

Effective future communication of flood risk in Scotland



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1 Introduction

In Scotland, the *Flood Risk Management (Scotland) Act 2009* tasked the Scottish Environment Protection Agency (SEPA) with producing six-yearly *Flood Risk Management (FRMP) Plans*. These FRMPs are developed to reduce the risks and impacts of flooding in vulnerable areas (SEPA, 2021a). Approved by Scottish Government Ministers, each of the 14 Local Plan District FRMPs co-ordinate the organisations and efforts involved in tackling local flooding; explain the different sources and risks of flooding in those areas (surface, rivers or coastal); and highlight individuals', communities' and business owners' responsibilities to protect themselves and their properties from flooding.

The 2009 Act also requires that FRMPs are implemented alongside associated *Local Flood Risk Management Plans* developed by local authorities. These Local Plans provide details on the implementation of actions locally, including timetables, costs and benefits. In 2018, the Scottish Government's *Programme of Work* aimed to raise awareness and increase resilience amongst communities through funding the Scottish Flood Forum, and committed to promoting the benefits of Flood Resilient Properties (FRP) (p.59, Scottish Government, 2018a). To promote these FRP benefits, the *Framework for Delivering Property Flood Resilience in Scotland* outlined the role and remit of the Property Flood Resilience Delivery Group (PFRDG) (Scottish Government, 2018b). The PFRDG produced the action plan *Living with Flooding* (Scottish Government, 2019) which aims to enhance property flood resilience.

An estimated 284,000 properties are currently at flood risk in Scotland (Scottish Government, 2019), yet it is clear from academic research that flood risk and flood-related climate change communications are not resulting in the levels of awareness and preparedness needed in the UK and elsewhere (e.g. Rollason et al., 2018 (UK); Valois et al., 2020 (Canada); Papagiannaki et al., 2019 (Greece); Snel et al., 2019 (Netherlands); Masud et al., 2019 (Australia)), nor is there widespread adoption of preventative and adaptive measures in Scotland (Glencross et al., 2021). The following study explores this issue in detail as it investigates how to effectively enhance flood risk and flood risk-related climate change communication in Scotland. It considers how managed adaptation can be supported within this flood risk communication frame. For simplicity, throughout this report we refer to both flood risk and flood risk-related climate change communication under the single term 'flood risk communication'.

This report begins with a description of our methodology before detailing the findings of an international literature review of academic and grey literature (i.e., reports;

websites; leaflets; audio-visual and social media etc.), supplemented by qualitative data gathered from workshops and interview participants who have lived experience and professional insight in communicating and/or acting on flood risk. The conclusions of this combined analysis are presented in examples and recommendations to explain and support effective future flood risk communication in Scotland.

1.1 Background - Effective future flood risk communication is essential

Our climate in the UK has changed and will continue changing (Kendon et al., 2020). Warmer and wetter weather is combining with more frequent extreme weather events to increase our future flood risk. Precipitation has increased by 5% in both winter and summer since 2010 alone, and the rate of sea level rise has increased since 1993 (Kendon et al., 2020). The impacts we will increasingly face in Scotland are already being seen, with more frequent periods of intense rainfall and resulting flash flooding. At the time of writing (Summer 2021), these deluges have recently inundated Edinburgh, London, Germany, Belgium, Italy, the Netherlands, New York, Japan, and China, and there is inevitably more ahead. Edinburgh's flash flood in July 2021 involved 37mm of rain, which overwhelmed the drainage and sewer systems and flooded the newly-opened St James Quarter retail complex (BBC News, 2021). It was another stark reminder that Scotland – and indeed the UK – no longer has any areas, town, cities, or villages or countryside that are not at flood risk (Neumann, 2021).

The UK has invested in and relied upon hard infrastructure to prevent flooding in the past decades, but these were built to cope with severe weather which had been observed in the past and do not factor in the increases in severe weather we expect with climate change. Instead, the challenge of the Scottish climate's 'new normal' i.e. more extreme weather in the coming decades, should be met by a resilient, prepared Scottish public, who understand their flood risk, the roles and responsibilities of themselves and others, and the appropriate actions they need to take to protect themselves and their property.

It is estimated that 284,000 Scottish properties are at risk from existing water courses (fluvial flooding), rainfall (pluvial flooding), and from coastal flooding, and this number will increase by almost a third to 394,000 by 2080 (Glencross et al, 2021). This highlights the importance of engaging the entire Scottish public in flood risk understanding and preparedness, even those deemed at very low risk.

1.2 Methodology

This research study was commissioned by the Centre of Expertise for Waters (CREW) and began in May 2020. Three data collection phases were agreed, each of which built on the findings from the previous data:

- Phase 1 - A Rapid Evidence Assessment (REA);
- Phase 2 - Interviews;
- Phase 3 - Two stakeholder engagement workshops.

A Rapid Evidence Assessment (REA) aims to collect, evaluate and review the best available research evidence on a subject in a systematic (and hence replicable) way within a very short period of time (Civil Service, 2014). While not as comprehensive as a systematic review, both techniques share robust, replicable and transparent methodologies (Civil Service, 2014; Twigger-Ross et al., 2014). The REA in this study collected relevant academic and grey literature that explored:

1. The public's understanding of flood risk;
2. The public's attitudes towards flood risk;
3. Expert recommendations for effective communication of flood risk;
4. Examples of effective flood risk communication;
5. Scottish research around flood risk.

The initial search sourced 2899 academic articles (after duplication deletion) across three search engines, Web of Science, Proquest and Compendex. These were supplemented by over 300 grey sources from searches using OpenGrey and Google search engines. A screening process involving all three authors was applied to the shortlist of 911 papers, including a quality assurance process, resulting in the final inclusion of 319 academic papers exploring the 5 aims above, of which over 100 were of flood risk communication examples alone. Screening of the grey literature resulted in 55 further sources and a further 67 websites. The sources were organised in Nvivo and analysed thematically by the authors.

The results from the REA analysis supported the development of the interview topic guide, which aimed to capture each participant's:

1. Knowledge and experience of previous & current flood risk communication;
2. Understanding of flood risk & climate change projections/uncertainty;
3. Perceptions of the understanding of organisational stakeholders & the public;
4. Suggested recommendations/improvements to current flood risk communication.

In total, 22 interviews were conducted with professional stakeholders between January and July 2021, all of whom had role remits related to enhancing flood risk or flood-related climate change awareness in Scotland. Interview and workshop recruitment was conducted using leads from the Project Steering Group, individuals from the research team's networks, and by snowballing¹ i.e. where one participant recommends someone else as a potential participant. Gender was equally distributed across men (n=11) and women (n=11). The interviewees background and roles ranged widely, and included engineering; hydrology; journalism; insurance; community engagement; policy development; infrastructural management; and communications. For confidentiality, the names of the individuals have been withheld, and they are instead described by a generic role title related to their occupation and the source of the data (interview or workshop).

Two workshops were conducted, one with 7 professional stakeholders in May 2021 (Workshop 1: 4 male & 3 female participants) and one with 10 community representatives in July 2021 (Workshop 2: 5 male & 5 female participants). Workshop 1 participants represented organisations from a range of sectors, including community engagement; transportation; environment & climate; the public sector; and the water industry. Workshop 1 aimed to capture participants:

1. Knowledge and experience of previous & current flood risk communication;
2. Understanding of flood risk & climate change projections/uncertainty;
3. Share their perceptions of the public's/their colleagues' understanding of flood risk;
4. Suggestions & recommendations for future effective flood risk communication.

Workshop 2 included individuals snowballed, with the assistance of members of the Scottish Flood Forum and NatureScot, from a range of community organisations with an interest in flood risk. The sample included elected members; community representatives; community development workers, and rural organisations. The sample came from the Highlands and Islands; Moray; Fife, and the Central Belt. Workshop 2 asked participants to:

1. Evaluate examples of current 'good weather' flood risk communications;
2. Review some new approaches to communicating flood risk;
3. Share their perceptions of the public's/their associates' understanding of flood risk;
4. Offer suggestions & recommendations for future effective flood risk communication.

¹ Snowball sampling is a nonprobability sampling technique in which existing study participants recruit future participants from their own social/professional network.

The interview and workshop audio were transcribed, and the data organised in Nvivo. They were then analysed by the research team using themes drawn from the literature analysis and emergent themes arising from the qualitative data. The findings were then compiled and integrated, and are discussed in the following sections.

2 Findings

2.1 Psychology and flood risk communication

Communicating flood risk aims to help people stay safe and protect themselves and their property. People must understand their flood risk so they can act to reduce that risk through mitigating and/or adaptive measures (Henstra et al., 2019; Bodoque et al., 2019). To empower people to keep themselves/their property safe and adapt to future flood risk, effective flood risk communications must ensure a) that professional stakeholders give clear and actionable advice/guidance; b) that the at-risk individuals receive the risk communication(s) and guidance; c) that they understand what it means for them; and d) that they correctly perceive the level of risk they face (risk perception). Should these four criteria be met, the individual is then empowered to take proportionate actions based on the risk they face. Therefore, this report defines flood risk-related communication as *increasing an individual's awareness and understanding of their own flood risk to empower them to act*.

Intuitively, raising awareness of risk should motivate people to act to prevent negative consequences. However, there is now strong research evidence that refutes a simple linear path between communicating a risk message, generating awareness and understanding, and a resultant action (Hügel & Davies, 2020). There is a disconnection between risk perception and consequent behaviour/actions (e.g. Rufat et al., 2020; Diakakis et al., 2018, Fox-Rogers et al., 2016; Soane et al., 2010). Evidence shows that raising awareness of flood risk simply by communicating the risk and its likelihood does not lead to action, and that raising awareness alone has 'severe limitations' (p.1681, Rollason et al., 2018).

More concerning is the academic evidence that shows communicating risk and likelihood alone can be counterproductive, and unintentionally *lower* both flood risk perceptions and people's motivation to act (e.g. Hügel & Davies., 2020; Corner et al., 2015). This counterintuitive finding is explained by *Protection Motivation Theory*, an increasingly popular explanation for the challenges of translating individuals' flood risk awareness into protective and adaptive behaviours (e.g. Weyrich et al., 2020; Grahn & Jaldell, 2019; Bubeck et al., 2018; Rollason et al., 2018;

Grothmann & Reusswig, 2006; Rogers, 1983). The theory explains that people interpret flood risk communication individually, and their risk perception is highly personal and subjective. If they perceive a risk is relevant and requires action, three other critical components must also be in place to motivate them to act, namely 1) confidence they can cope; 2) belief the measures they implement will work; and 3) belief they can afford the costs of those measures. These components are interwoven complex networks of thoughts and responses that generate (or not) the motivation to act in response to communications about their flood risk, regardless of whether they are short-, mid- or long-term risks. If one or more of these components are low, i.e., the risk is perceived as low; they can't afford the costs; they have a low ability to cope; or they have a low belief in the effectiveness of response measures, then the individual may not be motivated to act, termed a *non-protective* response. Confidence and belief in your ability to cope is fragile and is very easily undermined, as a community engagement worker noted:

"...a lady in Fife, who in her haste to put her floodgates in...put it in upside down, so it didn't work. It let in water. That confidence bit, that almost resilient element "I'm going to stop this happening", [when] those protection measures fail, that has a real impact on the confidence of people to respond and to recover."

(Community engagement worker)

Flood risk communications must navigate a fine line between prompting concern about a flooding threat and generating fear amongst the public. Feelings of worry and threat have been shown to trigger preparedness *intention* (e.g. Papagiannaki et al., 2019), though fear itself broadly has not (Babcicky & Seebauer, 2018; Dittrich et al., 2016; Bradford et al, 2012). There is little evidence suggesting such *intention* to implement preparedness measures is followed by actual implementation behaviour, however (Fox-Rogers et al., 2016). As described above, to act in response to a flood risk communication that you perceive as a relevant risk to you, you have to have confidence that you can cope, know that you can afford the responses you need to make, and you must believe that those responses could be effective (Botzen et al., 2019; Babcicky & Seebauer, 2018; Dittrich et al, 2016). Therefore, raising alarm and concern when promoting a message of flood risk may raise the *intention* to act amongst those who agree there is a risk to them, but almost certainly will not result in long-term preparedness and adaptation, particularly amongst socially vulnerable groups (Bradford et al, 2012; Dittrich et al., 2016; Babcicky & Seebauer, 2018). In Scotland, there are regulations preventing Category 1 responders raising fear and alarm amongst the public in their messaging and behaviours, and that was seen as both a positive and a burden by one Category 1 responder:

“...we are bound by a legal duty of care...part of that duty of care is not to cause fear, alarm or panic, and we can be as penalised for that as we can for anything else.”

(NHS Resilience specialist)

Socioeconomic factors impact significantly upon how flood risk communications are perceived, and hence their effectiveness (Babcicky & Seebauer, 2019; Seebauer & Babcicky, 2018; Bubeck et al., 2013; Grothmann and Reuswig, 2006). Those who have fewer resources, for example those living in poverty, have a higher flood risk perception i.e., feel more threatened by a flood risk communication (Harlan et al., 2019). Therefore, flood risk communication can cause fear and worry amongst socially vulnerable groups who cannot afford to respond, leaving them less likely to act to mitigate that threat. This lack of response can be further compounded by communicating flood risk awareness without also supplying support to prepare, prevent or adapt to the risk. Without the necessary awareness, understanding *and* resources to act to mitigate, prevent or adapt to their flood risk, individuals can develop maladaptive coping strategies including fatalism and wishful thinking (Babcicky & Seebauer, 2019; Rollason et al., 2018; Seebauer & Babcicky, 2018; Bubeck et al., 2013; Grothmann and Reuswig, 2006).

