‘Understanding Flood Resilience in Vulnerable Urban Communities in England’

A thesis submitted in partial fulfilment of the requirements of Liverpool John Moores University for the degree of Master of Philosophy

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Abstract

Flooding is expected to affect more people than any other natural hazard worldwide. Previous research in flood sciences tends to focus on measuring and reducing the risk of flooding, however, there is a general agreement that a shift of focus is required, to more dynamic approaches, such as embedding flood resilience within communities. Understanding resilience is therefore key in aiding communities, both pre- and post-disaster.

Existing literature highlights there is a lack of understanding in the field surrounding the definition of flood resilience and how to measure it. Application of existing methodologies is limited with England, due to differing community dynamics and accessible data sources. Therefore, this study aims to identify factors that may be applicable for measuring flood resilience within the England, utilising lay knowledge from community members with different flooding experiences.

Community flood resilience factors were taken from existing resilience analysis methodologies and other resilience research (*n=74*) and processed through a 3-stage sift. The remaining factors (*n=20*) were presented to flood action group members and members of the general public, through random sampling, in areas that had either experienced severe flooding (Kendal, Cumbria) or not experienced severe flooding (Chester, Cheshire), in a questionnaire, including a mix of closed questions (i.e. Likert Scales) and open questions, to allow participants to voice important opinions. The questionnaire was designed to gauge their opinions on flood resilience, previously determined community flood resilience factors, and provide an opportunity to recommend other factors.

Results indicated that whilst the factors presented to participants were believed to be applicable in measuring flood resilience, they vary in importance. Flood action group members rated socio-cultural factors (such as community representative bodies and sense of community) of higher importance, whilst both those who have previously experienced flooding and those who have not experienced flooding, tended to favour physical factors such as efficiency and maintenance of infrastructure. Whilst further potential factors were identified (previous flood experience and flood defences), these may not be applicable in all communities, due to differing local environments/contexts and community compositions.

Therefore, a dynamic 'bottom-up' model for flood resilience is suggested, with core factors applied (land use, community composition, resources, and flood insurance), and then additional factors that can be included in the framework, depending on the community and its circumstances.

Declaration

I declare that no portion of the work referred to in the thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

Acknowledgements

I would like to thank the National Flood Forum, namely Heather Shepherd, Tracy Garrett, and Jean Timmins, for all their assistance in contacting members of Flood Action groups and sending out questionnaires for me. I would like to extend my gratitude to Dr Sarah Percival, for the unparalleled help and support she has provided throughout, and the comments she has provided for helping to improve this study. I would also like to thank Dr Kostas Kiriakoulakis for his encouragement and useful comments. Finally, I would like to thank my family for their unwavering support and encouragement over the past few years.

1. Introduction

The severity of hydrological hazards is ever increasing across the globe, heavily impacting the livelihood of communities worldwide (Kundzewicz and Matczak, 2015), with approximately 34.2 million people being affected between 1990 and 2020 (Salas, 2023). It is expected by 2050 that 70% of the world's population will live in flood vulnerable urban areas (da Silva, Kernaghan and Luque, 2012), increasing the likelihood of flood-related disasters due to sheer community exposure. This risk is further heightened due to ever increasing climatological changes, with flooding expected to affect more people in the future than any other natural hazard (Hallegatte *et al.,* 2017).

Within the UK, approximately 1.8 million people live in areas with a greater than 1 in 75 annual chance of pluvial, fluvial, or coastal flooding, which is projected to rise to 2.6 million by 2050, under a 2^{o}C scenario (Kovatas and Osborn, 2016). This has a huge economic burden, with annual damages to properties in England from fluvial and coastal flooding estimated at more than £1 billion (Environment Agency, 2009). Furthermore, flooding is considered one of the most complex natural hazards to manage, as it has many added complications, including coincident flooding, which combines several flood types at once (Thorne, 2014). This was the case in the 2007 UK floods, which had an economic cost of around £3.2 billion (Penning-Rosswell, 2014), affecting around 48,000 households, and causing 13 deaths (Cabinet Office, 2008). Added to this, further major flood events have followed in the UK, including 2009, 2013/14, 2015 and most recently 2019/2020, causing widespread problems and impacts. Whilst there are extensive flood defences and Catchment Management Plans (CMPs) in the UK, current levels of flood adaptation are considered inadequate (Committee on Climate Change, 2017; Percival, Gaterell and Teeuw, 2019). Highlighting, further research and policy implementation is required to help achieve effective management and crucially reduce impacts of flooding on communities.

Flood risk has become the centre of research in current years, with many previous studies focusing on how to measure risk, as well as its communication (Kellens, Terpstra and De Maeyer, 2012). Many flood risk assessments consider Crichton's (1999) risk triangle of **Risk =**

Hazard x Vulnerability x Exposure, where vulnerability can be broken down further into physical vulnerability, socio-economic vulnerability, and resilience (e.g., IPCC, 2014; Percival and Teeuw, 2019; Biswas, 2023). However, there is a consensus that 'traditional' flood control measures and measurements are inadequate response to the growing risk (Restermeyer, Woltjer and van der Brink, 2014), and a shift from risk-based approaches to more dynamic approaches, such as flood resilience, is required. However, there are many unanswered questions regarding flood resilience, including what it is and how it is measured, despite its recognised importance.

Understanding flood resilience is a crucial part of a communities' pre-disaster preparation and post-disaster recovery (Frazier *et al.,* 2013). However, there is a lack of understanding surrounding resilience within natural hazards and flooding fields, yet it is widely used in other disciplines, such as psychology, ecology, and medicine (Manyena, 2006). Holling (1973) introduced the term 'resilience' into ecology, providing a definition of: "*a measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables*". This has provided a backbone that other fields have built on; however, it has created an ambiguity surrounding a definitive application of the concept, especially within flood sciences (McClymont *et al.,* 2020). Furthermore, this ambiguity extends to understanding how resilience is used within the field, as well as how it is measured.

Whilst some consider that resilience is the opposite of vulnerability (Wilson, 2012; Usamah *et al.,* 2014; Talubo, Morse and Saroj, 2022), many believe that it is measured as part of vulnerability, and risk (i.e., Crichton,1999; Klein, Nicholls and Thomalla, 2003; Manyena, 2014; Percival and Teeuw, 2019). However, being measured as part of vulnerability may lead to a generalisation of resilience, by not measuring it as a stand-alone factor, and therefore reduces its significance within flood risk analyses and the measures based on them, creating irregularities, and questioning the dependability of the measurements. This provides issues in measuring how people may react to flooding, as well as overestimating how prepared people are to flooding. Evidence of this inclusion can be identified in numerous studies (e.g., Fielding, 2012; Cutter *et al.,* 2013; Percival and Teeuw, 2019), which identify resilience as an important factor within flood risk assessments, yet also state more needs to be done. Whilst the inclusion of resilience to flooding has become widely accepted, there is very little exploration into the resilience of communities.

1.1 Communities and Flood Action Groups

Whilst communities may not necessarily have clear geographical boundaries, it is generally agreed that they are a system where man-made, social, ecological, and economic environments have influence over each other (Norris *et al.*, 2008). However, as with many other fields, the definition of community has been up for debate (Bradshaw, 2008). In the Oxford English Dictionary, there are at least 20 definitions for the term, with many being obsolete. However, the definition of '*A body of people who live in the same place, usually sharing a common culture or ethnic identity'* (Oxford English Dictionary, 2022) has been used in this study to define the term community, as this provides a general definition of community, that doesn't have geographical boundaries, that can be adapted for community flood resilience.

Measuring community resilience can assist in communities becoming less vulnerable to hazards (Cutter *et al,* 2008). Again, community resilience is a term that has many definitions, however, it is generally considered as 'the ability of communities to be able to recover quickly from disruptions, as well as their ability to adapt to future hazards' (National Institute of Standards and Technology, 2020; Abdel-Mooty *et al,* 2021). There is no consensus on whether community resilience is only applicable to people, or if it also extends to physical and ecological systems, depending on the field of study.

Whilst there have been few studies that have focused on community flood resilience, they generally only look at one or two communities, and therefore do not generate data required to identify generalisable trends within the data surrounding interactions between community characteristics (Laurien *et al.,* 2020). Therefore, a more in depth and holistic model is required for generalisation and direction, to help communities most at risk. To achieve this, utilising knowledge embedded within the community is key, as lay knowledge can provide key learning opportunities to increase the adaptive capacity of communities (McEwan *et al.,* 2016), as well as inform decisions by stakeholders. Whilst this has not been utilised prior to this study, communities over time in the UK have been creating Flood Action Groups, to give them a platform within flood risk management practices.

Flood action groups are grassroot community groups (>400 in England), who act as a representative voice for the wider community (National Flood Forum, 2020). Research by Forrest, Trell and Woltjer (2017) identified flood action groups as groups of people who have an interest in flood issues, and meet to discuss flood-related issues, providing advocacy for the local communities on pressing issues, as well as aiding in times of crisis.

Many of the groups are supported by the National Flood Forum (NFF), who are a charity dedicated to helping communities before, during and after flooding, whilst providing support with stakeholder relationships. Inclusion of these groups in flood research is vital as they provide vital lay knowledge about areas that may be otherwise missed, allowing the complexity of local flooding to be captured, as well as the effects following events (McEwen *et al.,* 2012). This knowledge usually lays latent in communities, and only called upon in times of disaster, however, it could be used proactively in order to harness local expertise and help flood risk management be as effective as possible. As a result of the Pitt review (2008), DEFRA now acknowledge that lay community knowledge is vital (DEFRA, 2008; McEwan *et al*., 2016), with previous research also using community knowledge within disaster risk and resilience management (i.e. Mercer *et al.,* 2010; Maskrey, 2011; Cox and Hamlen, 2015). Utilising this knowledge is important in enhancing flood resilience, giving a vital insight of the flood resilience existing within the communities prior to flood risk adaptation taking place.

1.2 Purpose of Study

Aligning with the concept of 'living with water' (Oladokun, Proverbs and Lamond, 2017), flood resilience aims to create a sustainable alternative to the construction of flood defences, whilst protecting as many communities as possible. However, with limited understanding about what flood resilience means and no definitive ways to measure how resilient communities are to flooding, the concept may become redundant within communities over time. Added to this, even though flood resilience and community involvement is widely accepted, there is limited evidence of this within existing methodologies to measure flood resilience. Many methodologies are based on prior research, or in partnerships with the private sector (Renschler *et al.,* 2010; Keating *et al.,* 2017), which can limit the application within communities. It is therefore vital that further research is conducted, to not only allow the concept of resilience to be measured and understood, but to grow, and become widely accepted in research and within communities, including those that have previously been affected by flooding, and those that have not. To close these gaps this study aims to understand and analyse factors that influence community resilience to flooding in vulnerable urban areas. This will include analysis of previous research, to gauge definitions of flood resilience, as well as identify possible factors to measure community flood resilience. Specific objectives included:

1. Identify existing resilience factors via desk study, which will then be sifted to ensure applicability within community flood resilience.
2. Undertake virtual questionnaires with flood action group members in England, assisted by the NFF, to assess key factors that are important in measuring community flood resilience, and how these may fit into a pilot framework.
3. Undertake field surveys in two contrasting areas, that have similar geographical and community compositions (Kendal, Cumbria (previously experienced severe flooding) and Chester, Cheshire (not previously experienced severe flooding)), to further assess the key factors that are important in measuring community flood resilience, and how these may fit into a pilot framework.
4. Collate and analyse data, listing final community flood resilience factor recommendations.

2. Literature Review

As an emerging topic, there are complications surrounding both defining and measuring flood resilience. Whilst many researchers have attempted to define the concept of resilience, there has been limited research operationalising it in practice (Nguyen and James, 2013). However, there have been several different methodologies to measure flood resilience, each of which focus on different scales, locations, and frameworks of resilience. For a complete understanding of resilience and how this can be measured, a review was conducted of existing literature surrounding the topic, and previous methodologies, on both defining flood resilience, and ways to measure it.

2.1 Defining Flood Resilience

Whilst research within the field of flood resilience is increasing, there is still a lack of consensus surrounding the definition of flood resilience. Currently there is no single definition for flood resilience (Adedeji *et al* 2018; McClymont et al 2020; Disse *et al* 2020), however there are similarities between existing definitions.

A review of papers published between 2017 and 2021 concluded over 30 different definitions of flood resilience in 70 papers. A frequency analysis showed that similar language is used throughout the definitions within the sample (*Figure 1)*, with the most common key words within these definitions including 'absorb' (*n=25)*, 'recover' *(n=25)* and 'adapt' *(n=22)*. This language is synonymous, not only with flood resilience, but also flood and disaster risk in general. Whilst the majority of the papers provide differing definitions, the most common definition was stated in 6 papers (Atreya and Kunreuther, 2017; Keating *et al.,* 2017; Campbell *et* al., 2019; Rezende *et* al., 2019; Laurien *et al*, 2020; Hochrainer-Stigler *et al*., 2020), provided by Keating *et al.,* (2017): "*the ability of a system, community, or society to pursue its social, ecological, and economic development and growth objectives, while managing its disaster risk over time, in a mutually reinforcing way*".

Figure 1: TagCloud of keywords in resilience definitions and frequencies.

Keating *et al* (2017) refer to three types of resilience within their definitions: System, community and economic. These create diverse and well-rounded definitions, which are not specific to a singular source, unlike Haque and Doberstein (2021), who's definition of community flood resilience simplifies the term, only referencing a community's ability to withstand external factors, with minimal support. Early definitions of resilience appear to encompass a broader concept of resilience, for example Wildavsky (1991), referred to it as 'bouncing back' after unanticipated dangers, which becomes more focused and branches into several disciplines within flood resilience, including community, socio-economic and systems resilience, with overlap between the disciplines, as shown in Figure 2. Papers were categorised by the focus of their definitions, with 'systems' being physical based approaches, 'community' equating to definitions that consider how communities react to flooding, and 'socio-ecological' definitions reflecting on the relationships between society and ecosystems. The 'other' category encompasses more generalised definitions, such as Xu *et al* (2021) '*The ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse* *event*'. These types of definitions are recorded throughout the review and are generally tautological.

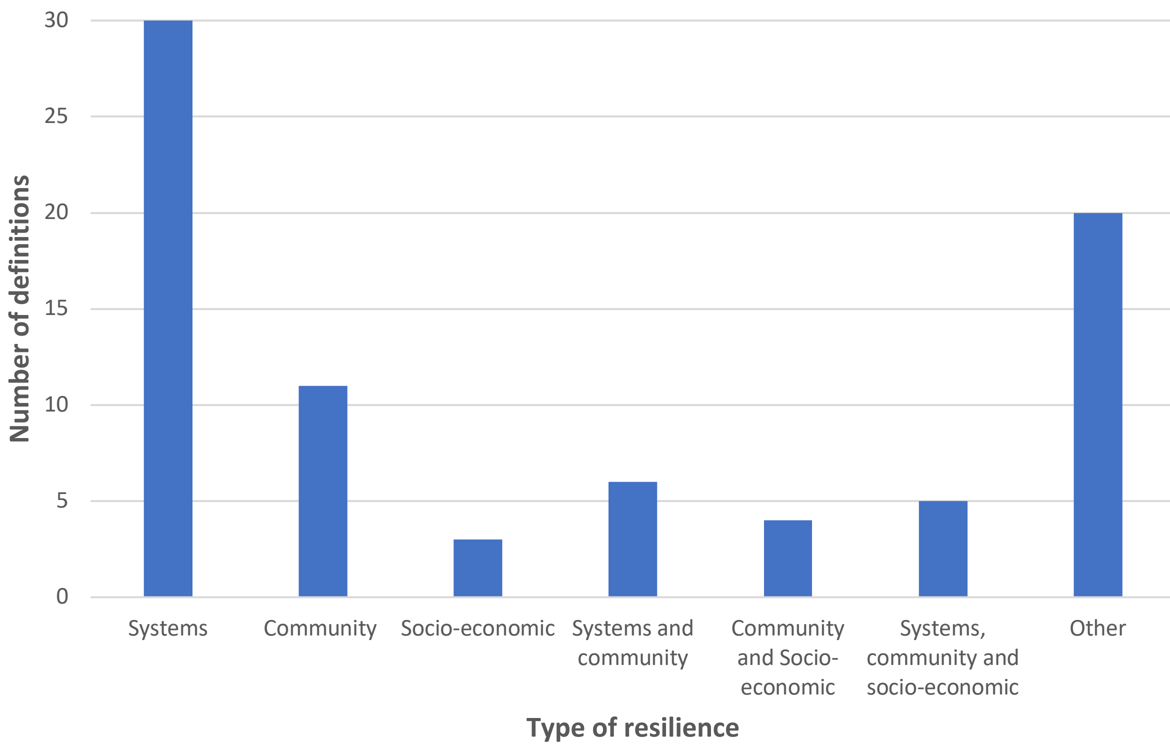

Figure 2: Themes of papers included in the review of flood resilience definitions.

The focus of the paper reviewed also affects the definition used and the theme of the definition, creating dichotomy within the field. Of the papers included in the review, 57% were based on flood resilience, with the other 43% split between disaster resilience, climate resilience, community resilience, urban resilience, and uncategorised resilience (*Figure 3*). For example, there are differences between urban resilience and flood resilience, however, there is overlap when it comes to the socio-economic focus of the two. Wardekker *et al.,* (2020) defines urban resilience as "*the ability of a city or urban system to withstand a wide array of shocks and stresses*". They also provided a second definition, which has a stronger socio-economic base, referring to how communities, businesses and systems adapt and grow after a disaster. Whilst Nurwulandari and Rismana (2021) define community flood resilience as: *"the ability of the community to survive and rise after a disaster".* Even though these papers have differing focus, there are similarities within the definitions, referring to 'survival' after disasters, as well as growth and recovery post-disaster.

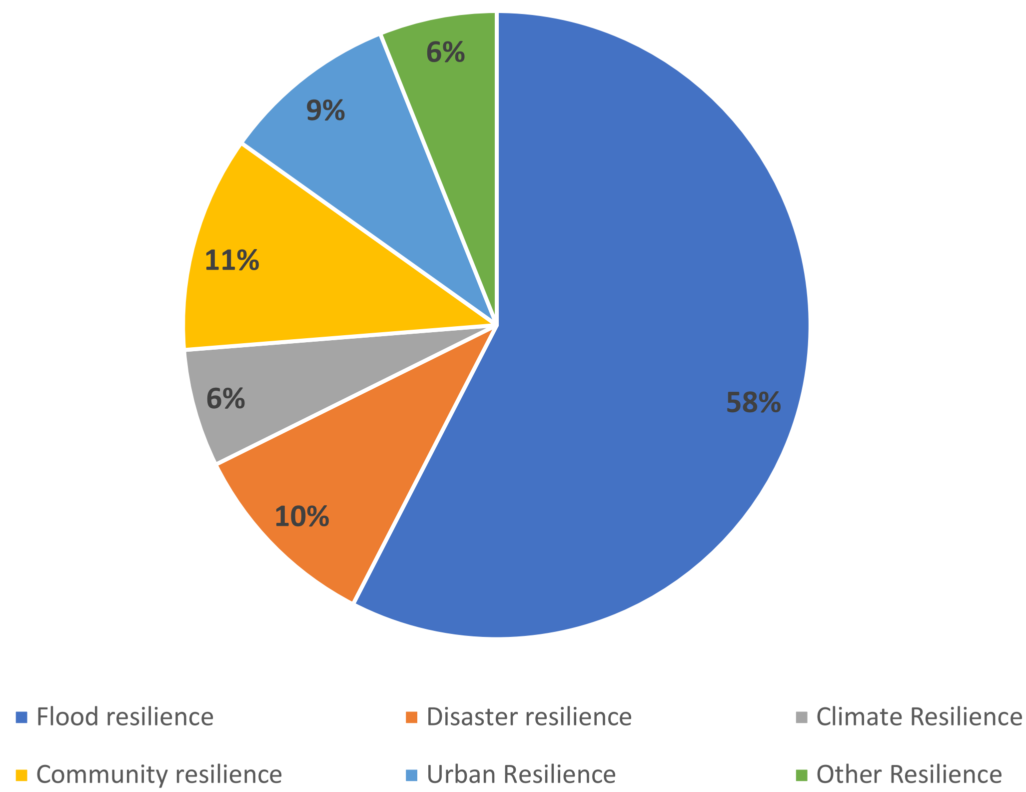

Figure 3: Types of resilience papers included in flood resilience definition review.

As a relatively new concept, there is a level of evolution expected within flood resilience, with increasing diversity, it is increasingly more difficult to define resilience. This has been widely observed within other fields, causing a lack of convergence (Monte *et al.,* 2021), creating confusion in emerging topics. However, there is a clear evolution of definitions within the field. Murdock *et al.,* (2018) research focused on flood resilience, providing a simple definition, referring to being able to cope with disturbances. Compared to Hemmati *et al.,* (2020), who also focused on flood resilience, stated resilience is not only the ability to cope, but also recover and adapt to any adverse effects. The latter appears to build on the definition provided by Murdock, suggesting that over the years, the definition is evolving even further, as other research has developed.

Within the public sector, there are once again variations in the definitions, if there is one provided. Within the HM Government (2016) National Flood Resilience Review, the focus is still very much risk-based, focusing on infrastructure and defences. However, the Flood and Coastal Erosion Risk Management (FCERM) scheme, set out by the Environment Agency, defines resilience in terms of flooding and coastal change, referring to the capacity of not only people but also places. Whilst it still refers to 'protecting' people and places, it also incorporates recovery and adaptation to coastal changes and climate changes (Environment Agency, 2023). This shows that there are further considerations of flood resilience within the governmental sector, and the understanding of the concept is developing.

Further evolution of the definition of flood resilience is expected, as there is an increase in focus on the topic, therefore it is unlikely a consensus on the definition will be reached within the near future, however, the use of conferences and working groups could aid with accelerating discussions and advances of the definition. Whilst there is no singular definition, many of them utilise similar language, and portray similar messages, which indicates a potential consolidation of knowledge, that is essential if there is a consensus to be reached. Further investigation into the definition and the publics perspective of this is required, to further investigate understanding of the topic within communities, and how this can influence models measuring flood resilience within communities.

Whilst there is further development required for the definition of community flood resilience, a general working definition for the thesis is suggested as: 'A communities ability to plan for, absorb, and recover from flood events, whilst being able to adapt effectively to future events'. This definition encompasses aspects of other previously provided definitions, however, requires further development in future research.

2.2 Measuring flood resilience

The complexity and confusion surrounding defining flood resilience extends into measuring flood resilience. Starting in 1990 with the International Decade for Natural Disaster Reduction (IDNDR), which was dubbed to be the decade that paid attention to fostering international co-operation in natural disaster reduction (United Nations Office for Disaster Risk Reduction, 2016), building frameworks for disaster reduction has become a parallel effort.

2.2.1 Resilience Frameworks

Aiming to conceptualise resilience definitions, resilience frameworks start to introduce groupings for definitions, creating foundations for factor based methodologies to be built upon. However, there has been no consensus on which framework is best used to measure community flood resilience. With each researcher having a different focus and view on resilience, three main frameworks have emerged: Ecological, Engineering and Adaptive resilience, which are illustrated in *Figure 4*.

Figure 4: Ball and cup model of system stability in the three main resilience frameworks. Adapted from Gunderson (2000) and Scheffer et al., (1993) in Laboy and Fannon (2016).

Engineering Resilience

Typically associated with infrastructure, engineering resilience assumes that the systems remain constant over time, and after a disaster returns to pre-disaster conditions (Angeler and Allen, 2016). Increasingly applied in planning, it normally depends on the deployment of flood resilient design or technologies (Zevenbergen, Gersonius and Radhakrishan, 2020). Originally proposed by Bruneau *et al*., (2003), the 4 Rs model identifies properties of social and technical resilience as robustness, redundancy, resourcefulness, and rapidity, however this was later adapted to include risk avoidance and recovery (Laboy and Fannon, 2015). This is outlined in *Figure 5.*

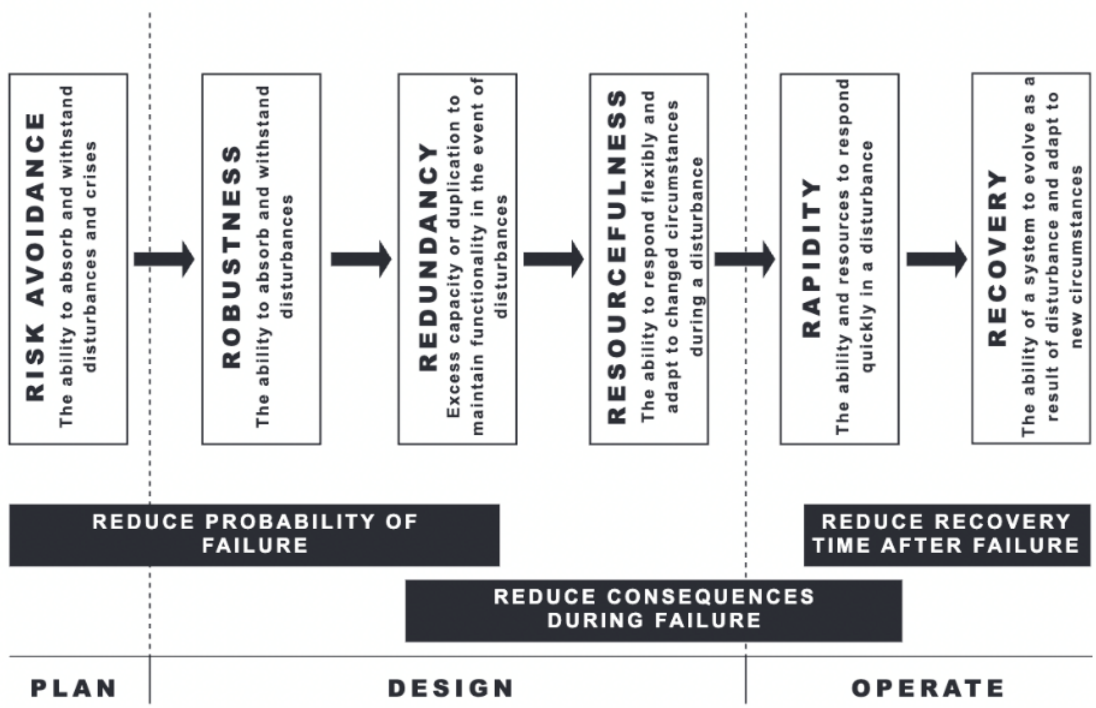

Figure 5: 6Rs model of dimension of engineering resilience (Laboy and Fannon, 2015)

Ecological Resilience

Ecological resilience is considered to have been founded by Holling (1973), as previously quoted. Whilst engineering resilience focuses on a singular equilibrium, ecological resilience is considered multiple equilibria, where post-disruption state can differ from the pre-disruptive state, whilst still being resilient (Linkov *et al.,* 2014). This also aligns with the concept of 'building back better' (UNISDR, 2017), which focuses on the phases after a disaster to increase resilience of communities, without the need to return to pre-disaster conditions, which is expected in engineering resilience.

Adaptive resilience

Also referred to as socio-ecological resilience, adaptive resilience can be described as '*the capacity of linked social–ecological systems to absorb recurrent disturbances such as floods so as to retain essential structures, processes, and feedbacks'* (Folke, 2006; Zevenbergen, Gersonius and Radhakrishan, 2020). Designed to overcome the limitations of engineering and ecological resilience, in the sense that they are both static, adaptive resilience introduces the consideration of a temporal dimension of resilience (Zevenbergen, Gersonius and Radhakrishan, 2020). Ensuring humans and ecological environment is at the forefront of research, adaptive resilience allows human well-being to be continually supported, whilst creating a holistic approach to measuring flood resilience (Chapin *et al,* 2010*;* Biggs, Schlüter and Schoon*,* 2015; Folke *et al.,* 2016). However, this can only be measured after a disaster (Cariolet, Vuillet and Diab, 2019), therefore limiting the application to areas that have experienced disasters.

2.2.2 Five Capitals of Flood resilience

Building on resilience frameworks, capital-based approaches have been widely considered and utilised within resilience towards natural disasters (Kusumastuti *et al.,* 2014). The notion of these capitals aligns with the notion of sustainability (Smith, Simard, and Sharpe, 2001), which is often related to the concept of disaster resilience and can be used to incorporate several or all resilience frameworks. These are built off of the 7 capitals of the Community Capitals Framework (CCF) (Guitierrez-Montes, Emery and Fernandez-Baca, 2009). Mayunga

(2007) used the capital framework to contribute to reducing community vulnerability whilst increasing resilience, as depicted in *Figure 6.*

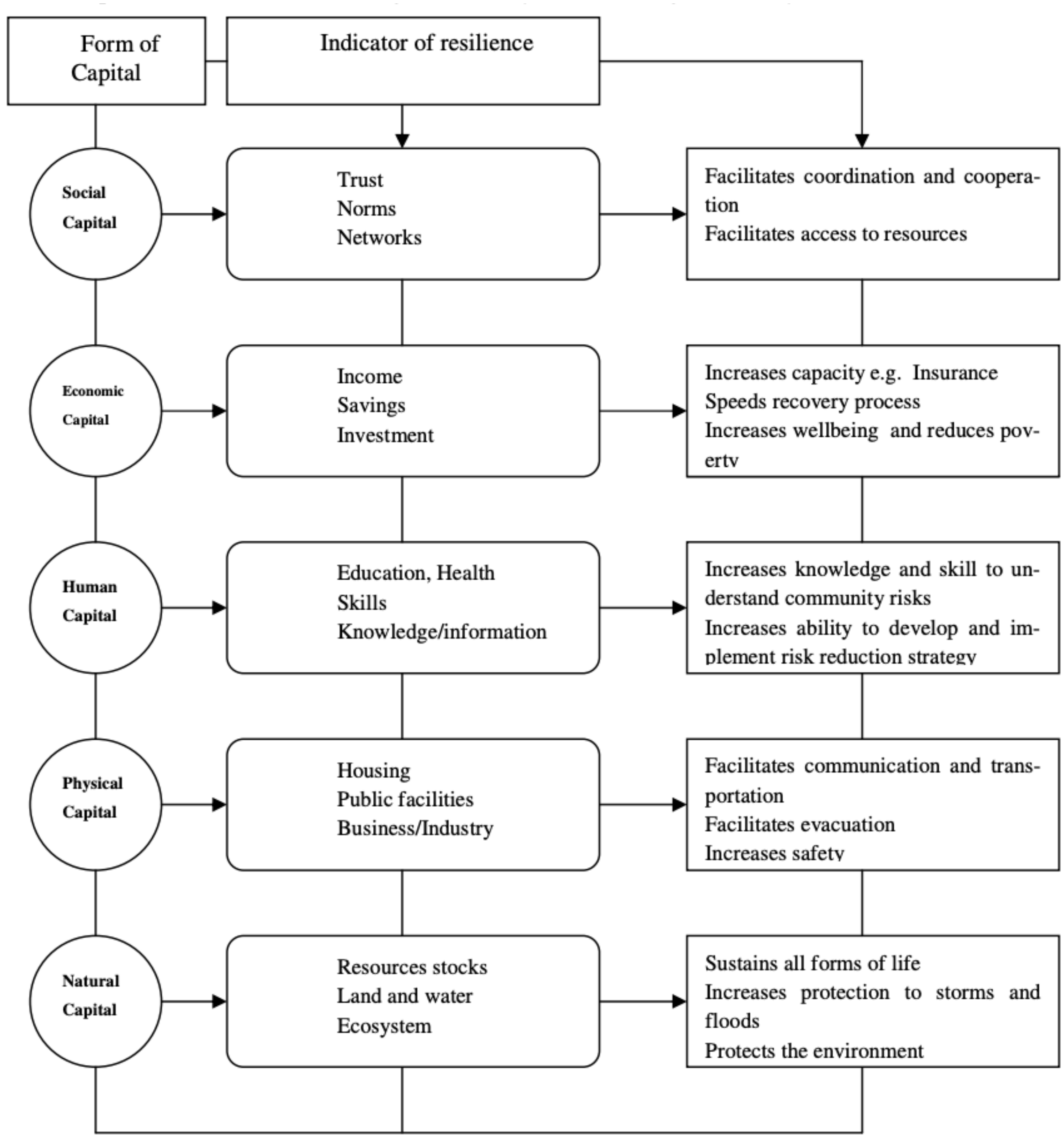

Figure 6: Outline of Capital Framework and factors used by Mayunga (2007)

Social Capital has been utilised in numerous studies (Bruneau *et al.,* 2003; Simpson and Katirai, 2006; Norris *et al.,* 2008; Keating *et al.,* 2017; Laurien *et al.,* 2020), however it is yet to be fully embraced as a critical component of resilience (Aldrich and Meyer, 2015). Considered to be a core mechanism underpinning effective individual and collective action (Adger, 2003), social capital often involves a strong emphasis on structural dimensions, with socio-cultural elements overlooked and underplayed (Carmen *et al.,* 2022).

<u>Physical Capital</u> focuses more on the built environment and transportation infrastructure. It is generally the most considered capital. A review by Rozer, Mehryar and Surminski (2022) identified 90% of papers on urban flood resilience included physical capital. There are many papers that just focus on the physical capital, such as Dong *et al.,* (2023), who focused on characterisation of a resilient transport network. This however creates a reductionist view of resilience, where a multi-dimensional view is required to encompass resilience and how communities work (Bulti, Girma and Megento, 2019).

<u>Human Capital</u> is generally the education, skills, and health of the community members, and is used to assess people’s skills and knowledge about what to do during a flood event (Nelson, Adger and Brown, 2007; Keating *et al.,* 2017). These factors are generally influenced by the communities themselves, especially if there is a flood action group within the local area. Studies have found that the actions and knowledge of flood action groups influence the flooding awareness and knowledge of individuals (Forrest, Trell and Woltjer, 2017).

<u>Natural Capital</u> represents parts of the natural environment that are key for sustainability and ought to be maintained for present and future generations (Brand, 2008). Within flood resilience, it is usually measured to assess how changes in the natural environment are reducing or exacerbating flood risk in the communities (Keating *et al.,* 2017).

<u>Fiscal (Financial) Capital</u> generally focuses on the economic burden of flooding, which is considered one of the most significant threats to community resilience (Wickes *et al.,* 2015). However, many of the factors that have been presented in other studies, such as disaster response budget (Keating *et al.,* 2017; ARUP, 2018) are not likely to be available at community level within England, and therefore this may need to be measured on a national scale and then implemented in a community scale.

Even though these capitals are usually used to categorise factors within models, there needs to be overlap between them, to ensure that a community is resilient (Keating *et al.,* 2017). This overlap represents the complexity of flooding, whilst providing a framework that is applicable within communities, however, this is not observed in all previous models.

2.2.3 Factor Based Methodologies

Many methodologies focus on qualitative approaches to measuring disaster and flood resilience. McClymont *et al.,* (2020) reviewed 67 papers on flood resilience and found that 61% of the methods used a qualitative approach, favouring descriptive interviews, focus groups and surveys. These are favoured due to the richness of the data, allowing deeper insights into issues (Tenny, Brannan and Brannan, 2022). Whilst these allow communities and stakeholders to voice their opinions, they are less diverse than using quantitative approaches (McClymont *et al.,* 2020). However, many methodologies use both qualitative and quantitative approaches, to add depth, diversity, and rigor to the process, that is important for encompassing the complexity of community flood resilience and providing a holistic methodology.

One of the first methodologies to implement this was Cutter *et al.,* (2008) who developed the Disaster Resilience of Place (DROP) model, to ameliorate the shortcomings in previous vulnerability and resilience models. One of the pioneering models for measuring resilience at community level, focusing on social resilience of places, whilst acknowledging other forms of resilience exist. This model aimed to present resilience as both inherent and antecedent conditions (*Figure 7).* Furthermore, the model encompassed 29 candidate factors in 6 dimensions and was created as a theoretical model and required additional research on resilient measures to allow operationalisation of the model.

