brought about positive outcomes in reducing the impact of flooding and speeding up the recovery process. The cost of such measures was found to be a major barrier, and generally businesses were found to be lacking in-depth understanding and knowledge to inform the development of a more strategic approach to managing these risks. Further support and guidance is clearly needed for businesses and more concerted effort is needed towards raising PFR awareness. This research provides robust evidence for commercial property owners and other stakeholders to facilitate improved decision making in the design and implementation of PFR measures.

Keywords: Property flood resilience, Commercial property, Flood experience, Case study

Introduction

Flooding is one of the most wide-reaching and frequently occurring natural hazards in the world with noticeable impacts, including physical damage to properties, critical infrastructures and assets. The losses caused because of business interruption and general disruption to communities is significant (Jha et al., 2012). In the UK, over 5.2 million properties (around one in seven homes and businesses) are exposed to flood risk from different sources of flooding including coastal, river, surface water, ground water and sewer flooding (Kenney et al., 2006 and Environment Agency, 2014; and Committee on Climate Change, 2019). As a means of mitigating these impacts, various approaches to protecting communities have been developed (Oladokun et al., 2017). Traditionally, these have relied on structural measures or engineered solutions, designed with defined limits of disturbance that provide good levels of protection (Proverbs and Lamond, 2017). However, these structural systems need to be maintained and are subject to failure and being overwhelmed. Despite the huge investment in structural approaches and engineering measures, flooding remains one of the greatest threats to buildings, businesses and the wellbeing of humans (Adedeji et al., 2018).

In recent years, UK flood risk management policy has recognised that flooding cannot be totally prevented and has embraced a proactive and more resilient approach of managing flood risk and living with floods which is captured under the 'living with water' philosophy (Environment Agency, 2020). This approach, in the context of property level flood risk, often entails building resilience into the system that is exposed to the risk so it can avoid, prevent or reduce the damage. This concept is commonly referred to as property level flood resilience or simply property flood resilience (PFR) and has, since its inception, gained wider recognition in the domain of flood risk management (Oladokun et al., 2017 and Kelly et al., 2019).

With the latest UK Flood and Coastal Erosion Risk Management strategy (Environment Agency, 2020) aiming to mainstream PFR there is a need for further evidence and evaluation in supporting the wider uptake of these approaches. However, most previous studies on PFR have concentrated almost exclusively on residential properties, and very little has been documented on the application of PFR to commercial property (Pottinger and Tanton, 2011 and Attems et al., 2019). Although many existing PFR measures designed for residential properties can be applied to commercial properties, resilience for commercial properties is not only a function of the physical characteristics of the property (Adedeji et al., 2018; Adebimpe et al., 2021 and Adeniyi et al., 2022) but also involves a much wider range of factors including laws, regulations, valuation and insurance. There are also a considerable number of stakeholders involved including the property owners themselves, employees and users, customers, supply chain organisations, local authority representatives, and building professionals. Thus, the flood risk of commercial properties is generally more complicated, relating to attitudinal, managerial, organizational, behavioural and regulatory factors (Skouloudis et al., 2023), calling for more multi-level and dynamic perspectives into the development of appropriate PFR for commercial property.

The aim of this research is to investigate the experiences and needs of commercial property owners / users towards identifying the barriers to the implementation of PFR. A critical review of the extent literature on PFR and its implementation is first presented, followed by a summary of the research design and methodology. Based on six case study examples of commercial properties that have had PFR installed, the views and experiences of the property owners / users are explored and interrogated. This leads to the development of some clear conclusions and recommendations on how to improve the further adoption of PFR in commercial properties.

Property Flood Resilience (PFR)

As its name suggested, PFR focuses on individual property to improve its capability of reducing the impact from flooding. PFR measures can be broadly categorised into two types: resistance measures that aim to keep flood waters out of a property; and resilience measures that minimise the potential of damage caused by floodwater once they enter a property and speed up the recovery (White et al., 2016; Connelly et al., 2020).