Another maladaptive coping response is learned helplessness where, like fatalism, the individual cannot see any escape from the impacts of flooding, nor any measure that can protect them, so does not act (Babcicky & Seebauer, 2019; Rollason et al., 2018; Rogers et al; 2016; Maidl & Buchecker, 2014; Bubeck et al., 2013; Grothmann and Reuswig, 2006). This evidence of the undermining of flood risk communication has led to one study calling for future flood risk communications to emphasise self-protection measures *more* than the risk of flooding itself (Diakakis et al., 2018).

Some individuals may even deny the risk is real, despite official communications to the contrary (also known as the ‘Ostrich’ effect – Fox-Rogers et al., 2016; Kjellgren, 2013). Denial of the reality of their flood risk means the individual perceives little or no risk to them and so has no motivation to prepare, mitigate or adapt (Babcicky & Seebauer, 2019). Individuals, communities or other stakeholders employing one or more of these maladaptive strategies are likely to undermine or ignore flood risk communications, leaving themselves very vulnerable to flooding. For example, an individual attended a workshop of climate change and future flood risk and exhibited denial (see also Box 5):

“One man...he really doesn't agree with the projections of flood risk and he was quite angry about that...he said that SEPA's projections are completely inaccurate, and that they're scaremongering...But he did also seem quite shocked... And it transpired...he'd just built a new

house on an area that was shown as a flood plain...”

(Flooding & climate change specialist)

The most common maladaptive coping strategy – the externalisation of responsibility to others – is perhaps the most difficult to address as it is hidden and untested until a flood event occurs (Babcicky & Seebauer, 2019). Externalisation of responsibility to local authorities and the government is a historic and enduring social response arising from paternalistic post-war flood protection policies. Today, a policy paradox still promotes this maladaptive coping strategy. The adaptive evolution of society and place in the Scottish Government's Climate Change Adaptation Act (2009) (CCAA) is undermined by the protectionist UK-wide Civil Contingencies Act (2004). The 2004 Act requires Category 1 responders adopt a command-and-control approach in times of flooding, preventing people acting independently, which is contrary to the CCAA's promotion of individual agency and responsibility (Henderson et al., 2020a). Individuals are therefore told to be both personally responsible and to defer personal safety to the state, adding to existing confusion about personal versus governing authorities' responsibility for flood risk protection.

In Scotland, one study investigated the impacts of providing bespoke flood risk communication at household level, addressing some maladaptive strategies by including support on implementing measures and taking action (Dittrich et al., 2016). The research found that this approach increased protective actions in Scottish households (ibid). However, overall few Scottish households currently have adopted preventative and adaptive measures (Glencross et al., 2021). Therefore, we recommend that future effective flood risk communication should take a bespoke household approach that includes practical advice on preparing, mitigating and adapting to flood risk. This will help build a flood resilient Scottish public, as one participant noted:

“*[perhaps]* you don't need to warn a community now, but you know projections are that it will become at risk in future and you need to put in property level protection or non-structural measures.”

(Flood specialist 1)

In conclusion, flood risk communications that do not focus on specifying *achievable, affordable, and appropriate* response strategies will undermine their effectiveness and negatively impact the Scottish public's resilience to flood risk. Consideration should also be given to ensuring all contact the public has with government-funded agencies, from planning departments to the police, empowers their individual agency through consistent flood risk communications and shared projections of future regional

flood risk. Fear and alarm must be avoided by properly educating all groups, and fully resourcing both the public and professionals to respond effectively to current flood risk and future flood risk projections.

We recommend that future flood risk communications must specify recommended actions that are *affordable*, *achievable* and *appropriate* to the socioeconomic and demographic profiles of individuals living in Scotland's diverse communities.

Recommendation 1

Future flood risk communications should include recommended actions that are affordable, achievable and appropriate to the socioeconomic and demographic status of diverse households.

2.2 Towards a baseline of understanding of flood risk

Communications to raise awareness and understanding of flood risk are inextricably interlinked with the individual's interpretation of that message i.e., their flood risk perception (Hügel & Davies, 2020) as discussed above. Therefore, simply providing information does not automatically generate understanding and awareness amongst the population (Snel et al., 2019). People can differ in key ways that impact upon our understanding of, and reaction to, flood risk communications. For example, we may interpret and process information differently from our neighbours, friends, family and colleagues. We might not share the same capacity to understand risk information, and may also differ widely in our ability to act upon any such information, too. The resources we can draw upon and our connection with our own communities also vary widely. As do our beliefs and trust in science. These differences present a challenge to developing a baseline of public understanding of flood risk, flood likelihood/probability and uncertainty.

Perhaps unsurprisingly, given the preceding list of potential individual differences, academic literature emphasises that there is no single 'public' (e.g. Lejano et al., 2018; Kjellgren, 2013), and this was supported by our study participants who felt that 'public' is a generic term that does not reflect the diversity of Scottish places, communities and environments and hence is not particularly helpful in designing effective flood risk communications. One participant noted "...We can't just think about the public as a single entity. It's very diverse." (*Environment specialist*). Therefore, to make flood risk communication more effective, we need to unpick this diversity and understand the capacities, capabilities and resources of the Scottish public. The following section adds insight through evidence on the effectiveness of flood risk communication across age, gender, social vulnerabilities, trust and place.

2.2.1. Social vulnerability

Flood risk perception is higher amongst those who have limited resources and are considered socially vulnerable (Harlan et al., 2019). Women, older people, low income households and ethnic minorities are disproportionately represented within categories of social vulnerability (Harlan et al., 2019; Mullins and Soetanto, 2013). Social vulnerability itself is higher in deprived Scottish neighbourhoods (SIMD, 2021) and deprived Scottish neighbourhoods have a higher risk of flooding than more affluent areas (Kazmierczak et al., 2015). Socially vulnerable demographic groups are more likely to live in poverty in Scotland, and there is a disproportionately higher representation of people from BAME groups, people with disabilities, and women with children living in poverty (Scottish Government, 2020a). These inequalities impact on effective flood risk communication, not only because individuals living in poverty may not have the resources to protect themselves, but also in other less obvious ways. For example, intergenerational approaches that educate children on flood risk and encourage them to involve their parents have been found to be less successful in socioeconomically deprived areas (Williams et al., 2017a). This has been attributed to the socioeconomic pressure on parents, which in turn leaves them with less resources to engage with their children than their more affluent neighbours (ibid). Amongst ethnic minority groups in the USA, language has been shown to be a barrier in disseminating information to non-native English speakers on social media, as has the complexity of terms and phrases used (Scott & Errett, 2018). In England, black participants from south east London did 'not accept the risk of flooding' (p.127, Mullins & Soetanto, 2013), and intensive community engagement approaches such as forums and workshops were proposed as the most effective method of raising awareness of flood risk amongst that community (ibid.)

Gender also impacts on flood risk perception. Recent evidence concludes that women generally perceive their flood risk to be higher than men when receiving the same information (see e.g. Weyrich et al., 2020; Harlan et al., 2019; Masud et al., 2019; Diakakis et al., 2018). However, as in the findings described earlier, this gender-related perception of risk did not translate into action preparedness, mitigation, or adaptation behaviours (see e.g. Weyrich et al., 2020; Lieske et al 2014; Fischer et al., 2011). Indeed, while women perceive flood risk to be greater, they also report that they feel less able to implement measures to protect themselves (Weyrich et al., 2020; Babicky & Seebauer, 2019; Bubeck et al., 2018). Given that almost half a million women live alone in Scotland (NRS, 2019) and that this is increasing amongst women aged over 65 (Scottish Government, 2020b), effectively communicating flood risk to this group without causing alarm will be challenging.

Risk perception has been found to increase with age (e.g. Masud et al., 2019; Harlan et al., 2019) though some earlier studies were less conclusive and ranged from older people having lower *intentions* to implement protective measures (Poussin et al., 2014) to age not being related to *intention* to implement protective measures (Coulston & Deeny, 2010). However, as discussed earlier, *intention* to implement protective measures is not related to actual behaviour (Fox-Rogers et al., 2016), and the inconsistencies in findings have resulted from the diversity of methodological and research approaches that have made direct comparisons across the field difficult in older literature (Koerth et al., 2017). However, we do know that our capabilities diminish as we age, though the speed and even the age at which this happens varies considerably amongst older people (Henderson et al., 2020b). These diminishing capabilities affect how we interact with the world, and what we are physically and cognitively able to achieve. This is also true of any adult with physical or mental health conditions that impact upon their capabilities and functioning. While there is a tendency amongst older people to deny our age-related decline (Henderson et al., 2020b), older participants in one Irish study highlighted their increasing age-related limitations and reported this was undermining their confidence in their own ability to cope (Fox-Rogers et al., 2016). For them, carrying sandbags, taking things upstairs and moving furniture were all cited as increasingly challenging (Fox-Rogers et al., 2016).

These findings are consistent with earlier UK research that evidenced the increased vulnerability of older people, and found that they are also the least likely to move house to somewhere safer (Bichard & Kazmierczak, 2012). Given that almost 1 in 5 people in Scotland are aged over 65 (NRS, 2019), effective future flood risk communication must ensure they do not raise fear or alarm amongst older people. Instead, communications should empower them to act within their capabilities through clear achievable actions to prepare, mitigate and adapt to their flood risk. This will almost certainly require practical support for most, and financial support for some (Fox-Rogers et al., 2016; Bichard & Kazmierczak, 2012).

Our earlier recommendation that sharing information on the implementation of preparedness measures would enhance everyone's capacity to act, including BAME groups, people living in poverty, and older people, is not new (Bradford et al., 2012; Bichard & Kazmierczak, 2012). Bespoke household-level communication on actions to prepare for, mitigate and adapt to flood risk, provided alongside social and financial support, will increase the effectiveness of future flood risk communications (Babcicky & Seebauer, 2019; Bubeck et al., 2018; Bichard & Kazmierczak, 2012; Bichard et al., 2012). This new approach requires policy support both nationally and locally to ensure flood risk communication training, skills

and tools are available alongside the necessary financial and physical support for preparedness, mitigation and adaptation measures. Given the current fiscal and societal challenges caused by the Covid pandemic in Scotland, a socially innovative policy solution is required which, if successful, could make Scotland a global leader in transformative flood risk communication strategies.

Recommendation 2

National and local policies should enshrine support for bespoke household-level flood risk communication to ensure the public, and particularly socially vulnerable and marginalised groups, can act in response to flood risk communication and so be resilient to future flood-related climate change impacts.

2.2.2 Place

Flooding is embedded in *Place*, defined here as the geographically-boundaried relationship between communities (social) and physical space (environmental). Adaptation and mitigation actions require detailed knowledge of the local environment, and local people may understand their hyperlocal environment better than local authorities, who in turn may be more aware of any localised nuances and idiosyncrasies than national institutions. Such place-based community expertise is well-recognised in the literature, e.g. it can contribute to more accurate and effective mapping (Twigger-Ross et al., 2014). By involving local people in a participatory way, national and local authorities can incorporate local knowledge and expertise in their flood risk communications, increasing the sense of responsibility for flood risk action amongst that community (Rufat et al., 2020; Koerth et al., 2017; McEwen et al., 2017; Geddes et al., 2017).

Flood risk exposure and resilience (e.g. confidence; resources; capacity to cope) are unequally distributed amongst different groups within each place (Rufat et al., 2020) as well as between them. Rural places have been found to have greater knowledge and understanding of flood risk than urban communities (Boronyak-Vasco & Jacobs, 2016; Botzen et al., 2009), though some urban population awareness of flood risk can be enhanced by proximity to rivers and coastlines (Kellens et al., 2013).

Rural communities' greater knowledge of flood risk can be partly attributed to livelihood dependency, i.e. making a living from the local land, and to the multiple occupations of individual rural residents, which exposes them to alternative perspectives on local problems (Boronyak-Vasco & Jacobs, 2016). Livelihood dependency can generate place-based social norms and values that prioritise livelihood sources and local shared knowledge

(Boronyak-Vasco & Jacobs, 2016), potentially to the detriment of preparedness, mitigation and adaptation initiatives. This could present a challenge to engaging some places in flood risk communication, as one participant noted:

"...for Highlands and Islands, where there is a natural resilience and independence... [communication] can actually be quite difficult because they're not necessarily receptive to information..."

(Flood specialist 1)

Difficulties of communicating flood risk could be magnified in dynamic rural environments, where the mix of household types evolves alongside the landscape and the agencies that govern them (Haer et al., 2016). Rural absentee owners, holiday accommodation, and tenants in rented properties, like transient residents in urban areas (city workers; students; the homeless) present a challenge when supporting the community's flood risk resilience, as they are less integrated in the social fabric of local flood risk than permanent residents (Kellens et al., 2013). Regardless of urban or rural location, those who rent properties may be constrained in what protective actions they can take by their landlords or lease (Harlan et al., 2019).

The evolving nature of place and the fluidity of local expertise was highlighted by one participant, who noted that when someone involved in community flood resilience moves out of the area "that knowledge goes [with them]" (*Community engagement worker*). Movement of the population brings other challenges for effective flood risk communication, as another participant noted that 'you get movement of people around... people unexpectedly enter areas that get hit with the flooding events' (*NHS officer*). Effective future flood risk communication must also consider those who are in the area for very short periods, as well as those in temporary or rented accommodation.

Recommendation 3

Statutory regulations should be developed that require providers of temporary accommodation/business premises to ensure their properties are flood resilient, including providing those temporarily occupying the property with clear guidance on actions to take in the event of a flood warning.

2.2.3 Shared local learning

Social capital, the support people can access from their social networks, is an important resource for communities, at risk of flooding (Babcicky & Seebauer, 2017). Evidence shows that social networks of neighbours, friends and

families, and the social capital such networks hold, play an important role in influencing the flood risk preparedness behaviours of individuals (e.g. Bubeck et al., 2018; Lawrence et al., 2014; Bubeck et al., 2013).