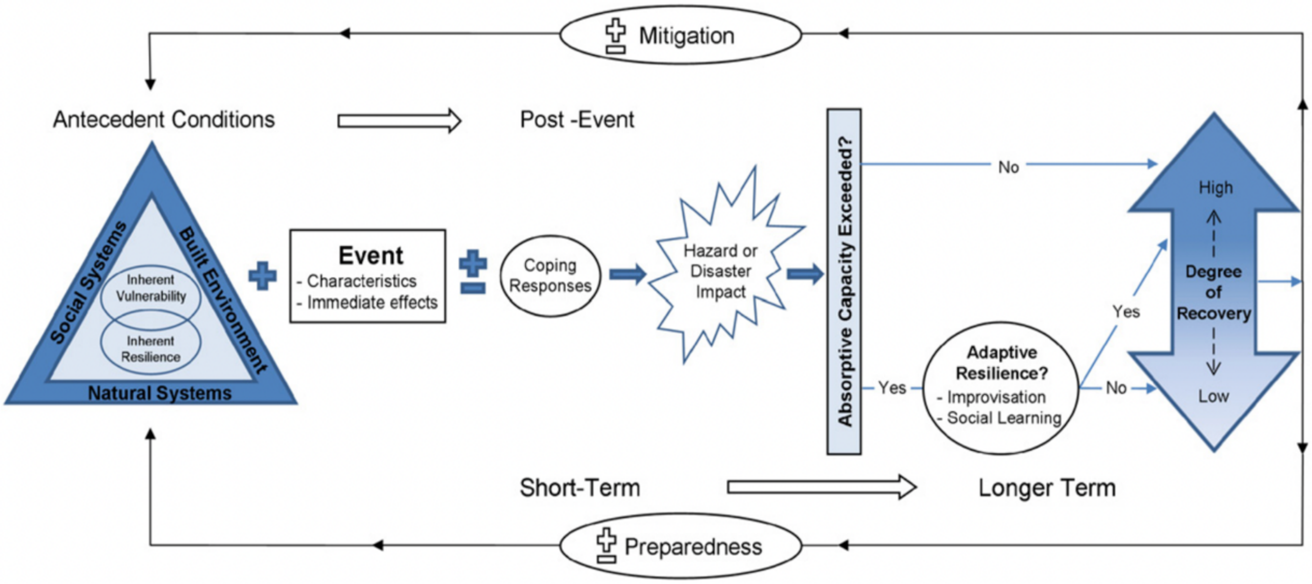

Figure 7: Schematic diagram of the DROP model, by Cutter et al., (2008)

Even though it was designed as a theoretical model, it has been adapted into functional models, such as Morelli *et al.,* (2021), who integrated the DROP methodology to create an in-depth analysis in coastal areas, whilst also highlighting the importance of stakeholder inclusion in creating methodologies. McEwen and Jones (2012) highlight the importance of 'lay' knowledge, further highlighting the importance of stakeholder inclusions, to allow a focus on community-lead adaptation. However, models need to encompass many communities to generalise insights about interactions within communities.

Laurien *et al.,* (2020) identified that the DROP model didn't generate the data required to identify and generalise insights about interactions within communities, due to only looking at limited communities. Therefore, in partnership with Zurich Insurance, the Flood Resilience Measurement for Communities (FRMC) was created. This was curated encompassing 44 indicators, encompassing the 5Cs of Human, Social Physical, Financial and Natural Capital (derived from the Sustainable Livelihoods Approach) (Flood Resilience Alliance, 2019). Outlined in *Figure 8,* the model is designed with communities at the forefront, through inclusion of household surveys and focus groups, as well as engineering experts (Keating *et al.,* 2017).

However, the complexity of the model meant that the data collected in the field needs to be assessed by an expert assessor (Campbell *et al.,* 2019), reducing the accessibility for communities, adding complexity to the design and distribution of the model. The model has also been developed to be used in multiple communities worldwide, which may generalise effects, and reduce the applicability of the model.

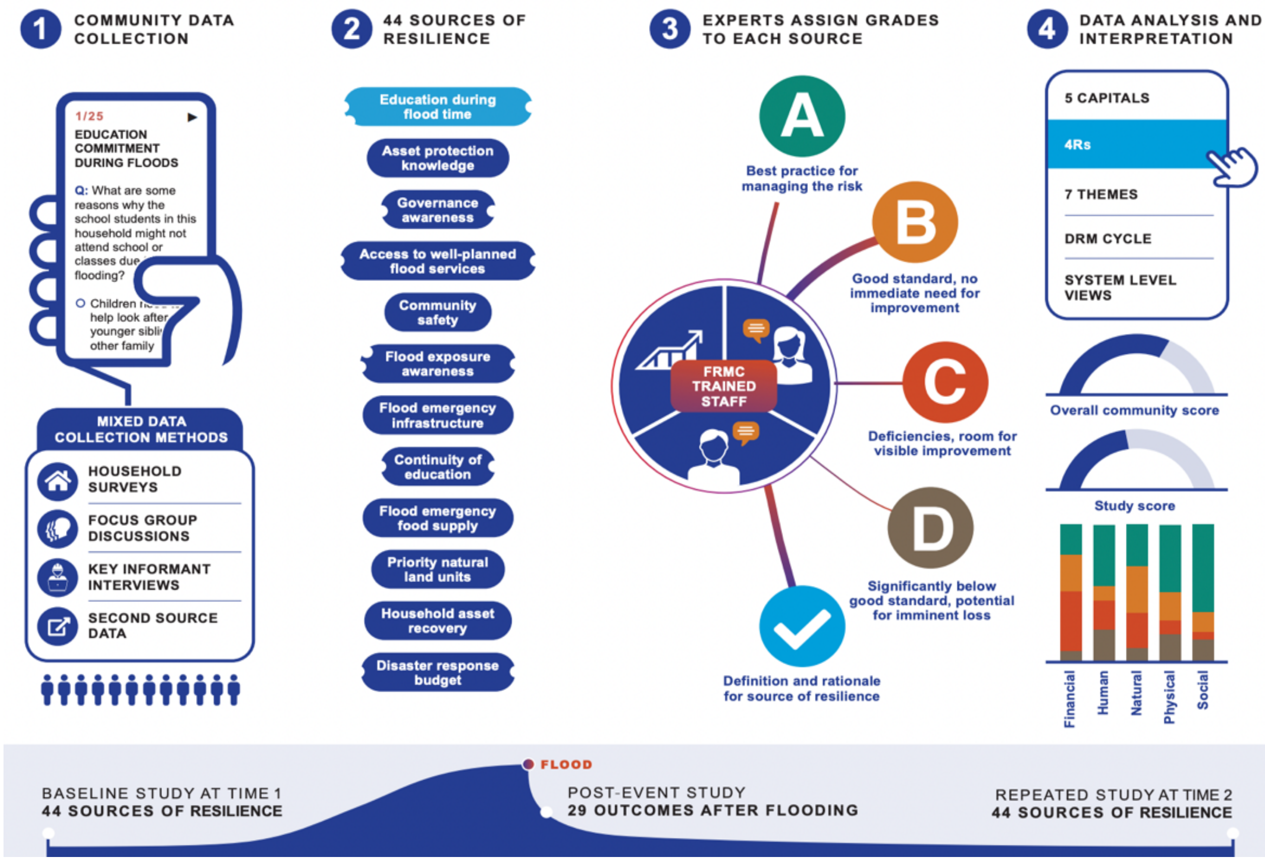

Figure 8: Diagram of DROP model by Keating et al., (2017).

Trying to reduce these issues, the Flood Resilience Rose (FRR) presents a new dynamic approach, creating a multi-layer approach, that not only focuses on resilience as a standalone factor, but as part of a risk-based approach (Karrasch, Restemeyer and Klenke, 2021). The model is based around four layers of action, namely Recovery, Protection, Preparedness and Prevention (*Figure 9*). Whilst this is designed to be a management tool, to assist with transformation towards flood resilience, it highlights that resilience is not a standalone tool, and can be used within flood risk management.

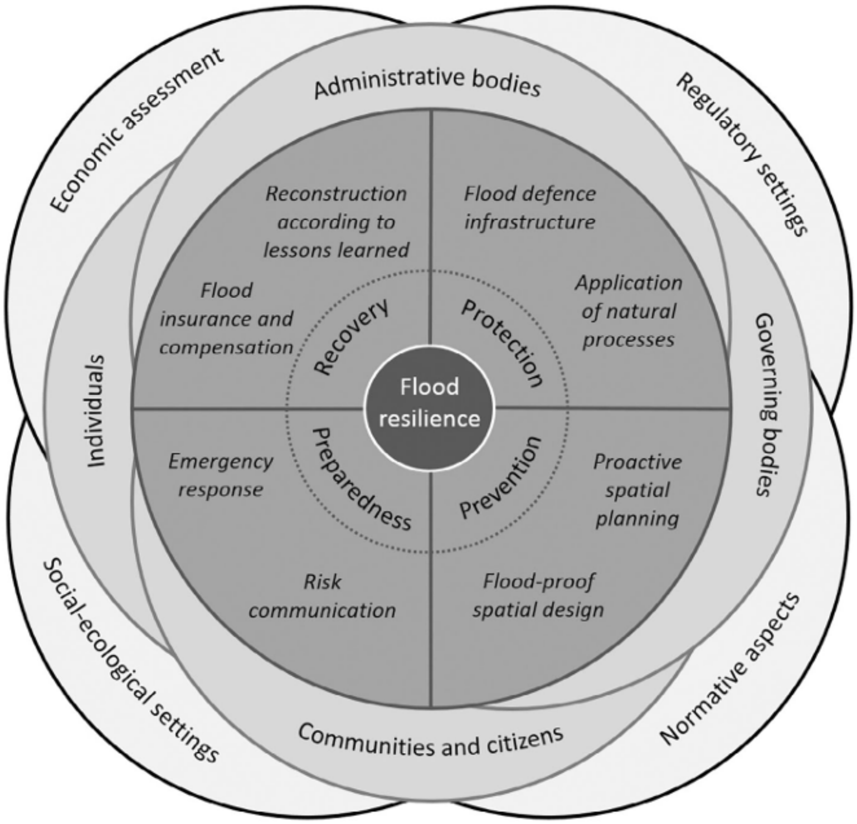

Figure 9: Diagram of the FRR, designed to illustrate the ability to increase resilience through operationalising the multi-layer safety approach (Karrasch, Restemeyer and Klenke, 2021).

Considerations of community composition is important in deciding which methodology to use. However, for England, there are limitations to many, as they are mostly developed in other countries, such as the USA, Bangladesh, and Nepal (Hochrainer-Stigler *et al.,* 2020). Whilst very diverse, factors that are applicable in these countries, may not be applicable in England. The concept of 'one size fits all' does not apply with resilience, as the composition of communities differ, therefore models need to be variable to be applicable within communities, whilst accurately representing the ever changing variables within them.

2.3 Complexity of Community-level Resilience Models

Communities are extremely complex, with a plethora of definitions for what a community is, as well as community resilience (Patel *et al.,* 2017). However, there is an increased focus into their resilience within the field of natural disasters and flooding. As with any other novel approach, difficulties are faced by not only researchers creating these models, but also communities adopting and implementing them.

At community level, adopting flood resilience measures can only be encouraged if it is justified, having the capacity to significantly improve the communities flood resilience (Hemmati, Ellingwood and Mahmoud, 2020; Olatunji, Adebimpe and Olkadokun, 2023), which has yet to be achieved by previous research.

Community resilience is strongly influenced by pre-disaster context and is usually a multi-layered process that can only be examined in the face of strain within the community (Wicks *et al.,* 2015). Several studies have identified that there may be several social-structural conditions, such as concentration of vulnerable groups, residential stability, and neighbourhood disadvantage, which can lead to poor functioning communities post-disaster (Cutter, Boruff and Shirley, 2003; Cutter *et al.,* 2008; Wicks *et al.,* 2015). This heterogeneity within communities needs to be considered when discussing community resilience (Harrington, Curtis and Black, 2008).

Whilst communities share many attributes, there are attributes such as racial or ethnic subgroups, that are most socially vulnerable to flooding (Chakraborty *et al.,* 2022), that may not be taken into consideration, especially when measuring the livelihoods and wellbeing of communities. This risks resilience becoming reductionist and technocratic (Wisner and Kelman, 2015), reducing the appearance of the effects and impacts within communities, especially those in the subgroups that are most socially vulnerable.

Consideration of household versus community resilience also needs to be included. Whilst a community may be considered resilient, this may not necessarily equate to uniformly resilient households or individuals (Frankenberger *et al.,* 2013), and therefore certain individuals within a community may be affected more. However, resilience is considered a multi-scalar phenomenon, with household, community and national scales often being interlinked (Batica, Gourbesville and Hu, 2013; Oladokun, Proverbs and Lamond, 2017). Therefore, frameworks should capture resilience at lower (individual and household), focal (community), and wider (county and nationwide) scales (Bulti, Girma and Megento, 2019).

These complexities need to be taken into consideration when designing frameworks and methodologies to measure flood resilience, to ensure that as many members of the community are represented as possible and ensuring resilience doesn't become reductionist, through only representing a single stakeholder or experience. One way of this is considering different capitals within the framework, with focus on social capital.

Development of a flood resilience model that is applicable within England is required to ensure that the communities are prepared for flooding, as well as being able to react to flooding. Current methodologies have limited applications, being overly complicated, and not community focused. Therefore, it is suggested that a new methodology is designed, that encompasses previous methods, such as those mentioned above, as well as external factors, which have been used in other fields of resilience. This, alongside community and stakeholder involvement, will help create a representative and holistic approach.

3. Methodology

3.1 Identification of Factors

74 community flood resilience factors were identified from a literature review of 93 papers. These papers covered a wide scope of themes within flooding and not all factors measured within the studies relate to flood resilience. Therefore, only factors that were considered applicable to community flood resilience (i.e. flood defences, infrastructure, and flood experience), and the scope of the study (applicable within England), were included in the initial identification, to ensure there was no deviation from the focus of the study. To reduce bias, it was ensured that the factors were well routed within existing research, as well as an extensive sift (section 3.2) was conducted on the identified factors.

The factors were split into 5 capitals (Fiscal, Natural, Physical, Human and Socio-cultural), which were built on the categories presented in the Community Capitals Framework (CCF) (Guitierrez-Montes, Emery and Fernandez-Baca, 2009). Within the CCF, there are 7 capitals included, however, Political capital was not included in this study, due to the study's scope, it would not be possible to measure political influences, (as these are generally at a national scale, therefore difficult to measure at community level) and social and cultural capital were combined, to provide simplicity when presenting factors. Whilst the origins of the CCF were originally designed to provide a way of organising information and ideas within community development (Flora and Flora, 2008), it has been utilised in this research to create categories that encompass predicted aspects of flood resilience, or what has been measured prior. This was adopted over other approaches as it allowed a simplified categorisation to present the factors, whilst exploring potential relationships between them.

3.2 Sifting

After initial factors were identified (Appendix 7.1), a 3 stage sift was conducted, to ensure a manageable number of factors were presented to participants, reducing the chance of multicollinearity, which may lead to bias or over-counting (Percival, 2016), whilst encompassing all potential aspects of resilience (*Figure 10*). The initial sift (Stage 1) removed any factors that would not have accessible data (*n=14*). Many of these factors were indicators related to previous flooding, and whilst these would be applicable in areas that have experienced flooding, many areas in England have not. Even though many of these factors are viable options, measuring them would be difficult, due to the lack of datasets available, as well as lack of experience by communities. Hope is one factor that was discounted in this first stage as many psychological factors (classed as psychological wellness) are very difficult to measure, not just at this scale, but at any scale. Whilst psychological wellness is an important factor (Norris *et al*., 2008), Cowen (2000) noted that wellness is a continuum, being affected with varying degrees of wellness throughout and after disasters, further increasing difficulty in measuring.

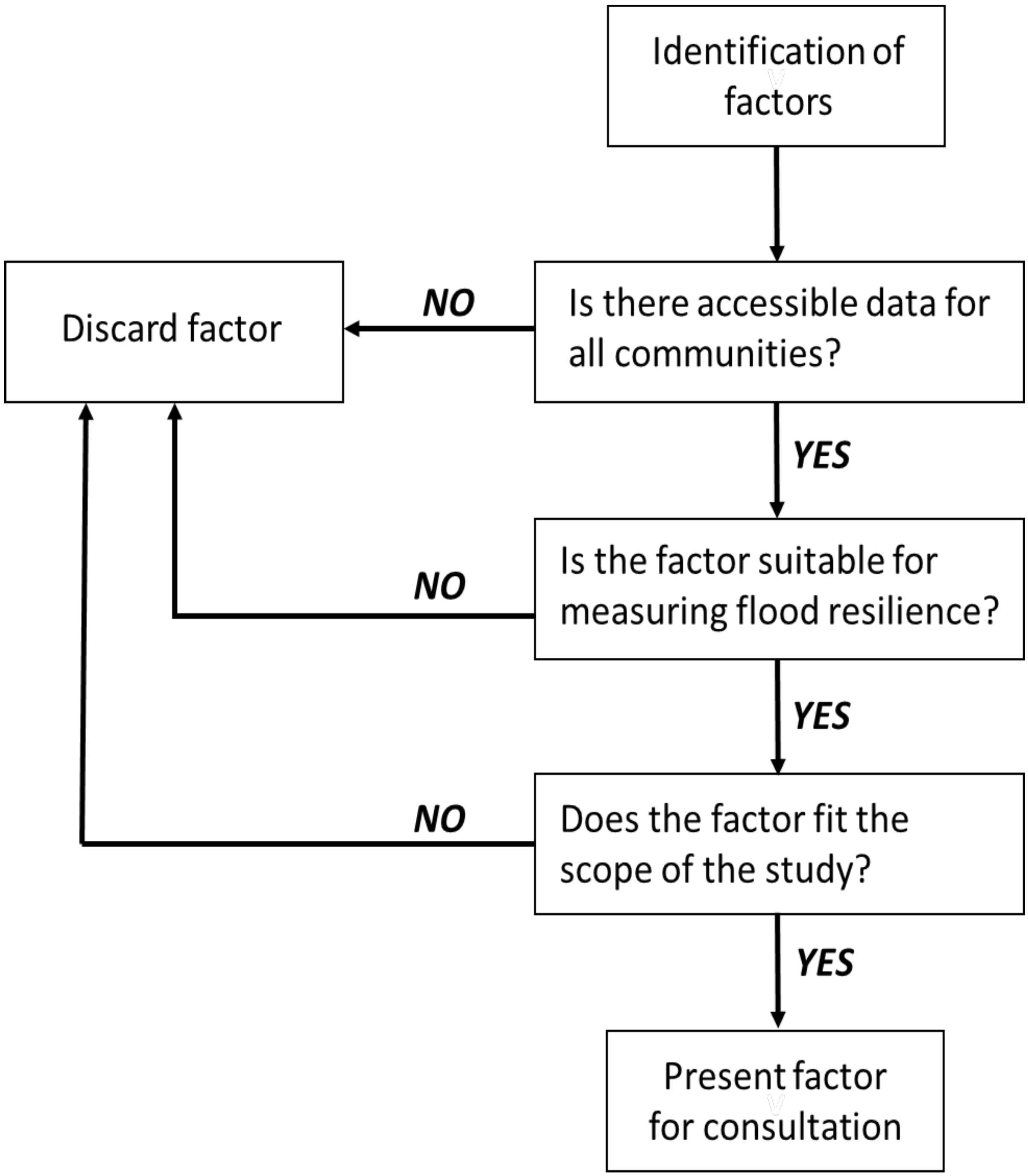

Figure 10: Flow chart outlining the sifting process for factors.

The second sift (Stage 2) removed factors that were not deemed suitable for measuring flood resilience in England (*n=13*). Factors such as healthcare were included in this sift, as there is widely accessible universal free healthcare provided by the National Health Service (NHS). Flood defences were also removed at this stage as well. Whilst these create protection for small areas against flooding, these account for resistance and not resilience. This is due to reducing the amount of water that can enter an area, be it a community or property (Owusu, Wright and Arthur, 2015), rather than aligning with the concept of adapting to live with water. Other factors, such as civic capacity and social support can be included within other factors in the model, and therefore not required to be standalone factors.

The final sift (Stage 3) discounted factors that would not fit in the scope of the study (*n=22*). Due to the scale of the study, factors such as sense of belonging, community flood plans and confidence were discounted from the analysis. Many of the factors that consider social reactions are important in creating a wholistic approach to flood resilience (McClymont *et al.,* 2019), yet they are notoriously difficult to measure (Stanke *et al.,* 2012), therefore, a more in-depth study is required to measure them. Finally, a total of 20 factors were carried through to the survey (*Figure 11).*

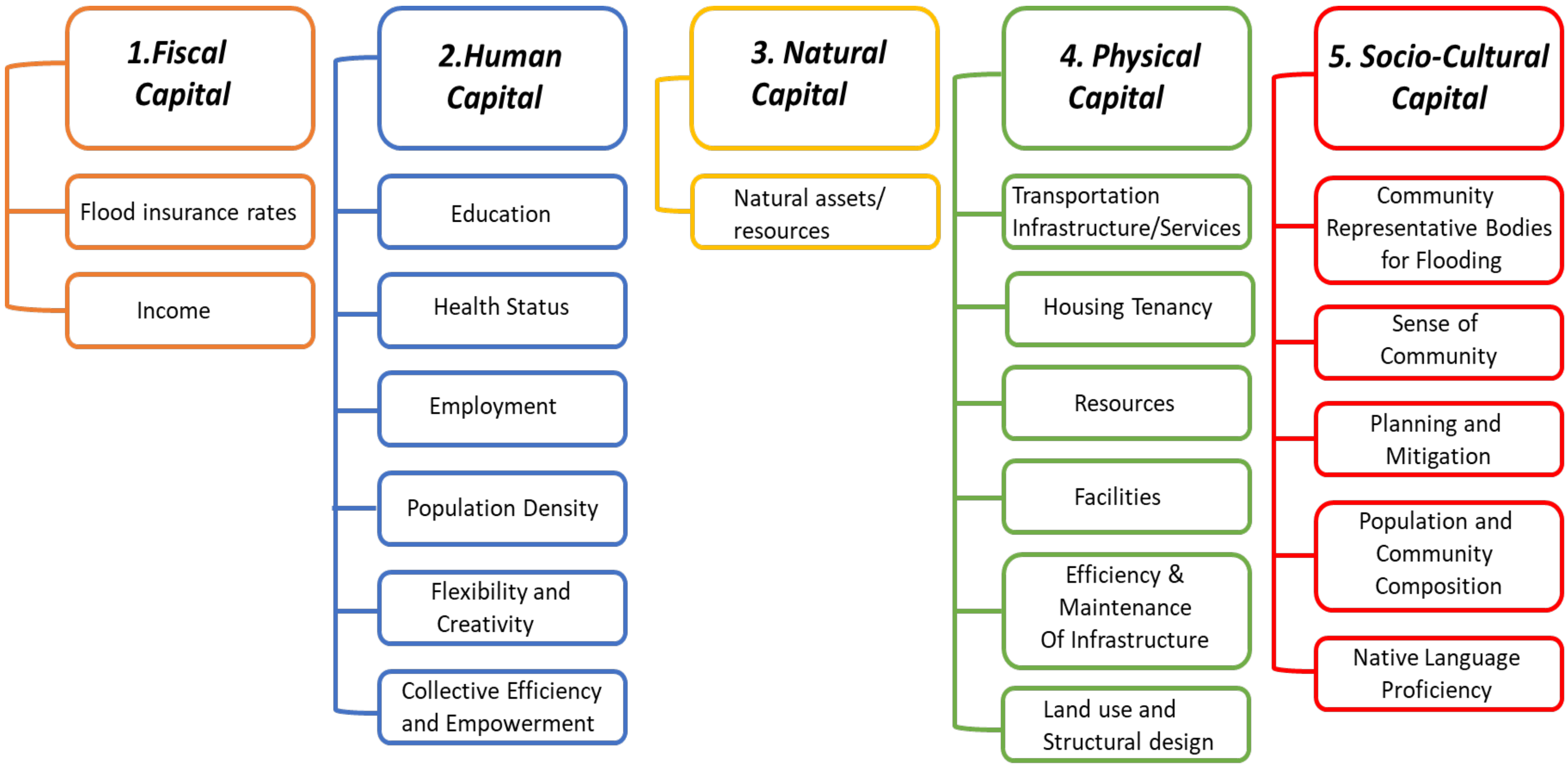

Figure 11: Flowchart outlining community flood resilience factors included in the survey, split into the 5 community flood resilience capitals applied to this study (Definitions provided in Appendix 8.1, Table 11).

3.3 Survey Design

The survey was designed to incorporate a mixture of open and closed questions. Closed questions were used to create structure, and allow ease in analysis (Patel and Joseph, 2016), as well as provide comparable data, such as demographic data, whilst open questions were designed to allow the respondents to illustrate important points and ensure they could express their opinions (O'Cathain and Thomas, 2004), and reduce researcher bias.

The questionnaire was created in 2 sections. Section 1 was designed to collect demographic data, flood experiences and opinions on flood resilience definitions, whilst section 2 was designed to present the previously mentioned flood resilience factors, and gauge opinions on their validity (*Appendix 8.2*).

The flood resilience factors were presented to the respondents in the format of a Likert scale, from 1-5 (1 being Unimportant, and 5 being Important). This was used to ensure all factors could be analysed, in a simple format, which would then allow the respondent to complete the survey with ease, whilst also providing the depth of information required for the study i.e., rating the factors significance for measuring community flood resilience. This was then followed by open questions, to allow respondents to express opinions on the factors presented to them and suggest factors they believe may be useful in measuring community flood resilience, which have not been included in previous methodologies thus far i.e., help give communities a voice within flood resilience research.

Initially, the survey was designed to be asked online and to members of flood action groups, who are assumed to have a more in-depth knowledge of flooding, recovery, and their local area due to their personal experiences with this hazard. However, responses were limited from these groups (48 responses, 1.2% of possible flood action group members), possibly due to survey fatigue (Shepherd per comms, 2022), therefore the data collection approach was altered, and the survey was also presented to members of the public, both online (via social media and 'Call for Participants') and in the field, through random sampling (i.e. approaching people on the Highstreet), in areas that had different flood histories (i) Kendal - previously experienced severe flooding; (ii) Chester - an area that has not experienced severe flooding. In order to capture different perceptions from different members of the public with different flood experiences. Random sampling was used to help reduce bias, by providing an equal opportunity for anyone to take part in the study. Expanding this study to include flood action group members, online participants and face to face participants, increased the reach and number of participants that were involved in the study, widening the target audience and further reducing bias.

3.4 Data collection

3.4.1 Online Data collection

Initially, the survey was distributed to flood action groups, aided by the NFF who acted as a gatekeeper. This was distributed to over 400 groups in England, however, only 48 responses were received. The survey was then opened to members of the public via social media platforms, community groups for Chester and Kendal, and their surrounding areas, as well as Call for Participants, an online service, which allows people who may be interested in the topic to participate in studies, resulting in a further 29 responses, not only from the two field locations, but also other parts of the country, such as Sheffield and Plymouth. Online surveys allowed a wider reach of study, increasing the representativeness of the data, through expanding the study from the north-west of England.

3.4.2 Field Data Collection

To enhance participation, face-to-face data collection occurred in both Kendal, Cumbria and Chester, Cheshire (*Figure 12*), with each location visited twice, resulting in a further 48 responses (23 from Chester and 25 from Kendal).

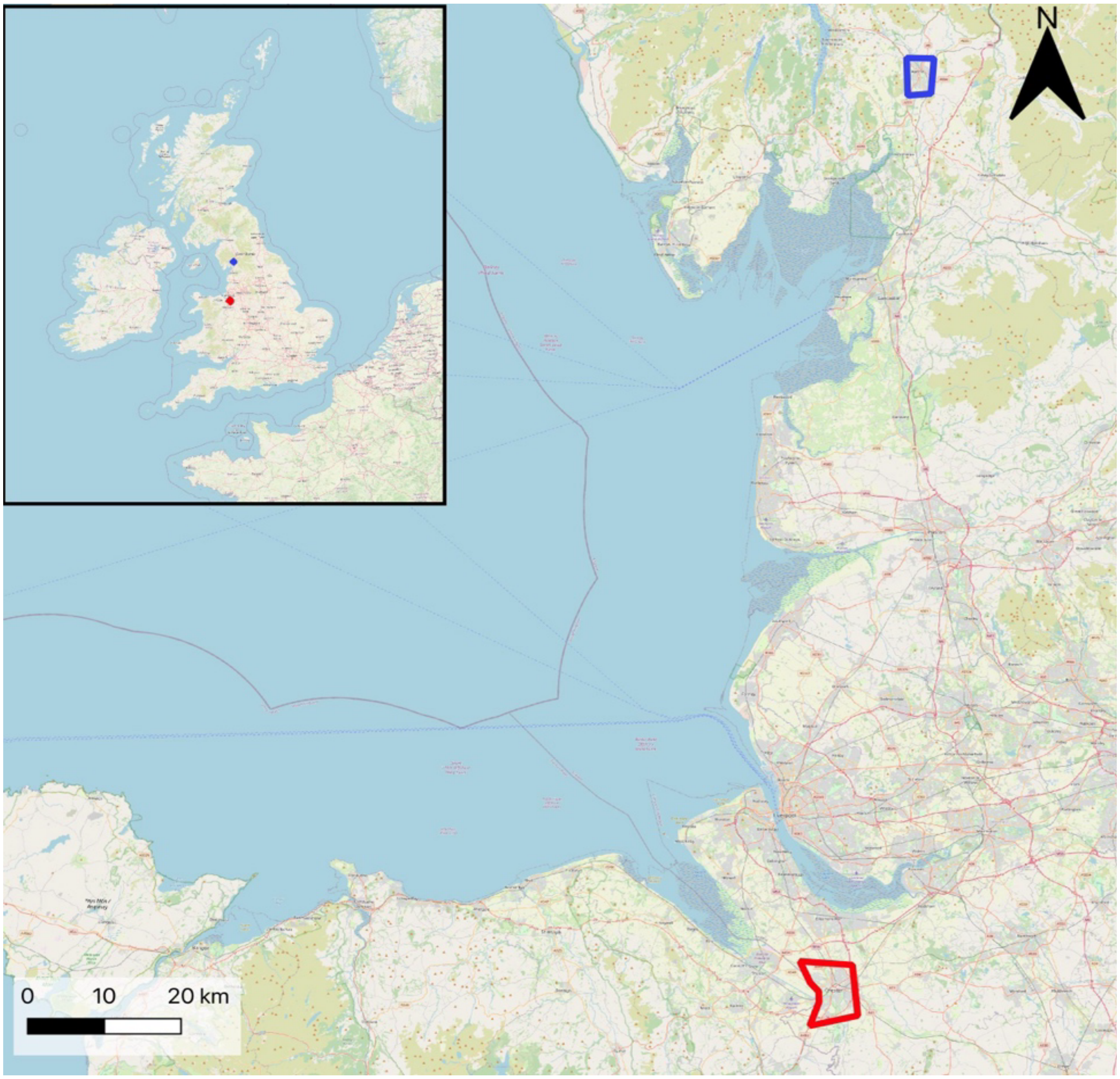

Figure 12: Location map of Chester (red) and Kendal (blue). Inset box shows the location of both Chester and Kendal within the UK.

Kendal

The town of Kendal is located in south-east Cumbria, situated predominantly on the floodplain of the river Kent, which flows through the town centre. There is a high risk of fluvial flooding from the river in Kendal and surface water flooding in places, affecting much of the town centre (*Figure 13)*. The risk for surface water flooding in the centre is actually quite low, with areas to the east of the river expected to be of a higher risk (*Figure 14)*.

Currently there are no public groundwater flood risk maps for this area and coastal flooding is not a risk in Kendal.

Kendal has experienced many floods including December 2015, which was particularly severe, affecting approximately 2,150 properties (Environment Agency, 2016). There is an active flood action group in the area (North-East Kendal Flood Action Group) that is currently aiding the new Kendal Flood Risk Management Scheme. This scheme is designed to increase the heights of current flood defences, restore land, creating recreation areas and install a new pumping station (Westmorland and Furness Council, 2023).

Figure 13: Flood risk map for surface water flooding in Kendal, Cumbria (Environment Agency, 2019).

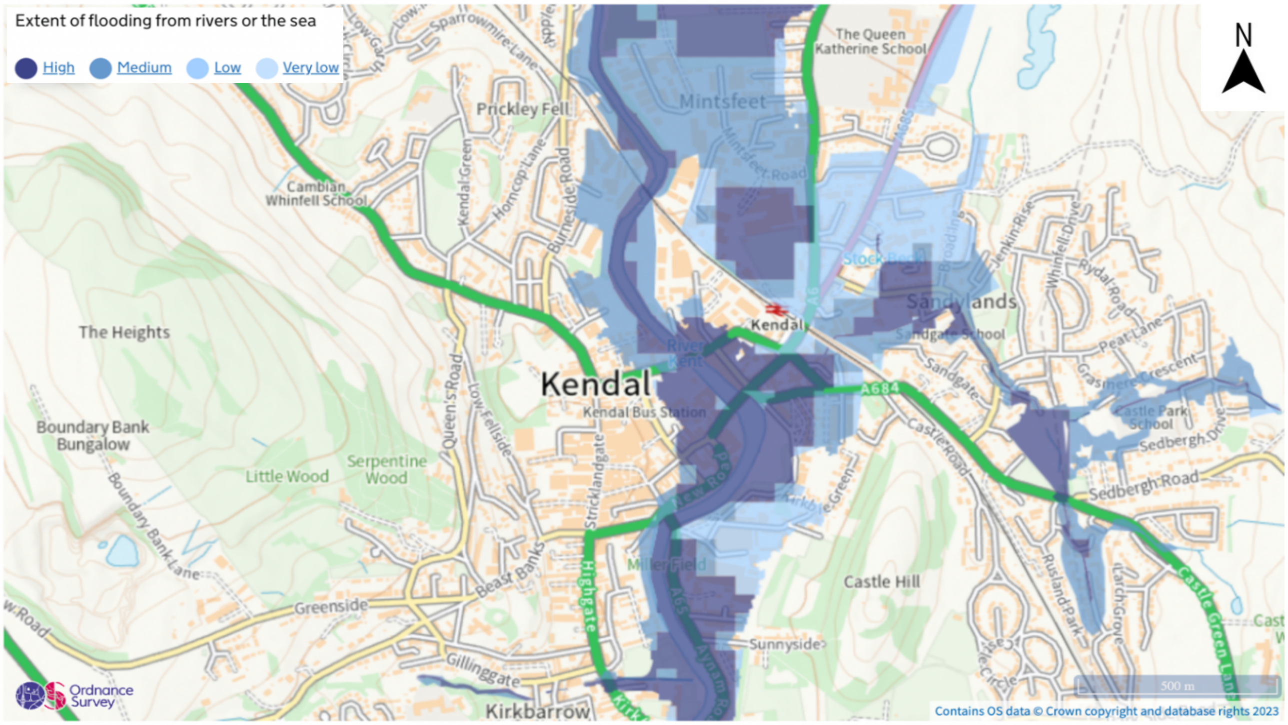

Figure 14: Flood risk map for fluvial flooding in Kendal, Cumbria (Environment Agency, 2019).

<u>*Chester*</u>

The city of Chester is located in West Cheshire, situated on the River Dee, which flows through the city. There are no known flood action groups in Chester, unlike Kendal, yet areas of the city and surrounding areas have experienced minor flooding from either surface water or groundwater (Cheshire East Council, 2022). Some recent flood events include Storm Christoph in 2021, that affected 436 properties across Cheshire West and Chester, however only 37 of these were from the Chester area (Atkins, 2022). Further, flash flooding events occurred in July 2023, affecting several places within Chester (Barnett, 2023). However, the risk of surface water flooding is very low/low in much of the city centre and risk of flooding from the River Dee is variable (*Figure 15*). Within the city centre there is no risk of fluvial (river) flooding, however, in the west of the centre, there is low risk of fluvial flooding. Yet this mainly covers field and flood plains, with a risk to small local communities in the northwest (*Figure 16)*. There is currently no public dataset for groundwater flooding in the area and again risk of coastal flooding is not present here.

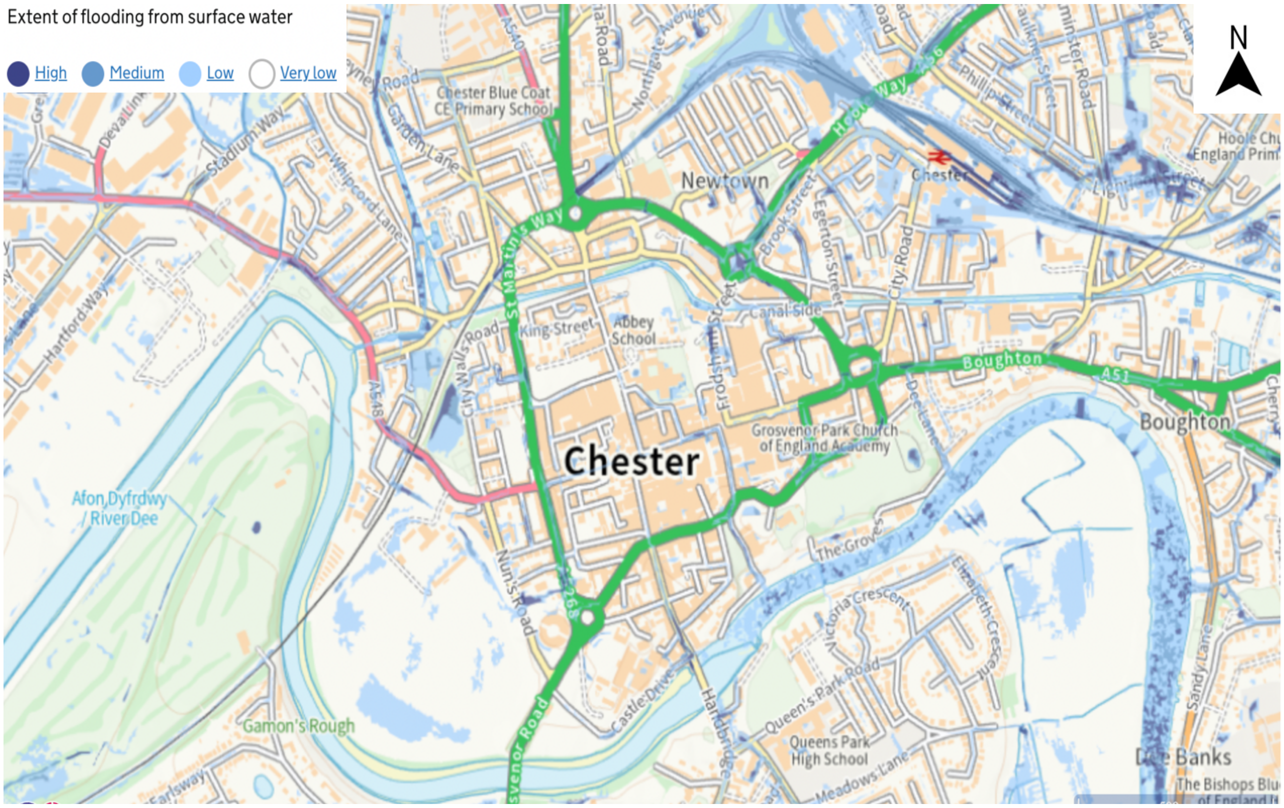

Figure 15: Flood risk for surface water flooding in Chester, Cheshire (Environment Agency, 2019).

