Are Story Maps a useful flood hazard and risk communication tool: A case study from St Blazey.

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I certify that all material in this dissertation which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

Abstract

Within the UK, flooding is a major concern and can cause significant impacts for communities. Attempts are being made to reduce the impacts of UK flooding and flood hazard and risk communication is an essential part of these efforts. Currently, communication efforts are failing to reach audiences and are not causing the desired behavioural changes that will keep individuals safe from flooding. It is vital therefore, that novel and innovative approaches are taken to address the failings of flood hazard and risk communication.

Story Maps present a novel mixed media approach to flood hazard and risk communication by combining maps, videos, images and text into a simple online interface. To investigate whether Story Maps could be useful communication resources, a case study approach was taken, which focussed on the St Blazey area, Cornwall, that is regularly flooded. Telephone and face-to-face interviews were conducted with key individuals involved in St Blazey and to a wider extent Cornwall's flood risk management. This provided detailed accounts of St Blazey's flooding issue and the problems interviewees faced when dealing with flooding and the communication of its risks. They also presented opportunities and failings of Story Maps and examples of how they could be utilised for flood hazard and risk communication. These insights were combined with feedback from Exeter students and St Blazey community members to help create a rounded picture of the usefulness of Story Maps.

This study concluded that Story Maps would be useful tools for flood hazard and risk communication. There are however, several considerations that must be made before and whilst a Story Map is utilised. These considerations must be conducted to avoid the failings that are associated with previous flood hazard and risk communication methods.

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Abbreviations

CLT	*Construal Level Theory*
EA	*Environment Agency*
FRM	*Flood Risk Management*
GIS	*Geographic Information Systems*
GST	*Goal Setting Theory*
LEDC	*Less Economically Developed Countries*
MEDC	*More Economically Developed Countries*
NEET's	*Not in Education, Employment or Training*
NIC	*Newly Industrialised Countries*
RQ1	*Research Question 1*
RQ2	*Research Question 2*
RQ3	*Research Question 3*
RQ4	*Research Question 4*
STARR	*St Austell Bay Resilient Regeneration Project*
UK	*United Kingdom*
US	*United States*

Acknowledgements

This masters research project has been an interesting experience, in which I have learnt many useful skills. At times, it has been an engaging and enthralling experience and during other times, challenging and frustrating, but overall, I have enjoyed the opportunity. I would like to thank the following people for their support throughout the research project.

Firstly, I would like to thank Kate Smith for suggesting I take up this opportunity and for her help throughout the process, even though she has had a difficult year. Without her recommendation, I doubt I would have conducted this research project. I would also like to thank Catherine Leyshon for her continued support throughout the project. Her guidance and support has been excellent and has helped me at many times, to continue with the research process, which at times, has been challenging.

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1.0: Introduction

This dissertation explores the potential uses, benefits, limitations and design ideals of Story Maps, within the context of flood hazard and risk communication. The evidence gathered aims to answer the question, *'Are Story Maps a useful flood hazard and risk communication resource?'*. A case study approach was utilised, focussing on the St Blazey region within Cornwall, which is regularly flooded from multiple sources. This introduction section begins by discussing the issue of flooding worldwide and then within Britain. It transitions into an analysis of why flood hazard and risk communication is required and empirical evidence that highlights the importance of conducting this activity. Finally, a brief overview of the methodology and research questions is presented.

1.1: Worldwide flooding and links to climate change

Flooding is a major natural hazard. It occurred most frequently, compared to other hazards, over at least the last twenty years (CRED, 2015). Between 1994-2013, floods accounted for 43% of all events recorded, affected nearly 2.5 billion people worldwide, destroyed or damaged 66 million properties and cost the world economy $636 billion (CRED, 2015). Their causes are diverse, multifaceted, and interrelated, presenting a significant issue worldwide, with various impacts, both primary and secondary (Doocy *et al.,* 2013 and Nelson, 2015). Major flooding experienced over the past 20 years includes episodes in Thailand 2011, which caused $30 billion of damage and the United States (U.S.), Korea, Pakistan and Germany floods, with damage costs of $9.5 to $18 billion between 1998-2011 (Berkman and Brown, 2015). Figure 1, presents the spatially diversity of flooding and that floods affect the United Kingdom (UK). Figure 2 displays the quantity of people affected by these events and the damage they cause.