Shared local learning from neighbours, friends, relatives and volunteers is also an important tool for effective flood risk communication (Seebauer & Babcicky, 2018; Babcicky & Seebauer, 2017; McEwen et al., 2017) as it can have a positive influence on an individual's belief that they can cope with flood risk (Bubeck et al., 2018; Twigger-Ross et al., 2014). However, while social networks can contribute positively to people's coping beliefs, they can also reduce our risk perception if we externalise responsibility for flood risk action to our surrounding social network (Babcicky & Seebauer, 2017).

Social capital and strong local networks are organically created and cannot be formally regulated. While they can offer beneficial resources like volunteers and local leadership, local social networks can also have negative impacts, e.g. by forming selective groups or cliques that exclude others; sharing the mistrust of authorities; reducing individual responses by reliance on others; and as conduits for inaccurate advice (Babcicky & Seebauer, 2017, 2019; Moyes et al., 2015; Adler & Kwon, 2000). For example, the Irish study mentioned earlier found local people were negative about sandbags and floodgates because they were flooded through the sewage systems and their floors (Fox-Rogers et al., 2016). Response measure failure was also reported by our sample in Scotland:

"...we're also seeing issues for homeowners who have toilet bungs and underfloor pumps and all the rest of it, and they've done everything that they thought was humanly possible and still they're being flooded."

(Community support worker)

Similarly, insurance is another response measure people rely on which, when it fails to support people, can find that learning shared widely in the community and beyond (see Box 1). However, there is a significant financial incentive for homeowners to refuse to acknowledge flood risk because acknowledging it could de-value your home (Bradford et al., 2012). This presents a challenge to flood risk communication, as people try to avoid flood risk discussions rather than participate in sharing learning. An insurance professional discussed the many small flood events each year that hit only a few houses in the UK, and noted that flood risk to homeowners is:

"...insidious. It's sort of hidden. And people don't want to talk about it...because it's just such a pain and you don't want it to impact the value of your home."

(Insurance professional 1).

A community worker in the frontline of flood recovery told us that some flooded homeowners won't claim on their home insurance policy because it would (rightly or wrongly) highlight that their home is at risk and therefore may devalue their home in future valuations and Home Reports. This hidden concern about home values is just one example of locally imposed limitations on resilience. Another limitation to local resilience is termed the '*prison of experience*', which describes how flood events of the past become the basis for action in future (Rollason et al., 2018; Fox-Rogers et al., 2016; Coulston & Deeny, 2010). These limitations give some sense of the depth of complexity that underlies the potential future effectiveness of flood risk communications.

So, while some community members may 'hide' and refuse to acknowledge their flood risk, and others can only imagine a flood event to a specific depth or coverage, shared local learning might leave still more believing that floodgates, bungs and insurance are not effective, reducing their likelihood of taking any protective measures in future (Botzen et al., 2019; Seebauer & Babicky, 2018; Bubeck et al., 2018; Joseph et al., 2015).

Therefore, while social networks are vital to communicating flood risk and flood-related climate change to motivate preparedness (Attems et al., 2020), and communities are healthier and safer when they take a collective approach to act and solve problems (Harlan et al., 2019), it is important to ensure the knowledge, beliefs, experiences and trust they share does not undermine their resilience. It is not just individuals that are complex, communities themselves do not always operate collectively:

"...you had one side of the street that was impacted by flooding and the other side wasn't. You had people on the [*unflooded*] side of the street that were out taking selfies of their neighbours' misery."

(Community support worker)

Currently, social approval plays no significant role in preparedness behaviour (Botzen et al., 2019). A social and cultural shift is required that perceives protecting place is a collective social good, through preparing and adapting our properties in readiness for the new climate normal. Women have been found to be more motivated to engage in adaptation if this assists others in their community rather than themselves, though this motivation does not automatically translate to action (Brink & Wamsler, 2019). Given women are underrepresented in public consultation (Henderson et al., 2020a), harnessing this altruistic motivation through framing preparedness and adaptation as a common good could encourage their involvement in community engagement. However, as many women already bear significant responsibilities for the care and protection of others, any engagement of this type should be carefully co-designed with the potential participants

to ensure it is empowering for women and does not add to their burden by holding them responsible for caring for the community.

Box 1 – *When protection fails – insurance*

"One of the issues that we've seen, particularly in the response to the August floods, is the number of insurance policies or insurance companies that have curtailed policies or revoked policies because of the failure to disclose material information... [in] one particular case, a relatively young couple, they had never experienced flooding. There had been no flooding within their area and when you read the policy, [it said] 'Had there been any flooding within 100 metres of the property?' That's the length of a football pitch. If you've just moved into an area you might not be aware that there's maybe flooding... The kind of scale and the size of it I think also impacts on people and their perceptions of what flooding actually is as well. That then limits how they're able to recover from it because they're then dealing with that added dimension of 'I should have known about it. I'm to blame'.

(Community support worker)

Creating a social shift to support preparedness and adaptation through shared local learning could also explore the potential of a new shared social identity i.e., that "I am part of a flood resilient community, and protecting this place is a common good" (e.g. Hügel & Davies, 2020; Henderson et al., 2020b; Brown et al., 2019). Social identities, our self-categorization of commonalities with a group (Turner et al., 1987), can benefit our health and wellbeing through promoting healthier behaviours and a sense of belonging (Henderson et al., 2020b). Creating a positive social identity around adaptation and mitigation implementation in flood risk communities could enhance efforts to communicate about flood risk and flood-related climate change. The power of a shared social identity as a flood risk community was explicitly and implicitly referenced by some of the participants, for example:

"...we [*professionals*] talk a lot about flood risk communities... but really most people don't even think they live in a flood risk community. It's not an identity. You don't go around [*saying*] "I know someone who lives with a flood risk"... when you find examples of communities who do recognise that, then they're much more effective in responding. People who live in Hull, for example."

(Flood insurance professional 2)

Therefore, developing positive shared social identities i.e., “we are a community that copes well with flooding”, could increase the effectiveness of local flood communications. However, like social networks, shared social identities cannot be regulated, and their impacts can also be negative. For example, they can reinforce the polarization of community members if there are contentious local flood-related issues or difficult decisions to be made (Henderson et al., 2020a).

In conclusion, we recommend that future flood risk communications should be positively framed and encourage acceptance of our new Scottish ‘climate normal’ as demonstrated in *Living with Flooding* (Scottish Government, 2019). Engaging communities in collective action to enhance their resilience and promote within them an empowering social identity of preparedness in place also supports a key tenet within the Scottish Government’s *Resilient Communities Strategic Framework and Delivery Plan* (Scottish Government, 2017), that is, that individuals, communities, and organisations collaborate and utilise their collective resources to help themselves cope with flood risk.

Recommendation 4

Future flood risk communications should be positively framed, demystify assumptions, and address local myths, encouraging collective action to enhance community resilience and promoting an empowering shared social identity of preparedness in place.

2.2.4 Developing a database of flood resilient measures

As discussed earlier, people must have confidence in the measures they implement to protect and/or adapt their property to their local flood risk. Effective flood risk communication should therefore capture and highlight locally effective measures through examples and case studies of best practice. However, we currently know very little about the uptake of protective and adaptive measures at household level, as they are highly localised and personally purchased/implemented. We do know individuals are more likely to adopt risk prevention and adaptive measures when they see neighbours, friends and/or relatives doing so (Dittrich et al., 2016; Haer et al., 2016; Bubeck et al., 2013) and so collecting local examples could create a very effective tool for communicating flood risk and generating engagement in protection and adaptation. Documenting existing adaptation would also support the *Living with Flooding Action Plan* (Scottish Government, 2019), which recommends existing resilience is recognised through the creation of a database of flood resilient properties (Action 2). Therefore, a database capturing hyperlocal protective

and adaptation efforts could form an important part of an effective flood risk communication strategy.

The creation of a database of current flood resilient measures could support effective flood risk communication in several other ways, too. For example, newly-implemented protective measures that prevent floodwater entering properties in recurrent flood risk areas will result in floodwater being displaced elsewhere. An extreme example of this is the installation of levees to protect fields from river flooding. Such displacement from previously-flooded areas can then impact negatively on other properties and the area’s wider flood risk management. Therefore, the database of current flood resilient measures could become a useful data source for stakeholders and organisations across Scotland, such as SEPA, Transport Scotland, NatureScot, Scottish Water, to understand how each community’s measures might impact on local flood dynamics and existing infrastructure.

Without some documentation and understanding of local measures, individuals with limited knowledge acting informally have the potential to create local community conflict, or even worsen their local flood risk, as discussed by a water infrastructure specialist in Box 2. In this related example, the householder she spoke to held the misinformed belief that cutting trees down to stop leaves blocking gullies would reduce the flood risk to his property. She was able to correct this misinformation and communicate that, counterintuitively to him, he instead needed to plant more trees and bushes to protect his property. Planting as a protective measure could be an effective ‘best practice’ action in a local flood resilient measures database.

Finally, the database of flood resilient measures would provide strong baseline evidence for any evaluation of the effectiveness of future flood risk communications. Therefore, we build on and extend *Living with Flooding’s* Action 2, which called for the development of a database of flood resilient properties (Scottish Government, 2019) by recommending that a database of flood resilient measures should be developed for every Scottish community. The benefits of this database to enhance effective flood risk communication would be at least threefold, as it would 1) share local learning, encouraging others to implement protective measures; 2) increase individual confidence in the effectiveness of response measures; and 3) ensure that hyperlocal mitigations and adaptations do not negatively impact on wider flood risk management efforts.

Recommendation 5

A database of flood resilient measures at household and property level should be developed for every Scottish community.

2.2.5 Costs

To be effective, flood risk communication must empower people to protect themselves and adapt to the new climate normal. Research has advocated flood risk communication as a tool to encourage individuals to buy insurance and spend on flood risk prevention (Botzen et al., 2013). However, including the benefits of implementing any measure in future flood risk communications will not increase preparedness responses if the costs of doing so are unaffordable (Weyrich et al., 2020; Soane et al., 2010). UK research previously concluded that financial support from the state for flood risk protection measures for those on low income may have to be enshrined in future policy (Bichard & Kazmierczak, 2012). An English study then demonstrated that financial support can lead to a very high uptake of preparedness measures when there was no cost to the householder (Joseph et al., 2015). There is support for this in Scotland, as a local councillor commented:

“...your responsibility as a home owner is, if possible, to have devices or apparatus for your property that you can deploy. Sometimes there's a cost to that and actually, I've always thought that funding as such could be a part of it, could be redirected towards making sure people have those devices for their property, rather than keeping it in a big pot for a great big expensive scheme...[a] grant scheme or something of that nature.”

(Local authority councillor)

Subsidies, loans or grant schemes could be developed alongside private purchasing pools, where householders group purchases together to get bulk discounts, and flood insurance rewards (i.e discounts for investment in flood protection measures) (Babcicky & Seebauer, 2019). This could help mitigate the perception that, as the pay-off from any investment in flood risk protection/adaptation measures may take many years to realise, an investment on flood resilience measures is not a priority (Bhattacharya-Mis et al., 2018). Encouraging householders to invest in resilience measures can reduce insurance premiums and increase the resale value of a property, as an insurance expert noted:

“...if you're going to invest in resilience measures does that add value to the property? You may not be thinking about selling it but if and when you do come to sell it, how much value does that add in terms of the sale price?”

(Insurance specialist 2)

The physical and psychological costs of taking action to prevent or adapt to flood risk are also important in motivating individuals' decision to act, and therefore must also be considered when developing an effective flood risk communication strategy. For example, the

Box 2 – Chop down the trees!

‘I went to a customer's house...he'd experienced some flooding. He had a beautiful garden, it was just full of concrete...I said, “Do your neighbours suffer from flooding?” “Oh, not as much as me.” He was at the lowest part of the area, and everybody else's gardens were all grass...You could see the tidemark round his house...He said, “You know, I go out...and I take the leaves away.” And I'm like, “That's fantastic, taking the leaves out of the gullies! Everybody can do their little bit.” He said, “If I had my way, I would just chop down all the trees.” And I was like, “(Gasps) Don't chop the trees down! We need the trees!”

I [used]...a great picture of a semi-detached house. One is concreted and one is full of grass...And it was that lightbulb effect for him. He was like, “Oh yeah, so if I actually plant some border bushes and trees, will you come and help me?” I was like, “Absolutely, I would come and help.” He was a very well-educated gentleman, but again that visual, it was like, “Oh yeah! Of course!”

(Infrastructure specialist, female, Workshop 1)

stress of commissioning and dealing with builders when adaptations or protective measures are installed in your home (Joseph et al., 2015) can demotivate the householder. This demotivation could be prevented by the development of means-tested Government scheme to make properties flood resilient. Such a scheme could use Scottish Government-approved installers, similar to the Government's investment in energy-saving home improvement schemes (Scottish Government 2021b). Once installed, the measures could be automatically added to the flood resilient measures database discussed earlier. Finally, as only measures appropriate to the property and the local risk would be installed, the individual would have more confidence in the effectiveness of those measures, which in turn would promote both positive emotions (Koerth et al., 2017) and effective local learning (Rollason et al., 2018; Fox-Rogers et al., 2016; Coulston & Deeny, 2010).

In conclusion, socially vulnerable groups need additional financial support in grants and/or loans if future flood risk communication is to be effective (Babcicky & Seebauer, 2019; Bichard and Kazmierczak, 2012). We therefore recommend a national means-tested scheme to financially support the installation of flood risk protection and adaptation measures. The benefits of such a scheme will be at least threefold, namely it will 1) enable low income households to respond appropriately to future flood risk communication, increasing their effectiveness; 2) add best practice examples to the flood resilient measures

database; and 3) raise awareness of local effective flood risk solutions and hence enhance positive local learning.