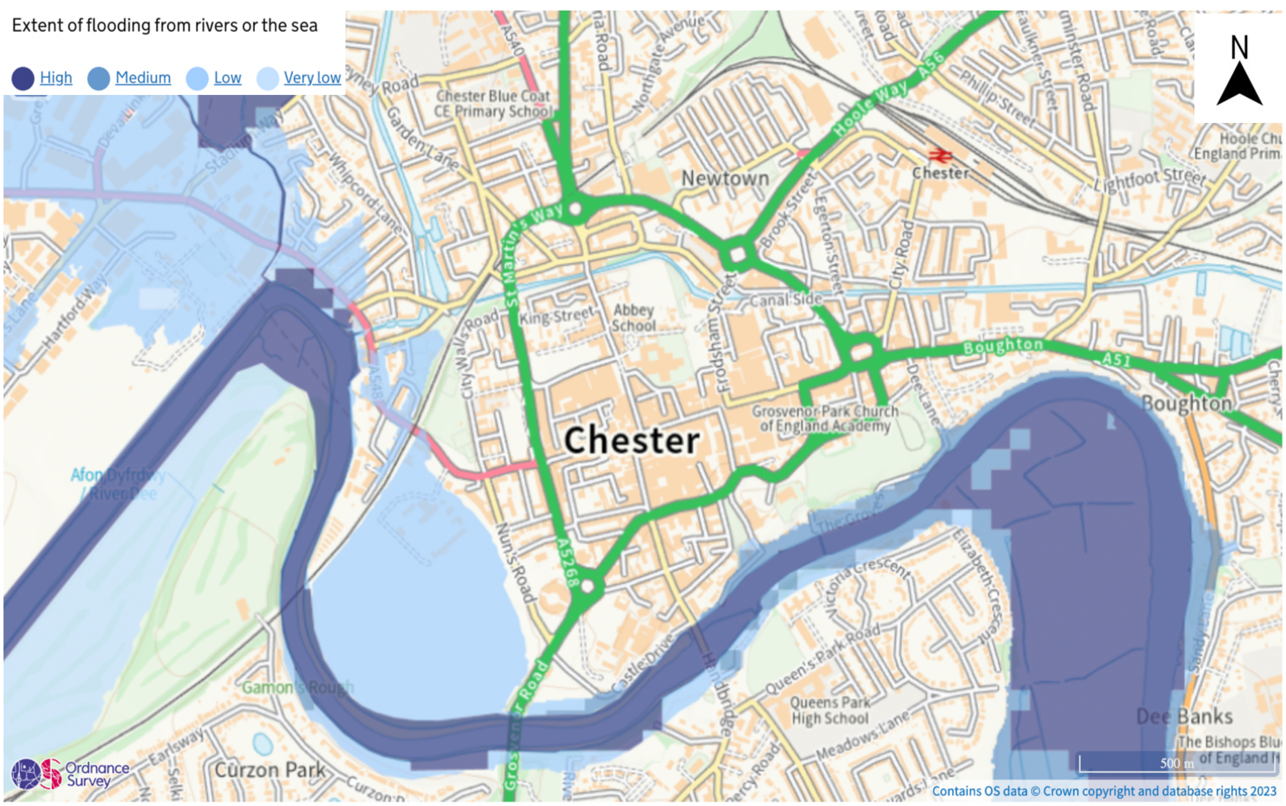

Figure 16: Flood risk map for fluvial flooding in Chester, Cheshire (Environment Agency, 2019).

3.5 Data Analysis

3.5.1 Thematic Analysis

A thematic analysis was conducted on several questions (Q6, 8 and 9), to allow a conceptualisation of the dataset, examining experiences and opinions of participants (Terry *et al*., 2017). This methodology has been used extensively within qualitative research, to produce an understanding of rich datasets (Lochmiller, 2021).

Themes were identified within the answers, resulting in over 25 in some cases (Q6). Without having the restrictions of a structured methodology, which is associated with deductive methodologies (Thomas, 2006). Inductive coding was instead used to allow the most dominant and significant themes to be drawn from the raw data. As with other qualitative methods, this was a two-stage process (King and Brookes, 2018; Cassell and Bishop, 2018), with the initial identification of themes being proceeded by categorisation of the themes by similarity. This was done to allow simplicity in coding, whilst keeping the richness of the data.

3.5.2 Statistical Analysis

A statistical analysis was also conducted on the data to explore any relationships between the variables. This was done using the software SPSS. Due to the majority of the data being Likert scale, care was taken when deciding on statistical testing. Within this study, Likert data was considered ordinal data, as the participants perceptions of the difference between the levels cannot be presumed equal, as is required in interval data (Joshi *et al.,* 2015). Therefore, non-parametric testing was used, including Spearman's Rho, which is best to use on larger data sets, which are continuous ordinal (Khamis, 2008).

4. Results

The survey data was split into three groups, members of flood action groups, those who had previously experienced flooding, and those who had not previously experienced flooding. This was done to see if opinions/perceptions on community flood resilience differ between community members with different flood experiences, especially those who are part of voluntary flood groups and, whose interests in flooding are due to personal impacts/experiences.

4.1 Demographic Data

Of the 125 participants, the majority were over the age of 60 (42%) (Figure 17). When broken down further, 75% of flood action group members were also over the age of 60, indicating that whilst this is only a small sample size, a lack of diversity is present within these voluntary flood groups. Both community members who had previously experienced flooding and had not previously experienced flooding had a more increased diversity of ages, ranging from 18-21 to 60+ (Figure 17 & Table 1). This resulted in the survey overall being answered by the wider population and representing a more well-rounded sample.

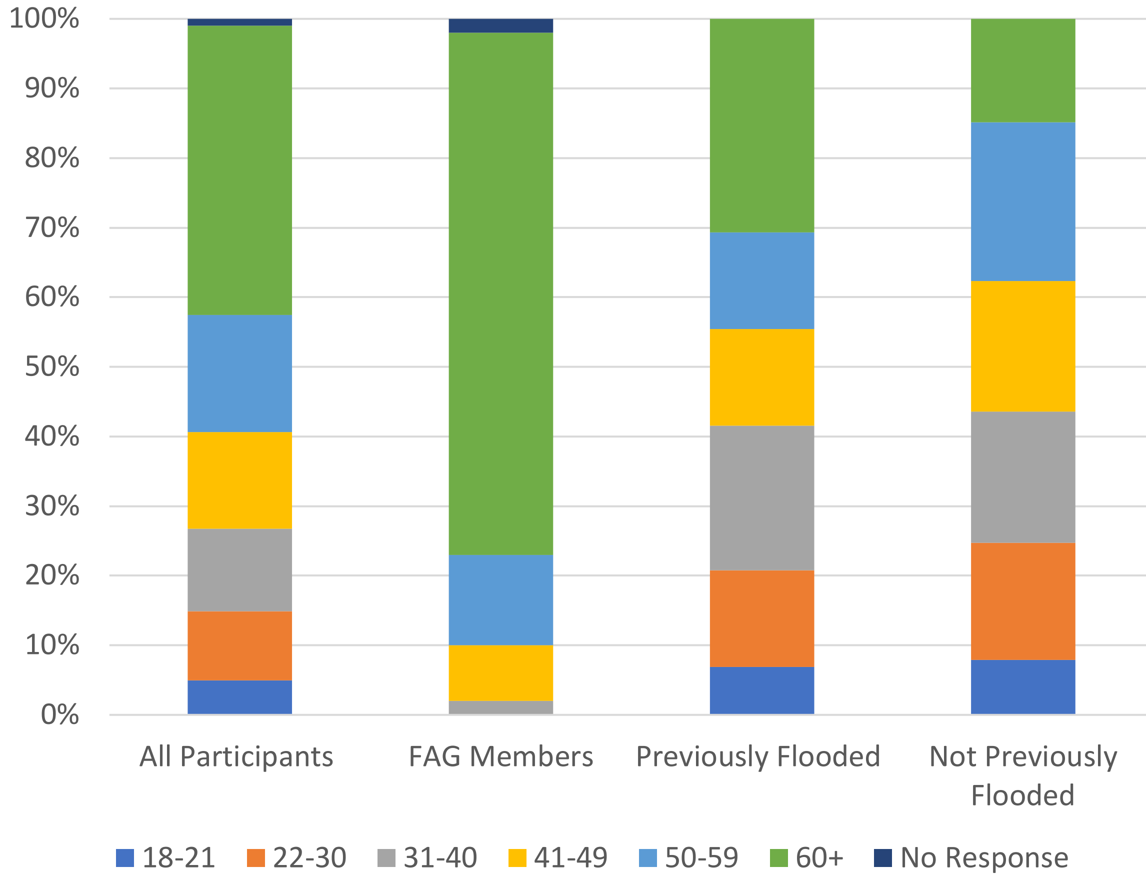

Figure 17: Age of participants.

Age	All Participants	Flood Action Group Members	Previously Flooded	Not Previously Flooded
18-21	5%	0%	7%	8%
22-30	10%	0%	14%	17%
31-40	12%	2%	21%	19%
41-49	13%	8%	14%	19%
50-59	17%	13%	14%	23%
60+	42%	75%	30%	15%
No Response	1%	2%	0%	0%

Table 1: Percentage of participants per age bracket.

When asked about occupancy (*Figure 18 & Table 2*), 37% of all participants were retired, however, this made up 71% of flood action group members. Also, of those who had previously experienced flooding, 24% were also retired, whilst 34% worked in customer service. 46% of those who had not previously experienced flooding worked in customer service, whilst only 10% were retired. The remainder of participants had varied job roles, including management (10% of all participants), Business (9% of all participants) and Engineering (4% of all businesses).

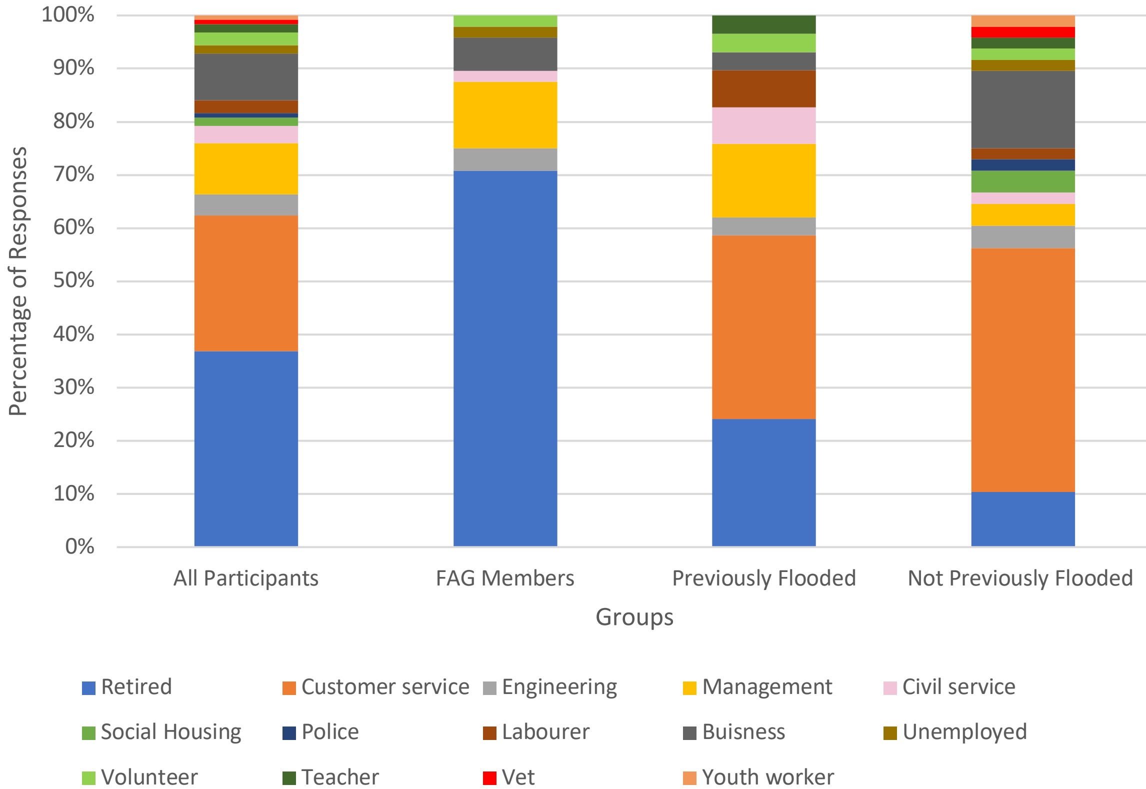

Figure 18: Occupation of participants

Role	All Participants	Flood Action Group Members	Previously Flooded	Not Previously Flooded
Retired	37%	71%	24%	10%
Customer service	26%	0%	34%	46%
Engineering	4%	4%	3%	4%
Management	10%	13%	14%	4%
Civil service	3%	2%	7%	2%
Social Housing	2%	0%	0%	4%
Police	1%	0%	0%	2%
Labourer	2%	0%	7%	2%
Business	9%	6%	3%	15%
Unemployed	2%	2%	0%	2%
Volunteer	2%	2%	3%	2%
Teacher	2%	0%	3%	2%
Vet	1%	0%	0%	2%
Youth worker	1%	0%	0%	2%

Table 2: Percentage of participants per occupation

Gender was relatively even within the sample, with 42% male and 56% female (56%), and prefer not to say and non-binary made up the other 2% (*Figure 19 & Table 3*). This percentage split was predominantly present throughout all three groups, with each having a higher percentage of female participants.

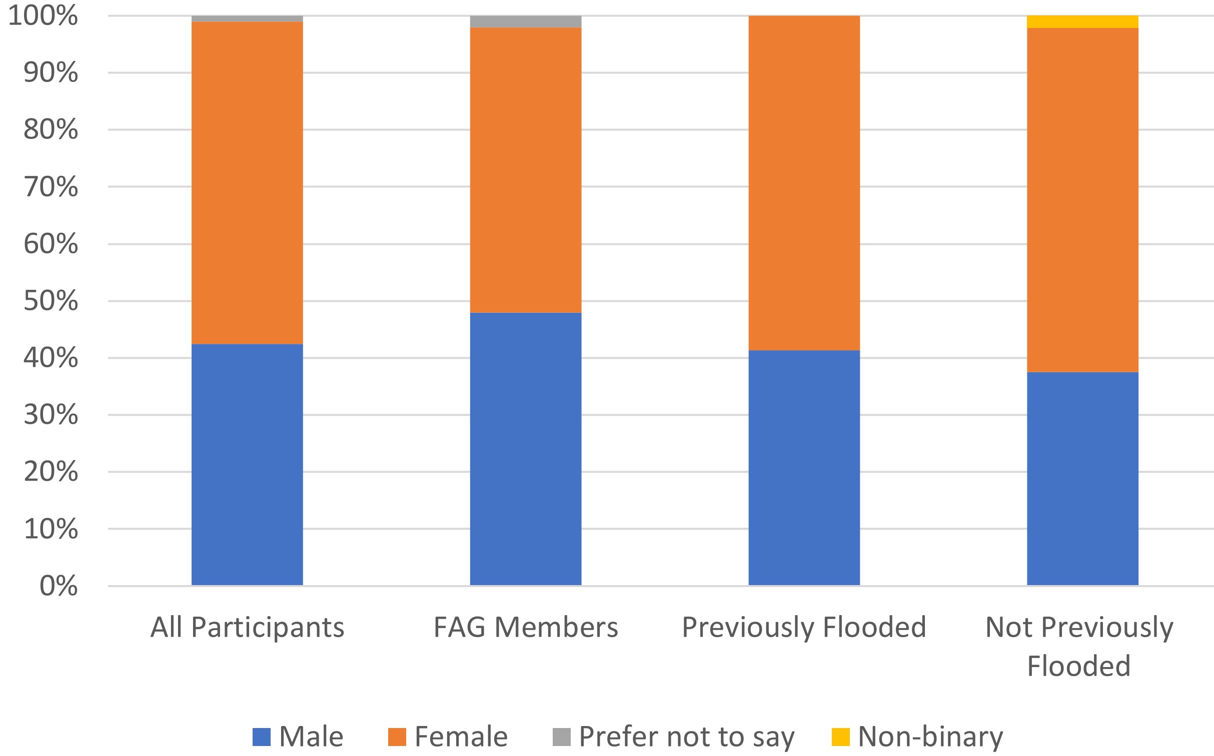

Figure 19: Gender of participants

Gender	All Participants	Flood Action Group Members	Previously Flooded	Not Previously Flooded
Male	42%	48%	41%	38%
Female	56%	50%	59%	60%
Prefer not to say	1%	2%	0%	0%
Non-binary	1%	0%	0%	2%

Table 3: Percentage of participants per gender

As expected, most respondents were from the North-West area (65%), as this is where both field study sites were situated (*Figure 20*). However, of the responses from flood action group members, 40% were in fact from the Midlands (*Figure 20 & Table 4*), which is where newer flood action groups are situated, compared to well-established groups who have potentially moved away from the NFF (but still supported by them) and gone on to become independent. This has occurred to many of the Cumbrian flood action groups in the last few years (National Flood Forum, per comms, 2022).

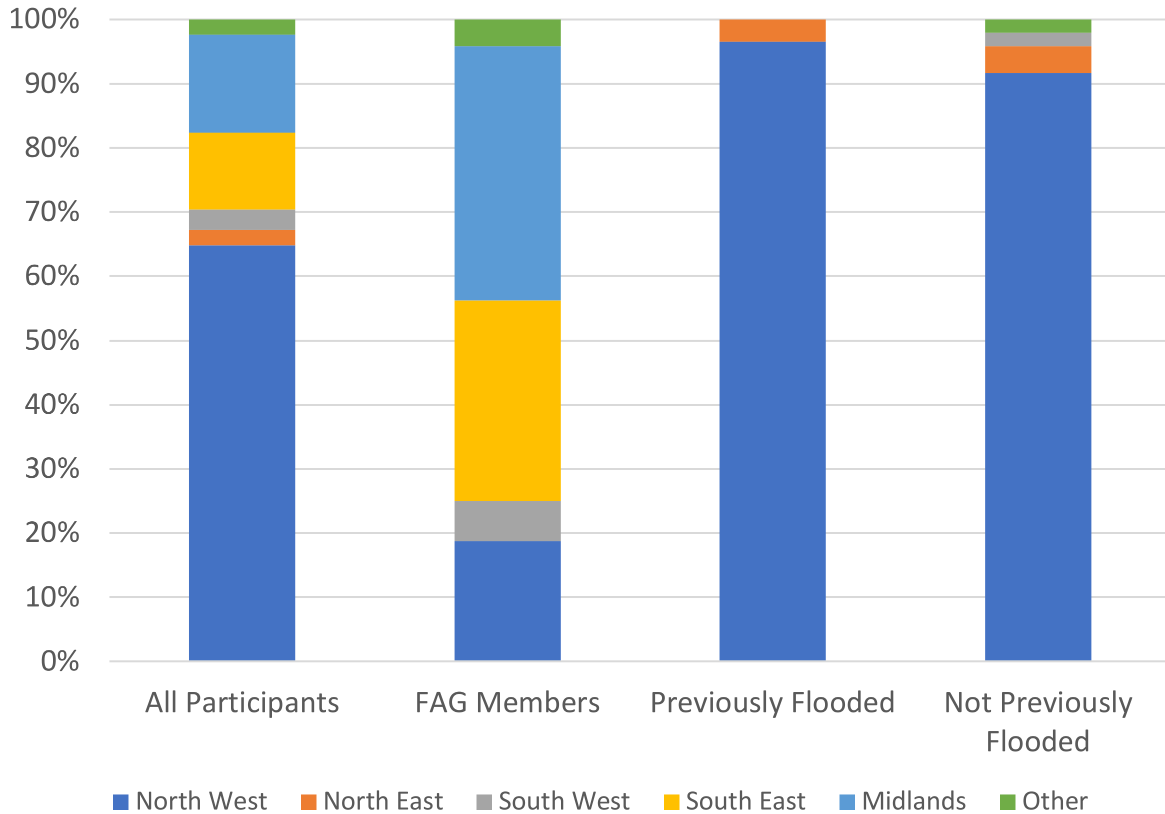

Figure 20: Geographic location of participants

Location	All Participants	Flood Action Groups Members	Previously Flooded	Not Previously Flooded
North West	65%	19%	97%	92%
North East	2%	0%	3%	4%
South West	3%	6%	0%	2%
South East	12%	31%	0%	0%
Midlands	15%	40%	0%	0%
Other	3%	4%	0%	2%

Table 4: Percentage of participants per geographic location.

4.2 Resilience Definitions

One of the key elements to this study was to gauge communities understanding of flood resilience (Question 6 of the questionnaire – *Appendix 8.2*). As previously mentioned, there is no consensus within the academic community surrounding the definition, and therefore lay knowledge is an important indicator on current understanding within communities. Responses were split into 9 categories, shown in *Figure 20.*

There were differing opinions between groups when asked about the definition of resilience. 59% of Community members who had previously experienced flooding believed that flood resilience relates to 'stop, withstand & prevent flooding/disruption' (*Figure 21 & Table 5*). This opinion was still a majority within those who have not previously experienced flooding (38%), however, flood action group members also stated that flood resilience means 'Experience, preparation, prediction, knowledge and education' (24%) (*Figure 21 &Table 5*). Overall, flood action group members had more varied views on the definition of flood resilience, with views that not only encompass engineering resilience (Five Capitals of Flood resilience Framework), such as defences, protection, maintenance, and alleviation (16%) but also more social resilience views, such as community support, awareness, safety, and coping (16%) (*Figure 21 &Table 5*). Whilst these views were shared by the other sample groups, they are less prominent, with general views being focused on physical resilience measures. However, many participants also provided more than one theme within their answers, with 22% including 2 or more themes. These cover both social and physical theming, suggesting that there is some awareness that flood resilience is not just one dimensional, and can incorporate multiple frameworks.

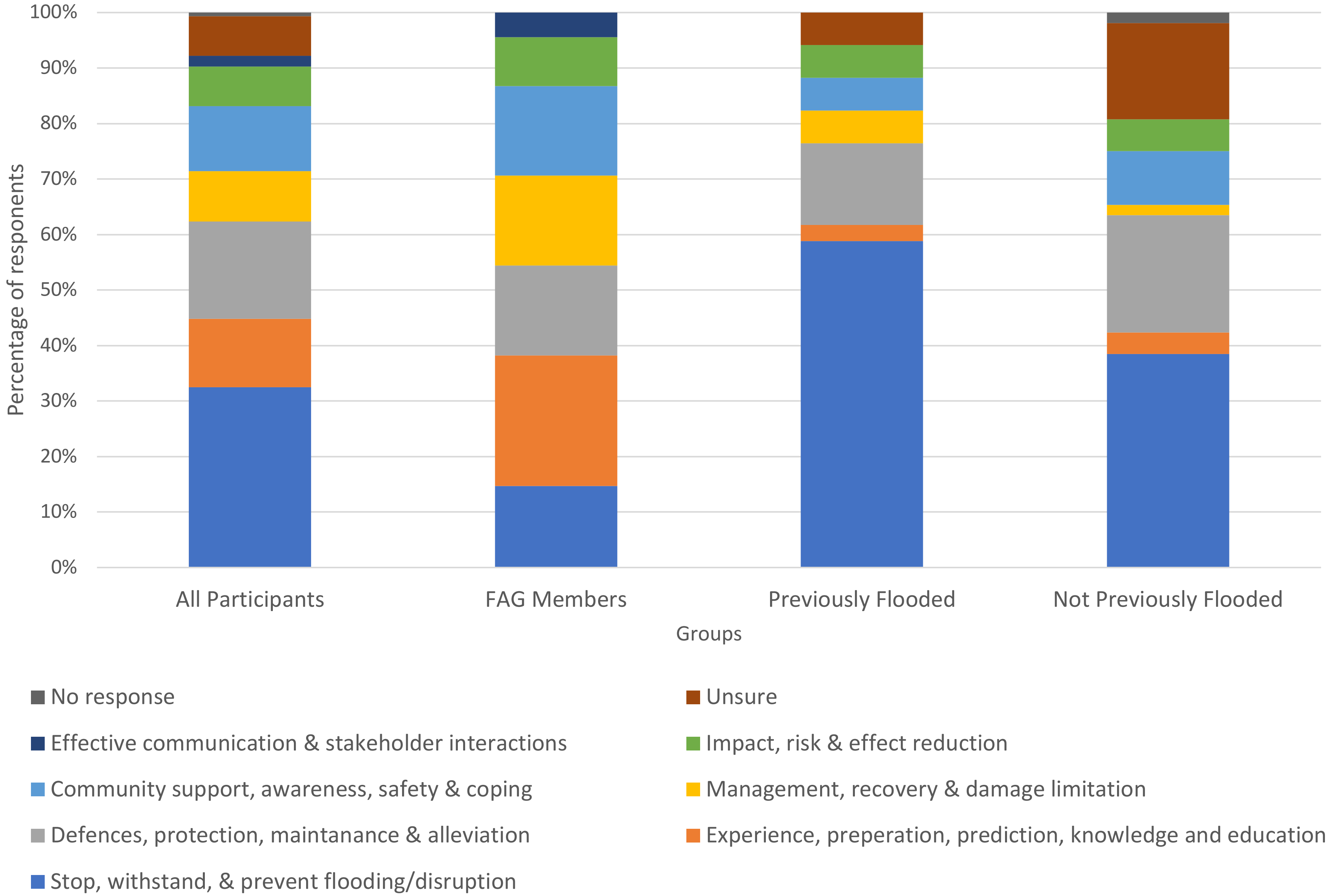

Figure 21: Key categories for definitions of flood resilience presented by participants.

Factor	All Participants	Flood Action Group Members	Previously Flooded	Not Previously Flooded
Stop, withstand, & prevent flooding/disruption	32%	15%	58%	38%
Experience, preparation, prediction, knowledge, and education	12%	24%	3%	4%
Defences, protection, maintenance & alleviation	18%	16%	15%	21%
Management, recovery & damage limitation	9%	16%	6%	2%
Community support, awareness, safety & coping	12%	16%	6%	10%
Impact, risk & effect reduction	7%	9%	6%	6%
Effective communication & stakeholder interactions	2%	4%	0%	0%
Unsure	7%	0%	6%	17%
No response	1%	0%	0%	2%

Table 5: Percentage of participants per category of flood resilience definitions.

4.3 Factors to Measure Flood Resilience

The 20 factors that were sifted from Section 4.2, were presented to the survey participants (Question 7, *Appendix 8.2)* in order for them to establish significance of the highlighted community flood resilience factors. The factors were presented in a Likert scale format, ranging from unimportant to important (*Table 6*). Responses were then compared between the three groups, to assess the differences in opinions, as well as create a rank of importance of the community flood resilience factors.

Q7. Please rate the following factors according to how important you believe they are in measuring flood resilience.	
Code	**Rank**
1	Unimportant
2	Somewhat Unimportant
3	Neutral
4	Somewhat Important
5	Important
6	No Response

Table 6: Coding of Likert Scale

A Spearman's Rho correlation was also conducted. This was favoured over Pearson's correlation due to the categorical nature of the data (Liu *et al.,* 2018). The correlation was conducted between the three grouping variables (flood action group member, previously flooded, not previously flooded) and each factor, to show if flood experience, and level of community involvement, had an impact on the opinions of participants. There were then further correlations conducted between age, location, and gender with each of the factors, again to see if any relationships existed between the variables. There were no notable correlations between any of these variables and the factors. These results and the survey responses to Question 7 can be seen in detail in the following sections (4.3.1-4.3.20).

4.3.1 Flood Insurance rates

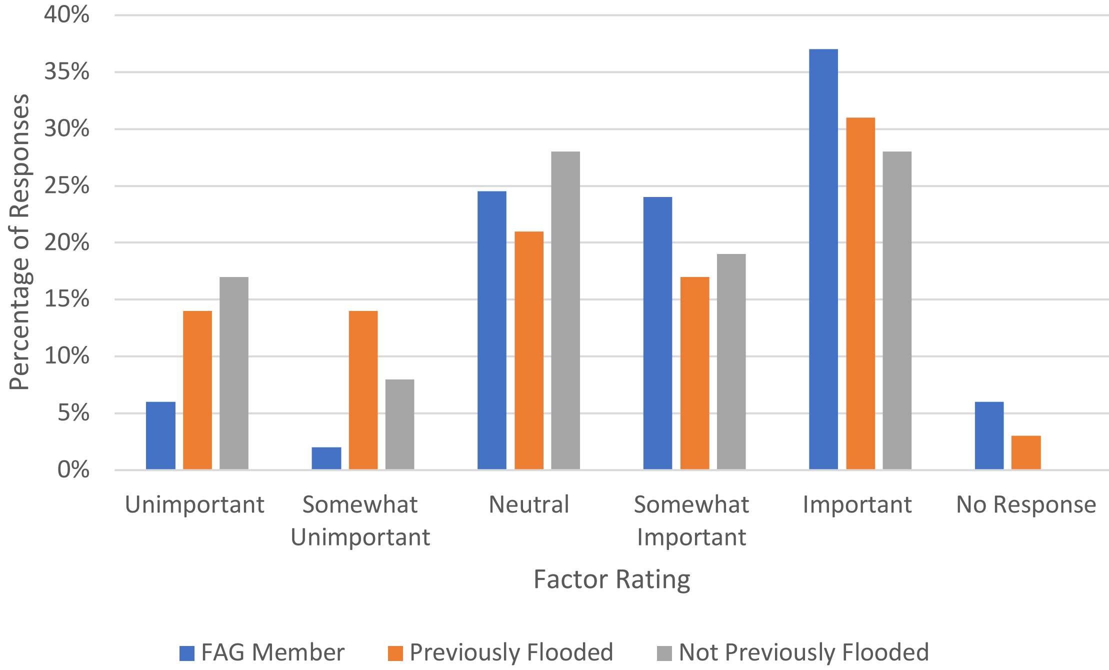

Figure 22: Breakdown of opinions of the three groups, on importance of including flood insurance rates when measuring community flood resilience.

It was generally agreed across the three groups that flood insurance rates are important when measuring flood resilience in communities. 61% of flood action group members ranked it as somewhat important/important, with only 8% answering somewhat unimportant/unimportant. Whilst 47% of those who had not previously experienced flooding ranked flood insurance rates as somewhat important/important, 28% also ranked it as neutral. Finally, community members who had previously experienced flooding had a more varied opinion on flood insurance rates, yet the consensus was still in agreement that it is somewhat important/important (48%). To further assess the relationships between the factor and the groups (flood action group members, previously experienced flooding, not experienced flooding) a Spearman's Rho correlation was conducted. There is a slight negative correlation between the variables, $r(123)= -0.17$, $p=0.054$, but this is not significant at the 0.05 level.

4.3.2 Income

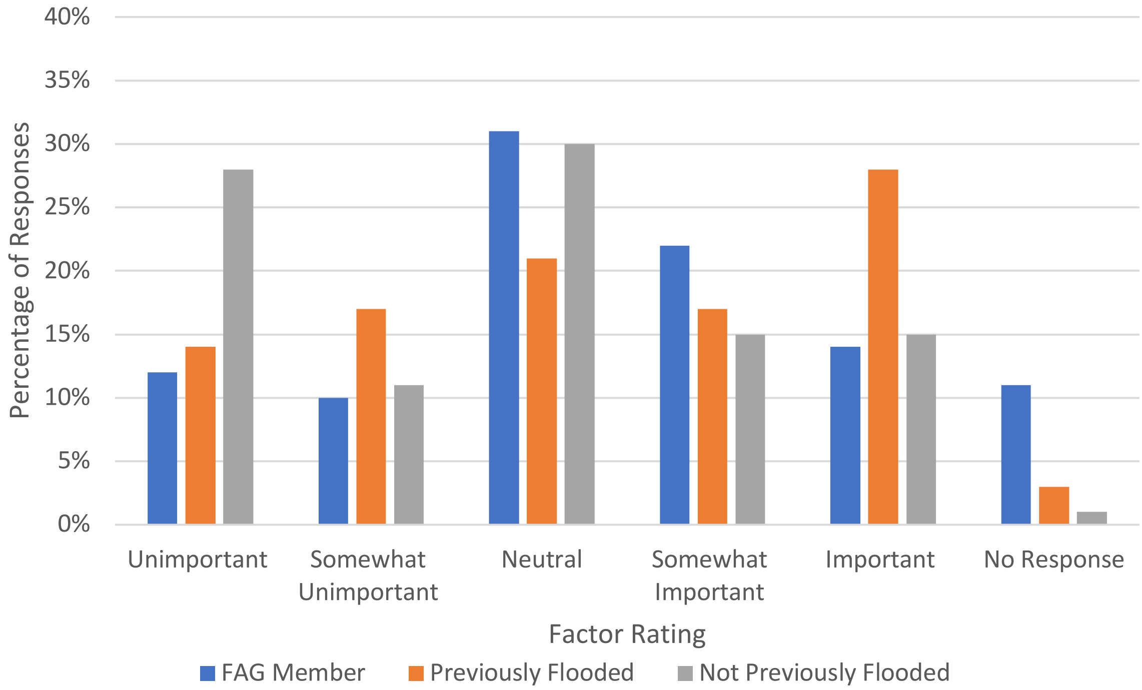

Figure 23: Breakdown of opinions of the three groups, on importance of including income when measuring community flood resilience.

Opinions on income were varied between the 3 groups. Flood action group members were split with 31% rating the importance of this factor as neutral and 37% rating it as somewhat important/important. However, 38% of community members who hadn't experienced flooding believed that income was a somewhat unimportant/unimportant factor, and only 17% believed that it was somewhat important/important. However, opinions of community members who had previously experienced flooding differed, with 45% rating income as somewhat important/important in community flood resilience, further highlighting the notable differences in opinions between those that had previously experienced flooding (including flood action group members) and those who have not. Again, a Spearman's Rho correlation was conducted to further assess the relationships between the respondent groups and the factor. There is a very slight negative correlation between the variables, $r(123)= -0.059$, $p=0.51$, again this was not significant at the 0.05 level.

4.3.3 Education

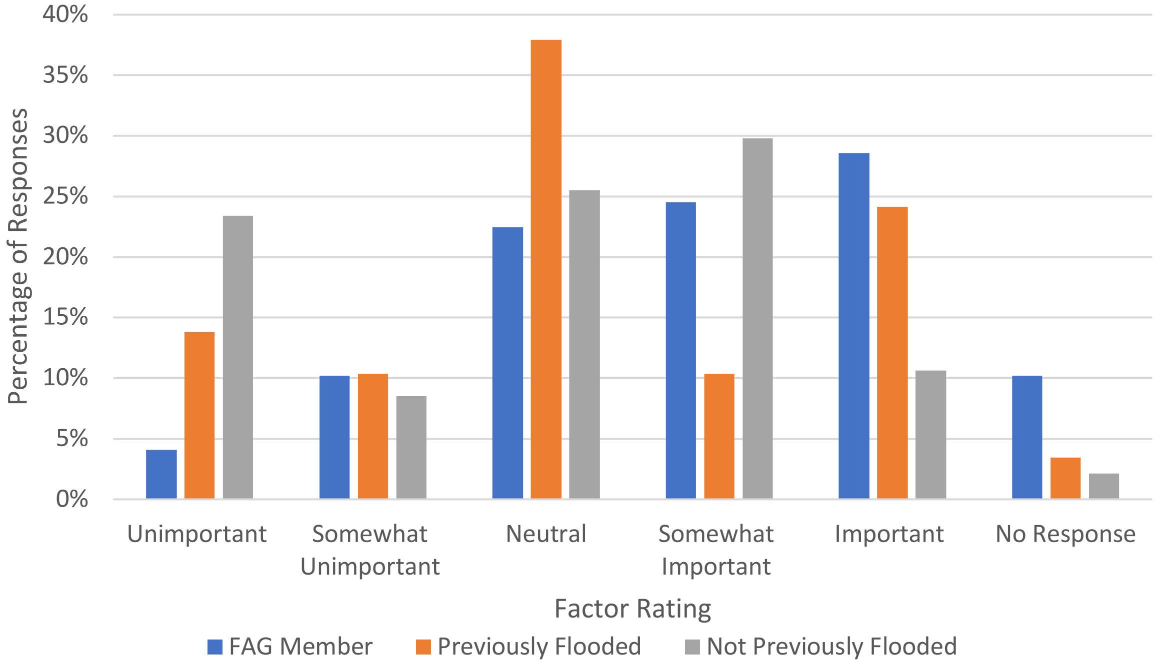

Figure 24: Breakdown of opinions of the three groups, on importance of including education when measuring community flood resilience.