The resistance measures focus on making individual properties watertight to floods of limited duration (a few hours) and depth (typically less than 600mm) to reduce damage to the internal fabric of the building and its contents (Department for Communities and Local Government, 2007). This will provide property owners the opportunity to relocate important items to a safer level. These resistance measures include both flood protection products (such as floodgates, door and window guards for doorways and low level windows), the installation of non-return valves on sewers to prevent backflow, barriers and flood doors that cover apertures and the use of resistant materials (such as engineering bricks, cladding systems, plastic skirts, flood-resistant doors, and wall coatings to limit water ingress) (Tagg et al., 2016).

In order to adopt resistance measures, it is essential to consider and ensure that the building structure has the capacity to resist four types of flood-related forces: (1) hydrostatic flood force that freestanding water exerts on a submerged object; (2) buoyancy force that a building receives from surrounding floodwaters; (3) hydrodynamic force that vertical surfaces receive from moving floodwaters; and (4) debris impact force to withstand the flood-borne debris strikes on the side of building (World Meteorological Organization, 2012). The advantage of applying resistance measures is that the building is kept dry and the contents (stock and valuable records) inside the building are not affected by flood. However, the stability of the building structure can be jeopardized because of the heavier load of floodwater (World Meteorological Organization, 2012).

In the case of flood water unavoidably entering a property, the resilience measures aim to minimise the damage caused to the building and its contents from the flood water and allowing a quicker recovery. Resilience measures start with careful selection of building materials, construction techniques and internal finishes so that the property can be easily cleaned without leaving any contaminants behind. A building should have flood vents or permanent openings that allow water to flow in and out of the structure without damaging the foundations (CIRIA and Environment Agency, 2003). Other effective resilience measures include raised electric sockets and wirings, sump and pump systems, equipment and machinery on raised plinths, emergency flood plans, and flood insurance (Dhonau and Rose, 2016 and Attems et al., 2019). Resilience measures are often less costly and require less space for construction, however there will be clean-up costs after a flood and periodic maintenance will be needed (Attems et al., 2019).

As these PFR measures have not been fully incorporated into the building regulations and standards, it is up to the individual property owners to decide which measures, how many and where to adapt them (Attems et al., 2019). Although these PFR measures have been proven very effective to improve resilience and can bring significant long-term benefits, their implementation so far is still very limited due to various barriers such as awareness, knowledge and cost. A research conducted across several European countries (the UK, Germany, France, the Netherlands, Spain, Greece and Cyprus) found that there is a general reluctance to accept the responsibility for the purchase and installation of such measures (White et al., 2016).

PFR in Commercial Properties

Commercial property such as retails, offices, hotels and industrial properties are valued at about £1.3 trillion in the UK (Statista, 2023), and they play a significant role in the UK economy with an estimated turnover of £3200 billion and employing about 22.8 million people (BIS, 2010). However, it is estimated that around 185,000 commercial properties are at direct risk of being affected by flooding (Environment Agency, 2009). Flooding can cause not only direct and tangible damage but also bring about indirect and intangible damage, (Merz et al., 2010) as illustrated in Table 1. The direct impacts entail physical damage to buildings and stock and physical / mental health impacts on people. Indirect impacts involve business disruption, lack of access and loss of business which are referred to as secondary effects of flooding (Lamond et al., 2017). The tangible impacts can be more easily measured and claimed through insurance, like damage to structure, furniture / fittings and loss of stock; while intangible impacts such as loss of reputation, issues with renewing insurance and the wellbeing of employees are difficult to measure and yet may have huge impact on a business in the long term (Joseph et al., 2014; Lamond et al., 2017; Moudrak and Feltmate, 2019; and Committee on Climate Change, 2019). Studies have suggested that the indirect impacts of flooding often exceed the costs of direct damage and claims for business interruption may dwarf claims against property insurance (Kleindorfer and Germaine, 2005; Heite et al., 2009). However, there is still relatively little guidance on the actions that businesses can take to minimise such damages and ensure they are resilient to future risks (ASC, 2016).