Recommendation 6

A national approach should be developed that financially supports the installation of household flood risk protection and adaptation measures, particularly for those on low incomes, to ensure future flood risk communication is more effective and Scottish households are more flood resilient.

2.2.6 Trust

To be effective, flood risk communication must come from trusted sources (Seebauer & Babicky, 2018; Kellens et al., 2013; Kuhlicke et al., 2011). Trust emerged frequently in the reviewed literature as critical to effective flood risk communication. However, trust was not always beneficial. For example, trust in scientists was associated with it being scientists' responsibility to solve flood risk (Soane et al., 2010); trust in governing authorities meant it was safe to live on a flood plain (e.g. Ludy & Kondolf, 2012); trust in your own knowledge made individuals over-confident that they were safe and protected (Snel et al., 2019); trust in volunteers to communicate accurate information due to their competence and experience was greater than trust in experts (Seebauer & Babicky, 2018). Further, trust in governing authorities did not increase people's preparedness behaviours and could actually reduce motivation to act (Weyrich et al., 2020; Papagiannaki et al., 2019). Trust in public defences is linked to low confidence in your own ability to cope, and reduced motivation to protect your property yourself (Attems et al., 2020).

Trust in structural flood defences has been repeatedly shown to be associated with a reduced sense of personal responsibility for flood protection (Babicky & Seebauer, 2019; Williams et al., 2017a; Bradford et al., 2012; Terpstra, 2011; Grothmann & Reuswig, 2006). In Scotland, as discussed earlier, flood risk has historically been managed through structural defences and policies by the UK government. Therefore, public trust in government and local authorities to protect Scottish communities from flooding remains high amongst some members of the public, and as a result, individuals either do not realise or ignore the advice that flood risk is their personal responsibility. One participant raises the issue of personal responsibility with people she works with:

"When they hear that it's their responsibility to protect their property as homeowners, you get looks of horror from people because they expect that to be the responsibility of the local authority."

(Community support worker)

When it comes to structural defences, flood risk communication can be undermined by what is termed the *safe development paradox* (see Hauer et al., 2020) or the *levee effect* (e.g. Fox-Rogers et al., 2016; Ludy & Kondolf, 2012). This refers to individuals' complacency that arises from the externalising of responsibility for flood protection to structural defences. This powerful reaction to structural flood defences has been found to emerge even at the planning stage, before such defences are built, leaving individuals unmotivated to act in response to flood risk communication despite being unprotected (Bubeck et al., 2013). Also of concern is the attribution of a lack of flooding over time to such structural flood defences, rather than simply because there were no severe weather events (Franceschinis et al., 2021). To be effective, flood risk communication must address this complacency both before and after structural defences are built.

Small errors or missteps in communication can have a significant impact and can undermine trust built with a target audience. For example, a single small error in a map led to distrust of all the data and modelling within that map in one UK study (Rollason et al., 2018). A participant in our study reflected on his work with the NHS and described trust as a significant 'problem we face in communicating risk to people' (NHS officer). Trust in future flood risk communication can be built by including a wide range of stakeholders in co-designing the communications, including communities (Rollason et al., 2018).

2.2.7 Shared responsibility, collaboration and communication

Like trust, shared responsibility is essential for developing effective flood risk communication. Indeed, one systematic review found that understanding your own responsibility is an important determinant of adaptation action (Koerth et al., 2017). Further, as adaptation is specific to the local area (Koerth et al., 2017), local knowledge of flooding can be a pivotal component of the development of future effective flood risk, prevention and adaptation communication. Sharing responsibility for the development of this communication can enhance the feeling of sharing risk, and hence reduce social vulnerability (Koerth et al., 2017). It can also enhance feelings of solidarity and care for the community (Koerth et al., 2017), framing the experience as positive, supportive and unifying.

Each community, and indeed each individual, faces different challenges, brings different strengths, and holds different definitions of flood risk. Amongst institutions and organisations, there are also differences between disciplines, terminology and approaches which can impact on sharing responsibility in a co-ordinated, holistic way (Knighton et al., 2018). Understanding these differences is

essential to sharing responsibility across communities, local authorities, private and public sector organisations (Masud et al., 2016).

There is also a recognised concern amongst some public organisations that informing the public that property flood risk adaptation and mitigation is their personal responsibility will 'scare' the public, so personal responsibility has not been well-advertised (Kjellgren, 2013) yet such transparency is vital to sharing responsibilities in future. By not highlighting personal responsibility, politicisation of flood risk can occur in communities, undermining both their resilience and their shared learning (Devitt & O'Neill, 2017).

Within the concept of personal responsibility lies several flawed assumptions, however, not least that a) individuals can cope alone with the consequences of flooding and b) individuals are isolationists acting alone in response to flood risk communication (Rufat et al., 2020). Further, a collaborative response to local and national flood risk is overtly encouraged in some flood risk-related policies while still acknowledging the importance of self-responsibility, e.g. the *Scottish Climate Change Adaptation Programme* states:

"The long-term sustainability of Scotland in a changing climate will depend on businesses, government, organisations, communities and the individuals in them accepting responsibility for their share of action and working collaboratively."

(p. 8, *Scottish Government, 2014*)

Some of the professional participants in this study were very supportive of the public, and noted that confusion over responsibilities was also felt amongst stakeholder organisations (e.g. See Box 3). Others were less sympathetic:

"Generally, people are quite ignorant...there is a perception that they've got no responsibility. It's the local authority or SEPA or anyone else but them. In the introduction of the Flood Risk Management Act, the first thing it says is it is the owner's responsibility. It is your responsibility to look after your own property during a flood event, and the message is just not getting out. People don't seem to know this or care about it."

(*Local authority flood specialist*)

The local authority flood specialist's comments highlight the importance of consistent flood risk communication messaging on shared responsibility, from policymakers to practitioners. Achieving this shared responsibility could involve professionals and communities coming together to share their perspectives during the co-designing of flood risk communications (Rollason et al., 2018). Such co-design of communication forms a 'negotiation of shared responsibility' that includes all stakeholders in the process

(p.18, Birkholz et al., 2014). As well as appreciating each other's perspectives, this approach also facilitates the identification of different risks across different groups and locations, enhancing relevance and message accuracy (Cheung & Feldman, 2019). Our evidence suggests that such negotiation with community members in anything that mitigates climate change impacts, such as flood risk communication, is fundamental to our collective climate resilient future (Cheung & Feldman, 2019; Koerth et al. 2017; Devitt & O'Neill, 2017; Birkholz et al., 2014). However, it is important to note that any negotiation is vulnerable to disharmony amongst the stakeholders, as they may hold conflicting opinions and/or be unwilling to challenge the group if they disagree with them (Buchecker et al., 2013).

This engagement does not remove the need to take individual responsibility ourselves, however. Such engagement could in fact promote personal responsibility as part of a mapping process highlighting clear and transparent responsibilities across all stakeholders in flood risk and flood risk communication, as emphasised by one of our professional participants (see Box 3). This will be explored further in later sections.

Box 3 – Taking ownership of responsibility

'The key thing about the messages is getting over to people and organisations and professionals what their responsibilities are. I mean, developers, house sellers, I think their responsibility is to let people know what the flood risk – if you're selling a house, you need to let people know it's in a floodplain or it's got a flood risk issue, and what you should be doing about it. If you're buying a house, you need to know the same sort of thing. If you're driving in conditions where it might be flooding, you need to know what your responsibilities are. So, I think the focus for me maybe is "what's your responsibility?" and how do we get that information over to people so they can embrace that responsibility, take whatever appropriate action they need, be aware of the consequences if they don't, and be aware of what support they've got from other people? You know, to take ownership of the responsibilities.'

(*Transport organisation officer*)

Transparency is essential in shared responsibility, as it enables the public to both trust the process and also to understand any limitations and difficulties faced by professionals and organisations generating flood risk communication tools and messages (Gustafson & Rice, 2020; Henstra et al., 2019; Kelly & Kelly, 2019; Twigger-Ross et al., 2015). The trust of communities can be easily undermined by a lack of transparency, for example, by

not making all responses to public consultations available to everyone (Henderson et al., 2020a). Leadership and clear roles amongst organisations must be transparent and clear in flood risk communications but this is not always the case. For example, English communities were confused about which agencies were responsible for what aspect of flood risk and flood prevention, and when they should be involved (Ping et al., 2016). In Scotland, one of our participants called for stronger guidance at strategic level around flood risk communication, stating that “we don’t have decision making and leadership at a strategic national level...it completely confuses the system.” (*NHS officer*).

As described earlier, some people prefer that the responsibility for flood risk management and communication lies entirely with governments and local authorities (e.g. Papagiannaki et al., 2019; Lawrence et al., 2014; Bradford et al., 2012). This is understandable given that the most socially vulnerable in all societies, including Scotland, have contributed least to climate change but face the biggest consequences. The recent Scottish Government programme of work notes Scotland has a moral responsibility to other countries because of this inequity:

“While the poor and the vulnerable have done the least to contribute to the climate emergency, they are being affected first and most severely by it.”

(*Scottish Government, 2021c*)

Our evidence suggests that socially vulnerable sections of the Scottish population face a similar inequity today, and that this inequity is compounded by flood risk communications demanding that they act while providing no support to do so.

Maladaptive coping strategies like externalisation can be overcome, in part at least, through skilled community engagement, and this in turn will facilitate shared responsibility. Training skilled facilitators to nurture participatory processes in flood risk communication may be more effective than the common current practice of relying upon flood risk specialists to engage communities (see Box 4). Building shared responsibility in this way may lessen the externalising of responsibility and hence increase the likelihood of individuals acting in response to flood risk communications (Babcicky & Seebauer, 2019; Rollason et al., 2018; Rogers et al; 2016; Maidl & Buchecker, 2014; Bubeck et al., 2013; Grothmann and Reuswig, 2006).

2.2.8 Understanding each other

Currently, the way in which the public perceives flood risk and the terms they use to discuss them differs from experts, such as engineers and hydrologists (Maidl & Buchecker, 2015; Bradford et al, 2012). Similarly, the way in which difference disciplines involved in flood risk

Box 4 - The challenge of engaging

“...not everybody that’s a brilliant engineer or planner has the skill set to work in community involvement...and that’s okay. But we need to recognise that there is a skill set involved. I think we maybe undervalue...the amount of time and effort required to bring that in to projects...there’s almost an assumption that it’s easy to do and it’s not. You’ve got to cost it in...You have a budget for community engagement, but it’s like statutory consultation processes...budgets are tight but... those statutory processes are not going to give you that holistic approach. And that probably includes the time you have to spend engaging with colleagues as well, and partner organisations. There’s just certain practical limitations around funding timescales and around what the funding is used for.”

(*Adaptation specialist*)

communication define and use flood-risk related terms also varies, and this can be confusing for professionals as well as the public. One expert participant explained the difference in defining and using return periods across insurance and engineering disciplines:

“...essentially, the hydrology view stops at the flood risk map. The insurance view then goes a step further and it says, “Which properties are under the flood risk map?” But not just the flood risk map, a more spatially-correlated flood extent... and they actually talk to the 1 in 200 not 1 in 100, because the regulator says you should hold enough capital so you don’t go bust in the 1 in 200-year event...This is completely different from the engineering view. Sorry, quite a technical answer but that’s a specific example of the completely different perspective. Obviously, communities don’t feature in this.”

(*Hydrologist*)

The hydrologist’s shortened answer demonstrates the differing usage of return periods within these highly technical disciplines, and shows why the nuance of these differences are very difficult to explain to the public. A transport officer explained this layered complexity:

“I think there’s different languages beyond different messages. I mean, there’s the technical language. There’s the policy language. There’s what the public wants to know. There’s what the public wants to hear. How do you work out consistent messages across all of those parties?”

(*Transport officer*)

To further illustrate this, this study briefly explored the definition of 'flood-related' amongst our community participants in Workshop 2. We asked the participants to agree or disagree with the statement 'This is flood-related' for 6 images (see Table 1). Unsurprisingly, everyone agreed a car driving through floodwater and a building damaged by a river was flood-related. More surprisingly, 60% also agreed that coastal erosion was flood-related (see Table 1). This was not a robust scientific exploration of definitions, but it raises some questions about definitional parameters that should be explored in future research, as these preliminary inconsistencies have implications for what might be considered flood risk communication. These examples also illustrate the complexity of aligning stakeholder and community agendas. Achieving that alignment is critical to developing transformative strategies to adapt to the increasing impacts of climate change (Chambwera et al., 2014; Noble et al., 2014).

Table 1: Defining flood-related risks: Six Images results (Workshop 2)		
This is flood-related	Agree	Disagree
Cars driving through flood water	10 (100%)	0
Collapsed building next to river in spate	10 (100%)	0
Waves inundating a railway line and hitting a train	9 (90%)	1 (10%)
Landslip at Rest and Be Thankful	7 (70%)	2 (20%)
Riverbank being shored up after flood erosion	8 (80%)	2 (20%)
Coastal erosion at Montrose	6 (60%)	4 (40%)

2.2.9 Participatory co-design of communication

As the earlier sections have demonstrated, informing people about actions they can take to cope with or reduce the impacts of flood risk is vital if flood risk communication is to be effective, and adaptation studies also support this (Brink & Wamsler, 2019; Koerth et al., 2017). People must also perceive communications to be relevant to them (Koerth et al., 2017), though relevance alone is not enough to empower people to act. To make flood risk communications more effective, engaging individuals and communities in co-designing flood risk communications encourages acceptance of their relevance and thereby increases the likelihood of action (Percival et al., 2020).