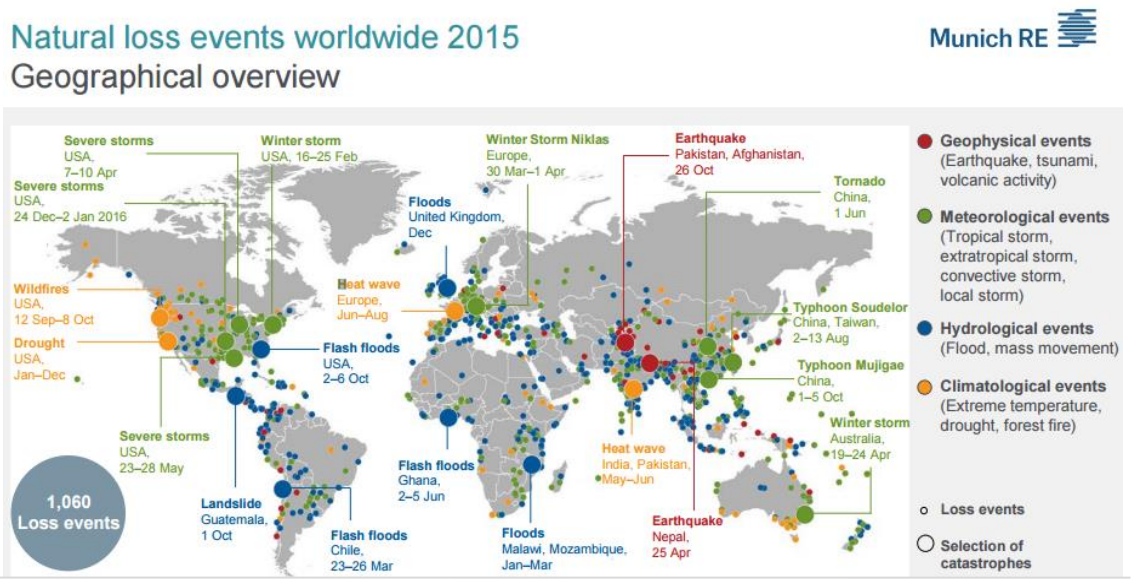

Figure 1: Natural disasters around the world in 2015. (Source: Munich RE, 2015).