Table 1 Classification of flood impacts on commercial properties (Merz et al., 2010)

Flood impact	**Tangible**	**Intangible**
Direct	• Structural damage • Damage to furniture and fittings	• Loss of document • Ill-health

	• Loss of stock • Damage to equipment and machinery	
Indirect	• Loss of production • Cost of evacuation of goods and staff • Clearing and cleaning up cost • Repair cost	• Loss of reputation • Business disruption • Issues with renewing insurance

Although many of the PFR measures designed for residential can potentially be applied to commercial properties, these properties have many different characteristics such as building size, operation and maintenance, economic and social impact from flooding, diverse stakeholders and supply chains involved, and different decision-making process. Very often, business owners focus on the operation of their businesses, and they are not fully aware of the flood risk and have not much knowledge on flood mitigation / resilience measures (Schelfaut et al., 2011; Nguyen & James, 2013). They need convincing evidence of the benefits of investing in PFR measures and specialists' support which is not yet widely available (Bhattacharya et al., 2018). Decision-making for and implementation of the PFR measures in commercial properties involves diverse stakeholders such as engineers, architects, surveyors, insurers, and financiers (Lamond et al., 2017), which makes the process more difficult to manage. As a result, PFR measures have not been widely implemented in commercial properties.

Research method

As there are few established theories and a lack of proven practice of PFR for commercial properties, the case study approach was considered an appropriate research method for this exploratory investigation (Yin, 2011). Six commercial properties located in flood affected areas of the Midlands and in the North of England in the UK were chosen through a purposive sampling approach. Potential cases were initially identified by drawing on the authors own professional networks and business contacts including local trade associations and regional offices of the Royal Institution of Chartered Surveyors (RICS). This was helpful in identifying a pool of potential cases. Further screening was undertaken based on flooding experience (required to be in last five years), business type (aiming for a range encompassing industrial, commercial and leisure), and by excluding large businesses. The intention being to focus on small and medium sized business types (i.e. SMEs) as these represent the majority of businesses in the UK economy and are known to be more vulnerable to flood risk due to their limited resources (Wedawatta et al., 2012). Cases were limited to six in light of funding and time constraints.

We acknowledge that the properties selected are not representative of the broader population of commercial properties in the UK and would caution against generalising these research findings. However, the findings do provide a valuable insight into current PFR practices among small to medium sized commercial properties including the practical considerations and benefits experienced by owners.

To support the reliability and validity of the study, findings for each case study were triangulated through the use of data and information gained from observations (i.e. site visits), documentary evidence and interviews (Yin, 2011). The field study was conducted in May / June 2021 and included site visits to physically inspect the property and the PFR measures installed and to observe their effectiveness. Documents such as flood emergency plans and insurance policies provided important background information towards understanding the aims of the PFR measures.

Interviews provided an opportunity to understand the motivation of the owners / users, including their awareness, needs, concerns and decision-making process for the PFR measures. Semi-structured interviews were chosen to maintain the focus as well as allow a certain degree of flexibility within the specific context of each individual property (Queiros et al., 2017). Interviews were conducted with either the property owners or facility / operation managers as they had detailed knowledge of their properties and flood history and were able to provide new insights into their flood risk management practice.

To support the validity and reliability, a standardised set of eleven open ended interview questions were used to help ensure consistency across interviews. The themes of the questions were informed based on the issues identified from the available literature and focused on gaining an understanding of flood experience, protection and resilient measures considered and implemented, the effectiveness of these measures, and the decision-making process. The interviews were conducted on the premises, followed by a guided tour enabling an opportunity to visually inspect any measures that had been implemented. Each interview lasted about 1 hour and was recorded to help accurately capture responses. Photos of the resilience measures implemented were taken with the consent of the interviewees. All interviews were undertaken and then coded by the same researcher, who is experienced and skilled in qualitative interview techniques.