Participatory processes and community engagement are never apolitical, particularly when they focus on the emotive issues of climate change adaptation and flood

protection (Hügel & Davies, 2020; Henderson et al., 2020a; Kelly & Kelly, 2019; Demeritt & Norbert, 2014; Kjellgren, 2013). In flood risk management, power imbalances in planning and managing flood risk prioritise the state and governing agencies over the individual (Hügel & Davies, 2020; Kelly & Kelly, 2019). After 70 years of flood risk management policy cycles, power still remains centralised and held by a small group of decision makers who act on a national level (Penning-Rowsell & Johnson, 2015), so encouraging organisations to engage in co-designing communications may be challenging for some organisations and stakeholders. As discussed earlier, post-war flood protection policies and this centralisation of power contributes to individual's externalisation of responsibility to local authorities and the government, and such power imbalances only further confound the policy paradox that impacts on the co-design of flood risk communications.

Participatory co-design of communication should be conducted with transparency, equality, inclusiveness, fairness, and be procedurally just, actively focusing on ensuring marginalised and socially vulnerable groups are heard by openly acknowledging the community participants as experts in their own lived experiences (Hügel & Davies, 2020; Henderson et al., 2020b; Kelly & Kelly, 2019). This may be challenging for scientists and governing agencies, and consideration should be given to training them (see Box 4) as they build sustained community participation and engagement into their working lives. To ensure success, the participation of Scottish communities and other stakeholders in the flood risk communication process must be sustainable and part of long-term ongoing dialogues between all participants (Hügel & Davies, 2020; Birkholz et al., 2014).

We recommend that flood risk communications are developed collaboratively with the communities they target, and that these efforts are sustained in the long-term. This will enhance flood risk communication in a number of ways, including: a) maximising its future effectiveness, as it will be designed by those who need to hear it; b) engaging hard-to-reach at-risk audiences in a deeper understanding of their flood risk; c) highlighting shared and personal responsibilities to communities; and d) building transparency in flood risk management in Scotland.

Recommendation 7

Flood risk communications should be developed locally in collaboration with the community at risk to maximise their effectiveness.

2.2.10 The Scottish flood risk communication network

Power imbalances in community engagement (Hügel & Davies, 2020) exist at multiple levels, and these should be openly addressed. For example, some members of the community might be empowered with information that, if withheld from others, allows them to lead or steer the local narrative, as this example demonstrates:

"We communicate with the local development trusts. We communicate with the local community councils...the intention was for them to pass on information, but what happens in reality is that most of them hold the information and don't want to give it out unless they're asked...So, there is a problem with getting the information down, because even within a very active group, the message is not getting passed on."

(Local authority, male, workshop 1)

The literature emphasises two-way communication is essential and participatory approaches are best practice in developing effective flood risk communication (e.g. Attems et al., 2020; Rollason et al., 2018), yet this presents significant challenges in mitigating potential power imbalances with no solution emerging from the literature (Hügel & Davies, 2020). Instead, all actors should be prepared to embrace tensions and accept the inevitable bureaucracy of governance if their collaboration is to be constructive (Hügel & Davies, 2020). To reduce intolerance within the collaboration, evidence suggests that focusing on the direct local threat of flood risk can include even those who do not believe in climate change and who would be unlikely to participate in action to adapt to climate change impacts (Taylor et al., 2019; Bruine de Bruin et al., 2014). This highlights the importance of carefully considering the semantics and language of flood risk when engaging a range of actors in collaborative activities.

In Scotland, the range of actors and organisations involved in flood risk communication today is considerable. We mapped the partnerships of the first 17 of our interviewees, none of whom worked for SEPA, the main Scottish flood risk communication agency. The participants listed over 80 partnered organisations, 60 of which are shown in Figure 1. As this was based on a sample of just 17 individuals, Figure 1 represents only a small snapshot of the organisations that exist in the wider flood risk communication network in Scotland. The size of the text in the diagram indicates the number of people mentioning that partner organisation, so the smaller the text in the diagram, the more peripheral the organisations engagement with these particular 17 individuals.

When we explained this diagram to later interviewees, they felt it evidenced how well their organisation collaborated with others in the network. Amongst the

community workshop participants, the response was more critical, however. An NHS officer specialising in resilience described Figure 1 as evidence of a wider 'chaotic' and 'fragmented' communication system. He added:

"...there are lots and lots of people out there really muddying the waters with communication...too many people who at some point have seen it as a way to improve their funding...the amount of people that want to get involved and think they've got something to say, and either are repeating something someone else has said, and therefore overwhelming people with additional information, or are changing messages to suit their own requirements, or are giving out frankly dangerous information sometimes."

(NHS officer)

His concern about a large number of actors overwhelming people with biased or dangerous information contrasted with the views of another participant, who felt the flood resilience network was too insular and did not communicate with other organisations and the public enough. He claimed the introspection of a small number of organisations undermined flood risk communication:

"They do seem to think that them coming in to some form of committee is the way to sort it...it's all them speaking to themselves. The communication bit is saying, "Yes we're putting out stuff tomorrow"...I'm looking at that and saying "I can't remember seeing that. Where did they put it? I can't remember us covering that" They go into a bubble and think "Right, we've ticked that box, we've ticked that box, we've ticked that box" and that comes out of this partnership working...which drains energy from what they're...meant to be doing."

(News editor)

Figure 1 also prompted other comments about leadership and long-term management of the flood risk communication network. A community development worker stated:

"It's the leadership and the strategic approach that's really lacking. And not just in flood risk, I mean, it's in everything to do with the environmental catastrophe that we're facing at the moment...your word diagram pretty much also shows the funding landscape at the moment, which is completely mental. The Scottish Government's just throwing little pots of money all over the place randomly instead of actually properly thinking, "Okay, we actually need like a five-year plan, a ten-year plan, a twenty-year plan, and the funding to back that up.""

(Community development worker)

Her comments were echoed by another community representative in Workshop 2, who stated “it’s just a total lack of leadership and commitment...no guidance from on high” (*Community flood group representative*). He continued:

“There has to be an overall approach...I want a plan. I want to see that plan, and I want to see when something’s going to happen to change the risk of flood...I’d like to know who’s doing it and when they’re doing it.”

(*Community flood group representative*)

The evidence above suggests that consistent guidance and strong leadership in Scottish flood risk communication is required to ensure future flood risk communication is effective. To facilitate this, we recommend a flood risk communication strategy is developed. This strategy should be co-designed with communities and a diverse range of other stakeholders from public, third and private sectors across Scotland.

Recommendation 8

A flood risk communication strategy should be co-designed with communities and an inclusive range of stakeholders with clear ownership of actions, strong leadership and shared guidance on effective approaches.

2.3. Conclusion – Developing a baseline of flood risk perception

It is not possible to provide a baseline for the Scottish population’s awareness, understanding and perception of flood risk due to the current lack of Scotland-specific research evidence. However, recent studies of similar at-risk populations elsewhere have found there remains a worrying lack of public awareness, e.g. in a recent large quantitative Canadian study, more than 25% of at-risk residents were unaware of their flood risk (Valois et al., 2020). The likelihood is that Scotland’s population shares a similar lack of awareness, and that this might be even higher amongst socially vulnerable groups who are already at greater flood risk. We therefore conclude that a robust baseline of flood risk perception is vital (Rufat et al., 2020) to ensure we communicate effectively with a complex public. To achieve this, we recommend the Scottish government urgently conducts a systematic survey of the Scottish public’s current flood risk perception. This could be expedited by incorporating the questions into the Scottish Household Survey or similar existing national measure.

Recommendation 9

The Scottish Government should conduct a systematic survey of the Scottish public’s current flood risk perception to increase the effectiveness of future flood risk communication.



Figure 1. Participant-listed partners (n=17)

3. Communicating flood risk

Traditionally, there has been a greater emphasis on the formats used for effective flood risk communications than on developing an effective communication strategy (Maidl & Buchecker, 2015). One-way communication – providing information mono-directionally to an audience with no feedback allowed from that audience – is a common approach in raising public flood risk awareness (Maidl & Buchecker, 2015). Yet it has had little success in influencing attitudes, preparedness and/or behaviour (Johnston et al., 2020; Maidl & Buchecker, 2015; Kjellgren, 2013; Kuhlicke et al., 2011). Two-way communication approaches, on the other hand, encourage engagement and feedback from the audience to the communicator, creating a dialogue from which negotiation can emerge (Ping et al., 2016; Demeritt & Norbert, 2014; Kjellgren, 2013). Here we define two-way communication in its broadest sense i.e. as including engaging with multiple groups and individuals in participatory ways, though some researchers believe the term two-way communication cannot encapsulate the plurality of flood risk actors and perspectives (e.g. Snel et al., 2019).

Both one- and two-way communication approaches are important tools in any flood risk communication strategy, as each plays a role in communicating with diverse audiences at different flood risk stages (Maidl & Buchecker, 2015; Demeritt & Norbert, 2014). Passive one-way communication approaches can be effective at conveying information, for example websites, leaflets, newspapers, and this is discussed in more depth in later sections. One-way communication can be particularly effective when flooding is imminent and during early recovery, as it can support the 'command and control' statutory response seen in countries from Australia to Scotland (e.g. Henderson et al., 2020a; Johnston et al., 2020;). However, two-way communication, particularly forms of participatory engagement, have been shown to be more effective at raising flood awareness and offering more support for preparedness (e.g. Johnston et al., 2020; Bodoque et al., 2019; Stieb et al., 2019; Ping et al., 2016; Kellens et al., 2013).

Communication approaches vary widely in cost, but one-way communication methods are generally more efficient in scale, time and financial expense. Two-way communication methods tend to have higher costs, as they require skilled facilitation, particularly in participatory and engagement approaches (see Box 4). The costs of developing and delivering such an approach requires specific budget allocation, as does its evaluation (Bodoque et al., 2019). Two-way communications are therefore limited by financial costs and hence are often focused

on smaller cohorts or specific groups, which are further limited by including only those who are willing to engage in the process (Maidl & Buchecker, 2015).

With this diversity in costs and purpose in mind, the following sections discuss current communication methods, tools and mediums alongside nascent approaches used in flood risk communication. These communication methods have emerged from the literature and the recommendations of our study participants. Most of them can be used in a participatory and engaging way with communities, but some also offer the potential of one-way communication only. Different contexts and purposes require different approaches, and so may require a combination of one-way and two-way communication methods within the same communication strategy (Kelly & Kelly, 2019). Indeed, our individual learning preferences and how we wish to receive information varies greatly (Snel et al., 2019). Before exploring approaches to flood risk communication, however, we must begin with a consideration of two central challenges faced by flood risk communication, that of communicating *uncertainty* and *probability*.

3.1. Uncertainty

When approaching the challenge of communicating future flood risk and flood-related climate change, uncertainty must be carefully considered (Corner et al., 2015). Uncertainty can negatively impact on people's motivation to act in a number of ways, including by discrediting or doubting the accuracy of projections; reducing the clarity of the message; impacting negatively on understanding of the threat; generating a perception of evasiveness and/or ambiguity in the science; reducing the belief in the source's credibility; and delaying policy responses to flood risk (Gustafson & Rice, 2020; Corner et al., 2015; Carr et al., 2016). It is a challenge that our interviewees who worked in flood risk communication know well:

"I don't know how you...communicate the uncertainty without making the whole message seem uncertain, that climate change isn't uncertain and flooding isn't uncertain. We know places flood and that's going to get worse, but how you manage to say that without saying "but we don't know by how much"?"

(Flood specialist 2)

Research evidence suggests that there are several ways to influence people's acceptance of uncertainty and ensure communication about climate change and flood risk is more effective, including highlighting the positives; making it relevant through relating it to human experience rather than relying on scientific data; and approaching uncertainty through dialogue as part of a conversation to address people's concerns (Corner et al., 2015). In

addition, and somewhat counterintuitively, caveats and limitations given as part of scientific communication have been found to increase perceptions of the trustworthiness of journalists and scientists (Gustafson & Rice, 2020). Therefore, uncertainty about flood risk can be communicated to the public by being honest and clear in the messaging, and by conceptualising the uncertainty to understand the best way to portray it (Gustafson & Rice, 2020).

3.2. Probability

The probability of a flood event occurring is one of the most challenging aspects of flood risk communication. Attempts to communicate probability within flood risk have been described as complex and 'incomprehensible' to the public (p.564, Snel et al., 2019). It is often expressed using numeric probability (e.g. 0.01 per year; 1% per year) or by return period (e.g. once in a 100 years). Probability is confusing to the public. One local authority flood specialist agreed this is very confusing:

"...we had two floods in [*the town*] with return periods of greater than one in 100 years. So, you know, they expected one in 100 year floods. We had two of them within the space of a year.

(*Local authority flood specialist*)

Communicating probabilities using return periods has widely led to the belief that if recent flooding has occurred, the risk is very low, and people become less concerned, as if the risk has passed (Grounds et al., 2018). However, as another participant stated "...What you're finding is the 1 in 50 event is not a 1 in 50 event anymore. It's your pretty standard flooding event" (*Local authority councillor, male, interview*). The reverse is also believed, that is, that a flood will occur once in a given return period (e.g. 50 years) and therefore that a flood is 'due' if that return period has elapsed flood-free (Grounds et al., 2018).

Communicating probability requires a different way of conceptualising likelihood if such myths are to be challenged (Recommendation 4). These misunderstandings should not only be corrected within communities, but also amongst stakeholder colleagues and partners from other organisations, as this comment from one specialist working in flood risk communication nationally illustrates:

"We've [*the organisation*] previously used the 1 in 200 year's language...at the time I would hear that and go, "Right, okay, so that area is never going to flood." And then you find out it's flooded twice in ten years. But how does that work if it's not 1 in 200 years, you know? It just doesn't really add up."