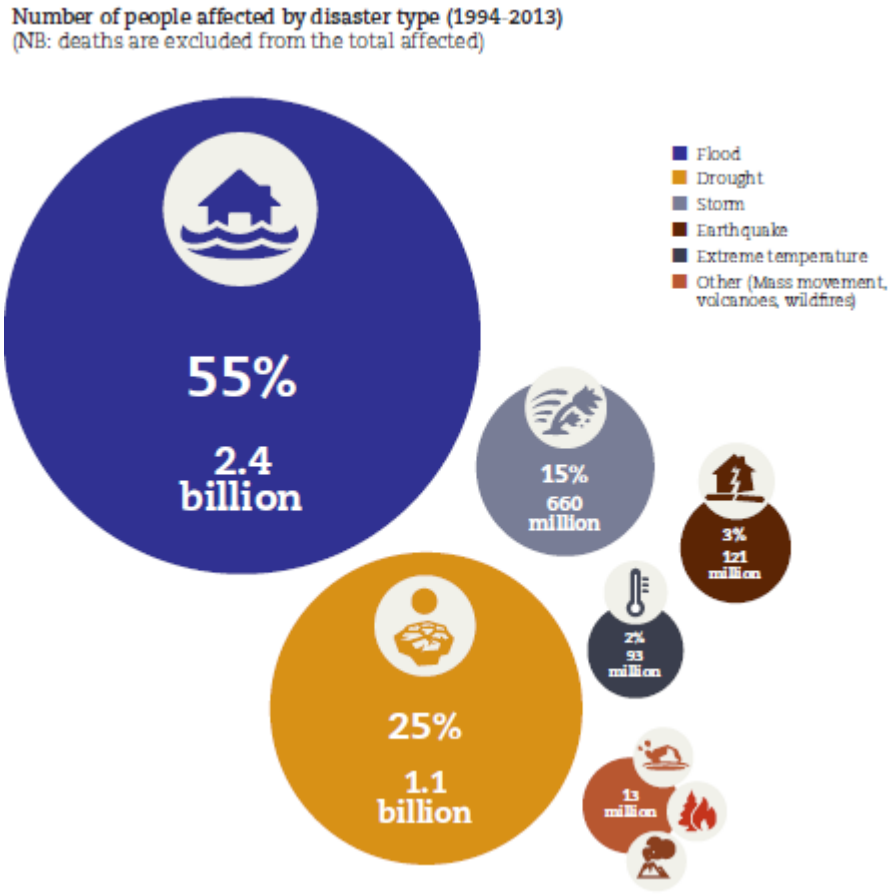

Figure 2: Number of people affected by disaster type (1994-2013). (Source: CRED, 2015).

Climate change is likely to compound the impacts of flooding and exacerbate flood risk. There have been suggestions that climate change will increase the magnitude and frequency of many meteorological events that lead to flooding. One recent model predicted that in 2050 “the current 100-year flood would occur at least twice as frequently across 40% of the globe” and would mean “approximately 450 million flood-prone people and 430 thousand km^2 of flood prone-cropland would be exposed to a doubling of flood frequency” (Arnell and Gosling, 2016:1). Further evidence by Stocker *et al.* (2013), highlights that the magnitude of flooding has increased, with 20^{th} and 21^{st} century floods being larger than those that occurred in the past five centuries in many regions around the world. Moreover, there is an increasing trend for extreme precipitation and discharge in some catchments, leading to increased flood risk at some regional scales (IPCC, 2015). Modelling however, is not perfect, and variability often occurs, but generally, climate change predictions indicate that flood risk is likely to increase (Arnell and Gosling, 2016). Institutions like the Tyndall Centre, OECD, IPCC, and the UK Met Office, support this conclusion and highlight that climate change is a significant issue in the flood hazard and risk debate (Few *et al.,* 2004, Hallegatte *et al.,* 2010, Stocker *et al.*, 2013 and Slingo *et al.,* 2014).

Figure 3 shows an increase in hydrological events, which include flooding, along with meteorological and climatological events, with this rise potentially related to the impacts of climate change. Part of this trend however, could be a product of greater reporting and recording of natural disasters as technology and information exchange has improved.

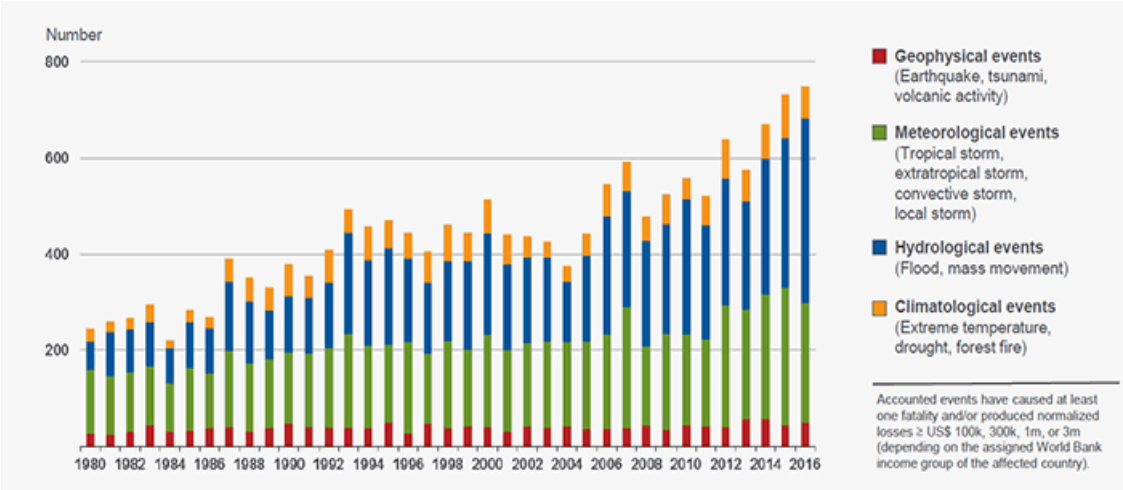

Figure 3: Number of world natural catastrophes, 1980-2016. (Source: Insurance Information Institute, 2017).