Thematic analysis is widely regarded as an appropriate qualitative data analysis technique because it can connect different conceptual issues and recognise the themes and trend emerged from the data (Braun and Clarke, 2006). To achieve triangulation, interview recordings were first transcribed (by using voice-to-word app and listening back for accuracy check), and then compared with the site visit notes and relevant documents from each case property (such as flood risk emergency plans). This combined evidence was then studied thoroughly before the transcripts were then coded manually according to the research themes (e.g. flooding history, PFR measures, effectiveness, cost, knowledge, and support). The findings across the cases were then compared to identify the trends and gaps in practice. Transcripts were shared with the participants to ensure their views had been accurately captured and represented and to enhance the credibility of the findings.

Research findings

Based on the data and information collected from the field study, a summary of the six cases is presented below and summarised in Tables 2 and 3. This provides a detailed account of the experience and views of commercial property owners and how they had attempted to improve their property flooding resilience.

Case No 1: Manufacturing factory

This property is a specialist coating factory in an industrial estate in the West Midlands. It was flooded two times in 2007 and most recently in 2018 when the River Cole burst its banks due to heavy and intense rainfall. The flood caused damage of around £1 million in the form of the loss of raw materials and furniture, damaged machinery and IT equipment, repairs to offices and warehouses, and costs of drying and cleaning. The owners had been unable to secure insurance due to the flood history of the property and had to use the company's own cash reserves to fund the repair. It took 2 weeks before production could resume and 9 months to get back to a state of normality. Realising that flood risk was a real threat to the business, one of the managers was assigned responsible for incorporating flood resilience into their business strategy and operational management. A range of resilience and resistance measures had been installed as summarised in Table 3.

The operation manager commented on their flood risk management strategy:

> *"As a business, we need to consider how we protect as much of our business as possible, knowing that one day it is going to flood again and planning for the fact that that's the case, you have to balance the work that people do on a day-to-day basis. We will be flooded in the future, but at least then, hopefully (with PRF measures), we can recover quicker and smarter."*

Case No 2: Business centre

This property is a 6 storeys business centre for office hire next to a river in the north of England. It was flooded in 2007 for only the 2nd time (the first time was in 19th century). During the 2007 flood, the water in the river had been building up for days so they saw the flood was coming and had time to move all the furniture, computers and everything else on the ground floor to the upper floors. When the Red Flood Alert was issued, the building had already been flooded for 4 hours. The business centre and the tenants returned to work the next day thanks to the actions taken beforehand. But it took 3 months to dry out and sanitise the brick walls, rewiring and changing carpet, costing £26,000 to repair the damage. After the 2007 flooding a range of measures were installed as summarised in Table 3.

When their insurance policy was renewed some 9 months later, after showing the insurance company their flood strategy and flood resilience measures, their insurance premium was not increased but they had to accept a significantly higher excess. When reflecting on the flooding and the actions taken, the manager said:

"So from a management point of view, because we acted so quickly, got the tenants moved, put them somewhere else and basically saved them from the floods, we had an improved reputation. We didn't lose any tenants."

Case No 3: Holiday cottage

This property is holiday cottage in front of a river in the Midlands. It was flooded in 2007 with 2 feet of water inside the property, causing some damages. The owner claimed £34,000 from the insurance company. Although the insurance premium has not been increased much since, the excess amount has been increased from £100 to £3,500. After the flood, the recovery took nearly a year so there was significant income loss. The owner explained the reason of the long delay:

"*The biggest time factor was actually finding a builder (after the flooding). Everybody (in town) wants a builder, so you sort of have to wait for your turn*."

The Environment Agency did an assessment after the flood but concluded that it was not cost effective to have any protection barriers along the river. After the flood, a range of measures were installed as shown in Table 3.

The owner did consider installing a flood gate, but worried that it would put off potential buyers and it does not look nice on the property. But the owner also believed that people's attitude is changing now, and the flood measures such as temporary flood gate may be a good thing as it shows the property is properly protected.

Case No 4: Sailing club

This property is a sailing club by a riverbank in the north of England. It has been flooded multiple times in the past, with the last in February 2021. Flooding normally happens in winter, which is not the sailing season, so the interruption to the business is not as significant. After the previous flood, the insurance premium for the property has not been increased too much, probably because flood is expected due to its location. When asked about flood protection projects and government support, the manager reported:

"*They (the Environment Agency) looked at the flood scheme for the whole village, and they decided it wasn't worth it on the basis of the properties protected, okay so they're offering individual householders seven and a half thousand pounds to work on flood resilience*."