(*Flood risk communication specialist*)

Participants who held a detailed understanding of return periods and probabilities readily acknowledged the difficulty the public and colleagues found in interpreting them, noting the issue was universal "...everyone has the same confusion with return intervals...It's universally misunderstood." (*Insurance professional 1*). Unsurprisingly, this led some to express frustration about their persisting use, like this policy expert:

"...it's a real bugbear for me...the way people talk about return periods...people think "Oh well, you're only going to get one every hundred years"... we've actually recently again had discussions internally...more people are saying we need to change this, and we need to agree a standard way of talking about it...what we don't have within [*the organisation*] is how to take that and use it in a way that people will understand it...I hate it every time I see the 1 in a 100-year flood...I always think it's not right."

(*Flood policy specialist*)

Return periods were also considered unhelpful and confusing by non-specialist participants. A news editor noted return periods still appear in the UK and global media, but felt the term is not helpful:

"...they ended up getting a 1-in-200 within a couple of months...I don't think those numbers resonate with the public anymore. They just think, "What does that mean?""

(*Scottish news editor, male, interview*)

Changing the communication of probability offers an opportunity to engage with the Scottish media to discuss approaches they feel would be better understood by their audience. This would be helpful, as although there is agreement across the literature and amongst our sample that flood risk probability should be presented in a different way, how to communicate it differently still remains a challenge. Methods suggested include focusing on magnitude rather than probability/likelihood (Taylor et al., 2019). For example, another UK study with a flood-experienced sample found using a simple flood depth simulator allowed the group to break out of their *prison of experience* and helped participants understand that not only would a flood event reoccur locally, it could also be of greater magnitude than before (Rollason et al., 2018).

Promising evidence is emerging from using 'when', not 'if' within timeframes, suggesting this approach might be more effective in encouraging preparedness and adaptation intentions than describing the probability of an annual recurrence (Corner et al., 2015). This is also referred to as *time of emergence*, and describes the time by which climate change impacts have almost certainly occurred (Taylor et al., 2019; Corner et al., 2015). We recommend that return periods are no longer used and

instead new approaches to communicating probability should be explored and their effectiveness tested.

Recommendation 10

Return periods should no longer be used and instead new approaches to communicating probability and risk should be employed and their effectiveness tested.

3.3. Examples of effective risk communication approaches

The following examples have been drawn from academic evidence and our study participants' recommendations. They are grouped to explored effectiveness and demonstrate best practise in 1) Dynamic mapping and 3D Visualisations; 2) Gaming; 3) Websites and Apps; 4) Social Media; 5) *Sustainable flood memories*; and 6) Broadcast and Print Media.

3.3.1. Dynamic mapping and 3D Visualisations

For decades, static maps have communicated information about flood risk areas in a non-interactive way, where the user has no control over variables such as time and flow, e.g. Potentially Vulnerable Area (PVA) maps (SEPA, 2015). While these maps are useful for certain purposes, technological advances have facilitated the development of highly sophisticated interactive digital tools for flood risk communication which engage the public more actively in understanding their flood risk. These include both *dynamic maps*, which we define here as two-dimensional maps where the user can control different variables and observe changes over time in a given catchment area; and *3D visualisations*, which we define here as animations that show users simulated flood event magnitude and consequences in a geographic area. As yet, however, such sophisticated interactive tools have not been consistently found to be more effective in controlled studies at raising awareness than basic communication strategies using more conventional methods such as talks and/or static images (Hügel & Davies, 2020; Lieske et al., 2014). Combining dynamic maps and/or 3D visualisations with other flood risk awareness and preparedness tools has the potential to be more effective, see e.g. Dynamic Coast (www.dynamiccoast.com; Rennie et al., 2021), as does engaging the users in the co-design of the tool. For example, working together with groups of stakeholders and/or communities to develop maps and visualisation tools (also known as *Collaborative Modelling*) has been found to be effective at engaging people with their flood risk (Sanders et al., 2020; Evers et al., 2012).

Currently, there is a lag between state-of-the-art science and the mapping of surface water flooding in the

UK due to under-investment in the field over the last decade (Stephens, 2021). For example, an effective and novel method to aid surface water flood forecasting in Glasgow was developed ahead of the city hosting the Commonwealth Games (Moore et al., 2015), yet after the funding of the project concluded the adoption of the approach appears to have stalled. Under-investment will hamper further developments in nascent technology-based flood risk communications in future. Yet technology has considerable potential as an effective method in communicating flood risk, as demonstrated by a recent study in the UK using Google Earth, which co-created a virtual tour tool with a local catchment group to highlight the potential of Natural Flood Management in the local catchment (Smith et al., 2020). At the time of writing, SEPA announced the development of new surface water flood mapping which will use innovative modelling techniques (SEPA, 2021b) to improve surface water flood mapping and support SEPA's forthcoming Flooding Services Strategy.

Two-dimensional (2D) maps show areas that may be affected by flooding and can be controlled by the user (e.g. see [Flood maps | Scottish Environment Protection Agency \(SEPA\)](#)), while three-dimensional (3D) visualisations simulate and animate the magnitude and consequences (e.g. see [Exeter Flood Visualisation](#)) (Chen et al, 2017; Evans, 2014). Animations can also demonstrate the effects of adaptation measures (Evans, 2014), and hence could be a useful tool in modelling the impacts of actions taken by communities in future. When constructed with a range of community actors, the creation of these tools can build trust in their accuracy, raise awareness of flood risk, and engage individuals in dialogues about protective measures which may help motivate individuals (Meyer et al., 2012).

Dynamic maps and 3D visualisations require clear guidance on their use and their limitations, as these tools can be very powerful and persuasive when viewed out of context, e.g. if the user does not have a clear understanding of the limitations in the data used to construct the map. As one flood specialist noted:

"I would say that everywhere is at risk, and sometimes those maps which were developed for a specific purpose – to help develop strategies and plans – can give a false sense of comfort or alarm. So they're not necessarily always as helpful as perhaps the public would hope."

(Flood specialist 1)

Generating fear and worry in flood risk communications can undermine community and individual resilience. Therefore, communicating with dynamic maps and 3D visualisations must be carefully managed to avoid distressing the user (see Box 5). This could also limit the media's tendency to sensationalise these tools even when

the underlying data are not comprehensive. For example, the *Climate Central* map release was picked up by the Scottish media, and the Daily Record ran a story under the headline '*Frightening climate change map shows Scottish cities under water in 2050*' (Davidson & Boyd, 2020), while the BBC News website headlined an earlier related story as '*Climate change: Sea level rise to affect 'three times more people*' (Amos, 2019). Similarly, The Sun ran a story about the availability of the *FireTree Flood app* under the headline '*TIDAL TERROR: Sea level 'doomsday' simulator reveals if YOUR home would be wiped out by rising oceans - It's pretty terrifying if you live on Britain's east coast*' (Keach, 2020). None of these stories featured a response from trusted experts like SEPA or the Scottish Government.

Future effective flood risk communication in Scotland requires a common aim of responsibly communicating only scientifically accurate information. All stakeholders, including the media, governing agencies, communities, and public, third and private sectors, should be partners in this aim. Stronger relationships between journalists and flood risk management organisations could help avoid sensational headlines, and so reduce the public fear or alarm we know undermines flood risk communication (see earlier). This may require Scottish organisations to be more proactive in their engagement with the media, as a national journalist highlighted:

"...I have not found them [SEPA] particularly proactive. There are standout media operators in Scotland who know that a story is going to get told and that actually, good or bad...it's better to be involved in telling it...A lot of press operations in Scotland come from a cautious position."

(UK/Scotland broadcast Journalist)

Even without the media's sensationalism, sharing dynamic maps and 3D visualisations with the public can generate negative reactions. An anecdote from one of our participants demonstrated this can happen even in a controlled setting with a facilitator present (see Box 5). She showed a community a map of the area's projected flood risk, triggering an unexpectedly emotional response from one shocked and angry individual. His reaction was a manifestation of the denial coping strategy, which in this case was mitigated by the sharing of local experience and learning by other attendees. Our participant immediately stopped using projection maps, concerned that she could trigger a similar reaction amongst other individuals or groups in future.

The potential of projections in dynamic maps and 3D visualisations to trigger an emotional reaction has been recognised in the literature, leading to one study recommending that visualisations are inadequate as standalone tools (Lieske et al., 2014). Other studies have found that engaging with people as they use the map

Box 5 - Presenting mapped projections

"...I had presented maps...when you fiddle around with the projections, then...these online sites... show sometimes almost all of [the area] completely under sea level or just flooded...One man...he really doesn't agree with the projections of flood risk and he was quite angry about that...he said that SEPA's projections are completely inaccurate, and that they're scaremongering...But he did also seem quite shocked...We then had a couple of other people that countered that by saying "I actually live [in the area] and I've seen the flooding there and I've seen the coastal erosion and you can see it yearly getting worse"... And it transpired... he'd just built a new house on an area that was shown as a flood plain...It was with a group of 20-odd of his peers that he was seeing these maps...I think it was the first time he had seen the sort of future projections...Since then I haven't really shown projections maps...They're really powerful and quite upsetting... it does involve some quite strong like livelihood changes, is really quite harrowing and quite emotive.

(Flooding & climate change specialist)

or visualisation can increase the effectiveness of that communication (e.g. Kelly & Kelly, 2019; Lieske et al., 2014; Kjellgren, 2013). Our example in Box 5, however, suggests that emotional responses might be triggered by the shock of the flood projection itself, regardless of the medium by which it is communicated, therefore we recommend that this engagement should also involve emotional support when users will be exposed to potentially shocking projections.

Dynamic maps and 3D visualisations are useful flood risk communication tools, but developers must follow clear guidance if they are to be effective. For example, evidence shows they become less effective when not enough attention is paid to ensuring the public understand how to interpret the maps correctly (Dobson et al., 2018; Strathie et al., 2017; Birkholz et al., 2014). Similarly, maps will be ineffective if the accompanying information to assist the user is inadequate (Henstra et al., 2019; Meyer et al., 2012). There is also concern over the accuracy/credibility of some maps released on public platforms (Percival et al., 2020), suggesting a need to educate the public to enable them to identify 'fake maps' that use poor or inadequate data.

Mapping, visualisations and animations can be very positive communication methods with the right audience and when used in the right way. For example, a UK study found that a demonstration of flood dynamics through mapping was considered more beneficial than a static flood risk map (Rollason et al., 2018). The dynamics gave

participants greater insight into their local flood risk than both the static maps and live river gauges as, unlike the dynamic maps, the static maps did not show over-topping and the river gauges offered no predicted levels. The resulting deeper insight into flood dynamics was found to enhance the participants' ability to prepare and hence their feelings of control (Rollason et al., 2018). Similar evidence of enhancing local community understanding of flood dynamics was found in another study using digital catchment observatories (Mackay et al., 2015). Given the insight these collaborative approaches to dynamic catchment modelling and messaging generate, local communities could be engaged in co-designing new digital flood risk communication resources for their local catchment area. However, significant challenges to implementing these methodologies would need to be addressed, including the technical infrastructure and communication between participants (Mackay et al., 2015).

We conclude that dynamic mapping and 3D visualisations are effective flood risk communication tools. However, their development and use must be carefully managed within a flood risk communication strategy due to their potential to trigger a negative response. During the development of these tools, consideration must be given to their interpretation (and possible misinterpretation) by diverse audiences with differing personal and professional needs (Percival et al., 2020; Cheung & Feldman, 2019; Houston et al, 2019). Therefore, where possible, they should be co-designed with other members of Scottish flood risk network, including communities (Percival et al., 2020).

Recommendation 11

Dynamic maps and 3D visualisations are effective communication tools, particularly when co-designed with communities and where support is provided to people during their use.

3.3.2. Gaming

Flood risk communication has been gamified in an attempt to educate and engage people through entertainment. Also known as *serious games* because of their multiple purpose, flood risk gaming approaches including role playing, mental modelling, physical activities in place, computer simulations/games and gaming apps. Often, these approaches place the players in key roles in flood risk management and simulate critical decision-making, increasing their participants' understanding of flood risk management complexities, e.g. *VigiFlood* (Adam & Andonoff, 2019); *ANYCaRE* (Terti et al., 2019). Many serious games have the potential to be played online or face-to-face individually/in groups, such as the *Decision Game*, which focuses on simulating household decision

making in flood risk preparedness (Yiannakoulias et al., 2020). Virtual reality (VR) simulations are increasingly being used for public engagement at festivals and gatherings as a brief accessible tool that enables players to experience simulated flood events audio-visually in an immersive, realistic way, e.g. *Flash Flood!* (Skinner, 2020). One participant noted VR is particularly successful at engaging children, and described its use in New York as part of a marketing campaign for <https://www.floodhelpny.org/> (see also Box 6):

"...when we were first rolling this out, we also had pop up Farmers Market-type stands with a VR experience that you could put on, you know, these goggles...then you could look around the neighbourhood, and it would show you different high watermarks. Like [*Hurricane*] Sandy and then also expected high tide marks...and the parents would walk right by, but kids see these electronic tools and it's like, you know, moths to a light and they would come...then you would hear them leave asking their parents, "Are we in a flood zone? What does that mean? What should we be doing?"

(Insurance professional, female, interview)

Physical games offer a different approach to engaging the public in flood risk communication. For example, an urban street game for adults, *Downpour!*, cast its players as flood risk advisors and tasked them with making decisions in real-time in response to a mock event, using actors and environmental tools to make the place-based experience more immersive (Wendler & Shuttleworth, 2019). Less physically demanding are table top games, which offer almost limitless possibilities for educating players on environmental threats, and can be adapted to be relevant to a wide range of diverse groups. Like other approaches, they can also be adjusted for different ages (Terti et al., 2019).