Flood action group members (53%) and community members who have not previously experienced flooding (40%) predominantly agreed that education is a somewhat important/important community flood resilience factor. With only 14% of flood action group members rating this factor as somewhat unimportant/unimportant. Whilst 32% of those who had not previously experienced flooding ranked education as somewhat unimportant/unimportant. However, those who had previously experienced flooding, 38% rated education as neutral importance and a further 34% rating it as somewhat important/important. Again, this highlights differences in opinions between the groups, yet they are generally skewed towards somewhat important/important. The Spearman's Rho correlation indicated a slight negative correlation between the variables, r(123) = -0.28, p = 0.015, which is significant at the 0.05 level.

4.3.4 Health Status

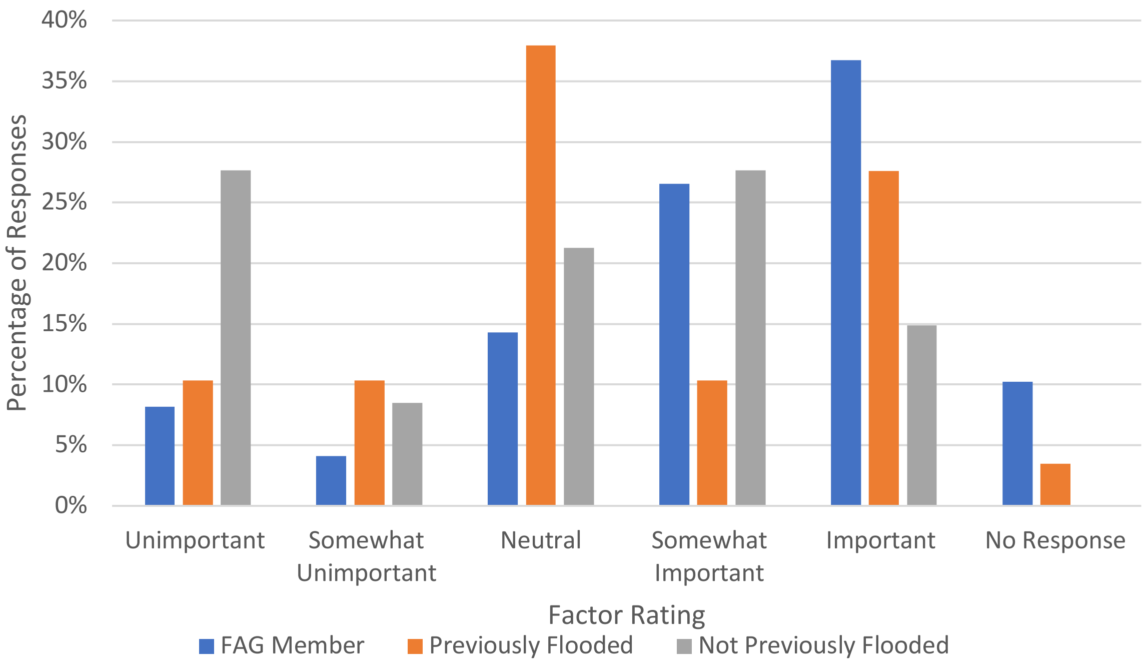

Figure 25: Breakdown of opinions of the three groups, on importance of including health status when measuring community flood resilience.

Opinions are again varied between the three groups for this factor. Whilst 63% of flood action group members rated health as a somewhat important/important factor, this was not shared by the other groups. Of those who have not previously experienced flooding, 43% agreed with the flood action group members and rated health as somewhat important/important, however 36% rated the factor as somewhat unimportant/unimportant. Of those who had previously experienced flooding, 38% rated the health factor as neutral in importance, and 38% rated it as somewhat important/important. Again, a Spearman's Rho correlation was conducted, which indicated a weak correlation between the variables, r(123)=-0.25, p=0.005, significant at the 0.01 level.

4.3.5 Employment

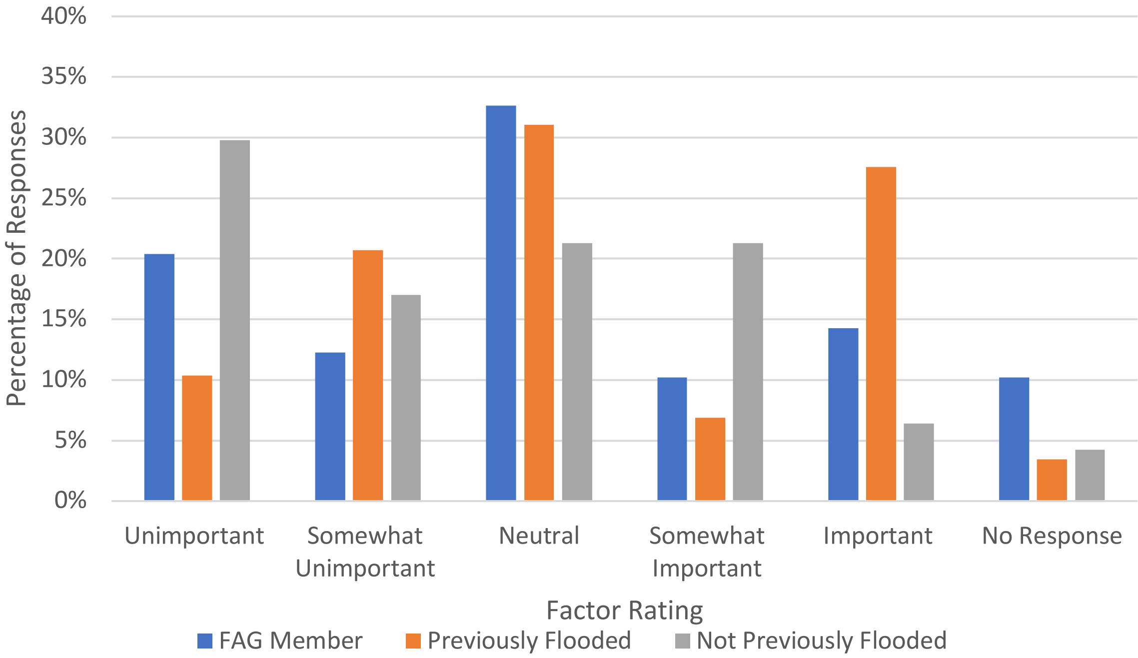

Figure 26: Breakdown of opinions of the three groups, on importance of including employment when measuring community flood resilience.

All three groups generally agree that employment is not the most important factor when measuring flood resilience in communities. 33% of flood action group members rated employment as neutral, whilst 33% rated it as somewhat unimportant/unimportant. Similarly, of those community members who have not previously experienced flooding, 47% rated it as somewhat unimportant/unimportant. Those who had previously experienced flooding generally increased the importance rating of this factor, with 34% rating it as somewhat important/important, and 31% rating it as somewhat unimportant/unimportant, further highlighting that this community flood resilience factor is not very significant. A Spearman's Rho correlation between the variables highlighted a very slight positive correlation between variables, $r(123) = 0.005$, $p = 0.96$, which is not significant at the 0.05 level.

4.3.6 Population Density

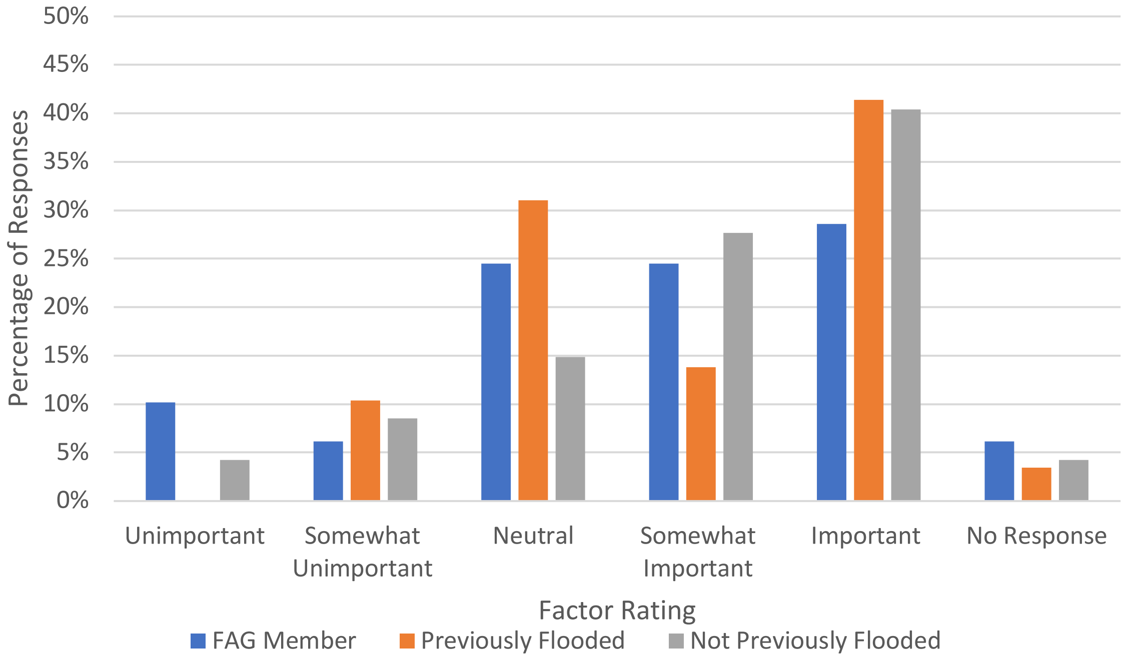

Figure 27: Breakdown of opinions of the three groups, on importance of including population density when measuring community flood resilience.

There was consensus between all three groups that population density is an important factor when measuring flood resilience in communities. Over 50% of all groups ranked the factor as somewhat important/important (flood action group = 53%, Not experienced flooding = 68%, Experienced flooding = 55%). Of the respondents that had previously experienced flooding, 0% rated population density as unimportant and only 10% rated it as somewhat unimportant. The Spearman's Rho correlation again indicated a slight positive correlation between the variables, r(123)= 0.073, p=0.42. However again this was not significant at 0.05 level.

4.3.7 Flexibility and Creativity

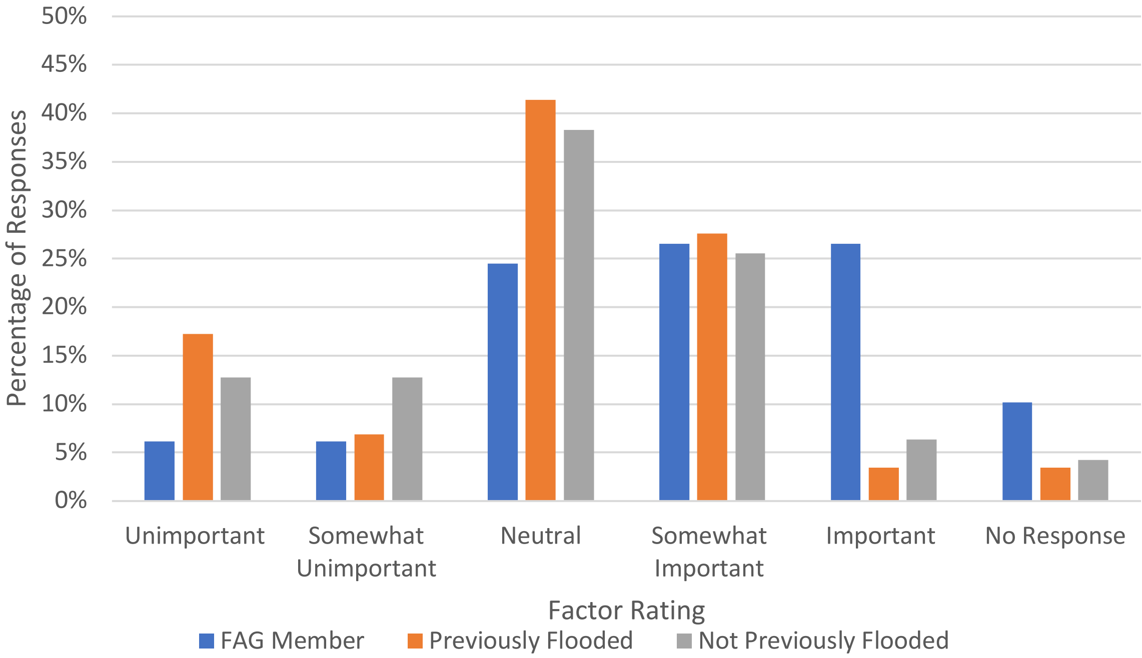

Figure 28: Breakdown of opinions of the three groups, on importance of including flexibility and creativity when measuring community flood resilience.

Again, there was no general consensus of the importance of this factor between the three participant groups. Flood action group members generally rated flexibility and creativity as somewhat important/important (53%), whilst 24% rated it as neutral importance. However, the other two groups predominantly rated the factor to be of neutral importance, with 41% of those who have previously experienced flooding rating it as neutral, and 38% of those who have not previously experienced flooding rating it as neutral. However, 32% of those who had not previously experienced flooding also rated flexibility and creativity as somewhat important/important. Further solidifying for this study there was no general agreement on the factor's importance. Highlighting this is a factor that needs further investigation in the future. A Spearman's Rho correlation highlighted a weak negative correlation between the variables, $r(123)=-0.29$, $p<0.001$, significant at the 0.01 level.

4.3.8 Collective Efficiency and Empowerment

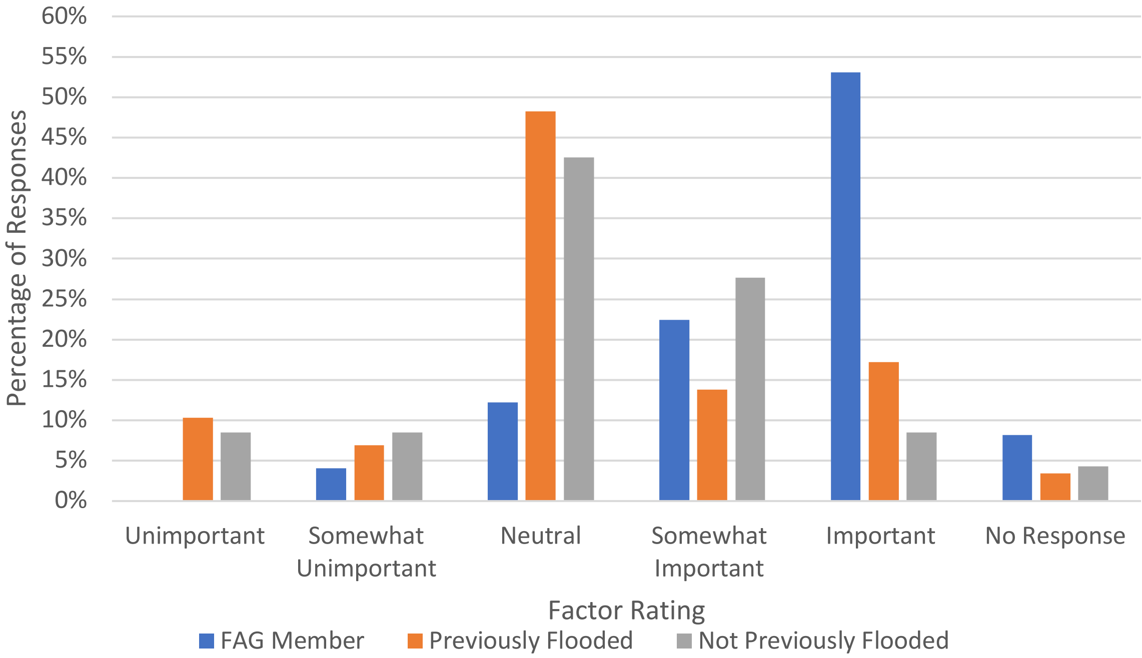

Figure 29: Breakdown of opinions of the three groups, on importance of including collective efficiency and empowerment when measuring community flood resilience.

Again, no general consensus was reached about the importance of this factor between the three groups, with collective efficiency and empowerment generally rated as neutral to important. 76% of flood action group members rated it as somewhat important/important, with 53% rating it as important. However, 48% of those who have previously experienced flooding rated it as neutral, and a further 43% of those who have not previously experienced flooding rated it as neutral as well. Finally, 36% of those who have not previously experienced flooding rated it as somewhat important/important. A Spearman's Rho correlation indicated a significant negative correlation between the variables, $r(123)=-0.44$, $p<0.001$, significant at the 0.01 level. Highlighting a potential inverse relationship between the variables.

4.3.9 Population and Community Composition

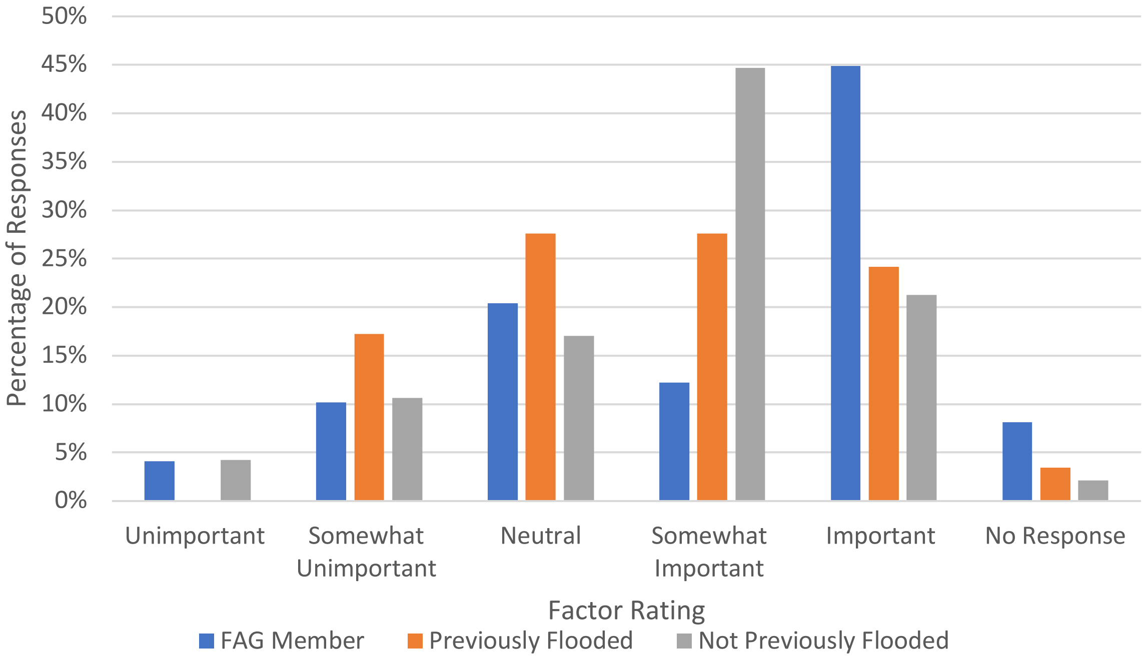

Figure 30: Breakdown of opinions of the three groups, on importance of including population and community composition when measuring community flood resilience.

There was general agreement between the participant groups that population and community composition is an important factor when measuring flood resilience in communities, with 59% of all participants rating it as somewhat important/important. Breaking this down further, 57% of flood action group members rated it as somewhat important/important, whilst 66% of those who have not previously experienced flooding rated it as somewhat important/important. However, those who have previously experienced flooding their perceptions were more varied, with 52% rating it as somewhat important/important and 28% rating it as neutral. Again, a Spearman's Rho correlation was conducted to further assess relationships between the groups $r(123) = -0.17$, $p = 0.062$, and again not significant at the 0.05 level.

4.3.10 Native Language Proficiency

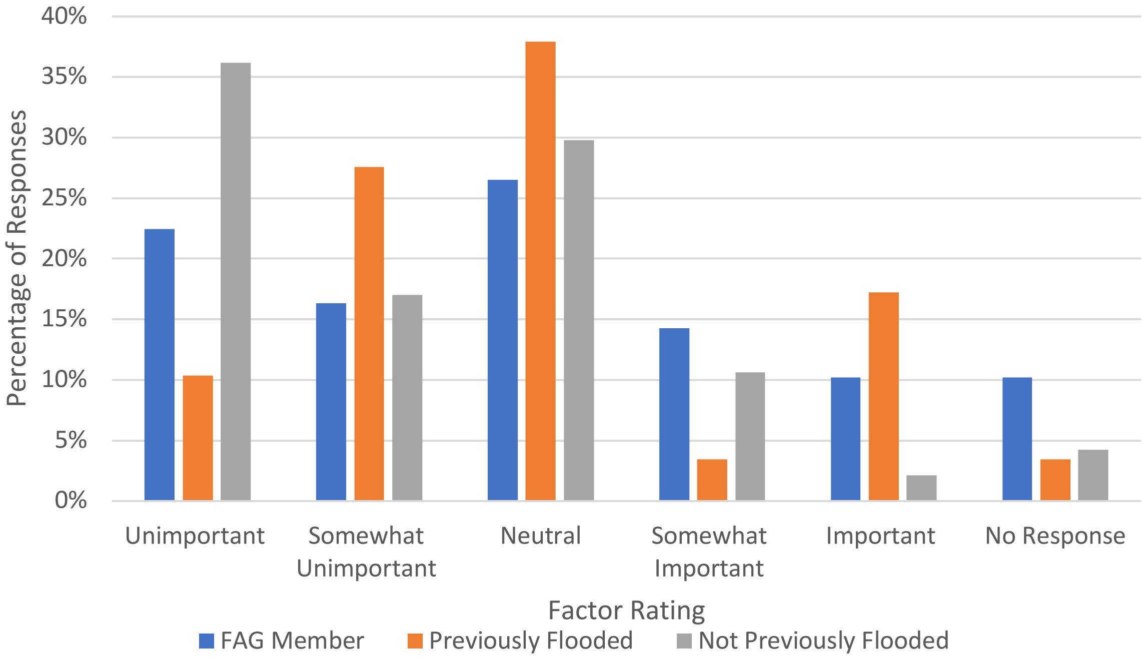

Figure 31: Breakdown of opinions of the three groups, on importance of including native language proficiency when measuring community flood resilience.

Opinions on the importance of native language proficiency as a factor varied. Flood action group members opinions were split, with 39% rating the factor as somewhat unimportant/unimportant and 27% rating it as neutral. Similarly, 53% of those who have not previously experienced flooding rated native language proficiency as somewhat unimportant/unimportant, followed by 30% rating it as neutral. Of those who had previously experienced flooding, 38% rated the factor as neutral, whilst 38% rated it as somewhat unimportant/unimportant. Whilst there is a general agreement that native language proficiency is a somewhat unimportant/unimportant factor, there is still some level of disparity between the group's perceptions. A Spearman's Rho correlation between the variables shows a very weak negative relationship r(123)=-0.045,p=0.62, that is not signification at the 0.05 level.

4.3.11 Natural Assets and Resources

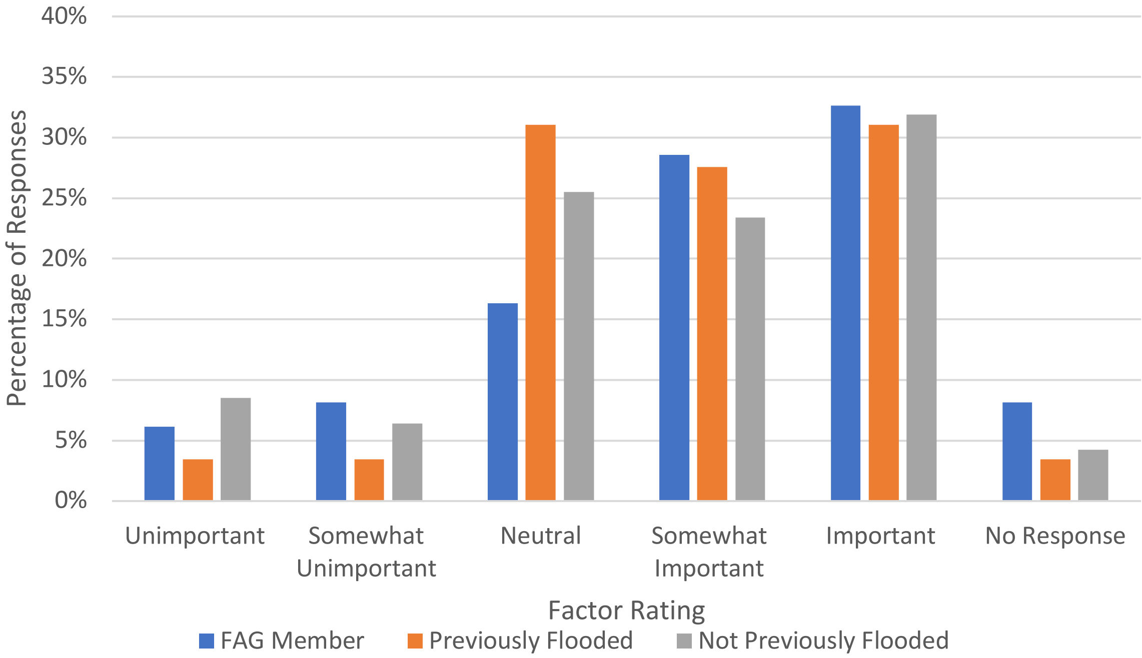

Figure 32: Breakdown of opinions of the three groups, on importance of including natural assets and resources when measuring community flood resilience.

Opinions on the importance of natural assets and resources as a factor were generally skewed towards somewhat important/important. 61% of flood action group members rated the factor as somewhat important/important, whilst only 14% rated it as somewhat unimportant/unimportant. Similarly, those who had previously experienced flooding, 59% rated the factor as somewhat important/important, and 55% of those who have not previously experienced flooding also rated it as somewhat important/important. Again, a Spearman's Rho correlation was conducted to further assess relationships between the respondent groups and the factor again a very weak negative correlation can be seen between the variables, r(123) = -0.058, p= 0.52, which is not significant at the 0.05 level.

4.3.12 Transportation Infrastructure and Services

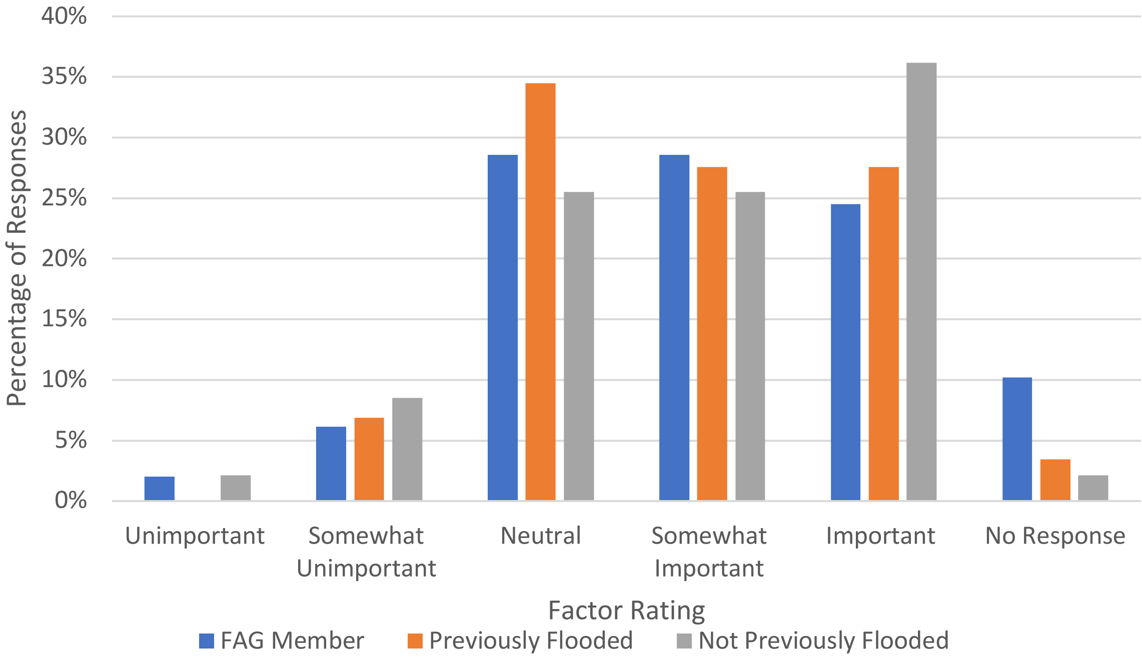

Figure 33: Breakdown of opinions of the three groups, on importance of including transportation infrastructure and services when measuring community flood resilience.

As with many of the other factors, opinions on transportation infrastructure and services were varied, but skewed towards somewhat important/important. 62% of flood action group members rated the factor as somewhat important/important, whilst 29% rated the factor as neutral. Similarly, of those who have not previously experienced flooding, 62% rated the factor as somewhat important/important, with 26% rating it as neutral. A similar trend was observed within those who have previously experienced flooding, with 55% rating it as somewhat important/important, followed by 34% rating it as neutral. A Spearman's Rho correlation between the respondent groups indicated a very slight negative correlation between the variables, $r(123) = -0.041$, $p = 0.65$, which is not significant at the 0.05 level.

4.3.13 Housing Tenancy

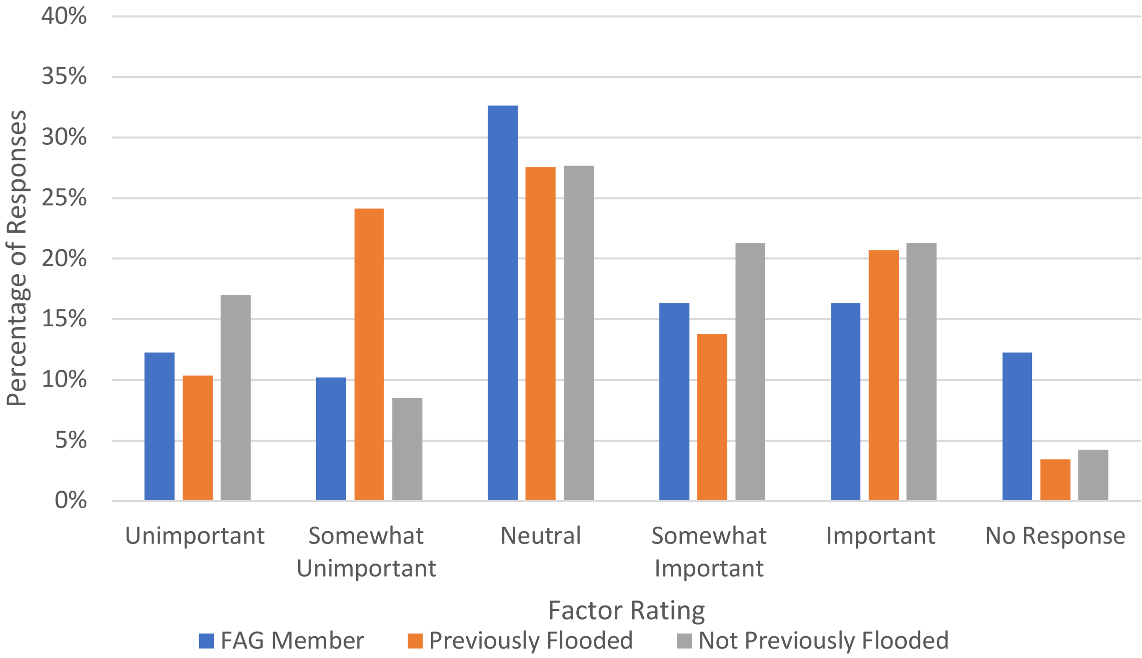

Figure 34: Breakdown of opinions of the three groups, on importance of including housing tenancy when measuring community flood resilience.

Opinions on housing tenancy as a community flood resilience factor were varied between the participant groups, however, within all three groups, it was predominantly rated as neutral. Within flood action group members, 33% rated the factor as neutral, whilst 33% rated it as somewhat important/important. However, within those who had previously experienced flooding, whilst 28% rated the factor as neutral, 34% rated the factor as somewhat unimportant/unimportant. Within those who had not previously experienced flooding, 28% rated housing tenancy as neutral, whilst 34% rated it as somewhat important/important. Again, Spearman's Rho correlation was conducted to further assess the relationships between the respondent groups and the factor. There is a very slight negative correlation between variables, r(123) = 0.079, p = 0.38, that is not significant at the 0.05 level.

4.3.14 Resources

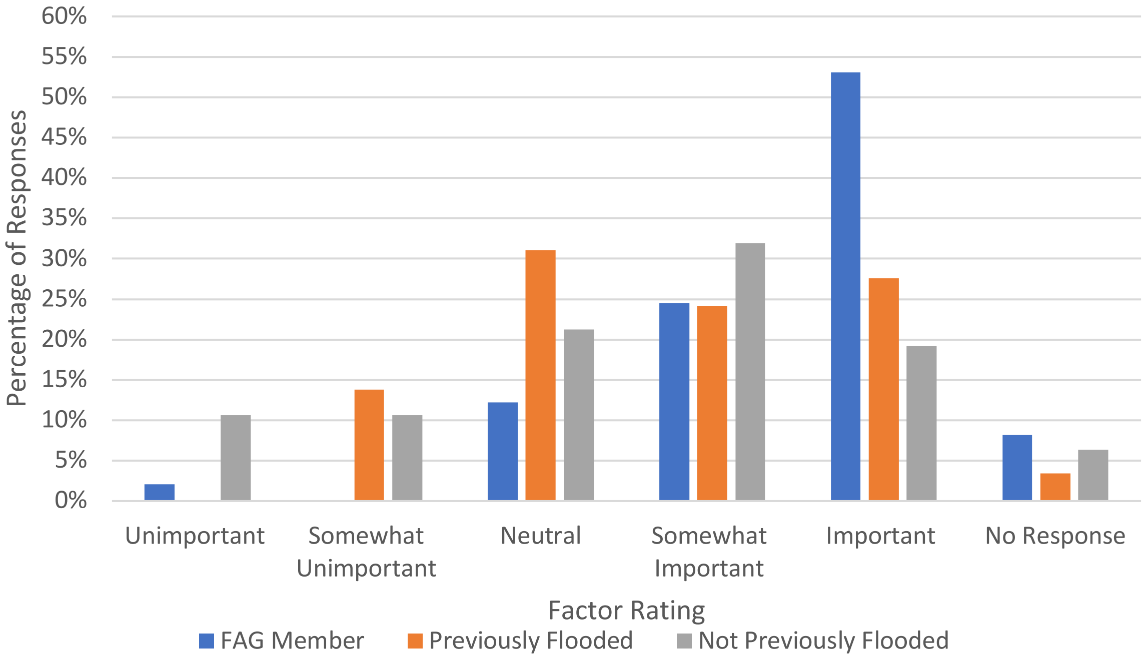

Figure 35: Breakdown of opinions of the three groups, on importance of including resources when measuring community flood resilience.

There was general agreement between the three groups that there is some importance in include resources as a factor when measuring flood resilience in communities. The majority of flood action group members rated the factor as somewhat important/important (78%), whilst only 2% rated it as unimportant. Whilst the other two groups also agree that the factor is important, opinions were not as strong. Of those who have not previously experienced flooding, 51% rated the factor as somewhat important/important, and 52% of those who had previously experienced flooding rated it as somewhat important. A Spearman's Rho correlation was conducted to further assess relations between the respondent groups and the factor. A weak inversive relationship between the variables is suggested, r(123) = -0.31, p<0.001, that is significant at the 0.01 level.