1.2: UK flooding, climate change and flood risk

Within the UK, flooding is also a persistent issue, with floods occurring regularly and flood risk a primary concern to both the government and other stakeholders. Within the UK, flooding and storms represent the majority of natural hazards: during the period 1990-2014, floods and storms each represented 43.2% of hazards experienced and flooding caused 63.1% of the economic losses associated with natural hazards (EM-DAT, 2014 cited in UNISDR, 2014). It must be noted here however, that the UK sits in a non-seismically active location meaning earthquakes and volcanic activity is exceptionally limited. Moreover, although the UK does suffer from tornados, with 34 tornados a year recorded between 1980-2012, these events are low frequency and intensity (95% rated as F0 or F1) and thus have a limited contribution to the number of natural hazards the UK experiences (Mulder and Schultz, 2015). Thus, the lack of these other natural hazard type explains, to an extent, the predominance of flooding and storms within these statistics. Nevertheless, flooding is very problematic, as 5.2 million properties are at risk of flooding in England and annual flood damage costs are approximately £1.1 billion, expected to rise to as much as £27 billion by 2080 (Bennett and Hartwell-Naugib, 2014).

Recent flood events include, the Coverack flash flood on 18th July 2017, which saw 4ft of water torrent through the town (BBC, 2017). Several people required rescuing as the flood affected approximately 50 properties (BBC, 2017). The

mud and silt in the water affected the road networks and caused rubble to be littered throughout the town, which could have affected Coverack's tourist season, and thus, the local economy (BBC, 2017).

Another example is the 2015/2016 storms, which caused flooding of <16,000 properties in England. Defences were overtopped, damaging nearly 5,000 businesses and over 100 bridges, with costs estimated to have exceeded £1.3 billion (Marsh *et al.,* 2016). Additionally, in Lancaster, thousands of properties were left without power for several days (Marsh *et al.,* 2016).

Two years previously, the significant winter storms of 2013/2014, caused by strong low-pressure systems, led to the wettest winter on record in the UK, with significant flooding throughout the country, especially along the South West coastline (Muchan *et al.,* 2015 and Huntingford *et al.,* 2014). Over 7,000 properties were flooded, with nearly 50,000 ha of farmland inundated in a single day. Transport was disrupted, with significant impacts on the Somerset Levels, where a major incident was declared and the community isolated for 4-6 weeks, with 150-200 homes flooded (Muchan *et al.,* 2015 and Huntingford *et al.,* 2014). These examples illustrate the flooding issue within the UK, which is likely to worsen due to climate change.

Although uncertainty remains regarding climate change and its projected impacts on flood risk, there are suggestions that the UK's future flood risk is likely to increase, with warmer, wetter winters causing precipitation rises of 0-25% by the 2050's and 10-40% by the 2080's, which could lead to increased winter flooding (Evans *et al.,* 2008 and Lamond *et al.,* 2010). Moreover, the number of intense summer rainfall events are likely to increase, potentially causing more summer pluvial flooding (Lamond *et al.,* 2010).

There is already evidence that supports these conclusions, with the 2000 and 2013/2014 floods demonstrating climate change signals. Kay *et al.* (2011) state that in seven of the eight catchments modelled (in South-East and North-East England), greenhouse gases, such as carbon dioxide and methane, had increased the flood chance during October and December 2000. This is supported by Pall *et al.* (2011), which found that nine out of ten cases they modelled showed that 20th Century greenhouse gas emissions had increased flood risk in England and Wales in 2000 by 20% and in two out of three cases by more than 90%.