To improve the property's flood resilience, a number of measures were taken as summarised in Table 3.

Case No 5: Rowing club

This property is a rowing club located next to the River Severn in the Midlands. The main building is two-storey with a gym, two squash courts, a bar, some offices, a boat house and affiliated outdoor tennis courts. The property has been flooded multiple times, with the most severe being in 2007 with the water as deep as 1.7m on the ground floor. The main damage from the flooding was to the wooden floor of the squash courts. Side boards had to be removed to allow the floor to partially float and the boards to swell without buckling. Drying of the floor using fans and dehumidifies running 24/7 took many days. The whole repair work cost around £800 with volunteers from the club (which would have costed £12,000 at the market price). Ultimately, it took 3-4 months to restore the squash courts. The property is insured but the excess amount is high at £5,000. After the 2007 flood, a number of measures were taken including some steps to improve resilience as shown in Table 3.

The owners did consider flood gates to prevent water coming into the building but decided this was not feasible as there are so many water entry points. The facility manager commented on their flood management strategy:

> "*Some people are probably better prepared than others. You have to decide according to your conditions, what kinds of benefits you can get and whether it is worth of the money spent*."

Case No 6: Touring theatre

This property belongs to a touring theatre company in the north of England. It is very close to a river and has been flooded twice in the past 20 years, with the latest in 2015. The 2015 flood hit them hard as it happened on Boxing Day and not many staff were around to deal with it. They claimed £11,700 from the insurance company and as a result, their insurance premium was increased. It took 3-4 weeks for them to be back to normal business. There has been some discussion about the installation of movable temporary flood defence with the local council and the Environment Agency, but it was concluded not be very practical and cost effective. After the 2015 flooding a wide range of measures were taken as summarised in Table 3.

The manager stressed the importance of the professional advice on PFR measures:

> "*I sort of get lost in the world that way as soon as you start. You need an expert to come in and tell you how to do it because … it has to be compact and safe and most of us to be able to use as well, and affordable*."

Table 2 is a summary of the six cases studied in this research, including their property characters, the flood they experienced and the impact on their businesses. To be more representative, this research included different types of commercial properties such as industrial, office and entertainment and hospitality. They have different flood experience and the impact of flooding on their businesses are also varied in terms of damage and impact.

Table 2 Summary of the case properties and their flood experience

Property characters and flood experience	**Case No 1**	**Case No 2**	**Case No 3**	**Case No 4**	**Case No 5**	**Case No 6**
Nature of business	Industrial	Office centre	Holiday rent	Sailing club	Rowing club	Touring theatre
No or storey of the property	1	6	2	2	2	2
Last flooded	2018	2007	2007	2021	2007	2015
Estimated financial loss	£1 million	£26k	£34k	--	£12k	£11.7k
Recover time (months)	9	3	12	--	4	1
Insurance premium increase	Unable to insure	No	No	No	No	Yes
Insurance excess amount increase	Unable to insure	Yes	Yes	No	No	No

(This table is produced by the authors)

Table 3 provides a summary of the PFR measures implemented in commercial properties studied in this research. There are some popular measures favoured by almost all of the businesses such as flood alert registration, raised electric sockets and wiring, and flood insurance, but some other measures such as flood defences and external flood risk evaluation were only implemented by a single business.

Table 3 PFR measures implemented in the case properties

PFR measures	Case No 1	Case No 2	Case No 3	Case No 4	Case No 5	Case No 6
Flood defence		√				
Flood alert registration	√	√	√	√	√	√
Flood insurance		√	√	√	√	√
Flood emergency plan	√	√			√	√
Remote flood monitoring	√			√		
Flood guards for door / window		√			√	√
Hard floor / carpet tiles	√		√	√	√	
Move equipment upstairs		√	√	√	√	√
Washable kitchen unit / furniture	√			√		
Raised electric sockets and wirings	√	√	√	√	√	√
Equipment / machinery on raised plinth	√			√	√	√
Record back up electronically	√	√				√
Pump systems			√			√
Air vent / overflow pipe			√			√
External flood risk evaluation						√
Working with local community	√	√	√			

(This table is produced by the authors)

Discussion

From the case studies presented above, it is interesting to see that while some common practices can be identified (e.g. flood alerts and raised sockets), different measures had been adopted to suit particular business needs. This suggests that each business may need a bespoke package of measures to suit their particular circumstances including nature of the business, flood risk, property characteristics and cost.