Like role playing games, where an individual imagines themselves in a new role and makes decisions in that role, mental model studies ask individuals to describe decisions they have taken/would take before and during a flood event. This generates greater insight into their behaviour and decision-making than assessing only their flood risk awareness or knowledge (e.g. Lazrus et al., 2016). Using images and cognitive representations can generate compelling mental models in people's minds (Corner et al., 2015), just as *DownPour!* does in an urban street. Mental models have emerged as a participatory process that focuses on individuals' perceptions and interpretations of the world (Kellens et al., 2013), and encourages community members and professionals to better understand cause and effect in flood risk (Steib et al., 2019; Wagner, 2007). By gaining a better understanding of these internal representations, more effective flood risk

communication might be designed (Kellens et al., 2013). A mental model approach normally generates insights and exposes gaps in understanding at an individual level, though conclusions could be drawn more widely where there is consensus in identified gaps (Lazrus et al., 2016).

Gaming and role playing offer an intuitively engaging approach to flood risk communication that could build community collaborations (Kelly & Kelly, 2019), and engage the public in understanding the complexities of decision-making during times of crisis and uncertainty. While gaming currently lacks robust systematic evaluation evidence of its effectiveness across all approaches, serious games have been identified as having the potential to support local learning and increase empathy and trust between communities and professionals involved in flood risk management (Hügel & Davies, 2020). Further, role playing online could mitigate some of the negative aspects found in 'live' group role play with adults, such as reducing the tensions within group dynamics, and the discomfort and embarrassment of the participants (McEwen et al., 2014). Serious games could be a useful method of engaging groups provided each game's effectiveness has been evaluated and demonstrated.

Recommendation 12

Serious games offer communicators potentially effective diverse communication tools that may increase players' understanding of flood risk decision making and encourage them to consider their own flood risk responses, but further research evidence of their effectiveness is needed.

3.3.3. Websites and apps

Websites are a very popular communication tool amongst organisations who need to share information. They are normally passive one-way communication resources that do not require users and communities to respond to or engage with them, though most offer a 'contact us' option. Websites can be a vital communication tool during times of crisis (Johnston et al., 2020; Maidl et al., 2015), and are often well-trusted by those who use them (e.g. Papagiannaki et al., 2019; Snel et al., 2019). However, websites are not used by everyone, particularly the elderly and those with limited resources (Snel et al., 2019; Bichard & Kazmierczak, 2012). Therefore, sharing information on websites should always be supplemented by sharing the same information through other flood risk communication tools and approaches.

Despite the limitations of websites, organisations across Scotland still rely on websites almost exclusively to communicate information to the wider public on flood risk, preparedness, mitigation and adaptation. Some of our participants regarded websites as very useful tools, as highlighted by one participant when describing his

organisation's website:

"[the website tells you] steps you can take in advance of flooding...preparing for flooding in advance. Simple steps you can take [like] moving all your valuables up into the upstairs, if you have one, so that your possessions are less exposed to flood damage; having a plan; having an emergency pack with some of the fundamentals that you'll need, mobile phone battery charger, torch, essentials like waterproof gear to be able to get yourself out [and] make sure you and your family are safe in the event there is a flood.

(Insurance specialist 2)

Another participant highlighted local authority websites as excellent sources of information:

"...ourselves and every local authority I'm aware of, on our flooding webpage, we have information on what to do to prepare for a flood, what to do during a flood, and what to do after a flood and the clean-up. And I know SEPA have all this information as well. However, I've got to say, when we last did a check on the amount of hits, it was very, very minimal. People just were not looking at it."

(Local authority, male, workshop 1)

Effective flood risk communication relies upon individuals receiving that communication. Therefore, if few people are accessing organisations' websites, it raises questions about the effectiveness of that approach.

A similar lack of use was reported for <https://www.floodhelpny.org/>, a \$1million website co-designed in New York by communities, scientists, and local governing agencies, amongst others. It was marketed extensively at a cost of approx. \$500,000 (see Box 6), and yet:

"I think this is best in class...[but]...take up and use of it is not what you would hope because nobody wakes up and says, "Oh, after I take out the rubbish, and read my mail, and watch Netflix, that's when I'm going to find out what my flood risk is today."

(Insurance professional 1)

Website use is limited by personal preference, as some people prefer face-to-face communication, and also by individual self-confidence, as those who believe they already know enough will not look for more information from any source (Snel et al., 2019). Without any systematic evaluation data explaining the public's engagement (or not) with Scottish organisations' websites, it is difficult to understand website usage figures. Without such evaluations we also cannot establish if existing organisational websites increase knowledge or impact on behaviour in Scotland.

Box 6 - Marketing a website

"...it was surrounded by that outreach campaign. So in addition to the social media stuff we put in bus shelters on routes follow the ribbon of risk along the coast. Big signs that said floodhelpny.org so if people were standing there, they would see that was an impacted area. So it wasn't just like we put it up and said "We will build it and they will come!" It was supported... I think it cost us a million to build that site and we spent half a million on advertising. It was a big effort... it's really good, accessible knowledge as well."

(Insurance professional, female, interview)

Some participants told us that their organisation's website has an old interface or was poorly designed, which may further contribute to low usage. For example, one participant commented that her national organisation's website "...is a very old website that hasn't been updated" (*Flooding & climate change specialist*). Another participant from a different national organisation noted there are issues with their website design, too, and commented that she felt powerless to get her organisation to change it:

"...best practice on websites is less text is better... we've kind of, gone against that rule book, but it's historical and that's just how it is."

(Flood risk communication specialist)

Therefore, we recommend that flood risk communication may be more effective for those who do use websites if those websites are regularly reviewed and updated. This is particularly important as public sector websites compete with commercial mobile applications for users wishing to access specific information quickly, particularly in flood risk forecasting. Both professional and community participants in our sample reported that they prefer using multiple mobile phone apps to predict the weather rather than relying on SEPA or the Met Office websites. This need for multiple apps was described as being necessary because there is a 'knack to weather prediction' (*Local authority flood specialist*) where reliance on one data source alone risked getting it wrong. The same local authority participant reported using five different apps to make his flood prediction more accurate. He noted he had never "seen it when they've all agreed". The belief that forecasting a flood event is an art and by implication, not a science, was supported by a news editor for a national broadcaster:

"...you'll have SEPA saying one thing or the Met office saying another thing... I think it is just an experience thing of just realising when something is going to be out of the ordinary..."

(Scottish news editor, male, interview)

The use of intuition and different apps in forecasting suggests more work needs to be done to give the public and professionals confidence in the forecasts and projections of national organisations, highlighting again the importance of investing in digital platforms to ensure they are easy to use, up-to-date and trusted.

We conclude that websites and apps have limited effectiveness as flood risk communication tools but should always be available to supplement other flood risk communication efforts. Further, we recommend ongoing investment be made in the Scottish flood communication digital infrastructure across public sector organisations involved in flood risk communications, to make them easier to use, up-to-date, to hence enhance their credibility and trust amongst the public.

Recommendation 13

Websites and apps have limited effectiveness as stand-alone flood risk communication tools, but can supplement other flood risk communication if ongoing investment is made in the Scottish flood communication digital infrastructure to ensure it is accurate and intuitive to use.

3.3.4. Social media

Social media is a two-way communication approach (Barker et al., 2019), though in practice it is often used by large organisations to disseminate one-way messages. Social media is useful for transient populations such as tourists (Percival et al., 2020), enabling these non-permanent members to become involved in the local social networks through virtual connectedness (Haer et al., 2016). Like websites and apps, not everyone uses social media, however, and older people in particular are more likely to be excluded from messages on social media platforms, hence we do not recommend social media as the only source of communication (Intrieri et al., 2020).

Social media supports communities to share photos and videos in real-time, enabling them to report issues with drains or flooding, for example (Ping et al., 2016). This dynamic two-way communication involves managing expectations, however, as flagged incidents can only be met by local agencies if they have the capacity to do so, and if that agency is actively monitoring that platform (Intrieri et al., 2020).

Social media platforms, unlike most websites, display usage numbers transparently, leading one participant to argue that organisations place too much reliance on this communication approach:

"They...[public organisations]... need to be not just thinking the job is done by punting it out on social media. Because again, we can all see how

many likes, retweets or views this stuff gets and its invariably really low level for public body accounts like that.

(Scottish news editor, male, interview)

This participant was also critical of the lack of engagement between the flood risk-focused organisations and the media more widely. He highlighted that while some public sector organisations' social media accounts got "a couple of thousand views at most" (*News editor*), approx. 700,000 people watch Reporting Scotland during major weather events. He argued "...maybe we overplay the impact and use of social media in things like this". The limitations of social media and the lack of media engagement more widely was recognised by a flood specialist from a national organisation criticised by the news editor. She noted:

"I actually think we maybe need to be a bit more intelligent about how we work media and social media...trying to get good science out there."

(Flood specialist 2)

Messages passed via social media networks can be more effective than a government-led top-down campaign in effecting the implementation of risk reduction measures (Haer et al., 2016), highlighting that community-led social media-based communication does have an important role in effective flood risk communication. This has been evidenced in Scotland on multiple occasions, such as during severe flooding in Aberdeenshire in 2015/16. In that event, social media platforms, particularly Facebook, were found to be as important a source of information as TV and radio (Philip et al., 2020). Local Facebook pages also enable communities to share learning and organise around flooding issues, not only in times of crisis as seen in Aberdeenshire, but also in times of good weather (Henderson et al., 2020a). As a form of community engagement, well-used interactive social media platforms like Facebook may be an effective platform for raising awareness. However, they are not used by everyone, hence communications shared on these platforms should also be shared through other communication methods.

We therefore recommend that public sector organisations consider using community-led social media to engage with local people, but otherwise only use social media as one of several digital and non-digital communication approaches due to its limited engagement.

Recommendation 14

Organisations involved in flood risk communication should consider using community-led social media to engage with local people, and use social media as one of a mix of several digital and non-digital communication approaches due to its limited engagement.

3.3.5. Sustainable flood memories

We extend the term '*sustainable flood memories*' here from McEwen et al's (2017) original definition to include a wider range of activities that share historical flood-related experiences amongst a community to generate shared learning. The range of community-based activities this term covers is broad, and these activities can be formal or informal, ad hoc or organised, such as face-to-face storytelling; flood museums; artefacts including artwork/ photographs of flood events and physical height marks on buildings; flood walks with children and adults; digital storytelling; and more.

Physical activities and artefacts are important in sustainable flood memories. For example, photographs have been found to be effective in illustrating risk mitigation and adaptation measures (Kjellgren, 2013), including in Scotland (see Box 2), and these can easily be stored in local community archives to increase future knowledge and understanding. For schoolchildren, physical rather than virtual flood walks in their local area have been found to increase their knowledge and motivation to explore flood risk (Rundgren et al, 2015). Incorporating photography within children's physical flood walks has also been found to be effective therapeutically with young people impacted by a flood event (Williams et al., 2017b).

Storytelling is a central part of any flood walk, as the participant is guided around the area while the impacts of previous flood event(s) are explained to them. Storytelling is also emerging as an effective tool in flood risk communication. Storytelling is a narrative of lived experience and is closely linked to our identity as the storyteller (Kelly & Kelly, 2019). As recipients, listening to these stories can be more persuasive if we can identify with the storyteller through a shared social identity (Lejano et al., 2018). Storytelling is therefore embedded in culture and place, allowing individuals to frame, interpret and apply the learning they take from stories told (Kelly & Kelly, 2019; Lejano et al., 2018). Stories and images also resonate with people because they reflect the social contexts that guide our understanding of the world (Corner et al., 2015). Storytelling as a flood risk communication approach has more recently explored new ways of communicating uncertainty and scientific information (Shanahan et al., 2019; Corner et al., 2015). For example, evidence suggests that listening to a narrative about flooding which incorporated scientific language was more effective than presenting the scientific language alone (Shanahan et al., 2019)

Advances in technology have enabled digital storytelling to emerge as a new flood risk communication tool. Digital stories create electronic archives of sustainable flood memories, preserving local flood histories and demonstrating coping strategies through apps, websites,

audio and video recordings, images, diaries, news reports etc. (e.g. see Hazard and Hope) (Kelly & Kelly, 2019; McEwen et al., 2017). Digital storytelling enables multiple perspectives to be gathered, capturing a rich, detailed archive of lived experience from diverse local voices that often otherwise go unheard (Adair et al., 2019; Kelly & Kelly, 2019). Digital storytelling archives also offer local authorities and other organisations greater insight into local communities' experiences when co-creating future effective flood risk communications, and these insights and stories can be applied beyond the local area to share experiences regionally, nationally and internationally (Holmes & McEwen, 2020; Adair et al., 2019). Sharing such digital memories, e.g. physically through a community film night, can bring a community together to increase understanding (Boronyak-Vasco & Jacobs, 2016).

Although sustainable flood memories approaches are rarely, if ever, systematically evaluated, early evidence suggests that protective responses can be increased by incorporating activities like anecdotes (Dittrich et al., 2016), and that approaches that build sustainable flood memories not only engage communities, but are also valued by communities (Holmes & McEwen, 2020; Kelly & Kelly, 2019; Lejano et al., 2018; McEwen et al., 2017). Importantly, organisations also recognise their value, and are increasing open to considering this as qualitative evidence (Holmes & McEwen, 2020).

Therefore, as part of a flood risk communication strategy, the development of community-led sustainable flood memories may help organisations and communities work together to increase their future flood resilience. We recommend that organisations support the development and dissemination of sustainable flood memories by flood-affected communities as a potentially effective flood risk communication tool. Those communities should also be supported to share their archives with others to encourage protective and adaptive actions.

Recommendation 15

Organisations and practitioners involved in flood risk communication should support the development and dissemination of community-led sustainable flood memories archives that can be shared with others to encourage protective and adaptive actions.