4.3.15 Facilities

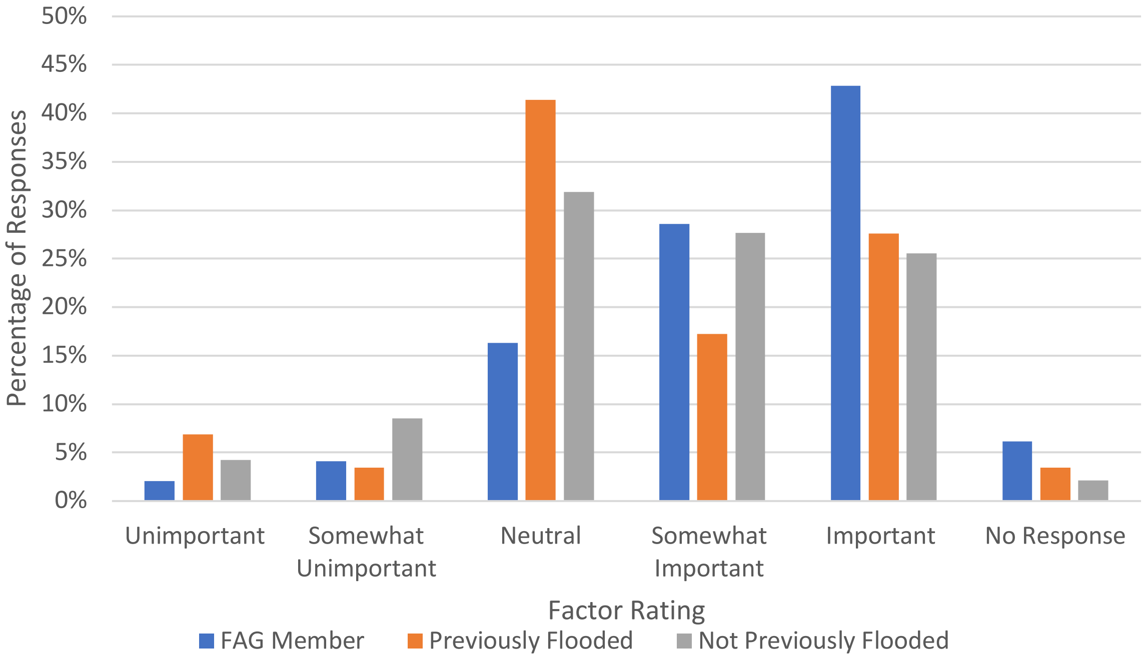

Figure 36: Breakdown of opinions of the three groups, on importance of including facilities when measuring community flood resilience.

Like resources, there is a general agreement between the three groups that there is an importance to include facilities as a factor when measuring flood resilience in communities. 71% of flood action group members rated facilities as somewhat important/important, whilst only 6% rated it as somewhat unimportant/unimportant. Similarly, those who had not previously experienced flooding generally agreed with flood action group members, with 53% rating the factor as somewhat important/important, and only 13% rating it as somewhat unimportant/unimportant. Of those who had previously experienced flooding, 45% rated it as somewhat important/important, whilst 41% rated it as neutral. Whilst the views of the two community groups were not as strong as flood action group members, they predominantly agreed that facilities are somewhat important/important in measuring community flood resilience. To further assess these relationships between respondent groups, Spearman's Rho correlation was conducted. There is a slight negative correlation between factors, $r(123) = -0.23$, $p = 0.01$, suggesting a minimal relationship that is significant at the 0.01 level.

4.3.16 Efficiency and Maintenance of Infrastructure

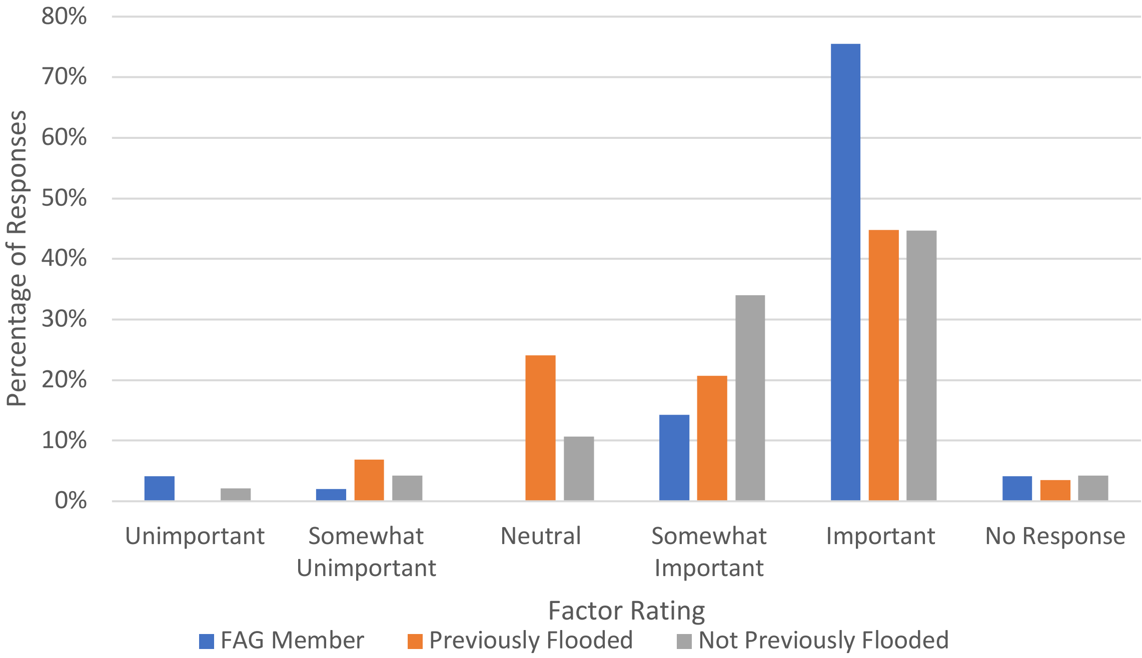

Figure 37: Breakdown of opinions of the three groups, on importance of including efficiency and maintenance of infrastructure when measuring community flood resilience.

Again, there was general agreement between the three groups that efficiency and maintenance of infrastructure is an important factor when measuring flood resilience in communities. 90% of flood action group members rated the factor as somewhat important/important. Similar agreement was observed within the other two groups. Of those who had not previously experienced flooding, 79% rated the factor as somewhat important/important, whilst 66% of those who had previously experienced flooding also rated it as somewhat important/important. Again, a Spearman's Rho correlation was conducted to further assess these relationships between the respondent groups. Again, a weak negative correlation can be noted between the variables, r(123)= - 0.27, p= 0.002, potentially suggesting a minimal inverse relationship, that is significant at the 0.01 level.

4.3.17 Land Use and Structural Design

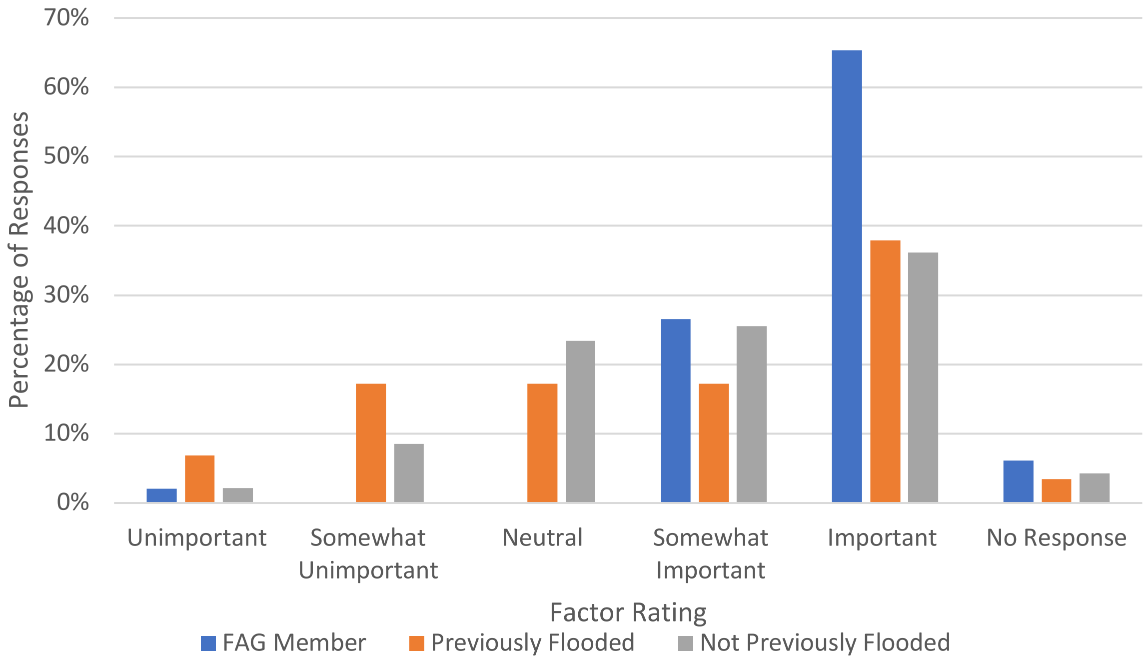

Figure 38: Breakdown of opinions of the three groups, on importance of including land use and structural design when measuring community flood resilience.

There was a general agreement that land use and structural design is an important factor when measuring flood resilience in communities, with all three groups generally rating it as somewhat important/important. 92% of flood action group members rated this factor as somewhat important/important, whilst only 2% rated it as unimportant. Highlighting flood action group members particularly identified this as a significant community flood resilience factor. Of those who had not previously experienced flooding, 62% rated the factor as somewhat important/important, followed by 23% rating it as neutral. Those who had previously experienced flooding also agreed that the factor is somewhat important/important (55%), whilst 24% rated it as somewhat unimportant/unimportant. A Spearman’s Rho correlation indicated a negative correlation between the variables, $r(123) = -0.34$, $p<0.001$, that is significant at the 0.01 level. Suggesting a potential inverse relationship between the variables.

4.3.18 Community Representative Bodies

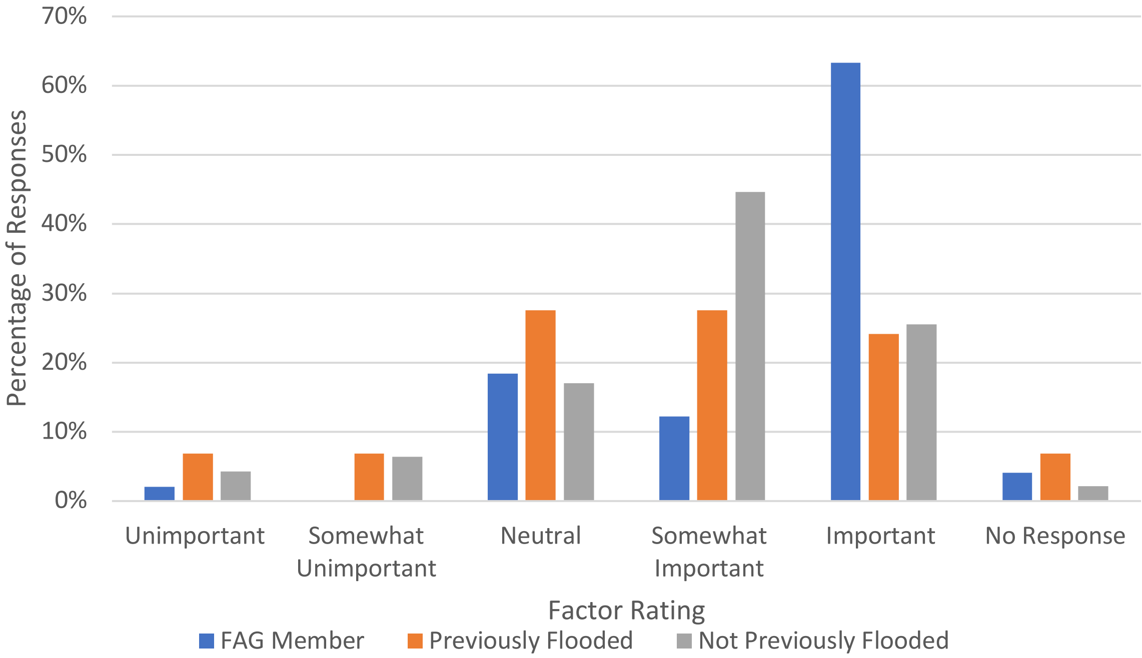

Figure 39: Breakdown of opinions of the three groups, on importance of including community representative bodies when measuring community flood resilience.

Again, there was consensus between the survey participant groups on the importance of community representative bodies in measuring community flood resilience. 76% of flood action group members rated the factor as somewhat important/important, whilst 18% rated it as neutral. Within those who had not previously experienced flooding, 70% rated it as somewhat important/important, with 17% rating it as neutral. However, whilst 52% of those who had previously experienced flooding also rated the factor as somewhat important/important, there were still 30% who rated it as neutral. Highlighting that although the majority agree this factor has merit when measuring flood resilience in communities, there is a varied view of where it sits in terms of its significance as a community flood resilience factor. A Spearman's Rho correlation indicated there is a weak negative correlation between the variables, r(123)= -0.29, p=0.001, again this suggests a slight inverse relationship between the variables, that is significant at the 0.01 level.

4.3.19 Sense of Community

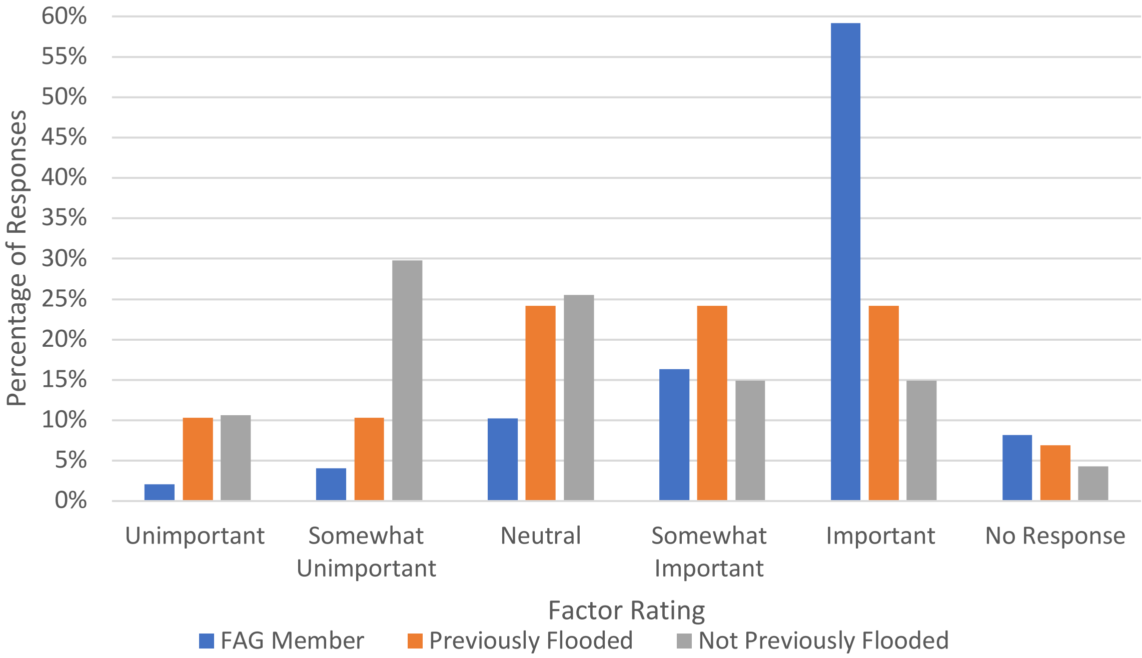

Figure 40: Breakdown of opinions of the three groups, on importance of including sense of community when measuring community flood resilience.

There were again mixed opinions between the three groups on the importance of sense of community as a flood resilience factor. Whilst 76% of flood action group members rated the factor as important/somewhat important, these views were not shared between the other groups. Similarly, of those who had previously experienced flooding, 48% rated the factor as somewhat important/important. However, 24% rated it as of neutral importance. Furthermore, those who had not previously experienced flooding, only 40% rated it as somewhat unimportant/unimportant. This highlights there are notable differences between those who had previously experienced flooding (including flood action group members) and those who have not. A Spearman's Rho correlation highlighted a slight negative correlation between the variables, $r(123)= -0.33$, $p<0.001$, significant at the 0.01 level. Again, suggesting a potential inverse relationship between the variables.

4.3.20 Planning and Mitigation

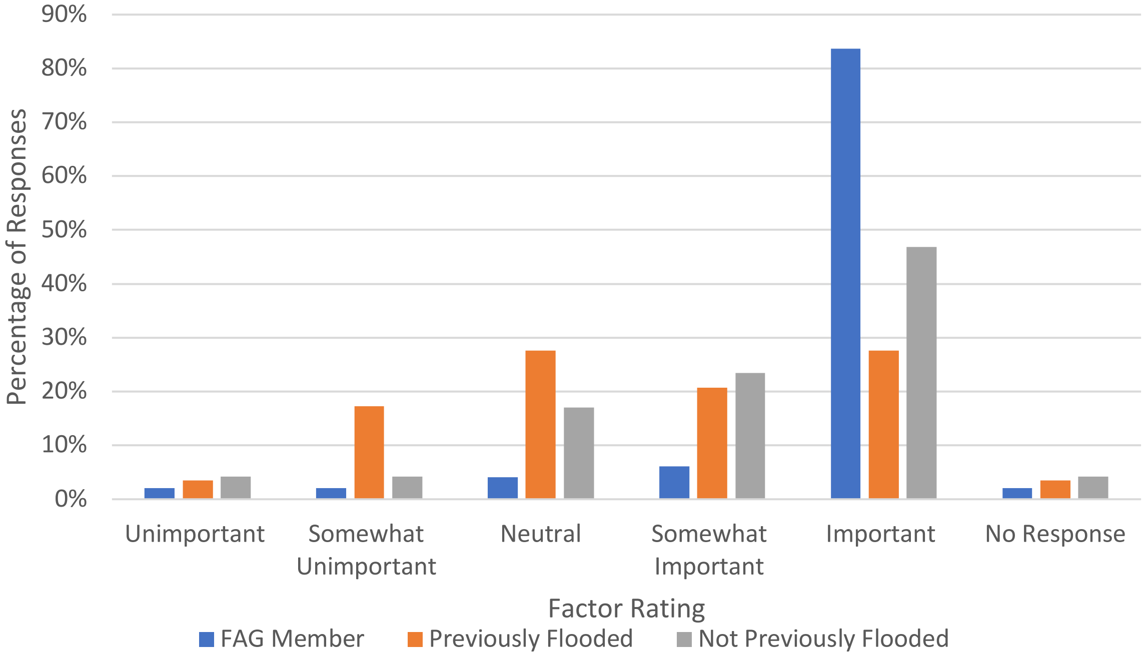

Figure 41: Breakdown of opinions of the three groups, on importance of including planning and mitigation when measuring community flood resilience.

There was general consensus between the three participatory groups that planning, and mitigation holds significant importance when measuring community flood resilience. This is particularly the case for flood action group members of which 90% rated the factor as somewhat important/important. Similarly, 70% of those who had not previously experienced flooding also rated it as a somewhat important/important factor. However, those who had previously experienced flooding had more varied views. 48% rated planning and mitigation as somewhat important/important, 26% rated it as neutral, and 21% rated it as somewhat unimportant/unimportant. A stark contrast in opinion to the other two groups. A Spearman's Rho correlation indicated that there is a negative correlation between the variables, $r(123)= -0.41$, $p<0.001$, significant at the 0.01 level. Suggesting a potential inverse relationship between the variables.

4.4 Final Factor Rankings

The ratings of all the participants were compiled and averaged for each factor presented in section 4.3 (*Table 7*) Whilst none of the factors were rated as 'unimportant', Native language proficiency had a whole sample average of 2.8, translating to an importance of 'neutral' to 'somewhat unimportant'. The highest-ranking community flood resilience factor was efficiency and maintenance of infrastructure, with a whole sample average rate of 4.4, equating to 'somewhat important'.

Factor	**Whole Sample**	**Flood Action Group Members**	**Previously Experienced Flooding**	**Not Previously Experienced Flooding**
	Average	**Average**	**Average**	**Average**
Efficiency and maintenance of infrastructure	4.4	4.7	4.6	4.0
Planning and mitigation	4.3	4.7	4.3	1.3
Land use and Structural design	4.2	4.7	4.4	3.6
Community representative bodies	4.1	4.5	4.1	3.7
Resources	4.0	4.5	3.9	3.5
Transportation infrastructure/services	3.9	4.0	4.2	3.7
Population Density	3.9	3.7	4.0	4.0
Facilities	3.9	4.2	3.7	3.7
Natural assets/resources	3.9	4.0	3.8	3.8
Population and community composition	3.9	4.1	3.9	3.6
Collective efficiency and Empowerment	3.8	4.5	3.1	3.5
Sense of community	3.8	4.5	3.5	3.2
Flood Insurance Rates	3.6	4.0	3.3	3.4
Health	3.5	4.1	2.8	3.4
Education	3.4	3.9	2.9	3.3
Flexibility and Creativity	3.4	3.9	3.2	3.1

Housing tenancy	3.4	3.5	3.2	3.4
Income	3.2	3.4	2.8	3.2
Employment	3.0	3.1	2.8	3.1
Native language proficiency	2.8	3.1	2.5	2.7

Table 7: Community flood resilience factors ranked in order of importance, determined by the averages of participant ratings for each group.

4.5 Factor Applicability

Respondents were also asked in the survey which of the above factors (Section 4.3) were not applicable when measuring community flood resilience, and if there were any factors not mentioned that should be. This was done to ensure even further knowledge was acquired in terms of respondent's opinions on community flood resilience i.e., into what they believe is important, whilst also harbouring lay knowledge to identify factors that have not previously been included here or in other studies.

4.5.1 Irrelevant Factors

22% of all participants believe that one or more of the presented factors were not applicable when measuring flood resilience in communities. Many of the comments were on the demographic/social aspects of the model (see *Figure 42 & Table 8)* .

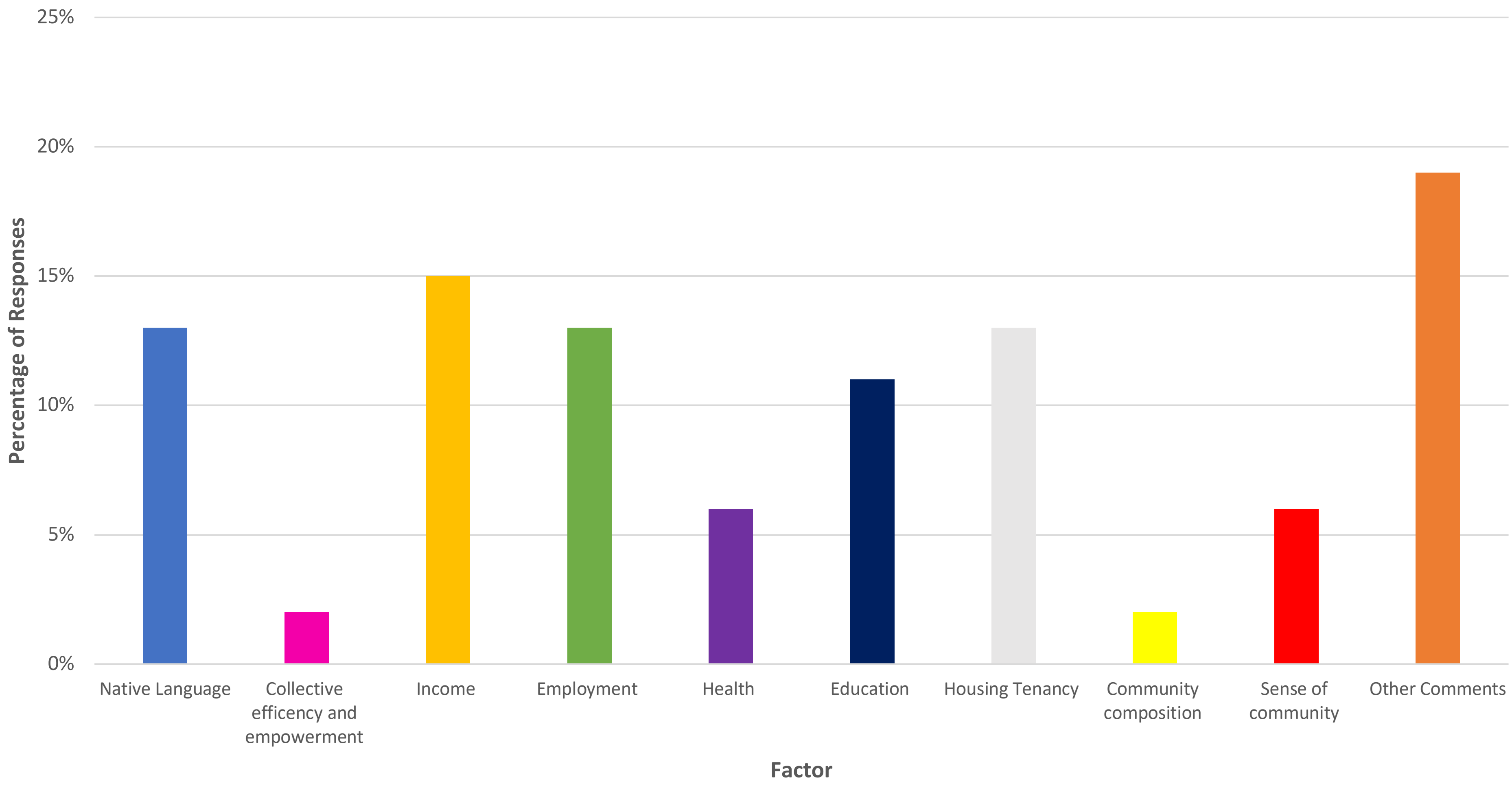

Figure 42: Factors deemed irrelevant by some community members when measuring community flood resilience.

Code	Factor	Frequency	%
1	Native Language	6	13%
2	Collective efficiency and empowerment	1	2%
3	Income	7	15%
4	Employment	6	13%
5	Health	3	6%
6	Education	5	11%
7	Housing Tenancy	6	13%
8	Community composition	1	2%
9	Sense of community	3	6%
10	Other Comments	9	19%

Table 8: Frequency and percentage of responses per factor deemed irrelevant by participants for measuring community flood resilience.

Apart from other comments, income was one of the most contested factors, with 19%, closely followed by native language, housing tenancy and employment, each with 13%. Many of the comments questioned the inclusion of these factors, with one participant, who had not previously experienced flooding stating, ‘*the main objective surely is preventing flooding’*. There were further comments surrounding demographic ‘personal’ data, suggesting factors such as income, education and age should only be used to ensure equality rather than flood resilience.

The ’other comments’ section was included for comments that don’t directly relate to the factors present, however the respondents answered yes. Many of these indicated confusion, about the direction of the question as well as the definitions of some factors.

These show that there may not be an understanding within communities, and flood action groups surrounding flood resilience, and how this is measured, as many of the factors that were deemed not applicable were social factors, which are seen in the literature as a key part of flood resilience.

4.5.2 Additional Factors

30% of respondents answered that there were additional factors that should be considered when measuring flood resilience. 27% of these responses were social based factors (19% stakeholder relationships and engagement, 2% communication, 6% community spirit, representation, and volunteering), whilst the remaining 73% were more physical (*Figure 43 & Table 9*)

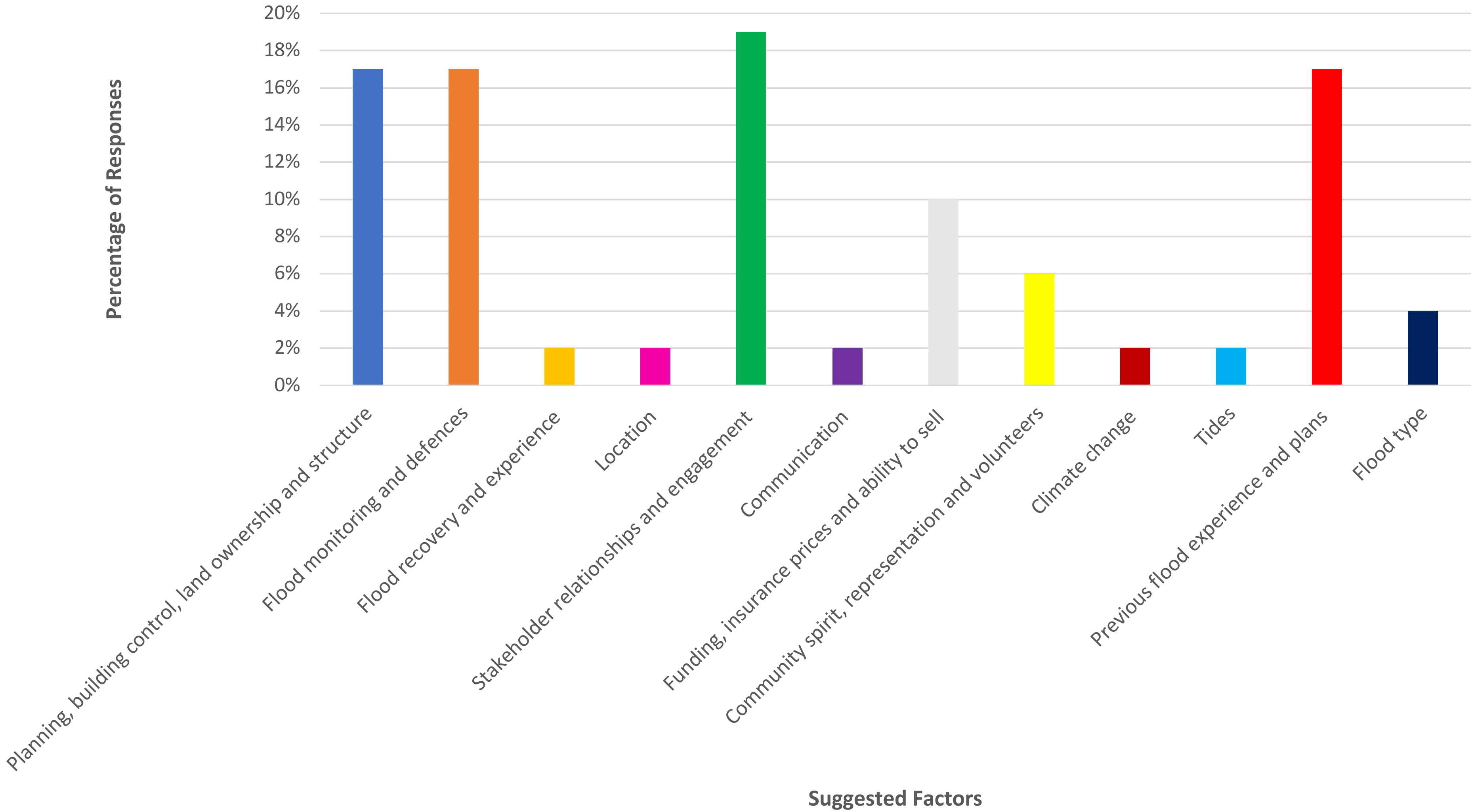

Figure 43: Factors suggested by community members that may be useful to include when measuring community flood resilience.

Code	Factor Group	Frequency	%
1	Planning, building control, land ownership and structure	8	17%
2	Flood monitoring and defences	8	17%
3	Flood recovery and experience	1	2%
4	Location	1	2%
5	Stakeholder relationships and engagement	9	19%
6	Communication	1	2%
7	Funding, insurance prices and ability to sell	5	10%
8	Community spirit, representation, and volunteers	3	6%
9	Climate change	1	2%
10	Tides	1	2%
11	Previous flood experience and plans	8	17%
12	Flood type	2	4%

Table 9: Frequency and percentage of factors suggested by participants to be included in measuring community flood resilience.

Some of the factors mentioned (*Figure 43, table 9*) could be included within the existing factors analysed (section 4.3). Community spirit, representation and volunteers could be included in community representative bodies (representation and volunteering) and sense of community (spirit). Further solidifying the inclusion of these factors.

17% of responses highlighted flood monitoring and defences as important. Whilst this was originally identified as a possible factor, it was disregarded as flood defences account to resistance and not resilience. However, there needs to be consideration of existing flood defences and how these affect communities, as well as plans for new defences. Similarly, flood recovery and experience were also mentioned (2%). Whilst these were discounted during the initial sifts, due to not being applicable in all areas, there needs to be considerations for areas that have experienced flooding, suggesting not one single model will fit all areas.

Planning, building control, land ownership and structure was another factor that came up multiple times (17%). Whilst this hasn’t previously been discussed, they are factors to consider within further research. Furthermore, fiscal factors such as funding, insurance prices and ability to sell buildings/land were also discussed. Whilst flood insurance rates were previously included, the other factors are novel. These novel factors can help create a more rounded and realistic framework for measuring flood resilience in communities, including factors that may not be considered by other researchers.

5.0 Discussion

Flooding is the most common natural disaster in Europe, as well as being the costliest in terms of economic damage (Whitfield, 2012). This hazard is also continuing to grow year-on-year, being driven by climate-change and socio-ecological changes (Ashley, Gersonius and Horton, 2020). Therefore, it is essential that a deeper understanding of how to manage the impact of flooding is achieved especially as the risk is ever increasing. Whilst flood risk can be dependent on spatial proximity to a hazard, such as a river, it also heavily depends on social aspects, such as community structure (O'Hare and White, 2018). With increasing focus on social aspects of flooding, there has been a gradual shift in flood management policy, from flood defence and stopping water, which is considered unattainable (Schanze, 2006; Scott *et al.,* 2013; Birkholz *et al.,* 2014), to flood risk management and 'learning to live with water', i.e., resilience (Nye, Tapsell, and Twigger-Ross, 2011). Whilst it is widely accepted that flooding cannot always be prevented (McClymont *et al.,* 2020), the impacts can be reduced by adhering to resilient principals. However, many of the flood resilience models that exist, such as the Flood Resilience Measurement for Communities, only consult researchers and practitioners (Laurien *et al.,* 2019), and ignore lay knowledge, a resource that could be vital to a deeper understanding of local systems and community dynamics, and in turn the flood resilience of that community (McEwen *et al.,* 2016).

Research into public perceptions of flood resilience of communities has been limited, and only developed in recent years. However, it has been found that in-depth examinations of community perceptions can aid in identification of hazards and inform organisations as to what resilient actions are best suited (Hewawasam and Matsui, 2022). There have been further calls for a hybrid knowledge exchange, resulting in co-production of flood knowledge between professionals and the community (Haughton, Bankoff and Coulthard, 2015) however this has yet to be applied to community flood resilience models.

This project attempted to start bridge some of these gaps by taking factors from existing flood resilience models to members of the communities, collecting their opinions on the importance of these factors, and identifying any other factors they believe are useful in measuring resilience.

5.1 Community Definitions of Flood Resilience

As expected, there were differing opinions on multiple aspects of community flood resilience, especially the definition. When asked about the definition of flood resilience, flood action groups had a completely different view to the other two groups. Flood action groups focused more on the social aspects of community flood resilience, such as 'community support, awareness, safety & coping' and 'effective communication & stakeholder interactions'. As these are generally people who have experienced flooding and want to advocate for their local community (McEwan *et al.,* 2018). Hence their focus on these factors is to be expected. Also, flood action groups may have experienced that lobbying for flood defences is not always viable, and therefore shift their focus to other more realistic strategies (Geaves and Penning-Rowsell, 2015). There is also the possibility that flood action group members have experienced breaching of flood defences, and realise that even with defences, they are not immune to future flood events (Bradford *et al.,* 2012). Whilst those who have previously experienced flooding may have also experienced breaching of flood defences, many of them were from Kendal, which hasn't experienced severe flooding since the commencement of flood defence construction in 2021 (Flood Hub, 2023b), therefore, may succumb to the safe development paradox, believing they are no longer at risk from flooding (Breen, Kebede and König, 2022). Those who have not previously experienced flooding are likely to be influenced by media coverage of extreme flood events (Cologna, Bark and Paavola, 2017), which is likely to limit public understanding of flood resilience, as there tends to be a focus on flood defences and their roles after large flood events, such as the 2015 storms in England (Flood Hub, 2023a).

5.2 Factor Analysis

5.2.1 Existing Factors

The factors that were presented to participants were well rooted in previous flood research, with some factors appearing in over 20 papers. One factor that was ranked low by the participants was <u>Native Language Proficiency</u>. This factor can be included within Five Capitals of Flood resilience framework's cultural capital, and was rooted from Cutter, Ash and Emrich (2014), who phrased this as 'English Language Capacity', measured as the % of community that are proficient in English. This embraces diversity within measurements (Bromley *et al.,* 2017), however, with only 1.8% of usual residents within England and Wales not being proficient in English (Office for National Statistics, 2022b), this factor may not be essential within a framework for England. However, with the UK receiving 31.2 million tourists in 2022 and predicted to receive 35.1 million in 2023 (Statistica, 2023), language proficiency may need to be considered if there are high levels of tourism in an area that has a high risk of flooding i.e., Lake District, Cumbria (fluvial and pluvial flooding), Boscastle, Cornwall (flash flooding). The adoption of native language capacity to be included within a wider factor of tourism may be beneficial, especially in coastal areas, which are expected to be affected by unprecedented flooding from sea level rise and extreme weather conditions i.e. Great Yarmouth, Norfolk (Vousdoukas *et al.,* 2018; Jarratt and Davies, 2019).