Flood Awareness

All the interviewees believed that flooding was likely to happen more frequently and more severely as a result of climate change, and that it was important to learn to live with water, exemplified in the operation manager's comments in Case No 1 (see above). This aligns well with the principle of the UK National Flood Risk Management strategy (Environment Agency, 2020). However, many interviewees reflected that they were not aware of their flood risk before the event, and many of their neighbouring businesses were not paying sufficient attention to the risks. Awareness and understanding of flood risk has been identified as one of the key factors that affect the effectiveness of how businesses respond (Halkos and Skouloudis, 2020 and Adeniyi et al., 2022). However, businesses generally focus more on the short-term benefits and other business priorities (Lamond et al., 2017). In particular, SMEs have been found to lack flood resilience capacity and are not adequately prepared for the impacts of flooding (Skouloudis et al., 2023).

This low maturity level of businesses' flood resilience capability was found to be attributed to their lack of significant flooding experience (Adeniyi et al., 2019). Flood experience can prompt individual and organisational learning, leading to improved knowledge and flood resilience (Kuang and Liao, 2020), which was clearly evident in the case studies. However, it is possible to share this flood experience and knowledge through local flood action groups / community / forums (McEwen et al., 2018), through business flood resilience 'champions' (Skouloudis et al., 2023), and annual community flood awareness events (Silvis et al., 2024). Research has shown that social norms may influence people's decision making and they are more likely to implement PFR measures if their neighbours, social networks and friends are doing so (Bubeck et al., 2013 cited in Botzen et al., 2019). Therefore, there is a need to raise the awareness of flood risk and resilience at the community level and encourage wider learning (Connelly et al., 2020), especially among the community of commercial property owners / occupants who are in flood prone areas but have not yet been flooded. Local business forums, networks and road shows from the local government, professional bodies and sector-based organisations would help in this regard. Businesses need to realise that flooding will not only cause the tangible and direct damages to their properties and operation but also intangible and indirect damages, and it is for their long-term interests to invest in PFR measures (Xiao et al., 2020).

Protection / resistant measures

All the businesses had registered for the free flood alert / warning service provided by the Environment Agency. This measure is simple and cost free to implement and can help businesses monitor the flood movement in real time and enable them to implement pre-planned precautionary steps to reduce the impacts (e.g. moving stored items to a safe location). However, there are some challenges in that the alert / warning is not always accurate, or may come in too late, or at an inconvenient time (e.g. late at night or weekends

/ holidays). With the rapid development in flood forecasting techniques and advancements in data management and the application of AI, it is expected the accuracy of flood forecasts will be improved significantly in the coming years (Sankaranarayanan et al., 2020) and businesses will benefit from more accurate and reliable flood alert / warning system.

Structural flood defence projects (like the flood defence wall in Case No 2) can be very effective, and businesses are willing to contribute to the cost of such projects, for example through increased rental charges. However, these projects are costly, come with various restraints and require the coordination of the Environment Agency, local authorities and other organisations. Also, such projects may not always be effective or viable (as in Case No 3, 4 and 6) and can also be overtopped. In addition to government investment and intervention and to achieve sustainable flood risk management, stakeholder engagement with the local community including individual businesses and the public is paramount (Geaves and Penning-Rowsell, 2016). Even with conventional community-based flood protection measures in place, PFR measures can still supplement other structural defences and provide for a more cost effective and higher degree of protection (Rehan et al., 2024). Generally, businesses need to take a more proactive approach in tackling latent risks including the installation of PFR measures specific to their own needs.