Furthermore, Schaller *et al.,* 2016 identified a climate change signal in the recent flooding of 2013/2014, which likely caused the extreme quantities of precipitation, which led to the floods. In this case, atmospheric warming increased the amount of moisture the atmosphere could hold and caused an increase in the number of January days with westerly flow, leading to increased extreme precipitation.

This level of attribution however is contested, with the SREX report stating that "no gauge-based evidence has been identified for a clear climate-driven, globally widespread, observed change in the magnitude/frequency of river floods during the last decades" (Kundzewicz *et al.,* 2014:6). This is sentiment is supported by Fowler and Wilby (2010) who suggested that attribution of rainfall trends, a significant impact on flood probability, to human influences e.g. climate change, is not yet possible below the scale of global land area. The difficulty of attributing climate change to natural hazards, such as flooding, is due to several reasons, for brevity however, only two are provided here. First, there is limited availability of long-term observations (Stone *et al.,* 2013). For example, in the UK, gauging stations have short records and thus accurately attributing climatic changes to increased river flows and risk/creation of flooding is challenging (Hannaford and Marsh, 2008). Second, discerning a climate change signal from other influences is difficult due to limited knowledge of the processes and mechanisms involved in changing environmental systems, adding complexity in discerning climate change influences from that of natural variability (Stone *et al.,* 2013). For instance, a flood event is governed by a variety of factors e.g. regional precipitation, basin morphology, land-use change, run-off and discerning a climate change signal, from these factors and others e.g. migration, river-engineering, economics etc. is difficult (Wilby, Bevan and Reynard, 2008). Thus, any relationship between climate change and flooding needs to be taken with caution.

1.3: The need for flood hazard and risk communication

With flooding a major threat to the UK and climate change potentially exacerbating the situation, it is vital that flood hazard and risk is managed effectively. To achieve this, relevant information must be communicated appropriately to those at risk.

Hazard and risk communication primarily consists of three parts. These are: communication of information, hazard and risk perception, and impact (e.g. changed behaviour or perception). Hazard and risk communication is defined as any purposeful exchange of information about health and environmental risks (or hazards) between interest parties, which is made up of individuals, groups or organisations (Covello *et al.,* 1986 and Trettin and Musham, 2000). Hazard and risk communication aims to ensure those at risk remain safe. This is achieved by altering hazard and risk perception, primarily subjective risk assessments, as this is how the public/laypersons perceive risk, which relies on many factors including experience, emotions, personal views and feelings (Smith, 2013, Bradford *et al*., 2012 and Slovic, 1987). This process is however complex, as multiple factors affect perception. Although communication can provide valuable knowledge/information about hazard and risk which improves individuals understanding, its influence on perception varies. Table 1 provides some risk perception factors, primarily focussing on those affecting flood risk perception.

Table 1: Factors affecting risk perception and reasons why these factors make a difference (Source: Drewitt, 2016 (with adaptations)).

Risk perception factors	Explanation of why factor makes a difference	References
Geographic location within flood area	• The higher the level of exposure to flood risk the more it influences risk perception. • Rural people generally perceive risk closer to the statistical measure, potentially due to a better connection with the natural environment.	Bradford *et al.* (2012) Smith, 2013 Plapp and Werner cited in Ammann *et al.* (2006)
Socio-economic and demographic profile	• Risk perception is affected by occupation, lifestyle, age, nationality and gender. • Even between individuals of the same age, gender and nationality, risk perception differs.	Rohrmann, 1994 Bradford *et al.* (2012)
Previous flood experience and knowledge of damage caused	• Memories formed during previous floods are retrieved by individuals when they are faced with similar risks and affects perception. • When faced with a flood event, risk perception can quickly and dynamically change.	Bradford *et al.* (2012) Plapp and Werner cited in Ammann *et al.* (2006) Smith, 2013 Kasperson *et al.* (1988)
Personal and psychological composition	• Individuals affective and behaviour attributes lead to particular emotions and tendencies/disposition to act and feel in a specific way when flooded, causing individualised risk perception.	Bradford *et al.* (2012) Plapp and Werner cited in Ammann *et al.* (2006)
Worry or fear evoked by hazard	• Even if individuals know about a hazard, unless they are worried, action is unlikely. • Worry and fear can lead individuals to pass responsibility for flood damage to structural protection failings or to pass responsibility for flood risk protection onto other individuals and higher powers.	Bradford *et al.* (2012) Plapp and Werner cited in Ammann *et al.* (2006)
Sense of home	• A sense of home can over-ride common sense about the risk of a hazard, with individuals convincing themselves of conclusions that do not reflect the reality of the risks they face.	Bryant, 2005
Media coverage	• Flood hazard and risk information arrives via many sources e.g. TV, Internet and Film, but the information is often incorrect, nevertheless it is used to defend individuals risk perception ideals.	Smith, 2013
Community decisions	• Collective decisions on precautionary measures and a community's general attitude about the risk they are under is reflected in individuals risk perception.	Garvin, 2001. Nott, 2006
Knowledge of the facts	• Knowledge of exposure, frequency and magnitude of past, present and future events influences how individuals perceive risk.	Plapp and Werner in Ammann *et al.* (2006).