<u>Employment</u> was another factor that was ranked as neutral importance from the respondents, however, with 37% of participants being retired, they may not consider employment as important. The industry that people work in can have a huge effect on the impact of flooding. In the winter of 2013/14, flooding cost the agriculture sector £19 million, whilst summer flooding of 2007 cost the industry £50 million (Environment Agency, 2021). This can affect not only farmers and their employees, but also trickle down to potential job losses in the supplier network and food processing (Gould *et al.,* 2020). There are suggestions that employment could be integrated with industrial structures, as these could be damaged and affect employment after a flood (Parker, 2019), however, this can also be included in other factors within the study, such as efficiency and maintenance of infrastructure, or land use and structural design.

<u>Income</u> was another contested factor, with 15% of the respondents who believed that some factors were not applicable, identifying it. However, this could be considered one of the key factors within fiscal capital, as well as within a framework. Income can affect both preparation and recovery to flooding. Within recovery, income can affect humanitarian assistance, as well as if residents relocate or stay within the community (Wisner and Kelman, 2015). Ahern and Galea (2006) highlighted the negative effects of low income on post-disaster functioning of communities, with those in neighbourhoods characterised by

uneven income distribution experiencing higher levels of depression. Furthermore, those who have a lower income and live in a flood prone area are less likely to purchase flood insurance (Browne and Hoyt, 2000), therefore, if a flood was to occur they would have no protection and may not be able to recover efficiently.

Flood Insurance is also considered a very important measure within the England's flood risk management scheme (Penning-Rowsell, Priest and Johnson, 2014), yet it is still optional within England, unlike other European countries (Surminski, 2015). When presented to the participants in the study, flood insurance rates were ranked as 'neutral' to 'somewhat important'. This is expected to be due to the creation of Flood Re, which was introduced within England to make flood insurance more accessible to those at the highest risk of flooding (Flood Re, 2023b), whilst raising awareness of the importance of flood resilience and flood insurance. Whilst this has increased accessibility for those homeowners who have previously experienced flooding, by reducing the price of quotes by 50% for those who have previous flood claims (Flood Re, 2022). There is very particular criteria that has to be met to ensure access to the scheme. This doesn't protect any building built after 2009, businesses or blocks of flats (Flood Re, 2023a). Therefore, many of those that fail in terms of Flood Re eligibility, may not be able to afford the high premiums or rates presented by insurance companies or even be able to get an offer of insurance at all. Highlighting the importance of the inclusion of flood insurance as a factor. It may be that the scope of this factor is widened, not only to include flood insurance rates, but also factors such as insurance accessibility and premiums.

Inclusion of physical factors, such as 'Efficiency and Maintenance of Infrastructure' and 'Land Use', was ranked highly by the participants. Suggesting many community members believe resilience is still very much a physical entity through protection and infrastructure. Land use can influence flood resilience in communities greatly. With increasing urban densification and inadequate urban drainage systems being drivers of pluvial flooding within England (Miller and Hutchins, 2017), consideration of land use needs to be included in measuring flood resilience in communities. This was also reiterated within the definitions provided by the respondents and discussed in section 5.1.

The factor of Efficiency and Maintenance of Infrastructure once again goes back to protecting people and their belongings. McAllister (2016) noted community infrastructure is the first form of defence against a flood, and community resilience may be dependent on the capacity of infrastructure to resist disruptive events. Further research has indicated that loss of critical infrastructure within communities can affect the socio-economic systems response post-flood (Nofal and van de Lindt, 2022). The importance of this indicates that whilst participants understood there is a social aspect of flooding, it is perceived the physical environment and stopping flooding is still the best way to increase resilience.

Furthermore, '<u>Transportation Infrastructure and Services</u>' was also ranked highly by both flood action group members and those who have previously experienced flooding. Disruptions to transport systems by extreme weather events can have catastrophic impacts on communities (Jaroszweski *et al.,* 2015). Railways provide a key transport system between cities, and local areas. When destroyed, they can create huge economic losses for areas, with estimations of annual damage of railways from flooding in the EU being around €581 million per year (Bubeck *et al.,* 2019). Rail damages and interruptions are likely to continue increasing, due to climate change and increasing flood risk (Ochsner *et al.,* 2022). Whilst rail damage is only applicable in some communities, disruption on the roads is likely to affect all communities. This not only affects our ability to commute, but also accessibility to potential evacuation routes, with risks of people becoming trapped in cars due to fast rising water, as was the case in the 2012 storms (Jaroszweski *et al.,* 2015). There is also the risk that disaster-relief operations can be severely hindered, which can lead to communities suffering, and even possible fatalities (Tachaudomdach *et al.,* 2021). Therefore, it is an important factor to consider, not only due to transportation networks being key to a community's and cities development (Bukvic *et al.,* 2021), but also to ensure community members can access the safest ways to evacuate, if required.

One of the highest rated socio-cultural factors was <u>Community Representative Bodies</u>, with an average rank of 'important'. This was generally agreed between flood action group members (average score of 4.5) and those previously flooded (average score of 4.1), however was ranked lower by those who had not previously been flooded (average score of 3.7). It was expected that flood action group members would rank this as important. However, as previous research by Geaves and Penning-Rosswell (2015) identified, the groups may not achieve their goals, with the risk of conflict between stakeholders. If groups have constantly been knocked back, they could view their role as unimportant and overlooked, and therefore not important. Similarly, with those who had not previously experienced flooding are probably not all aware of flood action groups and their roles, and therefore rate the factor more 'neutral'. The perceptions of the importance of this factor between those that have flooded and those who have not does spotlight though, the importance when analysing elements such as resilience, that real experiences can identify elements that in reality are important. This could suggest that the opinions and experiences of those who had previously experienced flooding (including flood action group members) is vital for measuring community flood resilience, whilst those who had not previously experienced flooding may not be as important in designing a methodology to measure community flood resilience.

5.2.2 Suggested Factors

Some participants suggested that <u>Previous Flood Experiences</u> should be integrated into the model. This has been classed as learning from flood experience and is usually mentioned in the context of adaptive capacity (Kuang and Liao, 2020). Previous flood experience can aid in future flood events, allowing adaptation and preparation (Garde-Hansen *et al.,* 2016), however, this does not mean that communities that have not previously experienced flooding are not resilient. There should, however, be a consideration of repeated flooding. Even repetition of smaller, 10-year magnitude floods over several years can have a huge impact on a community (Cutter *et al.,* 2008). Most of the previous research on repeated flooding has focused on mental health issues (e.g., Lamond, 2014; French *et al.,* 2019), therefore before it is included in a framework to measure resilience, a deeper understanding of the effects of repeated flooding is required.

<u>Flood Defences</u> were also suggested by numerous participants. Whilst these are still a chosen method of protection by the government, with £2.6 billion spent over a 6-year period from 2014 (DEFRA, 2022), these can equate to resistance not resilience, by aiming to stop water, rather than learning how to live with it. However, where there are existing defences, there is a risk of complacency by communities, who may believe they are

protected from all flooding, even when there are flood alerts (Rollason *et al.,* 2018). Construction of new flood defences can encourage more development in flood zones, increasing the pressure on defences (Fazey *et al.,* 2007). This could suggest that presence of flood defences may affect resilience, however, in a negative capacity.

There is also the consideration of Property Flood Resilience (PFR), which is at the forefront of the government's strategy to generally increase flood resilience in England. These are modifications to houses and buildings that are designed to lower a buildings flood risk and reduce the time needed and costs of repairs after a flood (Environment Agency, 2023b), aiding a more rapid recovery. However, the term resilience in this capacity refers to reducing damage by flood water when it enters a property (Flood Hub, 2021), again a physical component of resilience. There are also concerns that the focus on PFR can hinder the resilience of buildings, especially if it is inappropriate for that building. This is most likely with historic buildings (predominantly pre-1919 builds), where inappropriate remedial works and adaptations can affect the post-flood integrity and recovery of the building (Historic England, 2015).

5.2.3 Differing Opinions Between Groups

When assessing the factors presented to the participants, there were once again differing opinions on the importance rankings, with most differences observed between those who have previously flooded (including flood action group members) and those who haven't flooded. This was most noticeable on 'sense of community'. Whilst this was rated as 'somewhat important to important' by the majority of flood action group members, it was mostly ranked as neutral by the other two groups. This again could relate to the focus of FAGs, who rely on active and engaging community members (Dittrich *et al.,* 2016). Therefore, sense of community could be the reason why a group is successful or not.

A further factor that flood action group members ranked considerably higher than the other groups is 'Health Status'. Studies have found that health has strong links to flood resilience, even though it has received less attention in literature (Allen *et al.,* 2019). Health status is not just linked to physical health, but also mental health. Many health implications occur post-flood, with flooding in many countries increasing the likelihood of vector borne illnesses, due to a proliferation of mosquitos (Keim, 2008). However, this does not occur within England, therefore health risks post flood is linked to water quality and mental health. A study by Tunstall *et al.,* (2006) reported that flood victims generally attribute physical health problems to exposure to contaminated water and living in damp environments. However, mental health problems are prevalent in those exposed to flooding, including PTSD and anxiety, which can lead to a loss of sense of place and cause disturbances to social capital (Cruz *et al.,* 2020). However, there are links between sense of community through social cohesion, increased sense of purpose and connections with other residents, contributing to more favourable mental health outcomes (Greene and Palmer, 2015). It is likely that flood action group members have experienced health issues post-flooding, with many advocating for mental health resources for those who have experienced flooding, which is now being considered by the government (UK Health Security Agency, 2022). It has been noted in previous studies that learning from flood experience is important in nurturing flood resilience (Ten Brinke *et al.,* 2008; Zevenbergen *et al.,* 2008; Kuang and Liao, 2020), whilst a communities experience of extreme flooding and their perceptions of flood risk will affect how communities learn from and adapt to disasters (Albright and Crow, 2019). This, in turn, will affect their opinions on community flood resilience and how to measure this, which may explain the differences in opinions between groups.

Previous studies that have focused on flood experience and perceptions of climate change found that opinions do not change after experience flooding (Whitmarsh, 2008). However, within this study, it was identified that flood experience may affect opinions on the importance of several factors. This is expected to be due to many of the participants that have previously experienced flooding having relied on the factors post-flood (i.e. flood insurance, structural design and land use, community representative bodies), which can influence their understanding and responses (Soetanto, Mullins and Achour, 2017). Whilst there is limited research on flood experience and flood resilience, it is expected that those that have not previously experience flooding may not understand the complexity of flood resilience, and therefore believe that some factors (such as community representative bodies and sense of community) are less important.

Furthermore, the difference of opinions could also be due to the locations of the respondents. Whilst the majority of those that had previously experienced flooding were in the northwest, many of the flood action group members were from the midlands and southwest. Whilst many of the participants had experienced flooding, those in the northwest, especially in Kendal, may not have experienced severe flooding since 2015, whereas those in flood action group, especially based in the midlands, have experienced several floods over previous years (including 2022). This temporal difference in flood experience could equate to the differences between the groups. Whilst temporal scales have been previously discussed within previous flood resilience research, this has been focused on recovery, and the complexities involved with this (De Bruijn, 2004; McClymont *et al.,* 2020). Therefore, further research is required to identify if time between the flood event and surveys affect the results.

5.3 Correlation Analysis

There is a notable lack of correlation between the variables and factors. Whilst several of them are classed as statistically significant, there is no strong correlations recorded, with the strongest being planning and mitigation with r(123)=-0.413. Even though it was expected there would be some correlations might occur between the factor and the participant group e.g., flood action group members and flood insurance rates i.e., they would see this as essential due to their experiences. However, predominantly suggested relationships were inverse (negative), suggesting that resilience is complex, and some parts of resilience, are difficult to pinpoint and quantify. Factors such as emotions and feelings, which could be key in measuring the recovery of communities, are extremely difficult to measure, and adapt over time, especially following disaster events (Hodgson, 2007). These factors that constantly change over time, which tend to be qualitative data, may not be plausible to measure, even though they are a key part of resilience. This suggests that resilience measurements should be flexible over time, to help represent these changes within communities, however, a balance between flexibility and robustness is vital (Tempels and Hartmann, 2014). If this balance cannot be achieved, it may mean that resilience cannot be measured as a standalone element.

5.4 Difficulties in Measuring Community Flood Resilience

It is questioned if community flood resilience can be measured as a stand-alone theory, or if it should be incorporated into a wider picture. The difficulties stem from the lack of clarity in the definition of flood resilience. When looking at social resilience, there is a lack of clarity and consistency on the issue (Saja *et al.,* 2019), there is also the difficulties mentioned above of access to data and the nature of resilience itself. There is also the issue of mixed messages. Whilst 'flood resilience' is at the forefront of governmental policy when it comes to flooding, there is no concrete advice on what this is. The 'Building Back Better' guidelines aim to increase resilience, but at a property level through PFR (Environment Agency, 2023a). However, as previously discussed, there are issues associated with PFR, which may be a hinderance on a community's resilience and our understanding of it.

Consideration of data sources is also required when deciding how to measure flood resilience in communities. Many of the social factors such as health, education, native language, and population density can all be collated from census data. However, this is only updated every 10 years (Office for National Statistics, 2022a), and therefore the data may not be applicable or relevant.

Qualitative research methods are usually favoured within community-scale research, with social science perspectives being more prevalent (McClymont *et al.,* 2020). Whilst social aspects are a key part of measuring resilience, they are extremely hard to measure. For example, for factors such as 'sense of community' and 'flexibility and creativity', there is no data set available. These factors are extremely hard to measure and can only be done through engaging with communities. Whilst there are methodologies to measure sense of community (Jason, Stevens, and Ram, 2015), these still include surveys and depend on the involvement of communities. Even though these datasets may not be readily available, these factors still need to be considered in measuring community flood resilience and integrated into a final methodology. Whilst this increases the difficulty in measuring flood resilience within communities, it is possible for new data sets to be collated, that will allow access to these factors.

5.5 Limitations

The biggest limitation to this research was community involvement. Whilst the survey was originally aimed at flood action group members, there was a limited uptake in their responses. This is again likely due to survey fatigue (Shepherd, per comms, 2022). Therefore, the questionnaire was opened up to the general public and to those with different flood experiences. Whilst this added depth to the research, there was still a limited response. There should, therefore, be a wider scope of participants, not only community members, but key stakeholders that have a role in the community, such as business owners, public services, and community engagement officers. This will not only increase the number of participants, but also further increase the scope of the study.

There were also limitations with the demographics of the respondents. Nearly half of the participants were 60+, whilst only 5% were aged 18-21. This does not create an accurate representation of the population and limits the opinions of the younger population. Added to this, 65% of participants were from the North-West of England. Whilst both field sights were situated within the North-West, this limited the applicability of the factors, as it only represents one area of England, which have specific experiences. Therefore, the research needs expanding into other areas within England, to see if their experiences differ from those within the North-West, and potentially provide different community flood resilience factors.

Furthermore, the questionnaire design also created issues. Whilst the questions were designed for people who are expected to have a greater understanding of flooding, there was still confusion, especially surrounding Question 7, and ranking the factors. Whilst Likert scales are widely used within research, they may need further explanation to participants, especially with the number of factors (20) that were presented within this study.

There were also issues with asking the questionnaire within the field. As this was designed to be asked online, the survey took around 5-10 minutes for participants to complete. This was difficult within the field, due to time constraints of potential participants. There was also the issue of participants not fully understanding the questions or the factors presented to them. This could have meant participants were guessing, or just randomising answers. To reduce this, the question could be simplified and re-worded, to keep participants engaged with the survey. There could also be examples given to help explain factors or a reduction in the number of factors analysed.

Further, the use of surveys can suffer from self-report bias and respondent disengagement (Soland *et al.,* 2019), whilst Likert scales reduce the respondents view to a single scale and cannot provide a complete view of the respondent's opinions. This can limit the applicability of the study, and therefore supplementary interviews should be conducted in order to encourage engagement, whilst also gaining more insight into the participants opinions, hopefully encouraging participants to voice their views further, and create an in-depth understanding of them.

5.6 Summary of Community Flood Resilience Factors

Overall, the factors that were originally presented to the participants are still considered valid to measuring community flood resilience. However, there is still much more research required to design a functional and accurate community flood resilience model. One of the main issues is 'not one model fits all' (Jones, 2019). Therefore, the model framework would need to be flexible and potentially adopt a 'pick and mix' situation dependent on the contexts of the area and the hazards. This would involve the creation of new datasets, that would encompass all aspects of communities, including their composition and flood experiences, as well as physical aspects including land use, flood defences and facilities available. Whilst this would derive from both qualitative and quantitative data, it is suggested that an index is created, similar to those used in flood risk, to help simplify and visualise the data.

A similar approach has been used by the EU Flood Directive, which allows countries to consider what is applicable in their country, allowing a level of flexibility (Priest *et al.,* 2016). Whilst factors such as land use, community composition, flood insurance and resources would be a core part of the model, factors such as flood defences, previous flood type and experience and native language can be added in, dependent on the community and their experiences.

However, this research has allowed community voices to be heard and considered in relation to factors that are important in measuring community flood resilience. Whilst research by Forrest, Trell and Woltjer (2019) investigates social contributions to local flood resilience, including flood action group members and stakeholders, this method is yet to be done for measuring community flood resilience.

5.7 Recommendations for Further Research

To further this research, the study needs to be expanded, to encompass further communities, flood action groups, and other key stakeholders, such as the Environment Agency and local government. This will allow factors to be investigated further, as well as incorporating further stakeholders that influence local decision making.

There also needs to be further research and exploration into the use of a dynamic framework, which can be adapted to multiple communities, which have different experiences, different local environments, different flood types experienced and community compositions. This will allow a model to be curated that will be applicable in multiple communities, rather than specific target areas, and ensure that the findings can be extrapolated to further communities in England.

Furthermore, further research is required on some of the factors, and how they relate to community flood resilience. Factors such as flood defences, which can be considered as both resilience and resistance measures, can affect community flood resilience in different ways, and therefore research into this is required before including it in a framework. There are also factors like repeated flooding, which are understood to decrease resilience, however, the implications are not widely understood, therefore again, more research is required into this.

There also needs to be a consideration of weighting of the factors. Whilst this study identifies potential factors, it doesn't consider the weighting of the factors. This can be done statistically, or through consultation with community members and key stakeholders, to consider if all of the factors and their weighting.

There also needs to be further research into the use of quantitative data within flood resilience. As indicated in Section 5.3, the use of correlation analysis showed limited to no correlation. Whilst this was suggested to be due to the complexity of flood resilience, there needs to be further research into other methods to quantify the dynamic qualitative data that is critical in measuring flood resilience, as well as other statistical measurements that may be suitable for the data. This is also likely to change as the research methods and data collection adapt.

6. Conclusion

Whilst flooding is expected to increase exponentially due to climate change, there is a requirement to help communities become more resilient to flooding. This shift in focus has led to an influx of research within the flood resilience sector. This has created confusion and lack of direction, not only in defining resilience, but how to measure it.

This study aimed to include community members in the decision making process surrounding identifying important factors for measuring community flood resilience. Three key groups were targeted, flood action group members, those who have previously experienced flooding and those who have not experienced flooding. Existing factors, taken from current methodologies and prior research, were presented to participants, through questionnaires.

Participants generally agreed with the inclusion of some of the factors presented to them (i.e. planning and mitigation, land use and structural design), however, there were differing opinions between the three groups on many of the factors. Flood action group members tended to have stronger opinions on the inclusion of socio-economic factors, whereas the other groups tended to lobby the inclusion of more physical factors, such as land use and structural design.

Participants also highlighted that flood experiences and flood defences should be included when measuring community flood resilience, however these are not applicable in all areas. This suggests that measuring community flood resilience may not be as simple as a single methodology, and require a dynamic methodology, where some factors can be added in or removed, depending on the local environment and contexts of the community.

There are some difficulties when measuring community flood resilience, with limited data sets, and an overall lack of understanding when it comes to community flood resilience. There therefore needs to be further research into dynamic methods for measuring community flood resilience, which incorporates community and stakeholder knowledge, to create a much more holistic approach in order to reduce future flood impacts in our urban communities.

7. References

Abdel-Mooty, M.N., Yosri, A., El-Dakhakhni, W. and Coulibaly, P., (2021). Community flood resilience categorization framework. *International Journal of Disaster Risk Reduction*, *61*, p.102349.

Adedeji, T.J., Proverbs, D.G., Xiao, H. and Oladokun, V.O., (2018). Towards a conceptual framework for property level flood resilience. *International journal of safety and security engineering*, *8*(4), pp.493-504.

Adger, W.N., (2010). Social capital, collective action, and adaptation to climate change. *Der klimawandel: Sozialwissenschaftliche perspektiven*, pp.327-345.

Adini, B., Cohen, O., Eide, A.W., Nilsson, S., Aharonson-Daniel, L. and Herrera, I.A., (2017). Striving to be resilient: What concepts, approaches and practices should be incorporated in resilience management guidelines?. *Technological Forecasting and Social Change*, *121*, pp.39-49.

Ahern, J. and Galea, S., (2006). Social context and depression after a disaster: the role of income inequality. *Journal of Epidemiology & Community Health*, *60*(9), pp.766-770.

Albright, E.A. and Crow, D., (2019). Beliefs about climate change in the aftermath of extreme flooding. *Climatic Change*, *155*(1), pp.1-17.

Albright, E.A. and Crow, D.A., (2021). Capacity building toward resilience: How communities recover, learn, and change in the aftermath of extreme events. *Policy Studies Journal*, *49*(1), pp.89-122.

Aldrich, D.P. and Meyer, M.A., (2015). Social capital and community resilience. *American behavioral scientist*, *59*(2), pp.254-269.

Allen, T.R., Crawford, T., Montz, B., Whitehead, J., Lovelace, S., Hanks, A.D., Christensen, A.R. and Kearney, G.D., (2019). Linking water infrastructure, public health, and sea level rise: Integrated assessment of flood resilience in coastal cities. *Public Works Management & Policy*, *24*(1), pp.110-139.

Angeler, D.G. and Allen, C.R., (2016). Quantifying resilience. *Journal of Applied Ecology*, *53*(3), pp.617-624.

Arbon, P., (2014). Developing a model and tool to measure community disaster resilience. *Australian Journal of Emergency Management*, *29*(4), pp.12-16.

Arbon, P., Steenkamp, M., Cornell, V., Cusack, L. and Gebbie, K., (2016). Measuring disaster resilience in communities and households: Pragmatic tools developed in Australia. *International Journal of Disaster Resilience in the Built Environment*, *7*(2), pp.201-215.

ARUP (2018) *City Resilience Index*. [Online] Available at: https://www.cityresilienceindex.org/#/resources [Accessed: 09/07/2023]

Asadzadeh, A., Kötter, T., Salehi, P. and Birkmann, J., (2017). Operationalizing a concept: The systematic review of composite indicator building for measuring community disaster resilience. *International journal of disaster risk reduction*, *25*, pp.147-162.

Ashley, R., Gersonius, B. and Horton, B., (2020). Managing flooding: from a problem to an opportunity. *Philosophical Transactions of the Royal Society A*, *378*(2168), p.20190214.

Atkins (2022) *Cheshire West and Chester Section 19 flood investigation – Main report.* [Online] Available at: https://www.cheshirewestandchester.gov.uk/asset-library/flooding/s19-storm-christoph-report.pdf [Accessed: 26/07/2023]

Atreya, A. and Kunreuther, H., 2016. Measuring community resilience: the role of the community rating system (CRS). *Available at SSRN 2788230*: https://ssrn.com/abstract=2788230

Aven, T., (2019). The call for a shift from risk to resilience: What does it mean?. *Risk Analysis*, *39*(6), pp.1196-1203.

Barnett, J., (2023) 'Chester: Firefighters tackle flooding incidents after thunderstorms'. *The Standard.* [Online] Available at: https://www.chesterstandard.co.uk/news/23643341.chester-firefighters-tackle-flooding-incidents-thunder-storms/ [Accessed: 12/07/2023]

Batica, J., (2015) Methodology for flood resilience assessment in urban environments and mitigation strategy development. *Doctoral Dissertation, Université Nice Sophia Antipolis)*

Batica, J., Gourbesville, P. and Hu, F.Y., (2013), September. Methodology for flood resilience index. In *International conference on flood resilience experiences in Asia and Europe–ICFR, Exeter, United Kingdom*.

Béné, C., Chowdhury, F.S., Rashid, M., Dhali, S.A. and Jahan, F., (2017). Squaring the circle: Reconciling the need for rigor with the reality on the ground in resilience impact assessment. *World Development*, *97*, pp.212-231.

Berke, P.R. and Campanella, T.J., (2006). Planning for post disaster resiliency. *The ANNALS of the American academy of political and social science*, *604*(1), pp.192-207.

Biggs, R., Schlüter, M. and Schoon, M.L., (2015). An introduction to the resilience approach and principles to sustain ecosystem services in social–ecological systems. *Principles for building resilience: Sustaining ecosystem services in social–ecological systems*, pp.1-31.

Birkholz, S., Muro, M., Jeffrey, P. and Smith, H.M., (2014). Rethinking the relationship between flood risk perception and flood management. *Science of the total environment*, *478*, pp.12-20.

Biswas, S. and Nautiyal, S., (2023). A review of socio-economic vulnerability: The emergence of its theoretical concepts, models and methodologies. *Natural Hazards Research*.
Bradford, R.A., O'Sullivan, J.J., Van der Craats, I.M., Krywkow, J., Rotko, P., Aaltonen, J., Bonaiuto, M., De Dominicis, S., Waylen, K. and Schelfaut, K., (2012). Risk perception–issues for flood management in Europe. *Natural hazards and earth system sciences*, *12*(7), pp.2299-2309.

Bradshaw, T.K., (2008). The post-place community: Contributions to the debate about the definition of community. *Community Development*, *39*(1), pp.5-16.

Brand, F., (2009). Critical natural capital revisited: Ecological resilience and sustainable development. *Ecological economics*, *68*(3), pp.605-612.

Breen, M.J., Kebede, A.S. and König, C.S., (2022). The Safe Development Paradox in Flood Risk Management: A Critical Review. *Sustainability*, *14*(24), p.16955.

Bromley, E., Eisenman, D.P., Magana, A., Williams, M., Kim, B., McCreary, M., Chandra, A. and Wells, K.B., (2017). How do communities use a participatory public health approach to build resilience? The Los Angeles County Community Disaster Resilience Project. *International journal of environmental research and public health*, *14*(10), p.1267.

Browne, M.J. and Hoyt, R.E., (2000). The demand for flood insurance: empirical evidence. *Journal of risk and uncertainty*, *20*, pp.291-306.

Bruneau, M., Chang, S.E., Eguchi, R.T., Lee, G.C., O'Rourke, T.D., Reinhorn, A.M., Shinozuka, M., Tierney, K., Wallace, W.A. and Von Winterfeldt, D., (2003). A framework to quantitatively assess and enhance the seismic resilience of communities. *Earthquake spectra*, *19*(4), pp.733-752.

Bubeck, P., Dillenardt, L., Alfieri, L., Feyen, L., Thieken, A.H. and Kellermann, P., (2019). Global warming to increase flood risk on European railways. *Climatic Change*, *155*, pp.19-36.

Bukvic, A., Borate, A., Hughes, S., Weaver, R., Imburgia, D. and Stiles Jr, W.A., (2021). Exploring neighborhood-level resilience to flooding: Why the context and scale matter. *Journal of Flood Risk Management*, *14*(2), p.e12698.

Bulti, D.T., Girma, B. and Megento, T.L., (2019). Community flood resilience assessment frameworks: A review. *SN Applied Sciences*, *1*, pp.1-17.

Burby, R., (2003). Making plans that matter: Citizen involvement and government action. *Journal of the American Planning Association*, *69*(1), pp.33-49.

Butler, C. and Walker-Springett, K., (2016) Social and political dynamics of flood risk, recovery and response. A report of the findings of the Winter Floods Project. *The University of Exeter*

Cabinet Office (2008). The Pitt Review: Lessons Learned from the 2007 Floods. *Cabinet Office: London* [Online] Available at: https://webarchive.nationalarchives.gov.uk/ukgwa/20100806203134/http://archive.cabinetoffice.gov.uk/pittreview/thepittreview.html [Accessed: 13/07/2023]

Cabinet Office (2019) *Community Resilience Development Framework*. [Online] Available at: https://www.gov.uk/government/publications/community-resilience-development-framework [Accessed: 09/07/2023]

Campbell, K.A., Laurien, F., Czajkowski, J., Keating, A., Hochrainer-Stigler, S. and Montgomery, M., (2019). First insights from the Flood Resilience Measurement Tool: A large-scale community flood resilience analysis. *International Journal of Disaster Risk Reduction*, *40*, p.101257
Cariolet, J.M., Vuillet, M. and Diab, Y., (2019). Mapping urban resilience to disasters–A review. *Sustainable cities and society*, *51*, p.101746.

Carmen, E., Fazey, I., Ross, H., Bedinger, M., Smith, F.M., Prager, K., McClymont, K. and Morrison, D., (2022). Building community resilience in a context of climate change: The role of social capital. *Ambio*, *51*(6), pp.1371-1387.

Cassell, C. and Bishop, V., (2019). Qualitative data analysis: Exploring themes, metaphors and stories. *European Management Review*, *16*(1), pp.195-207.

Castleden, M., McKee, M., Murray, V. and Leonardi, G., 2011. Resilience thinking in health protection. *Journal of public health*, *33*(3), pp.369-377.

Chakraborty, L., Rus, H., Henstra, D., Thistlethwaite, J., Minano, A. and Scott, D., (2022). Exploring spatial heterogeneity and environmental injustices in exposure to flood hazards using geographically weighted regression. *Environmental Research*, *210*, p.112982.

Chandra, A., Acosta, J., Howard, S., Uscher-Pines, L., Williams, M., Yeung, D., Garnett, J. and Meredith, L.S., (2011). Building community resilience to disasters: A way forward to enhance national health security. *Rand health quarterly*, *1*(1).

Chapin, F.S., Carpenter, S.R., Kofinas, G.P., Folke, C., Abel, N., Clark, W.C., Olsson, P., Smith, D.M.S., Walker, B., Young, O.R. and Berkes, F., (2010). Ecosystem stewardship: sustainability strategies for a rapidly changing planet. *Trends in ecology & evolution*, *25*(4), pp.241-249.

Cheshire East Council (2022) *Flood Risk* [Online] Available at: https://www.cheshireeast.gov.uk/planning/flooding/floods-and-flood-risk/flood-risk.aspx#:~:text=Many%20floods%20in%20Cheshire%20East,also%20prone%20to%20groundwater%20flooding. [Accessed: 10/6/2023]

Chowdhooree, I., Sloan, M. and Dawes, L., (2019). Community perceptions of flood resilience as represented in cognitive maps. *Journal of flood risk management*, *12*(4), p.e12478.

Chuang, W.C., Garmestani, A., Eason, T.N., Spanbauer, T.L., Fried-Petersen, H.B., Roberts, C.P., Sundstrom, S.M., Burnett, J.L., Angeler, D.G., Chaffin, B.C. and Gunderson, L., (2018). Enhancing quantitative approaches for assessing community resilience. *Journal of environmental management*, *213*, pp.353-362.

Cohen, O., Leykin, D., Lahad, M., Goldberg, A. and Aharonson-Daniel, L., (2013). The conjoint community resiliency assessment measure as a baseline for profiling and predicting community resilience for emergencies. *Technological Forecasting and Social Change*, *80*(9), pp.1732-1741.

Cologna, V., Bark, R.H. and Paavola, J., (2017). Flood risk perceptions and the UK media: Moving beyond "once in a lifetime" to "Be Prepared" reporting. *Climate Risk Management*, *17*, pp.1-10.

Committee on Climate Change (2016) *UK Climate Change Risk Assessment 2017 – Synthesis Report: Priorities for the Next Five Years* [Online] Available at: https://www.theccc.org.uk/uk-climate-change-risk-assessment-2017/synthesis-report/ [Accessed: 02/05/2023]

Cowen, E.L., (2000). Community psychology and routes to psychological wellness. In *Handbook of community psychology* (pp. 79-99). Boston, MA: Springer US.

Cox, R.S. and Hamlen, M., (2015). Community disaster resilience and the rural resilience index. *American Behavioural Scientist*, *59*(2), pp.220-237.

Crichton, D., (1999). The risk triangle. *Natural disaster management*, *102*(3), pp.102-103.

Cruz, J., White, P.C., Bell, A. and Coventry, P.A., (2020). Effect of extreme weather events on mental health: a narrative synthesis and meta-analysis for the UK. *International journal of environmental research and public health*, *17*(22), p.8581.

Cutter, S.L., Ash, K.D. and Emrich, C.T., (2014). The geographies of community disaster resilience. *Global environmental change*, *29*, pp.65-77.

Cutter, S.L., Barnes, L., Berry, M., Burton, C., Evans, E., Tate, E. and Webb, J., (2008). A place-based model for understanding community resilience to natural disasters. *Global environmental change*, *18*(4), pp.598-606.

Cutter, S. L., Barnes, L., Berry, M., Burton, C., Evans, E., Tate, E., and Webb, J., (2008b) Community and regional resilience: Perspectives from hazards, disasters and emergency management. *Geography.*

Cutter, S.L., Burton, C.G. and Emrich, C.T., (2010). Disaster resilience indicators for benchmarking baseline conditions. *Journal of homeland security and emergency management*, *7*(1).

Cutter, S.L., Boruff, B.J. and Shirley, W.L., (2012). Social vulnerability to environmental hazards. In *Hazards vulnerability and environmental justice* (pp. 143-160). Routledge.

Da Silva, J., Kernaghan, S. and Luque, A., (2012). A systems approach to meeting the challenges of urban climate change. *International Journal of Urban Sustainable Development*, *4*(2), pp.125-145.

Davydov, D.M., Stewart, R., Ritchie, K. and Chaudieu, I., (2010). Resilience and mental health. *Clinical psychology review*, *30*(5), pp.479-495.

De Bruijn, K.M., (2004) Resilience indicators for flood risk management systems of lowland rivers. *International Journal of River Basin Management*, *2(3),* pp. 199-210

Department of Environment, Flood and Rural Affairs (2008) The Governments Response to Sir Michael Pitts Review of the Summer 2007 [Online] Available at: https://webarchive.nationalarchives.gov.uk/ukgwa/20130402151656/http://archive.defra.gov.uk/environment/flooding/documents/risk/govtresptopitt.pdf [Accessed: 17/02/2023]

DEFRA (2014) *A short guide to Flood Re* [Online] Available at: https://consult.defra.gov.uk/flooding/floodreinsurancescheme/supporting_documents/A%20short%20guide%20to%20Flood%20Re.pdf [Accessed: 06/07/2023]

DEFRA (2022) *Over 314,000 homes better protected due to flood defence work* [Online] Available at: https://www.gov.uk/government/news/over-314000-homes-better-protected-due-to-flood-protection-work [Accessed: 07/07/2023]

Disse, M., Johnson, T.G., Leandro, J. and Hartmann, T., (2020). Exploring the relation between flood risk management and flood resilience. *Water Security*, *9*, p.100059.

Dittrich, R., Wreford, A., Butler, A. and Moran, D., (2016). The impact of flood action groups on the uptake of flood management measures. *Climatic Change*, *138*, pp.471-489.
Dong, S., Gao, X., Mostafavi, A., Gao, J., and Gangwal, U (2023) Characterising resilience of flood-disrupted dynamic transportation networks through the lens of link reliability and stability. *Reliability engineering and systems safety*, *232*, p.109071

Edwards, K.A., Alschuler, K.A., Ehde, D.M., Battalio, S.L., Jensen, M., (2017) Changes in resilience predict function in adults with physical disabilities: a longitudinal study. *Archives of Physical Medicine and Rehabilitation*, *98*(2), pp.329-336.

Environment Agency (2009) *Flooding in England: A national assessment of flood risk* [Online] Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/292928/geho0609bqds-e-e.pdf [Accessed: 25/07/2023]

Environment Agency (2016) *Kendal Flood Investigation Report* [Online] Available at: https://cumbria.gov.uk/elibrary/Content/Internet/544/3887/6729/6735/4271394334.PDF [Accessed: 14/04/2023]

Environment Agency (2017) How frightened should we be of flooding? [Online] Available at: https://environmentagency.blog.gov.uk/2017/10/27/how-frightened-should-we-be-of-flooding/ [Accessed: 07/02/2023]

Environment Agency (2019) *Learn more about flood risk*. [Online] Available at: https://check-long-term-flood-risk.service.gov.uk/map [Accessed: 13/07/2023]

Environment Agency (2021) *The Costs and impacts of the winter 2013 to 2014 floods.* [Online] Available at: https://www.gov.uk/flood-and-coastal-erosion-risk-management-research-reports/the-costs-and-impacts-of-the-winter-2013-to-2014-floods [Accessed: 03/07/2023]

Environment Agency (2022) *Measuring resilience to flooding and coastal erosion*. [Online] Available at: https://www.gov.uk/flood-and-coastal-erosion-risk-management-research-reports/measuring-resilience-to-flooding-and-coastal-change [Accessed: 11/07/2023]

Environment Agency (2023a) *Building Back Better and Property Flood Resilience* [Online] Available at: https://environmentagency.blog.gov.uk/2023/05/22/building-back-better-and-mainstreaming-property-flood-resilience/ [Accessed:08/07/2023]

Environment Agency (2023b) *Property Flood Resilience* [Online] Available at: https://consult.environment-agency.gov.uk/hnl/propertyfloodresilience/ [Accessed: 07/07/2023]

Fazey, I., Fazey, J.A., Fischer, J., Sherren, K., Warren, J., Noss, R.F. and Dovers, S.R., (2007). Adaptive capacity and learning to learn as leverage for social–ecological resilience. *Frontiers in Ecology and the Environment*, *5*(7), pp.375-380.