Moving vulnerable / valuable items above the expected flood level and/or raising equipment and machinery on plinths was found to be amongst the most common steps. These measures do not cost much and are straightforward to implement, while the benefits can be significant as equipment, machinery and raw materials can all be protected. This helps businesses reduce the damage caused and resume operation more quickly after an event (Moudrak and Feltmate, 2019). However, in cases where the flooding is unexpected or arrives at night, during a weekend or vacation time, (e.g. as in Cases 1, 5 and 6) the opportunity to move equipment and the like is limited. Some items may also be too heavy to move. Hence, as flooding becomes more frequent and severe, more proactive or automated responses will be needed.

Flood gates (door and window guard) were also found to be a common measure and were seen to be effective in keeping water out (as in Case No 2, 4 and 6). These products are relatively straightforward and inexpensive to install, use and maintain, and the added benefit is that it gives tenants and potential buyers a peace of mind and the confidence that the property is well protected (Moudrak and Feltmate, 2019). This demonstrates how PFR measures can reduce not only the tangible damages, but also the intangible and indirect damages to commercial properties and businesses (Merz et al., 2010). However, these measures are only effective if all entry points are protected, and care is needed for those with multiple water entry points which may not always be possible and effective (e.g. in Case No 5).

Flood insurance is an effective way of transferring risks, and in providing the resources necessary for rapid recovery (Hudson and Berghäuser, 2023). A majority of the businesses had flood insurance in place and many of the interviewees reported no increase in their insurance premiums, albeit excesses were found to have increased significantly. Case number 1 was considered uninsurable by the owners and they had taken more extensive

PFR measures demonstrating the evident financial benefits these can bring about. Decisions on whether to adopt PFR measures was often based on their appraisal of the perceived flood risk and the effectiveness of the measures (Botzen et al., 2019). A well-designed flood insurance scheme can incentivise the implementation of PFR measures (Hudson and Berghäuser, 2023), which is evident in the cases studied in this research. Therefore, insurers can play an important role in raising awareness, providing information, incentivising PFR measures and collaboration with other stakeholders (Lamond et al., 2017).

Resilience measures

Many of the property owners were acutely aware of the importance of business data / files, and most had established a digitalised database, as exemplified in Cases 1, 2 and 6. However, as highlighted in Case No 1, flood risk is not always a main priority and sometimes employers are preoccupied with their day-to-day business operations. It is imperative that businesses develop their own business continuity plan to minimise business interruption and loss in trade (Sakai and Yao, 2023). It takes time to change the organisational culture of a business and incorporating flood resilience into the overall business risk management strategy, as done in Case No 1, was seen to be a very effective way of achieving this. Businesses would benefit from a more nuanced approach to flood resilience by considering factors specific to their businesses (Halkos and Skouloudis, 2020).

Raising electrical sockets and moving gas and electric meters above likely flood levels was found in most of the case studies. These two measures are relatively simple to implement during the repair and recovery process and in the event of future flooding can ensure the property is able to resume functionality more quickly. This needs to become standard practice in new build commercial projects and in the repair of flood damaged properties. This can be achieved through changes to the Building Regulations or alternatively from raising awareness of design professionals such as architects and building surveyors. Embedding flood risk awareness in the education and training of designers would also assist with this.

The benefit of using floor tiles (e.g. Case No 1) or other hard impermeable flooring (as in the Case No 3, 4 and 5) is that it is very easy to clean enabling a swift return to business activity. The squash courts in Case No 5 shows how costly it can be to restore wooden flooring. Another flood resilient measure observed in the case studies was the use of stainless-steel kitchen units and sacrificial low-cost furniture (in Case No 1 and 5). This allows facilities to be washed clean and ready to use quickly and can reduce a lot of the cost and disruption in the event of flooding.