3.3.6. Broadcast media and printed sources

Printed sources, like newspapers and leaflets, play an important role in supporting effective flood risk communication in Scotland. Posters, printed leaflets and letters are already used in risk communication in Scotland, as demonstrated during the recent Covid crisis. Evidence suggests some people find leaflets and brochures useful communication approaches (Attems

et al., 2020; Snel et al., 2019), particularly older people (Hickman and Flikweert, 2013), and those who are not resident in the area, e.g. tourists; transient workers etc. (Percival et al., 2020). Similarly, local variable messaging signs next to roads have been found to be an effective tool for communicating with visitors and those passing through local places (Intrieri et al., 2020). During political elections in the UK, letters are used to communicate with the public, and this method has been used to direct householders in Switzerland towards online resources highlighting their flood risk (Maidl & Buchecker, 2015).

The broadcast and print media play a critical and well-evidenced role as providers of public information during a time of crisis, in Scotland and beyond (e.g. Snel et al., 2019; Ryan, 2018; Diakakis et al., 2018; Kellens et al., 2013; Ludy and Kondolf, 2012). They report on longer-term issues like climate change, but also report in the short-term on extreme weather events, sharing information about actions to take before, during and after a flood event. Broadcast media coverage focuses heavily on ratings, and extreme weather events provide higher viewing figures:

"...for any weather event, the viewing figures for Reporting Scotland and for STV News go through the roof...I mean adding a couple of hundred thousand onto programmes at times... as well as the public service of telling people what's happening...for news, for producers of programmes, weather is a good story. As well as the altruistic side of it, telling people what's happening and how to get help.

(News editor)

A large flood event provides powerful pictures for the media. In contrast, engaging the media in supporting effective flood risk communication in good weather can be more challenging, as they operate in a competitive fast news environment that means even flood events might not make it into the final radio and TV bulletins:

"...a lot of it is also defined by what else is happening on the day. So, for instance, over the last year, because Covid has been an all-consuming issue, it would be a higher bar for flooding to get on. If it's a day when there's less other issues or news-worthy subjects being covered, then perhaps it might be a slightly lower bar for the flooding to get on, but like I say, it's a mixture of risk-to-life impact to people and the pictures, availability of pictures, certainly when it comes to television."

(UK/Scotland broadcast journalist)

Evidence from the literature suggests that broadcast and print media need to be engaged in flood risk communication while retaining their ability to hold decision-makers to account (Devitt & O'Neill, 2017).

One way they could support flood risk communication in local communities more is by publicising current examples of best practice in community engagement in Scotland, highlighting the positive collaborations between communities and key organisations:

“...there's been news stories done on what we're seeing [*but not on*] what we're doing about it just now [*for example*] “This is the work the agencies are doing. This is the collective work that organisation authorities are doing, with communities, and this could be the impact in the future” ...the danger is that they sensationalise something and the impact is total annihilation, whereas you know the true picture is somewhere below that. So it's actually getting a helpful news story out there that we'd be able to educate people, with pictures, with films...that kind of thing...there's lots of...positive stories but I think it needs to be communicated, balanced and right.”

(Infrastructure manager, male, interview)

We therefore recommend that organisations work more closely with the media to build a positive narrative within Scottish flood risk communication, and use multiple types of broadcast and print media when communicating flood risk information to maximise the reach of their messages.

Recommendation 16

Stakeholder organisations involved in flood risk communication should work closely with the media to build a positive narrative within Scottish flood risk communication, and use multiple types of broadcast and print media when communicating flood risk information to maximise the reach of their messages.

4. The future of effective flood risk communication – a strategic approach

The evidence we collected suggests that flood risk communication is most effective when it involves people interacting with other people, e.g. through community engagement and participatory activities; through discussions with family, friends and neighbours etc. The research clearly shows that multiple platforms, mediums and approaches must be used when the goal is to reach as many members of the public as possible. Further, the evidence shows all actors in the system need to better understand the complexity of roles and responsibilities across the flood risk management system if communications are to be consistent, effective

and scientifically accurate (e.g. Hügel & Davies, 2020; Knighton et al., 2018; Masud et al., 2016). Therefore, we conclude more work is needed across all disciplines involved in flood risk communication in Scotland to a) strengthen approaches to public participation and community engagement processes (Hügel & Davies, 2020); b) ensure the public has the capacity to be involved in co-creating messages (Kelly & Kelly, 2019); and c) explore how responsibilities are framed in flood risk communication (Koerth et al., 2017).

Our participants suggested that there is a pressing need for leadership of the flood risk communication network, just as there is a need for clear flood risk communication guidance for practitioners. Both of these could sit within a new Scottish flood risk communication strategy (see *Recommendation 8*). Guidance for practitioners could be developed from the academic and qualitative evidence presented in this report. This guidance could support practitioners and other stakeholders to understand *why* they need to communicate; *who* the message is for; *where* the message should be communicated; *when* the message would most resonate; *how* the message is best communicated; and *what* impact is intended. This would empower flood risk communication practitioners across Scotland to maximise the effectiveness of their efforts, and help build a more resilient Scotland.

5. Conclusion & Recommendations

This research sought to determine how to communicate flood risk and related climate change projections more effectively by exploring the Scottish public's understanding of flood risk, flood likelihood/probability, flood risk in relation to climate change and climate change projections, and uncertainty. It then identified tools and methodologies that could communicate flood risk and related climate change predictions to both technical and non-technical audiences more effectively. Throughout data collection and reporting, we also explored how to develop a good understanding amongst the public and partners of what adaptation means, and how to engage all audiences in adaptation and adaptive actions. Our conclusions are reported below before our recommendations are outlined.

1. The public's understanding of flood risk, flood likelihood/probability, flood risk in relation to climate change and climate change projections, and uncertainty in relation to flood risk and climate change.

Due to the lack of Scotland-specific research evidence, currently it is not possible to provide a baseline for the Scottish public's understanding of flood risk, flood

likelihood/probability, flood risk in relation to climate change and climate change projections, and uncertainty in relation to flood risk and climate change. There is anecdotal and research evidence that suggests public awareness and understanding of flood risk and related climate change projections is low in Scotland. We found that this could in part be caused by several challenges which impact upon the effectiveness of flood risk communication, including that:

- Return periods were considered confusing by academic evidence and the study participants, both of which recommended they should not be used to communicate flood risk likelihood/probability;
- Uncertainty can negatively impact on people's motivation to act in a number of ways, including by discrediting the accuracy of projections; reducing the clarity of the message; reducing the belief in the source's credibility; and delaying policy responses to flood risk;
- Communicating flood risk and flood-related climate change projections can create an emotional, negative response from the affected individuals;
- Communicating flood risk without associated protective actions undermines people's motivation to act in response to the message and encourages the development of maladaptive coping responses;
- Adopting maladaptive coping responses like fatalism, learned helplessness, denial and wishful thinking lowers the individual's perception of flood risk in response to flood risk communication;
- Social vulnerability impacts negatively upon the ability to receive and act upon the flood risk communications;
- A lack of financial resources amongst those on low incomes reduces their capacity to respond to flood risk communications and consequently, encourages the adoption of non-protective maladaptive coping strategies to deny or dismiss the risk;
- Reduced capabilities (e.g. as people age; amongst those with long-term health conditions) leaves some vulnerable groups without the capacity to respond to flood risk communications, and consequently, encourages the adoption of non-protective maladaptive coping strategies to deny or dismiss the risk;
- Individuals may externalise responsibility for their flood risk protection to governing authorities and consequently fail to take action to protect their own properties in response to flood risk communication;
- A policy paradox, where individuals are told to be both personally responsible and to defer personal safety to the state, adds to existing confusion about

personal versus governing authorities' responsibility for flood risk protection;

- Communities rarely participate in the design of flood risk communications, and this lack of engagement reduces their perceived relevance and credibility;
- Differing use of terminologies causes confusion both within and between technical and public audiences;
- Confusion also exists amongst organisational stakeholders and the public about the roles and responsibilities of actors in the Scottish flood risk communication network.

2. Which tools and methodologies exist which can support communication of current and future flood risk and how can flood risk and related climate change predictions be communicated more effectively?

Examples of best practice in current and future flood risk communication approaches were gathered from the academic literature and the study participants' experience, and the accompanying evidence of their effectiveness was evaluated. The approaches were then grouped into eight categories:

1. *Dynamic mapping and 3D visualisations* are effective when based on robust data with clear guidance for use and explanations of limitations, and can be made more effective in future by co-designing the tool with its target users and offering support during use;
2. *Serious games* and the gamification of flood risk communications have the potential to be effective flood risk communication tools, capable of increasing players understanding of their own flood risk; the complexity of flood risk decision making; and giving greater insight into flood dynamics. However, this approach requires more robust systematic research evidence of effectiveness;
3. *Websites and apps* have limited reach and hence limited effectiveness as stand-alone flood risk communication tools, but can usefully complement and support other flood risk communication approaches. Further evaluation of their impact on the knowledge and behaviour of those who do use them is needed;
4. *Social media* is limited in its effectiveness as a communication tool as it only targets users of social media and so should only be used alongside other approaches when communicating with the public;
5. *Sustainable flood memories* approaches show potential for effective flood risk communication, as early evidence suggests that such methods (e.g. digital storytelling, flood walks, imagery like marks on buildings and other community-generated artefacts)

can build archives of historic flood experience which encourage shared local learning, including demonstrating protective solutions and adaptations that can be used in future floods events;

6. *Broadcast and Print Media* are effective mediums for flood risk communication, though a closer relationship between the current flood risk communication network and the media is needed to reduce sensationalist reporting and the panic and fear that causes, and to encourage positive narratives showcasing protection and adaptation solutions that are already being implemented effectively;
7. *Shared local learning* is an effective flood risk communication approach that can also build a positive shared social identity amongst local people as members of a flood resilient community;
8. *Participatory approaches and community engagement* were considered by many academic studies and by most study participants as best practice in communicating flood risk effectively, as they involve individuals in proactively managing their own flood risk; allow local people to share their own expertise; and enable communities to engage with flood risk specialists.

3) *What strategy can be adopted to develop a good understanding, amongst the public and partners, of what 'managed adaptation' means and looks like in practice?*

The evidence from this study suggests that developing a managed adaptation strategy to encourage an understanding of the concept and in practice can only be achieved if the public and partners already understand and engage with flood risk communications i.e. correctly perceive their flood risk and understand that this risk demands action now to protect everyone in future. As this is currently not the case across the majority of the general public, it is too early in the development of effective communication approaches to develop a good understanding of managed adaptation amongst the public and partners. Therefore, it is recommended that the concept and its practice must be integrated in all future flood risk communication strategies to develop a good understanding, amongst the public and partners, of what 'managed adaptation' means and looks like in practice.

Recommendations

In total, 17 recommendations are made, based upon the evidence gathered in this study. These recommendations are targeted at policy-makers or organisations and communication practitioners, except our first recommendation, which is appropriate to both. It recommends that:

1. Future flood risk communications should include recommended actions that are *affordable, achievable and appropriate* to the socioeconomic and demographic status of diverse households.

To achieve this will require commitment from policymakers, organisations and flood risk communication practitioners, as it requires both clear communication and financial support for those least able to afford to protect themselves and adapt to their increasing flood risk. The remaining 16 recommendations are targeted specifically at policy-makers or organisations and communication practitioners:

For policymakers:

2. National and local policies should enshrine support for bespoke household-level flood risk communication to ensure the public, and particularly socially vulnerable and marginalised groups, can act in response to flood risk communication and so be resilient to future flood-related climate change impacts;
3. Statutory regulations should be developed that require providers of temporary accommodation/ business premises to ensure their properties are flood resilient, including providing those temporarily occupying the property with clear guidance on actions to take in the event of a flood warning;
4. A database of flood resilient measures at household and property level should be developed for every Scottish community;
5. A national approach should be developed that financially supports the installation of household flood risk protection and adaptation measures, particularly for those on low incomes, to ensure future flood risk communication is more effective and Scottish households are more flood resilient;
6. A flood risk communication strategy should be co-designed with communities and an inclusive range of stakeholders with clear ownership of actions, strong leadership and shared guidance on effective approaches;
7. The Scottish Government should conduct a systematic survey of the Scottish public's current flood risk perception to increase the effectiveness of future flood risk communication.

For organisations and practitioners involved in flood risk communication:

8. Future flood risk communications should be positively framed, demystify assumptions, and address local myths, encouraging collective action to enhance community resilience and promoting an empowering shared social identity of preparedness in place;
9. Flood risk communications should be developed

locally in collaboration with the community at risk to maximise their effectiveness;

10. Return periods should no longer be used and instead new approaches to communicating probability and risk should be employed and their effectiveness tested;
11. Dynamic maps and 3D visualisations are effective communication tools, particularly when co-designed with communities and where support is provided to people during their use;
12. Serious games offer communicators potentially effective diverse communication tools that may increase players' understanding of flood risk decision making and encourage them to consider their own flood risk responses, but further research evidence of their effectiveness is needed;
13. Websites and apps have limited effectiveness as stand-alone flood risk communication tools, but can supplement other flood risk communication if ongoing investment is made in the Scottish flood communication digital infrastructure to ensure it is accurate and intuitive to use;
14. Organisations involved in flood risk communication should consider using community-led social media to engage with local people, and use social media as one of a mix of several digital and non-digital communication approaches due to its limited engagement;
15. Organisations and practitioners involved in flood risk communication should support the development and dissemination of community-led sustainable flood memories archives that can be shared with others to encourage protective and adaptive actions;
16. Organisations involved in flood risk communication should work closely with the media to build a positive narrative within Scottish flood risk communication, and use multiple types of broadcast and print media when communicating flood risk information to maximise the reach of their messages.

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SEPA Flood Maps: <https://www.sepa.org.uk/environment/water/flooding/flood-maps/>

Climate Central: <https://coastal.climatecentral.org/>

FireTree Flood app: <http://flood.firetree.net/>

Hazard and Hope: <https://www.hazardandhope.com/>

Exeter Flood Visualisation: <https://www.youtube.com/watch?app=desktop&v=kmjkcXYRVh8>

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