Fenner, R., O'Donnell, E., Ahilan, S., Dawson, D., Kapetas, L., Krivtsov, V., Ncube, S. and Vercruysse, K., (2019). Achieving urban flood resilience in an uncertain future. *Water*, *11*(5), p.1082.
Flood Hub (2021) *Property Flood Resilience (PFR) Booklet* [Online] Available at: https://thefloodhub.co.uk/wp-content/uploads/2018/09/Property-Flood-Resilience-PFR-booklet.pdf [Accessed: 07/07/2023]

Flood Hub (2023a) *A Catchment Based Approach to Managing Flood Risk*. [Online] Available at: https://thefloodhub.co.uk/wp-content/uploads/2022/02/Catchment-management-booklet.pdf [Accessed: 07/07/2023]

Flood Hub (2023b) *Kendal Flood Risk Management Scheme.* [Online] Available at: https://thefloodhub.co.uk/kendal/kendal-flood-risk-management-scheme/ [Accessed: 11/07/2023]

Flood Re (2022) *Annual Report and Financial Statements* [Online] Available at: https://www.floodre.co.uk/wp-content/uploads/Flood-Re-Annual-Report-2022.pdf [Accessed: 06/07/2023]

Flood Re (2023a) *Qualifying Policies which may be ceded to Flood Re* [Online] available at: https://www.floodre.co.uk/find-an-insurer/eligibility-criteria/ [Accessed: 06/07/2023]

Flood Re (2023b) *What Is Flood Re?* [Online] Available at: https://www.floodre.co.uk/about-us/ [Accessed: 06/07/2023]

Flood Resilience Alliance (2019) *The Flood Resilience Measurement of Communities* [Online] Available at: http://repo.floodalliance.net/jspui/handle/44111/2981 [Accessed: 13/02/2023]

Flora, C.B., and Flora, J., (2008) Rural Communities: legacy and change (Third Edition). *Westview Press.*

Folke, C., (2006). Resilience: The emergence of a perspective for social–ecological systems analyses. *Global environmental change*, *16*(3), pp.253-267.

Folke, C., Biggs, R., Norström, A.V., Reyers, B. and Rockström, J., (2016). Social-ecological resilience and biosphere-based sustainability science. *Ecology and Society*, *21*(3).

Forrest, S., Trell, E.M. and Woltjer, J., (2017). Flood Groups in England: Governance arrangements and contributions to community resilience to flooding. In *Governing for Resilience in Vulnerable Places*. Routledge.

Forrest, S., Trell, E.M. and Woltjer, J., (2019). Civil society contributions to local level flood resilience: Before, during and after the 2015 Boxing Day floods in the Upper Calder Valley. *Transactions of the institute of British geographers*, *44*(2), pp.422-436.

Frankenberger, T., Mueller M., Spangler T., and Alexander S. October 2013. Community Resilience: Conceptual Framework and Measurement Feed the Future Learning Agenda. Rockville, MD: Westat.

Frazier, T.G., Thompson, C.M., Dezzani, R.J. and Butsick, D., (2013). Spatial and temporal quantification of resilience at the community scale. *Applied Geography*, *42*, pp.95-107.
French, C.E., Waite, T.D., Armstrong, B., Rubin, G.J., Beck, C.R. and Oliver, I., (2019). Impact of repeat flooding on mental health and health-related quality of life: a cross-sectional analysis of the English National Study of Flooding and Health. *BMJ open*, *9*(11), p.e031562.

Garde-Hansen, J., McEwen, L., Holmes, A., and Jones, O., (2016) Sustainable flood memory: Remembering as resilience. *Memory Studies*, *10(4),* p384-405

Geaves, L.H. and Penning-Rowsell, E.C., (2015). ‘Contractual’ and ‘cooperative’ civic engagement: The emergence and roles of ‘flood action groups’ in England and Wales. *Ambio*, *44*, pp.440-451.

Gissing, A., Keys, C. and Opper, S., (2010). Towards resilience against flood risks. *Australian Journal of Emergency Management, The*, *25*(2), pp.39-45.

Gould, I.J., Wright, I., Collison, M., Ruto, E., Bosworth, G. and Pearson, S., (2020). The impact of coastal flooding on agriculture: A case-study of Lincolnshire, United Kingdom. *Land Degradation & Development*, *31*(12), pp.1545-1559.

Greene, G., and Palmer, S.R., (2015). Resilience and vulnerability to the psychological harm from flooding: The role of social cohesion. *American Journal of Public Health*, *105*(9), pp.1792-1795.

Gutierrez-Montes, I., Emery, M. and Fernandez-Baca, E., (2009). The sustainable livelihoods approach and the community capitals framework: The importance of system-level approaches to community change efforts. *Community development*, *40*(2), pp.106-113.

Gunderson, L.H., (2000). Ecological resilience—in theory and application. *Annual review of ecology and systematics*, *31*(1), pp.425-439.

Hallegatte, S., Vogt-Schilb, A., Bangalore, M. and Rozenberg, J. (2017) *Unbreakable: Building the Resilience of the Poor in the Face of Natural Disasters*. *World Bank Publications.*

Haque, C.E. and Doberstein, B., (2021). Adaptive governance and community resilience to cyclones in coastal Bangladesh: Addressing the problem of fit, social learning, and institutional collaboration. *Environmental Science & Policy*, *124*, pp.580-592.

Harrington, C., Curtis, A. and Black, R., (2008). Locating communities in natural resource management. *Journal of Environmental Policy & Planning*, *10*(2), pp.199-215.

Haughton, G., Bankoff, G. and J Coulthard, T., (2015). In search of 'lost' knowledge and outsourced expertise in flood risk management. *Transactions of the Institute of British Geographers*, *40*(3), pp.375-386.

Hemmati, M., Ellingwood, B.R. and Mahmoud, H.N., (2020). The role of urban growth in resilience of communities under flood risk. *Earth's Future*, *8*(3), p.e2019EF001382.

Hewawasam, V. and Matsui, K., 2022. Assessing Community Perceptions on Urban Flood Resilience in Sri Lanka. *Geosciences*, *12*(11), p.406.

Historic England (2015) *Flooding and Historic Buildings* [Online] Available at: https://historicengland.org.uk/images-books/publications/flooding-and-historic-buildings-2ednrev/heag017-flooding-and-historic-buildings/ [Accessed: 07/07/2023]

HM Government (2016) *National Flood Resilience Review* [Online] Available at: https://www.gov.uk/government/publications/national-flood-resilience-review [Accessed:11/07/2023]

Hochrainer-Stigler, S., Laurien, F., Velev, S., Keating, A. and Mechler, R., (2020). Standardized disaster and climate resilience grading: A global scale empirical analysis of community flood resilience. *Journal of Environmental Management*, *276*, p.111332.

Hodgson, R.W., (2007). Emotions and sense making in disturbance: community adaptation to dangerous environments. *Human Ecology Review*, pp.233-242.

Holling, C.S., (1973). Resilience and stability of ecological systems. *Annual review of ecology and systematics*, *4*(1), pp.1-23.

IFRC (2014) *IFRC Framework for Community Resilience*. [Online] Available at: https://www.ifrc.org/document/ifrc-framework-community-resilience [Accessed:09/07/2023]

Irwin, S., Schardong, A., Simonovic, S.P. and Nirupama, N., (2016). ResilSIM—A decision support tool for estimating resilience of urban systems. *Water*, *8*(9), p.377.

Jaroszweski, D., Hooper, E., Baker, C., Chapman, L. and Quinn, A., (2015). The impacts of the 28 June 2012 storms on UK road and rail transport. *Meteorological Applications*, *22*(3), pp.470-476.

Jarratt, D. and Davies, N.J., (2020). Planning for climate change impacts: Coastal tourism destination resilience policies. *Tourism Planning & Development*, *17*(4), pp.423-440.

Jason, L.A., Stevens, E. and Ram, D., (2015). Development of a three-factor psychological sense of community scale. *Journal of community psychology*, *43*(8), pp.973-985.

Jones, L., (2019). Resilience isn't the same for all: Comparing subjective and objective approaches to resilience measurement. *Wiley Interdisciplinary Reviews: Climate Change*, *10*(1), p.e552.

Joshi, A., Kale, S., Chandel, S. and Pal, D.K., (2015). Likert scale: Explored and explained. *British journal of applied science & technology*, *7*(4), pp.396-403.

Karrasch, L., Restemeyer, B. and Klenke, T., (2021). The 'Flood Resilience Rose': A management tool to promote transformation towards flood resilience. *Journal of Flood Risk Management*, *14*(3), p.e12726.

Keating, A., Campbell, K., Szoenyi, M., McQuistan, C., Nash, D. and Burer, M., (2017). Development and testing of a community flood resilience measurement tool. *Natural Hazards and Earth System Sciences*, *17*(1), pp.77-101.

Keim, M.E., (2008). Building human resilience: the role of public health preparedness and response as an adaptation to climate change. *American journal of preventive medicine*, *35*(5), pp.508-516.

Kellens, W., Terpstra, T. and De Maeyer, P., (2013). Perception and communication of flood risks: A systematic review of empirical research. *Risk Analysis: An International Journal*, *33*(1), pp.24-49.

Khalili, S., Harre, M. and Morley, P., (2015). A temporal framework of social resilience indicators of communities to flood, case studies: Wagga wagga and Kempsey, NSW, Australia. *International journal of disaster risk reduction*, *13*, pp.248-254.

Khamis, H., (2008). Measures of association: How to choose? *Journal of Diagnostic Medical Sonography*, *24*(3), pp.155-162.

King, N. and Brooks, J., (2018). Thematic analysis in organisational research. *The SAGE handbook of qualitative business and management research methods: Methods and challenges*, p.219-236.

Klein, R.J., Nicholls, R.J. and Thomalla, F., (2003). Resilience to natural hazards: How useful is this concept? *Global environmental change part B: environmental hazards*, *5*(1), pp.35-45.

Kovats, R.S., and Osborn, D., (2016) *UK climate change risk assessment evidence report: Chapter 5, people and the built environment*. [[Online] Available at: https://www.theccc.org.uk/wp-content/uploads/2016/07/UK-CCRA-2017-Chapter-5-People-and-the-built-environment.pdf [Accessed: 25/07/2023][Online] Available at: https://www.theccc.org.uk/wp-content/uploads/2016/07/UK-CCRA-2017-Chapter-5-People-and-the-built-environment.pdf [Accessed: 25/07/2023]

Kuang, D. and Liao, K.H., (2020). Learning from Floods: Linking flood experience and flood resilience. *Journal of environmental management*, *271*, p.111025.

Kundzewicz, Z.W. and Matczak, P.I.O.T.R., (2015). Hydrological extremes and security. *Proceedings of the International Association of Hydrological Sciences*, *366*, p.44-53.

Kusumastuti, R.D., Husodo, Z.A., Suardi, L. and Danarsari, D.N., (2014). Developing a resilience index towards natural disasters in Indonesia. *International journal of disaster risk reduction*, *10*, pp.327-340.

Laboy, M. and Fannon, D., (2015). Learning Comprehensive Building Design through a Resilience Framework. *Proceedings. Sheffield, UK: Sheffield School of Architecture*.

Lamond, J., (2014). The role of flood memory in the impact of repeat flooding on mental health. *Flood recovery, innovation and response IV*, *184*.

Laurien, F., Hochrainer-Stigler, S., Keating, A., Campbell, K., Mechler, R. and Czajkowski, J., (2020). A typology of community flood resilience. *Regional Environmental Change*, *20*, pp.1-14.

Laurien, F., Keating, A., Mechler, R., Etienne, E., Velev, S., Szoenyi, M., McQuistan, C., Ianni, F. and Campbell, K., (2019). Lessons Learned from Measuring Flood Resilience.

Linkov, I., Bridges, T., Creutzig, F., Decker, J., Fox-Lent, C., Kröger, W., Lambert, J.H., Levermann, A., Montreuil, B., Nathwani, J. and Nyer, R., (2014). Changing the resilience paradigm. *Nature Climate Change*, *4*(6), pp.407-409.

Lochmiller, C.R., (2021). Conducting thematic analysis with qualitative data. *The Qualitative Report*, *26*(6), pp.2029-2044.

Liu, Q., Li, C., Wanga, V. and Shepherd, B.E., (2018). Covariate-adjusted Spearman's rank correlation with probability-scale residuals. *Biometrics*, *74*(2), pp.595-605.

Liu, J.J., Reed, M. and Girard, T.A., (2017). Advancing resilience: An integrative, multi-system model of resilience. *Personality and Individual Differences*, *111*, pp.111-118.

Madewell, A.N. and Ponce-Garcia, E., (2016). Assessing resilience in emerging adulthood: The resilience scale (RS), Connor–Davidson resilience scale (CD-RISC), and scale of protective factors (SPF). *Personality and Individual differences*, *97*, pp.249-255.

Manyena, S.B., (2006). The concept of resilience revisited. *Disasters*, *30*(4), pp.434-450.

Manyena, S.B., (2014). Disaster resilience: A question of ‘multiple faces’ and ‘multiple spaces’?. *International journal of disaster risk reduction*, *8*, pp.1-9.

Andrew, M., (2018). Revisiting community-based disaster risk management. In *Reducing Disaster Risks* (pp. 42-52). Routledge.

Mayunga, J.S., (2007). Understanding and applying the concept of community disaster resilience: a capital-based approach. *Summer academy for social vulnerability and resilience building*, *1*(1), pp.1-16.

Mayunga, J.S., 2009. *Measuring the measure: A multi-dimensional scale model to measure community disaster resilience in the US Gulf Coast region*. *Doctoral Dissertation.* Texas A&M University.

McAllister, T., (2016). Research needs for developing a risk-informed methodology for community resilience. *Journal of Structural Engineering*, *142*(8), p.C4015008.

McClymont, K., Morrison, D., Beevers, L. and Carmen, E., (2020). Flood resilience: a systematic review. *Journal of Environmental Planning and Management*, *63*(7), pp.1151-1176.

McEwen, L., Garde-Hansen, J., Holmes, A., Jones, O. and Krause, F., (2016). Sustainable flood memories, lay knowledges and the development of community resilience to future flood risk. *Transactions of the Institute of British Geographers*, *42*(1), pp.14-28.

McEwen, L., Holmes, A., Quinn, N. and Cobbing, P., (2018). 'Learning for resilience': Developing community capital through flood action groups in urban flood risk settings with lower social capital. *International journal of disaster risk reduction*, *27*, pp.329-342.

McEwen, L. and Jones, O., (2012). Building local/lay flood knowledges into community flood resilience planning after the July 2007 floods, Gloucestershire, UK. *Hydrology Research*, *43*(5), pp.675-688.

McEwen, L., Krause, F., Hansen, J.G. and Jones, O., (2012), July. Flood histories, flood memories and informal flood knowledge in the development of community resilience to future flood risk. In *BHS eleventh national symposium, hydrology for a changing world, Dundee* (pp. 9-11).

MCP (2017) *Maine Flood Resilience Checklist. A self-assessment tool for Maine's coastal communities to evaluate vulnerability to flood hazards and increase resilience.* [Online] Available at: https://www.maine.gov/dacf/mgs/hazards/coastal/MaineFloodResilienceChecklistOverview.pdf [Accessed: 09/07/2023]

Mercer, J., Kelman, I., Taranis, L. and Suchet-Pearson, S., (2010). Framework for integrating indigenous and scientific knowledge for disaster risk reduction. *Disasters*, *34*(1), pp.214-239.

Miller, J.D. and Hutchins, M., (2017). The impacts of urbanisation and climate change on urban flooding and urban water quality: A review of the evidence concerning the United Kingdom. *Journal of Hydrology: Regional Studies*, *12*, pp.345-362.

Monte, B.E.O., Goldenfum, J.A., Michel, G.P. and de Albuquerque Cavalcanti, J.R., (2021). Terminology of natural hazards and disasters: A review and the case of Brazil. *International Journal of Disaster Risk Reduction*, *52*, p.101970.

Morelli, A., Taramelli, A., Bozzeda, F., Valentini, E., Colangelo, M.A. and Cueto, Y.R., (2021). The disaster resilience assessment of coastal areas: A method for improving the stakeholders' participation. *Ocean & Coastal Management*, *214*, p.105867.

Munawar, H.S., Khan, S.I., Anum, N., Qadir, Z., Kouzani, A.Z. and Parvez Mahmud, M.A., (2021). Post-flood risk management and resilience building practices: A case study. *Applied Sciences*, *11*(11), p.4823.

Murdock, H.J., De Bruijn, K.M. and Gersonius, B., (2018). Assessment of critical infrastructure resilience to flooding using a response curve approach. *Sustainability*, *10*(10), p.3470.

National Flood Forum (2020) *What is a Flood Action Group?* [Online] Available at: https://nationalfloodforum.org.uk/working-together/communities/what-is-a-flood-action-group/ [Accessed: 17/02/2023]

National Flood Forum (2022) Conversations with Sophie Laidlaw, Sarah Percival, Heather Shepherd and Jean Timmins, June.

National Institute of Standards and Technology (2020). *COMMUNITY RESILIENCE PLANNING GUIDE for BUILDINGS and INFRASTRUCTURE SYSTEMS: A Playbook.* [Online] Available at: https://www.nist.gov/publications/community-resilience-planning-guide-buildings-and-infrastructure-systems-playbook [Accessed: 31/07.2023]

Nelson, D.R., Adger, W.N. and Brown, K., 2007. Adaptation to environmental change: contributions of a resilience framework. *Annual. Review. Environmental. Resources.*, *32*, pp.395-419.

Nguyen, K.V. and James, H., (2013). Measuring household resilience to floods: a case study in the Vietnamese Mekong River Delta. *Ecology and Society*, *18*(3).

Nofal, O.M. and Van De Lindt, J.W., (2022). Understanding flood risk in the context of community resilience modeling for the built environment: Research needs and trends. *Sustainable and Resilient Infrastructure*, *7*(3), pp.171-187.

Nohrstedt, D. and Weible, C.M., (2010). The logic of policy change after crisis: Proximity and subsystem interaction. *Risk, hazards & crisis in public policy*, *1*(2), pp.1-32.

Norris, F.H., Stevens, S.P., Pfefferbaum, B., Wyche, K.F. and Pfefferbaum, R.L., (2008). Community resilience as a metaphor, theory, set of capacities, and strategy for disaster readiness. *American journal of community psychology*, *41*, pp.127-150.

Ntontis, E., Drury, J., Amlôt, R., Rubin, G.J. and Williams, R., (2018). Emergent social identities in a flood: Implications for community psychosocial resilience. *Journal of Community & Applied Social Psychology*, *28*(1), pp.3-14.

Nurwulandari, F.S. and Rismana, G.A., (2021). Community resilience to face flood disaster in the Baleendah Village, Bandung Regency, Indonesia. In *IOP Conference Series: Earth and Environmental Science* (Vol. 737, No. 1, p. 012051). IOP Publishing.

Nye, M., Tapsell, S. and Twigger-Ross, C., (2011). New social directions in UK flood risk management: moving towards flood risk citizenship? *Journal of flood risk management*, *4*(4), pp.288-297.

O'Cathain, A. and Thomas, K.J., (2004). " Any other comments?" Open questions on questionnaires–a bane or a bonus to research?. *BMC medical research methodology*, *4*(1), pp.1-7.

Ochsner, M., Palmqvist, C.W., Olsson, N.O. and Hiselius, L.W., (2023). The effects of flooding on railway infrastructure: A literature review. *Transportation Research Procedia*, *72*, pp.1786-1791.

Office for National Statistics (2022a) *About the Census* [Online] Available at: https://www.ons.gov.uk/census/aboutcensus/aboutthecensus [Accessed: 06/07/2023]

Office for National Statistics (2022b) *Language, England and Wales: Census 2021* [Online*]* Available at: https://www.ons.gov.uk/peoplepopulationandcommunity/culturalidentity/language/bulletins/languageenglandandwales/census2021#:~:text=In%202021%2C%2063.8%25%20(15.8,main%20languages%20within%20the%20household. [Accessed: 02/07/2023]

O'Hare, P. and White, I., (2018). Beyond 'just' flood risk management: the potential for—and limits to—alleviating flood disadvantage. *Regional Environmental Change*, *18*, pp.385-396.

Oladokun, V.O., Proverbs, D.G. and Lamond, J., (2017). Measuring flood resilience: A fuzzy logic approach. *International Journal of Building Pathology and Adaptation*, *35*(5), pp.470-487.

Olatunji, E.O., Adebimpe, O.A. and Oladokun, V.O., (2023). A fuzzy logic approach for measuring flood resilience at community level in Nigeria. *International Journal of Disaster Resilience in the Built Environment*.

Ostadtaghizadeh, A., Ardalan, A., Paton, D., Jabbari, H., and Khankeh, H.R., (2015) Community disaster resilience: a systematic review on assessment models and tools. *PLOS Currents*. *7.*

Owusu, S., Wright, G. and Arthur, S., (2015). Public attitudes towards flooding and property-level flood protection measures. *Natural Hazards*, *77*, pp.1963-1978.

Oxford English Dictionary (2022). *Community* (definition) [online] Available at: https://www.oed.com/viewdictionaryentry/Entry/37337;jsessionid=6E9C8FF524F9030E286A98A499B736C6#:~:text=A%20body%20of%20people%20who,particular%20body%20of%20people%20lives. [Accessed 06/02/2023]

Parker, D.J., (2020). Disaster resilience–a challenged science. *Environmental Hazards*, *19*(1), pp.1-9.

Parsons, M., Morley, P., Marshall, G.R., Hastings, P., Reeve, I., Glavac, S., Stayner, R., McNeill, J., and McGregor, J. (2016) The Australian natural disaster resilience index: Conceptual framework and indicator approach. *Bushfires and Natural Hazards CRC*.

Patel, H.R. and Joseph, J.M., (2016). Questionnaire designing process: A review. *Journal of Clinical Trials*, *6*(2), pp.2-7.

Patel, S.S., Rogers, M.B., Amlôt, R. and Rubin, G.J., (2017). What do we mean by 'community resilience'? A systematic literature review of how it is defined in the literature. *PLoS currents*, *9*.

Penning-Rowsell, E.C., Priest, S. and Johnson, C., (2014). The evolution of UK flood insurance: incremental change over six decades. *International Journal of Water Resources Development*, *30*(4), pp.694-713.

Penning-Rowsell, E.C., (2015). A realistic assessment of fluvial and coastal flood risk in England and Wales. *Transactions of the Institute of British Geographers*, *40*(1), pp.44-61.

Percival, S.E., (2016) Portsmouth coastal vulnerability and risk: assessment and mapping of impacts at microscale. *Doctoral Thesis*.

Percival, S., Gaterell, M. and Teeuw, R., (2019). Urban neighbourhood flood vulnerability and risk assessments at different diurnal levels. *Journal of Flood Risk Management*, *12*(3), p.e12466.

Percival, S. and Teeuw, R., (2019). A methodology for urban micro-scale coastal flood vulnerability and risk assessment and mapping. *Natural Hazards*, *97*(1), pp.355-377.

Pfferbaum, R.L., Pfferbaum, R.L., Van Horn, R.L., Klomp, R.W., Norris, F.H., and Reissman, D.B., (2011) Communities advancing resilience toolkit (CART) The CART integrated system. *Journal of Public Health Management and Practice*.

Priest, S.J., Suykens, C., Van Rijswick, H.F., Schellenberger, T., Goytia, S., Kundzewicz, Z.W., van Doorn-Hoekveld, W.J., Beyers, J.C. and Homewood, S., (2016). The European Union approach to flood risk management and improving societal resilience: lessons from the implementation of the Floods Directive in six European countries. *Ecology and Society*, *21*(4).

Rahman, M.B., Nurhasanah, I.S. and Nugroho, S.P., (2016). Community resilience: learning from Mt Merapi eruption 2010. *Procedia-Social and Behavioural Sciences*, *227*, pp.387-394.

Renschler, C.S., Frazier, A.E., Arendt, L.A., Cimellaro, G.P., Reinhorn, A.M. and Bruneau, M., (2010), July. Developing the 'PEOPLES' resilience framework for defining and measuring disaster resilience at the community scale. In *Proceedings of the 9th US national and 10th Canadian conference on earthquake engineering* (pp. 25-29). Canada Toronto.

Restemeyer, B., Woltjer, J. and van den Brink, M., (2014). A strategy-based framework for assessing the flood resilience of cities–A Hamburg case study. *Planning Theory & Practice*, *16*(1), pp.45-62.

Rezende, O.M., Miranda, F.M., Haddad, A.N. and Miguez, M.G., (2019). A framework to evaluate urban flood resilience of design alternatives for flood defence considering future adverse scenarios. *Water*, *11*(7), p.1485.

Rollason, E., Bracken, L.J., Hardy, R.J. and Large, A.R.G., (2018). Rethinking flood risk communication. *Natural hazards*, *92*, pp.1665-1686.

Rozer, V., Mehryar, S., and Surminski, S., (2022) From managing risk to increasing resilience: a review on the development of urban flood resilience, its assessment and the implications for decision making. *Environmental Research Letters*.

Saja, A.A., Goonetilleke, A., Teo, M. and Ziyath, A.M., (2019). A critical review of social resilience assessment frameworks in disaster management. *International journal of disaster risk reduction*, *35*, p.101096.

Salas, E.B., (2023) *Global number of people affected by floods 1990-2020* [Online] Available at: https://www.statista.com/statistics/1293353/global-number-of-people-affected-by-floods [Accessed:15/05/2023]

Schanze, J., (2006). Flood risk management–a basic framework. In *Flood risk management: Hazards, vulnerability and mitigation measures* (pp. 1-20). Springer Netherlands.

Scheffer, M., Hosper, S.H., Meijer, M.L., Moss, B. and Jeppesen, E., (1993). Alternative equilibria in shallow lakes. *Trends in ecology & evolution*, *8*(8), pp.275-279.

Schelfaut, K., Pannemans, B., Van der Craats, I., Krywkow, J., Mysiak, J. and Cools, J., (2011). Bringing flood resilience into practice: the FREEMAN project. *Environmental Science & Policy*, *14*(7), pp.825-833.

Scott, M., White, I., Kuhlicke, C., Steinfuhrer, A., Sultana, P., Thompson, P. (2013) Living with flood risk. *Plan Theory Practice. 14(1).* P. 103-140

Sempier, T.T., Swann, D.L., Emmer, R., Sempier, S.H., and Schneider, M. (2010) *Coastal community index: a community self-assessment* [Online] Available at: https://repository.library.noaa.gov/view/noaa/37845 [Accessed: 09/07/2023]

Shepherd, H., (2022) Conversation with Sophie Laidlaw and Sarah Percival, June.

Sherrib, K., Norris, F.H., and Galea. S. (2010) Measuring capacities for community resilience. *Social Indicators Research, 99*. P227-247

Simpson, D.M. and Katirai, M., (2006). Indicator issues and proposed framework for a disaster preparedness index (DPi). *University of Louisville, 49*.

Smith, G., (2012) Planning for post-disaster recovery: A Review of the United States Disaster Assistance Framework. *Public Entity Risk Institute, 1*. P1

Smith, R., Simard, C. and Sharp, A. (2001) A proposed approach to environment and sustainable development indicators based on capital. *Prepared for the Canadian Economics Association Meeting*.

Soetanto, R., Mullins, A., and Achour, N., (2017) The perceptions of social responsibility for community resilience to flooding: the impacts of past experience, age, gender and ethnicity. *Natural Hazards, 86*. p1105-1126

Soland, J., Zamarro, G., Cheng, A., and Hitt, C., (2019) Identifying Naturally Occurring Direct Assessments of Social-Emotional Competencies: The Promise and Limitations of Survey and Assessment Disengagement Metadata. *Educational Researcher, 48(7).* p466-478

Stanke, C., Murray, V., Amlot, R., Nurse, J., and Williams, R., (2012) The effects of flooding on mental health: Outcomes and recommendations from a review of the literature. *National Library of Medicine.*

Statistica, (2023) *Inbound tourist visits to the UK 2002-2023* [Online] Available at: https://www.statista.com/statistics/287133/annual-number-of-overseas-visits-to-the-united-kingdom-uk/ [Accessed: 07/07/2023]

Surminski, S., (2015) The role of flood insurance in reducing direct risk. *In Future directions of consumer flood insurance in the UK*.

Tachaudomdach, S., Upayokin, A., Kronprasert, N., and Arunotayanun, K., (2021) Quantifying road-network robustness toward flood-resilient transportation systems. *Sustainability 13(6)*. p3172

Talubo, J.P., Morse, S., and Saroj, D., (2022) Whose resilience matters? A socio-ecological systems approach to defining and assessing disaster resilience for small islands. *Environmental Challenges, 7*. p100511

Tanner, T., Lewis, D., Wrathall, D., Bronen, R., Cradock-Henry, N., Huq, S., Lawless, C., Nawrotzki, R., Prasad, V., Rahman, M.A., Alaniz, R., King, K., McNamara, K., Nadiruzzaman, M., Henly-Shepard, S., and Thomalla, F., (2015) Livelihood resilience in the face of climate change. *Nature Climate Change, 5(1)*. p23-26

Tempels, B., and Hartmann, T., (2014) A co-evolving frontier between land and water: dilemmas of flexibility versus robustness in flood risk management. *Water International, 39(6)*. p872-883

Ten Brinke, W.B.M., Saeijs, G.E.M., Helsloot, I., and van Alpen, J., (2015) Safety chain approaches in flood risk management. *Municipal Engineer, 161(2)*. p93-102

Tenny, S., Brannan, J.M., and Brannan, G.D (2022) Qualitative Study. *StatPearls*.

Terry, G., Hayfield, N., Clarke, V., and Braun, V., (2017) Thematic Analysis. *The SAGE Handbook of Qualitative Research in Psychology, 2*. p17-37

Thathsarani, U.S., and Gunaratne, L.H.P., (2018) Constructive and index to measure the adaptive capacity to climate change in Sri Lanka. *Procedia Engineering, 121.* p278-285

Thomalla, F. (2014) Livelihood resilience in the face of climate change. *Nature Climate Change*.

Thomas, D.R., (2006) A general inductive approach or analysing qualitative evaluation data. *American Journal of Evaluation, 27(2)*. p237-246

Thorne, C., 2014. Geographies of UK flooding in 2013/4. *The Geographical Journal, 180(4)*. p297-309

Tunstall, S., Tapsell, S., Green, C., Floyd, P., and George, C., (2006) The health effects of flooding: social research results from England and Wales. *Journal of Water and Health, 4(3)*. p365-380

Tyschuk, Y., and Wallace, W.A., (2018) Modeling human behaviour on social media in response to significant events. *IEEE Transactions on Computational Social Systems, 5(2)*. p444-457

UK Health Security Agency (2022) *Flooding and Health: assessment and management of public mental health*. [Online] Available at: https://www.gov.uk/government/publications/flooding-and-public-mental-health-assessment-and-management/flooding-and-health-assessment-and-management-of-public-mental-health [Accessed: 11/07/2023]

UNISDR (2017) *Build back better in recovery, rehabilitation and reconstruction* [Online] Available at: https://www.unisdr.org/files/53213_bbb.pdf [Accessed: 05/04/2023]
United Nations Office for Disaster Risk Reduction (2016) *The last 60 years: Achievements in DRR by the UN General Assembly* [Online] Available at: https://www.undrr.org/our-work/history#:~:text=1990%2D1999%3A%20The%20International%20Decade%20for%20Natural%20Disaster%20Reduction&text=...%20%22The%20GA%20recognizes,in%20particular%20for%20developing%20countries%3B. [Accessed: 29/05/2023]

Usamah, M., Handmer, J., Mitchell, D., Ahmed, I., (2014). Can the vulnerable be resilient? Co-existence of vulnerability and disaster resilience: informal settlements in the Philippines. *International Journal of Disaster Risk Reduction, 10*. p178-189.

USIOTWSP, (2007) *How resilient is your coastal community? A guide for evaluating coastal community resilience to Tsunamis and other coastal hazards* [Online] available at: https://www.crc.uri.edu/download/CCRGuide_lowres.pdf [Accessed: 09/07/2023]

VNRC (2013) *The resilient communities scorecard: a tool for assessing your community* [Online] Available at: https://vnrc.org/community-planning-toolbox/tools/resilient-communities-scorecard/ [Accessed: 09/07/2023]

Vousdoukas, M.I., Bouziotas, D., Giardino, A., Bouwer, L.M., Mentaschi, L., Voukouvalas, E. and Feyen, L., (2018). Understanding epistemic uncertainty in large-scale coastal flood risk assessment for present and future climates. *Natural Hazards and Earth System Sciences, 18(8)*. p2127-2142.

Wardekker, A., Wilk, B., Brown, V., Uittenbroek, C., Mees, H., Driessen, P., Wassen, M., Molenaar, A., Walda, J. and Runhaar, H., (2020). A diagnostic tool for supporting policymaking on urban resilience. *Cities, 101*. p102691

Westmorland and Furness Council (2023) *Kendal Flood Risk Management Scheme* [Online] Available at: https://www.southlakeland.gov.uk/business-and-trade/town-and-village-projects/kendal-flood-risk-management-scheme/ [Accessed: 10/06/2023]

Whitfield, P.H., (2012) Floods in future climates: a review. *Journal of Flood Risk Management, 5(4)*. p336-365.

Whitmarsh, L., (2008) Are flood victims more concerned about climate change than other people? The role of direct experience in risk perception and behavioural response. *Journal of Risk Research, 11(3)*. p315-374

Wickes, R., Britt, C., Broidy, L. (2017) The resilience of neighbourhood social processes: a case study of the 2011 Brisbane flood. *Social Science Research, 62*. p96-119

Wicks, R., Zahnow, R., Taylor, M. and Piquero, A.R. (2015) Neighbourhood structures, social capital, and community resilience: Longitudinal evidence from the 2011 Brisbane flood disaster. *Social Science Quarterly, 96(2)*. p330-353.

Wildavsky A. (1991) Searching for Safety. *Transaction Books.*

Willner, S.N., Otto, C., and Levermann, A (2018) Global economic response to river floods. *Nature Climate Change, 8(7)*. p594-598

Wilson, G.A., (2012) Community resilience and environmental transitions.

Wisner, B. and Kelman, I. (2015) Community resilience to disasters. *International Encyclopaedia of the Social and Behavioural Sciences*. p354-360

Xu, W., Cong, J., Proverbs, D. and Zhang, L., (2021). An Evaluation of Urban Resilience to Flooding. *Water, 13(15)*. p2022

Zevenbergen, C., Gersonius, B., Radhakrishan, M., (2020) Flood Resilience. *Philosophical Transactions of the Royal society, 358(2168)*. p20190212

Zevenbergen, C., Veerbeek, W., Gersonius, B., and Van Herk, S., (2008) Challenges in urban flood management: travelling across spatial and temporal scales. *Journal of Flood Risk Management, 1(2).* p81-88.