Knowledge and professional support

Skouloudis et al. (2022) identified knowledge / understanding and organisational learning and planning as the main factors that shape SME's resilience capacity to flooding. This was also evident in the case studies and was demonstrated in case No 6, where the services of a professional flood risk consultancy have been engaged. All businesses complained about the lack of information and advice regarding the availability and suitability of PFR measures. In many instances, they had to either follow their neighbours' practice or seek information from online sources such as YouTube. This issue is also prevalent in other European countries (White et al., 2016) where there are a huge range of PFR measures available on the market, however not all products will be suitable for the businesses' specific needs. Businesses, especially SMEs, are unlikely to be self-motivated to install PFR measures and there is an urgent need for a systematic and conscious process of careful engagement to ensure transparent knowledge transfer between businesses and policy makers (Ingirige and Wedawatta, 2014). White et al. (2016) found high levels of public awareness of PFR measures in some European countries where there was a national flood risk management policy initiative and therefore an active PFR sector such as in the UK, Germany and France. In contrast, countries such as Spain, Greece and Cyprus, the knowledge of PFR technologies was almost non-existent due to a lack of such flood risk management strategies. Therefore, policy makers, manufacturers and installers of PFR measures can play a more active role by promoting the benefits of PFR products more widely.

Building and construction professionals (surveyors, engineers, constructers, etc.) also have the potential to play a more active role in providing advice to businesses on PFR and flood resilience capacity building (Lamond et al., 2017 and Adeniyi et al., 2022). The publication of the *Code of Practice for Flood Resilience Measure* (Kelly et al., 2019) is a welcoming first step in this direction. There is a need for the government and other professional bodies and organisations such as the Royal Institution of British Architects (RIBA), Royal Institution of Chartered Surveyors (RICS), Chartered Institute of Building (CIOB) to provide a 'go-to' hub to provide the information businesses need in terms of flood resilience measures (e.g. the cost-benefit analysis of each measure, and the trusted manufacturers and contractors, etc.). These professional bodies are acutely aware of this need and have already started working towards this, but this effort is very often segmented and siloed. PFR measured can only be effectively implemented if they are considered from a holistic system perspective with the involvement of multiple stakeholders (Barendrecht et al., 2020). More concerted collaborative effort is needed to fully meet the businesses' needs in terms of flood resilience.

Conclusions

Based on an analysis of flood affected commercial properties, this research explored the current views and experiences of owners as well as highlighting the responses and PFR interventions adopted. Evidence indicates that businesses tend to take up mainly low cost PFR measures to suit their specific property characteristics and business activities. Registration for flood alerts, flood insurance and raising electric sockets and wirings were found to be commonly adopted measures. However, many businesses lack sufficient knowledge and understanding of flood risk and have not fully considered the wider range of PFR measures and alternative options. The costs of installing PFR still represents a major barrier to their implementation with more costly interventions, such as employing professional flood risk consultants and installing pumping systems, are not being widely implemented.

This research extends current insights into PFR and presents a much-needed in-depth understanding of the practical issues and considerations experienced by commercial property owners. The findings represent valuable insights for commercial properties owners who may be planning to implement PFR measures. They also provide useful lessons learnt for stakeholders including surveyors, loss adjusters, civil engineers and insurers who may be engaged in designing and installing PFR. The findings reinforce the need to embed PFR measures into future building codes and regulations in order to support the design and construction of more flood resilient properties. PFR manufacturers and suppliers are encouraged to develop innovative and cost-effective products to better meet the needs of commercial properties.

It is recommended that further steps are taken to raise awareness among commercial property owners about the increasing risk of flooding and the steps that can be taken to mitigate this. Businesses need to embed effective flood risk management into their longer-term business strategy and employer organisations such as the Federation of Small Businesses need to do more to help raise awareness. More guidance from the government and other professional bodies would help businesses to embrace PFR measures and better manage their flood risk.

The findings herein are based on a small sample of SMEs and therefore may not reflect the experiences of the wider population or indeed the experiences of larger business organisations. Further research could be extended to consider a wider cross section and sample of commercial properties including the experiences and needs of larger companies. This could also consider evaluating the effectiveness and return on investment of different PFR measures to assist businesses in their decision making and designing their preferred interventions. Comparative studies between commercial and public buildings would also be of interest and an international study would help provide a deeper understanding of PFR practices to support the development and maturity of what is a fairly new approach.

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