Zurich (2023) *Flood Resilience Measurement for Communities (FRMC)* [Online] Available at: https://www.zurich.com/en/sustainability/people-and-society/zurich-flood-resilience-alliance/measuring-flood-resilience [Accessed: 13/02/2023]

8. Appendix

8.1 Factors

8.1.1 Initial factors Identified from Previous Research

Factor	**References**
Fiscal Capital	
Crop Damage	(Abdel-Mooty *et al*., 2021), (Munawar *et al*., 2021)
Disaster Response budget	(Keating *et al.,* 2017), (ARUP, 2018)
Flood insurance rates	(Keating *et al.,* 2017), (Karrasch, Restemeyer and Klenke, 2021)
Income	(Keating *et al*., *2017), (*Wickes *et al.,* 2015), (Thathsarani and Gunaratne, 2018), (Atreya and Kunreuther, 2016)
GDP Per Capita	(Asadzadeha *et al.,* 2016)
Businesses	(Cabinet Office, 2019)
Economic investment	(Norris *et al.,* 2008), (Cutter *et al.,* 2008a), (Castleden *et al.,* 2011), (Ostadtaghizadeh *et al.,* 2015), (Chandra *et al.,* 2011), (Sherrieb, Norris and Galea, 2010)
Post-disaster economic development	(Norris et al., 2008), (Cutter et al., 2008a), (Ostadtaghizadeh et al., 2015), (Chandra et al., 2011), (Sherrieb, Norris and Galea, 2010)
Post-disaster economic programming	(Ostadtaghizadeh *et al.,* 2015)
Financial structure/security	(Keating *et al*., 2017), (ARUP, 2018), (USIOTWSP, 2007), (Cutter *et al*., 2008b), (Mayunga, 2009), (Renschler *et al*., 2010a), (Renschler *et al.,* 2010b), (Cutter, Burton and Emrich, 2010), (Batica and Gourbesville, 2013), (Batica, 2015), (Arbon *et al.,* 2014), (Arbon *et al.,* 2016), (VNRC, 2013), (Frankenberger *et al.,* 2013), (IFRC, 2014), (Parsons *et al.,* 2016), (Irwin *et al.,* 2016), (MCP, 2017)
Dynamism	(ARUP, 2018), (Cutter *et al.,* 2008b), (Renschler *et al.,* 2010a), (Renschler *et al.,* 2010b), (MCP, 2017)
Human Capital	
Fatalities	(Abdel-Mooty *et al.,* 2021)
Injuries	(Abdel-Mooty *et al.,* 2021)
Recovery time	(Abdel-Mooty *et al.,* 2021)

Education	(Keating *et al*., 2017), (Rahman, Nurhasanah and Nugroho, 2016), (Davydov *et al.,* 2010), (Khalili, Harre and Moreley, 2015), (Bene *et al.,* 2017), (Madewell and Ponce-Garcia, 2016), (Schelfaut *et al.,* 2011) (Tyshchuk and Wallace, 2018), (Thathsarani and Gunaratne, 2018), (Bukvic *et al.,* 2021), (Chowdhooree, Sloan and Dawes, 2018), (ARUP, 2018), (Cabinet Office, 2019), (USIOTWSP, 2007), (Cutter *et al.,* 2008b), (Mayunga, 2009), (Cutter, Burton and Emrich, 2010), (Arbon *et al.,* 2014), (Arbon et al., 2016), (VNRC, 2013), (Frankenberger et al., 2013), (IFRC, 2014), (Parsons *et al.*, 2016), (Irwin *et al.*, 2016), (MCP, 2017)
Flood exposure perception	(Keating *et al.,* 2017)
Flood vulnerability perception	(Keating *et al.,* 2017)
First aid knowledge	(Keating *et al.,* 2017)
Health status	(Keating *et al.,* 2017), (Norris *et al.,* 2008), (Cutter, Ash and Emrich, 2014), (Khalili, Harre and Morley, 2015), (Ntontis *et al.,* 2017), (Cutter *et al.,* 2008a), (Castleden *et al.,* 2011), (Chandra *et al.,* 2011), (Sherrieb, Norris and Galea, 2010), (Pfefferbaum, Pfefferbaum and Van Horn, 2011)
Food security	(Keating *et al.,* 2017), (Cabinet Office, 2019)
Village or district flood plans	(Keating *et al.,* 2017)
Flood regulations and enforcement	(Keating *et al.,* 2017), (Albright and Crow, 2021)
Healthcare	(Keating *et al.,* 2017), (Norris *et al.,* 2008), (ARUP, 2018) (Chandra *et al.,* 2011), (Sherrieb, Norris and Galea, 2010)
Confidence	(Rahman, Nurhasanah and Nugroho, 2016), (Davydov *et al.,* 2010), (Liu, Reed and Girard, 2017)
Social Skills	(Rahman, Nurhasanah and Nugroho, 2016), (Tanner *et al.,* 2014)
Sense of belonging	(Davydov *et al.,* 2010), (Cutter, Ash and Emrich, 2014), (Tyshchuk and Wallace, 2018), (Cabinet Office, 2019), (Renschler *et al.,* 2010a), (Renschler *et al.,* 2010b), (Sempier *et al.,* 2010), (Cutter, Burton and Emrich, 2010), (Arbon *et al.,* 2014), (Arbon *et al.,* 2016), (Frankenberger *et al.,* 2013)
Native language proficiency	(Cutter, Ash and Emrich, 2014), (Cabinet Office, 2019)
Volunteerism	(Bene *et al.,* 2017), (Butler and Walker-Springett, 2016), (Wickes *et al.,* 2015)

Access to political power/resources	(Norris *et al.,* 2008), (Wickes *et al.,* 2015), (Cutter, Boruff and Shirley, 2003), (Cutter *et al.,* 2008a), (Thathsarania and Gunaratne, 2018), (Castleden *et al.,* 2011), (Ostadtaghizadeh *et al.,* 2015), (Chandra *et al.,* 2011), (Sherrieb, Norris and Galea, 2010), (Cohen *et al.,* 2013), (Pfefferbaum, Pfefferbaum and Van Horn, 2011)
Population and community composition	(Keating *et al.,* 2017), (Cutter, Ash and Emrich, 2014), (Edwards *et al*., 2017), (Wickes, Britt and Broidy, 2017), (Wickes *et al.,* 2015), (Cutter, Boruff and Shirley, 2003), (Bukvic *et al.,* 2021), (ARUP. 2018), (Cabinet Office, 2019), (USIOTWSP, 2007), (Cutter *et al.,* 2008b), (Mayunga, 2009), (Renschler *et al.,* 2010a), (Renschler *et al.,* 2010b), (Cutter, Burton and Emrich, 2010), (Batica, Gourbesville and Hu, 2013), (Batica, 2015), (Arbon *et al.,* 2014), (Arbon *et al.,* 2016), (VNRC, 2013), (Frankenberger *et al.,* 2013), (IFRC, 2014), (Parsons *et al.,* 2016), (Irwin *et al.,* 2016), (Atreya and Kunreuther, 2016)
Employment	(Thathsarania and Gunaratne, 2018)
Population Density	(Asadzadeha *et al.,* 2016), (Bukvic *et al.,* 2021), (Cabinet Office, 2019)
Doctors per capita	(Asadzadeha *et al.,* 2016)
Crime rates	(ARUP, 2018)
Relative level of deprivation/ socioeconomic status	(Keating *et al.,* 2017), (Cabinet Office, 2019), (Cutter *e al.,* 2008b), (Renschler *et al.,* 2010a), (Renschler *et al.,* 2010b), (VNRC, 2013), (Parsons *et al.,* 2016), (Irwin *et al.,* 2016)
Preparedness	(Norris *et al.,* 2008), (Cutter *et al.,* 2008a), (Castleden *et al.,* 2011), (Chandra *et al.,* 2011), (Sherrieb, Norris and Galea, 2010), (Cohen *et al.,* 2013), (Pfefferbaum, Pfefferbaum and Van Horn, 2011)
Hope	(Norris *et al.,* 2008), (Sherrieb, Norris and Galea, 2010)
Safety	(Keating *et al.,* 2017), (ARUP, 2018), (Cutter, Burton and Emrich, 2010), (Frankenberger *et al.,* 2013), (IFRC, 2014), (Parsons *et al.,* 2016)
Critical reflection and problem solving skills	(USIOTWSP, 2007), (VNRC, 2013), (IFRC, 2014)
Flexibility and creativity	(Renschler *et al.,* 2010a), (Renschler *et al.,* 2010b), (Batica, Gourbesville and Hu, 2013), (Batica, 2015), (Frankenberger *et al.,* 2013), (Parsons *et al.,* 2016)
Collective efficiency and empowerment	(ARUP, 2018), (USIOTWSP, 2007), (Cutter *et al.,* 2008b), (Renschler *et al.,* 2010a), (Renschler *et al.,* 2010b), (Batica, Gourbesville and Hu, 2013), (Batica, 2015), (Arbon *et al.,* 2014), (Arbon *et al.,* 2016), (VNRC, 2013), (Frankenberger *et al.,* 2013), (IFRC, 2014), (Parsons *et al.,* 2016), (MCP, 2017)
Quality of life	(Cutter *et al.,* 2008b), (Renschler *et al.,* 2010a), (Renschler *et al.,* 2010b)

Natural Capital	
Community conservation plans	(Keating *et al.,* 2017)
Natural Capital	(Fenner *et al.,* 2019), (Chuang *et al*., 2018), (Cabinet Office, 2019)
Natural assets/resources	(ARUP, 2018), (USIOTWSP, 2007), (Cutter *et al.,* 2008b), (Renschler *et al.,* 2010a), (Renschler *et al.,* 2010b), (Sempier *et al.,* 2010), ((Batica, Gourbesville and Hu, 2013), (Batica, 2015), (VNRC, 2013), (Frankenberger *et al.,* 2013), (IFRC, 2014), (Parsons *et al.,* 2016), (Keating *et al.,* 2017), (MCP, 2017)
Conservation of natural resources	(Keating *et al.,* 2017), (ARUP, 2018), (USIOTWSP, 2007), (Cutter *et al.,* 2008), (Sempier *et al.,* 2010), (VNRC, 2013), (Frankenberger *et al.,* 2013), (IFRC, 2014), (MCP, 2017)
Physical Capital	
Flood Distribution	(Abdel-Mooty *et al.,* 2021), (Keating *et al.,* 2017)
Property Damage	(Abdel-Mooty *et al*., 2021), (Munawar *et al*., 2021)
Flood protection	(Keating *et al.,* 2017), (Karrasch, Restemeyer and Klenke, 2021)
EWS	(Keating *et al.,* 2017), (Gissing, Keys and Opper, 2010), (Munawar *et al.,* 2021)
Transportation infrastructure/services	(Keating *et al.,* 2017), (Cutter, Ash and Emrich, 2014), (Bene *et al.,* 2017), (Thathsarania and Gunaratne, 2018), (Bukvic *et al.,* 2021), (ARUP, 2018), (Cabinet Office, 2019)
Type and conservation of buildings	(Norris *et al.,* 2008), (Cutter, Ash and Emrich, 2014), (Adini *et al.,* 2017), (Cutter *et al.,* 2008a), (Bukvic *et al.,* 2021), (Ostadtaghizadeh *et al.,* 2021), (Sherrieb, Norris and Galea, 2010)
Available resources	(Nohrstedt and Weible, 2010)
IT capacity	(Albright and Crow, 2021)
Housing tenancy	(Wickes *et al.,* 2015), (Bukvic *et al.,* 2021), (ARUP, 2018)
Hospital bed per capita	Asadzadeha *et al.,* 2016)
Flood defences	(Munawar *et al.,* 2021), (Chowdhooree, Sloan and Dawes, 2018)
Appropriate land use and zoning	(ARUP, 2018)
% land conversion	(ARUP, 2018), (Chuang *et al.,* 2018)
Resources	(Norris *et al.,* 2008), (Chandra *et al.,* 2011), (Sherrieb, Norris and Galea, 2010), (Pfefferbaum, Pfefferbaum and Van Horn, 2011)

Facilities	(Keating *et al.,* 2017), (ARUP, 2018), (USIOTWSP, 2007), (Cutter *et al*., 2008b), (Mayunga, 2009), (Renschler *et al*., 2010a), (Renschler *et al.,* 2010b), (Sempier *et al.,* 2010), (Cutter, Burton and Emrich, 2010), (Batica, Gourbesville and Hu, 2013), (Batica, 2015), (Arbon *et al.*, 2014), (Arbon *et al*., 2016), (VNRC, 2013), (Frankenberger *et al.,* 2013), (IFRC, 2014), (Parsons *et al.,* 2016), (Irwn *et al.,* 2016), (MCP, 2017)
Infrastructure	(Keating *et al.,* 2017), (ARUP, 2018), (USIOTWSP, 2007), (Cutter *et al.*, 2008b), (Mayunga, 2009), (Renschler *et al*., 2010a), (Renschler *et al*., 2010b), (Sempier *et al.,* 2010), (Cutter, Burton and Emrich, 2010), (Batica, Gourbesville and Hu, 2013), (Batica, 2015), (Arbon *et al*., 2014), (Arbon *et al.*, 2016), (VNRC, 2013), (Frankenberger *et al.,* 2013), (IFRC, 2014), (Parsons *et al.,* 2016), (Irwn *et al.,* 2016), (Atreya and Kunreuther, 2016)
Protective infrastructures	(Keating et al., 2017), (USIOTWSP, 2007), (Frankenberger *et al.,* 2013), (Irwin *et al.,* 2016), (MCP, 2017)
Efficiency and maintenance of infrastructures	(Keating *et al*., 2017), (ARUP, 2018), (Mayunga, 2009), ((Sempier *et al.,* 2010), (VNRC, 2013), (Frankenberger *et al.,* 2013), (IFRC, 2014), (Irwn *et al*., 2016), (MCP, 2017)
Land use and structural design	(Bukvic *et al.,* 2021), (ARUP, 2018), (USIOTWSP, 2007), (Cutter *et al.,* 2008b), (Mayunga, 2009), (Sempier *et al.,* 2010), (VNRC, 2013), (Frankenberger *et al.,* 2013), (Parsons *et al.,* 2016), (Irwin *et al.,* 2016), (MCP, 2017)
Socio-cultural, Capital	
Communication infrastructure	(Keating *et al.,* 2017), (Gissing, Keys ad Opper, 2010), (Karrasch, Restemeyer and Klenke, 2021), (Chowdhooree, Sloan and Dawes, 2018), (Cabinet Office, 2019)
Community representative bodies for flooding	(Keating *et al.,* 2017)
Social inclusiveness/sense of community	(Keating *et al.,* 2017), Khalili, Harre and Morley, 2015), (Bene *et al.,* 2017), (Wickes, Britt and Broidy, 2017), (Butler and Walker-Springett, 2016), (Wickes *et al.,* 2015), (ARUP, 2017), (Cabinet Office, 2019), (USIOTWSP, 2007), (Cutter *et al.,* 2008b), (Renschler *et al.,* 2010a), (Renschler *et al.,* 2010b), (Sempier *et al.,* 2010), (Cutter, Burton and Emrich, 2010), (Batica, Gourbesville and Hu, 2013), (Batica, 2015), (Arbon et al., 2014), (Arbon et al., 2016), (VNRC, 2013), (Frankenberger et al., 2013), (IFRC, 2014), (Parsons et al., 2016), (Atreya and Kunreuther, 2016)
Civic capacity	(Albright and Crow, 2021), (Berke and Thomas, 2006), (Burby, 2003), (Smith, 2012), (Cutter *et al.,* 2008a), (Chandra *et al.,* 2011), (Pfefferbaum, Pfefferbaum and Van Horn, 2011)

Planning and Mitigation	(Norris *et al.,* 2008), (Cutter *et al.,* 2008a), (Castleden *et al.,* 2011), (Chandra *et al.,* 2011), (Sherrieb, Norris and Galea, 2010), (Pfefferbaum, Pfefferbaum and Van Horn, 2011)
Adaptability	(Norris *et al.,* 2008), (Cutter *et al.,* 2008a), (Castleden *et al.,* 2011), (Chandra *et al.,* 2011), (Sherrieb, Norris and Galea, 2010), (Cohen *et al.,* 2013), (Pfefferbaum *et al.,* 2013)
Special needs for assistance	(USIOTWSP, 2007), (Cutter et al., 2008b), (Renschler *et al.*, 2010a), (Renschler *et al.*, 2010b), (Cutter, Burton and Emrich, 2010), (IFRC, 2014), (Parsons *et al.,* 2016), (Irwin *et al.,* 2016), (MCP, 2017)
Social support	(Keating *et al.,* 2017), (ARUP, 2017), (Renschler *et al.*, 2010a), (Renschler *et al.*, 2010b), (Sempier *et al.,* 2010), (Frankenberger *et al.,* 2013), (IFRC, 2014), (Parsons *et al.,* 2016)
Collective action and decision making	(Renschler *et al.*, 2010a), (Renschler *et al.*, 2010b), (Frankenberger *et al.,* 2013), (Parsons *et al.,* 2016)

Table 10:Full factor table before sifting

8.1.2 Factor Sifting

Factor	**References**
Fiscal Capital	
Crop Damage	(Abdel-Mooty *et al.*, 2021), (Munawar *et al.*, 2021)
Disaster Response budget	(Keating *et al.,* 2017), (ARUP, 2018)
Flood insurance rates	(Keating *et al.,* 2017), (Karrasch, Restemeyer and Klenke, 2021)
Income	(Keating *et al.*, *2017), (*Wickes *et al.,* 2015), (Thathsarani and Gunaratne, 2018), (Atreya and Kunreuther, 2016)
GDP Per Capita	(Asadzadeha *et al.,* 2016)
Businesses	(Cabinet Office, 2019)
Economic investment	(Norris *et al.,* 2008), (Cutter *et al.,* 2008a), (Castleden *et al.,* 2011), (Ostadtaghizadeh *et al.,* 2015), (Chandra *et al.,* 2011), (Sherrieb, Norris and Galea, 2010)
Post-disaster economic development	(Norris et al., 2008), (Cutter et al., 2008a), (Ostadtaghizadeh et al., 2015), (Chandra et al., 2011), (Sherrieb, Norris and Galea, 2010)
Post-disaster economic programming	(Ostadtaghizadeh *et al.,* 2015)

Financial structure/security	(Keating *et al*., 2017), (ARUP, 2018), (USIOTWSP, 2007), (Cutter *et al*., 2008b), (Mayunga, 2009), (Renschler *et al*., 2010a), (Renschler *et al*., 2010b), (Cutter, Burton and Emrich, 2010), (Batica and Gourbesville, 2013), (Batica, 2015), (Arbon *et al*., 2014), (Arbon *et al*., 2016), (VNRC, 2013), (Frankenberger *et al*., 2013), (IFRC, 2014), (Parsons *et al*., 2016), (Irwin *et al*., 2016), (MCP, 2017)
Dynamism	(ARUP, 2018), (Cutter *et al*., 2008b), (Renschler *et al*., 2010a), (Renschler *et al*., 2010b), (MCP, 2017)
Human Capital	
Fatalities	(Abdel-Mooty *et al*., 2021)
Injuries	(Abdel-Mooty *et al*., 2021)
Recovery time	(Abdel-Mooty *et al*., 2021)
Education	(Keating *et al*., 2017), (Rahman, Nurhasanah and Nugroho, 2016), (Davydov *et al*., 2010), (Khalili, Harre and Moreley, 2015), (Bene *et al*., 2017), (Madewell and Ponce-Garcia, 2016), (Schelfaut *et al*., 2011) (Tyshchuk and Wallace, 2018), (Thathsarani and Gunaratne, 2018), (Bukvic *et al*., 2021), (Chowdhooree, Sloan and Dawes, 2018), (ARUP, 2018), (Cabinet Office, 2019), (USIOTWSP, 2007), (Cutter *et al*., 2008b), (Mayunga, 2009), (Cutter, Burton and Emrich, 2010), (Arbon *et al*., 2014), (Arbon et al., 2016), (VNRC, 2013), (Frankenberger et al., 2013), (IFRC, 2014), (Parsons *et al*., 2016), (Irwin *et al*., 2016), (MCP, 2017)
flood vulnerability perception	(Keating *et al*., 2017)
Health status	(Keating *et al*., 2017), (Norris *et al*., 2008), (Cutter, Ash and Emrich, 2014), (Khalili, Harre and Morley, 2015), (Ntontis *et al*., 2017), (Cutter *et al*., 2008a), (Castleden *et al*., 2011), (Chandra *et al*., 2011), (Sherrieb, Norris and Galea, 2010), (Pfefferbaum, Pfefferbaum and Van Horn, 2011)
food security	(Keating *et al*., 2017), (Cabinet Office, 2019)
Village or district flood plans	(Keating *et al*., 2017)
Flood regulations and enforcement	(Keating *et al*., 2017), (Albright and Crow, 2021)
healthcare	(Keating *et al*., 2017), (Norris *et al*., 2008), (ARUP, 2018) (Chandra *et al*., 2011), (Sherrieb, Norris and Galea, 2010)
Confidence	(Rahman, Nurhasanah and Nugroho, 2016), (Davydov *et al*., 2010), (Liu, Reed and Girard, 2017)
Social Skills	(Rahman, Nurhasanah and Nugroho, 2016), (Tanner *et al*., 2014)

Sense of belonging	(Davydov *et al.,* 2010), (Cutter, Ash and Emrich, 2014), (Tyshchuk and Wallace, 2018), (Cabinet Office, 2019), (Renschler *et al.,* 2010a), (Renschler *et al.,* 2010b), (Sempier *et al.,* 2010), (Cutter, Burton and Emrich, 2010), (Arbon *et al.,* 2014), (Arbon *et al.,* 2016), (Frankenberger *et al.,* 2013)
volunteerism	(Bene *et al.,* 2017), (Butler and Walker-Springett, 2016), (Wickes *et al.,* 2015)
access to political power/resources	(Norris *et al.,* 2008), (Wickes *et al.,* 2015), (Cutter, Boruff and Shirley, 2003), (Cutter *et al.,* 2008a), (Thathsarania and Gunaratne, 2018), (Castleden *et al.,* 2011), (Ostadtaghizadeh *et al.,* 2015), (Chandra *et al.,* 2011), (Sherrieb, Norris and Galea, 2010), (Cohen *et al.,* 2013), (Pfefferbaum, Pfefferbaum and Van Horn, 2011)
Employment	(Thathsarania and Gunaratne, 2018)
Pop. Density	(Asadzadeha *et al.,* 2016), (Bukvic *et al.,* 2021), (Cabinet Office, 2019)
Doctors per capita	(Asadzadeha *et al.,* 2016)
Relative level of deprivation/ socioeconomic status	(Keating *et al.,* 2017), (Cabinet Office, 2019), (Cutter *e al.,* 2008b), (Renschler *et al.,* 2010a), (Renschler *et al.,* 2010b), (VNRC, 2013), (Parsons *et al.,* 2016), (Irwin *et al.,* 2016)
preparedness	(Norris *et al.,* 2008), (Cutter *et al.,* 2008a), (Castleden *et al.,* 2011), (Chandra *et al.,* 2011), (Sherrieb, Norris and Galea, 2010), (Cohen *et al.,* 2013), (Pfefferbaum, Pfefferbaum and Van Horn, 2011)
Hope	(Norris *et al.,* 2008), (Sherrieb, Norris and Galea, 2010)
Safety	(Keating *et al.,* 2017), (ARUP, 2018), (Cutter, Burton and Emrich, 2010), (Frankenberger *et al.,* 2013), (IFRC, 2014), (Parsons *et al.,* 2016)
Critical reflection and problem solving skills	(USIOTWSP, 2007), (VNRC, 2013), (IFRC, 2014)
Flexibility and creativity	(Renschler *et al.,* 2010a), (Renschler *et al.,* 2010b), (Batica, Gourbesville and Hu, 2013), (Batica, 2015), (Frankenberger *et al.,* 2013), (Parsons *et al.,* 2016)
Collective efficiency and empowerment	(ARUP, 2018), (USIOTWSP, 2007), (Cutter *et al.,* 2008b), (Renschler *et al.,* 2010a), (Renschler *et al.,* 2010b), (Batica, Gourbesville and Hu, 2013), (Batica, 2015), (Arbon *et al.,* 2014), (Arbon *et al.,* 2016), (VNRC, 2013), (Frankenberger *et al.,* 2013), (IFRC, 2014), (Parsons *et al.,* 2016), (MCP, 2017)
Quality of life	(Cutter *et al.,* 2008b), (Renschler *et al.,* 2010a), (Renschler *et al.,* 2010b)
Natural Capital	
Community conservation plans	(Keating *et al.,* 2017)

natural assets/resources	(ARUP, 2018), (USIOTWSP, 2007), (Cutter *et al.,* 2008b), (Renschler *et al.,* 2010a), (Renschler *et al.,* 2010b), (Sempier *et al.,* 2010), ((Batica, Gourbesville and Hu, 2013), (Batica, 2015), (VNRC, 2013), (Frankenberger *et al.,* 2013), (IFRC, 2014), (Parsons *et al.,* 2016), (Keating *et al.,* 2017), (MCP, 2017)
conservation of natural resources	(Keating *et al.,* 2017), (ARUP, 2018), (USIOTWSP, 2007), (Cutter *et al.,* 2008), (Sempier *et al.,* 2010), (VNRC, 2013), (Frankenberger *et al.,* 2013), (IFRC, 2014), (MCP, 2017)
Physical Capital	
Flood Distribution	(Abdel-Mooty *et al.,* 2021), (Keating *et al.,* 2017)
Property Damage	(Abdel-Mooty *et al*., 2021), (Munawar *et al.*, 2021)
EWS	(Keating *et al.,* 2017), (Gissing, Keys and Opper, 2010), (Munawar *et al.,* 2021)
Transportation infrastructure/services	(Keating *et al.,* 2017), (Cutter, Ash and Emrich, 2014), (Bene *et al.,* 2017), (Thathsarania and Gunaratne, 2018), (Bukvic *et al.,* 2021), (ARUP, 2018), (Cabinet Office, 2019)
Type and conservation of buildings	(Norris *et al.,* 2008), (Cutter, Ash and Emrich, 2014), (Adini *et al.,* 2017), (Cutter *et al.,* 2008a), (Bukvic *et al.,* 2021), (Ostadtaghizadeh *et al.,* 2021), (Sherrieb, Norris and Galea, 2010)
Available resources	(Nohrstedt and Weible, 2010)
IT capacity	(Albright and Crow, 2021)
Housing tenancy	(Wickes *et al.,* 2015), (Bukvic *et al.,* 2021), (ARUP, 2018)
hospital bed per capita	Asadzadeha *et al.,* 2016)
Flood defences	(Munawar *et al.,* 2021), (Chowdhooree, Sloan and Dawes, 2018)
Appropriate land use and zoning	(ARUP, 2018)
% land conversion	(ARUP, 2018), (Chuang *et al.,* 2018)
Resources	(Norris *et al.,* 2008), (Chandra *et al.,* 2011), (Sherrieb, Norris and Galea, 2010), (Pfefferbaum, Pfefferbaum and Van Horn, 2011)
Facilities	(Keating *et al.,* 2017), (ARUP, 2018), (USIOTWSP, 2007), (Cutter *et al*., 2008b), (Mayunga, 2009), (Renschler *et al*., 2010a), (Renschler *et al.,* 2010b), (Sempier *et al.,* 2010), (Cutter, Burton and Emrich, 2010), (Batica, Gourbesville and Hu, 2013), (Batica, 2015), (Arbon *et al.*, 2014), (Arbon *et al*., 2016), (VNRC, 2013), (Frankenberger *et al.,* 2013), (IFRC, 2014), (Parsons *et al.,* 2016), (Irwn *et al.,* 2016), (MCP, 2017)

Infrastructure	(Keating *et al.,* 2017), (ARUP, 2018), (USIOTWSP, 2007), (Cutter *et al.*, 2008b), (Mayunga, 2009), (Renschler *et al*., 2010a), (Renschler *et al*., 2010b), (Sempier *et al.,* 2010), (Cutter, Burton and Emrich, 2010), (Batica, Gourbesville and Hu, 2013), (Batica, 2015), (Arbon *et al*., 2014), (Arbon *et al*., 2016), (VNRC, 2013), (Frankenberger *et al.,* 2013), (IFRC, 2014), (Parsons *et al.,* 2016), (Irwn *et al.,* 2016), (Atreya and Kunreuther, 2016)
Protective infrastructures	(Keating et al., 2017), (USIOTWSP, 2007), (Frankenberger *et al.,* 2013), (Irwin *et al.,* 2016), (MCP, 2017)
Efficiency and maintenance of infrastructures	(Keating *et al*., 2017), (ARUP, 2018), (Mayunga, 2009), ((Sempier *et al.,* 2010), (VNRC, 2013), (Frankenberger *et al.,* 2013), (IFRC, 2014), (Irwn *et al*., 2016), (MCP, 2017)
Land use and structural design	(Bukvic *et al.,* 2021), (ARUP, 2018), (USIOTWSP, 2007), (Cutter *et al.,* 2008b), (Mayunga, 2009), (Sempier *et al.,* 2010), (VNRC, 2013), (Frankenberger *et al.,* 2013), (Parsons *et al.,* 2016), (Irwin *et al.,* 2016), (MCP, 2017)
Socio-Cultural Capital	
Communication infrastructure	(Keating *et al.,* 2017), (Gissing, Keys ad Opper, 2010), (Karrasch, Restemeyer and Klenke, 2021), (Chowdhooree, Sloan and Dawes, 2018), (Cabinet Office, 2019)
community representative bodies for flooding	(Keating *et al.,* 2017)
social inclusiveness/sense of community	(Keating *et al.,* 2017), Khalili, Harre and Morley, 2015), (Bene *et al.,* 2017), (Wickes, Britt and Broidy, 2017), (Butler and Walker-Springett, 2016), (Wickes *et al.,* 2015), (ARUP, 2017), (Cabinet Office, 2019), (USIOTWSP, 2007), (Cutter *et al.,* 2008b), (Renschler *et al.,* 2010a), (Renschler *et al.,* 2010b), (Sempier *et al.,* 2010), (Cutter, Burton and Emrich, 2010), (Batica, Gourbesville and Hu, 2013), (Batica, 2015), (Arbon et al., 2014), (Arbon et al., 2016), (VNRC, 2013), (Frankenberger et al., 2013), (IFRC, 2014), (Parsons et al., 2016), (Atreya and Kunreuther, 2016)
civic capacity	(Albright and Crow, 2021), (Berke and Thomas, 2006), (Burby, 2003), (Smith, 2012), (Cutter *et al.,* 2008a), (Chandra *et al.,* 2011), (Pfefferbaum, Pfefferbaum and Van Horn, 2011)
Planning and Mitigation	(Norris *et al.,* 2008), (Cutter *et al.,* 2008a), (Castleden *et al.,* 2011), (Chandra *et al.,* 2011), (Sherrieb, Norris and Galea, 2010), (Pfefferbaum, Pfefferbaum and Van Horn, 2011)
Adaptability	(Norris *et al.,* 2008), (Cutter *et al.,* 2008a), (Castleden *et al.,* 2011), (Chandra *et al.,* 2011), (Sherrieb, Norris and Galea, 2010), (Cohen *et al.,* 2013), (Pfefferbaum *et al.,* 2013)

Special needs for assistance	(USIOTWSP, 2007), (Cutter et al., 2008b), (Renschler *et al*., 2010a), (Renschler *et al*., 2010b), (Cutter, Burton and Emrich, 2010), (IFRC, 2014), (Parsons *et al.,* 2016), (Irwin *et al.,* 2016), (MCP, 2017)
social support	(Keating *et al.,* 2017), (ARUP, 2017), (Renschler *et al*., 2010a), (Renschler *et al*., 2010b), (Sempier *et al.,* 2010), (Frankenberger *et al.,* 2013), (IFRC, 2014), (Parsons *et al.,* 2016)
collective action and decision making	(Renschler *et al*., 2010a), (Renschler *et al*., 2010b), (Frankenberger *et al.,* 2013), (Parsons *et al.,* 2016)
Native language proficiency	(Cutter, Ash and Emrich, 2014), (Cabinet Office, 2019)
Population and community Composition	(Keating *et al.,* 2017), (Cutter, Ash and Emrich, 2014), (Edwards *et al*., 2017), (Wickes, Britt and Broidy, 2017), (Wickes *et al.,* 2015), (Cutter, Boruff and Shirley, 2003), (Bukvic *et al.,* 2021), (ARUP. 2018), (Cabinet Office, 2019), (USIOTWSP, 2007), (Cutter *et al.,* 2008b), (Mayunga, 2009), (Renschler *et al.,* 2010a), (Renschler *et al.,* 2010b), (Cutter, Burton and Emrich, 2010), (Batica, Gourbesville and Hu, 2013), (Batica, 2015), (Arbon *et al.,* 2014), (Arbon *et al.,* 2016), (VNRC, 2013), (Frankenberger *et al.,* 2013), (IFRC, 2014), (Parsons *et al.,* 2016), (Irwin *et al.,* 2016), (Atreya and Kunreuther, 2016)
Crime rates	(ARUP, 2018)

Table 11: Factors table including sifting. Sift 1: Yellow (accessible data), Sift 2: Green (suitability for flood resilience), Sift 3: Blue (further research required)

8.1.3 Definitions of Final Factors Included in the Questionnaire

Factor	**Definition**
Fiscal Capital	
Flood insurance rates	*Cost per year (£) of property insurance that covers dwellings and businesses for loss sustained by water damage from flooding*
Income	*The amount of money earnt per person (£)*
Human Capital	
Education	*The highest level of formal qualification achieved per person*
Health status	*% of individuals deemed to be 'healthy' i.e. above pre-defined standards.*
Employment	*% of labour force employed*
Population Density	*Number of people per km^2*

Flexibility and creativity	*The ability for community members to be willing to change and overcome issues using original ideas*
Collective efficacy and empowerment	*The perception of a group that they can successfully work together to accomplish valued goals*
Natural Capital	
Natural assets/resources	*Availability, accessibility and management of natural resources such as water and land that provide space to live and work*
Physical Capital	
Transportation infrastructure/services	*Existing levels of public transportation.*
Housing tenancy	*% of homes that are owned, privately rented or social housing.*
Resources	*Access to essential supplies to aid with flood protection and recovery*
Facilities	*Access to critical provisions prior, during and after a flood.*
Efficiency and maintenance of infrastructures	*The upkeep and development of infrastructure, prior to a flood.*
Land use and structural design	*Characterisation of land based on what can be built on it and what the land can be used for*
Socio-Cultural Capital	
Community representative bodies for flooding	*The existence of Flood Action Groups in the community*
Social inclusiveness/sense of community	*% of people that believe they hold a place in society*
Planning and Mitigation	*% of population that have a plan for flooding and understand how to reduce the effects.*
Population and community Composition	*Key characteristics of a population, e.g. age, sex and ethnicity.*
Native language proficiency	*% of population who can speak English*

Table 12: Definitions of the remaining factors after sifting process, which were presented to participants through the questionnaire

8.2 Questionnaire

1. **How old are you?**

18-21. 22-30. 31-40. 41-50. 51-60. 60+

2. **What gender do you identify as?**

Male Female. Non-binary. Other

3. **What is your occupation?**

4. **Where do you reside?**

5. **Have you previously experienced flooding?**

Yes. No

5b. If yes, please select all that apply:

River. Rain. Coastal. Surface. Groundwater. Flash. Other. Not sure

6. **What does flood resilience mean to you?**

7. **Please rate the following factors according to how important you believe they are in measuring flood resilience (1 is least important, 5 is most important).**

Flood insurance rates	**1**	**2**	**3**	**4**	**5**
Income	**1**	**2**	**3**	**4**	**5**
Education	**1**	**2**	**3**	**4**	**5**
Health status	**1**	**2**	**3**	**4**	**5**
Employment	**1**	**2**	**3**	**4**	**5**

Pop. Density	**1**	**2**	**3**	**4**	**5**
Flexibility and creativity	**1**	**2**	**3**	**4**	**5**
Collective efficiency and empowerment	**1**	**2**	**3**	**4**	**5**
Population and community composition	**1**	**2**	**3**	**4**	**5**
Native language proficiency	**1**	**2**	**3**	**4**	**5**
Natural assets and resources	**1**	**2**	**3**	**4**	**5**
Transportation infrastructure and services	**1**	**2**	**3**	**4**	**5**
Housing tenancy	**1**	**2**	**3**	**4**	**5**
Resources	**1**	**2**	**3**	**4**	**5**
Facilities	**1**	**2**	**3**	**4**	**5**
Efficiency and maintenance of infrastructures	**1**	**2**	**3**	**4**	**5**
Land use and structural design	**1**	**2**	**3**	**4**	**5**
Community representative bodies for flooding	**1**	**2**	**3**	**4**	**5**
Social inclusiveness/ sense of community	**1**	**2**	**3**	**4**	**5**
Planning and mitigation	**1**	**2**	**3**	4	5

8. **Are any of the factors previously mentioned not applicable in measuring flood resilience? If so which and why?**

9. **Are there any factors not previously included that are important in measuring flood resilience? If yes, please explain the factor and why it's important**

8.3 Factor Ratings Per Group

Factor	Whole Sample	Flood Action Group Members	Previously Experienced Flooding	Not Previously experienced Flooding
	Average	Average	Average	Average
Flood Insurance Rates	3.6	4.0	3.3	3.4
Income	3.2	3.4	2.8	3.2
Education	3.4	3.9	2.9	3.3
Health	3.5	4.1	2.8	3.4
Employment	3.0	3.1	2.8	3.1
Population Density	3.9	3.7	4.0	4.0
Flexibility and Creativity	3.4	3.9	3.2	3.1
Collective efficiency and Empowerment	3.8	4.5	3.1	3.5
Population and community composition	3.9	4.1	3.9	3.6
Native language proficiency	2.8	3.1	2.5	2.7
Natural assets/resources	3.9	4.0	3.8	3.8
Transportation infrastructure/services	3.9	4.0	4.2	3.7
Housing tenancy	3.4	3.5	3.2	3.4
Resources	4.0	4.5	3.9	3.5
Facilities	3.9	4.2	3.7	3.7
Efficiency and maintenance of infrastructure	4.4	4.7	4.6	4.0
Land use and Structural design	4.2	4.7	4.4	3.6
Community representative bodies	4.1	4.5	4.1	3.7

Sense of community	3.8	4.5	3.5	3.2
Planning and mitigation	4.3	4.7	4.3	3.8

Table 13: Average rating of factors from the whole sample, and variable groups of Flood action group members, those previously flooded and those who have not experienced flooding.