Risk communication, also extendable to hazard[1] communication, has a range of impacts, regardless of the interference caused by other risk perception factors. These include: increasing knowledge and interest in specific issues (i.e. flooding), influencing behaviours and attitudes, aiding decision making and understandings of correct procedures in flood emergencies/crises and assisting in conflict resolution (Boholm, 2008). The absence of communication can have a major influence on the public's risk awareness, their preparations for disasters and motivation to take preventative actions (Basic, 2009 in Kellens *et al.,* 2009 and Hagemeier-Klose and Wagner, 2009). This can have consequential impacts upon their resilience and influences the extent of damage and disruption caused by disasters (Basic, 2009 cited in Kellens *et al.,* 2013 and Hagemeier-Klose and Wagner, 2009).

There is also quantifiable evidence that hazard and risk communication produces important outcomes. For example, Tanaka (2005), reported that when earthquake risk information was received through multiple communication channels, there was a higher level of earthquake preparedness in both Japan and California. There has however, been limited research specifically on flood hazard and risk communication, with Kellens *et al.* (2013) revealing that out of 57 peer-reviewed articles around flood risk perception and communication, only two papers were identified exclusively on the topic of flood risk communication, highlighting a gap in the literature. One of these articles was Terpstra *et al.* (2009), which revealed that risk communication had a moderate effect on changing Dutch participants' risk perception and that without communicating risk information people's attitudes can 'polarise'. This can lead to unrealistic optimism about flood risk ('it can't happen here'), resulting in a lack of attitudinal change and preparedness. O'Sullivan *et al.* (2012) also investigated flood risk communication, revealing that higher preparedness could be obtained through communication of best practice for flood preparation, alongside the benefits of being prepared.

[1]Risk is defined as: 'The combination of the probability of an event and its negative consequences', following terminology located in (UNISDR 2009a:25).
Hazard is defined as: 'A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage, following terminology located in (UNISDR, 2009a:17).

Furthermore, an improved understanding of complex concepts surrounding risk, were linked to greater awareness and enhancement of social resilience. Inaction or incorrect actions however, were the responses if people misinterpreted or failed to understand risk messages and information. Finally, Yamada *et al.* (2011) implemented a community flood risk communication program in Japan and revealed that it effectively enhanced residents' awareness of both self and mutual help efforts in community based flood risk mitigation.

Flood hazard and risk communication is; however, a complex process and a variety of issues and considerations must be addressed before implementation, which will be explored in the literature review. Although an array of recommendations for flood hazard and risk communication have been presented in various research papers, including Faulkner and Ball (2007), O'Sullivan *et al.* (2012), Bradford *et al.* (2012) and Höppner *et al.* (2012), there is no exact science on how to conduct this form of communication. Thus, opportunities arise for original solutions and innovative methods, to be introduced. These themes, critical to this study, are explored further in Sections 2.5 and 3.1.

1.4: Story Maps

Story Maps, created by Esri, present a potential new communication method. Esri was established in California in 1969 and has become a global market leader in GIS software, deploying their software into over 350,000 organisations (Esri, 2017a). The companies ArcGIS software is one of the best GIS software's in the world and can conduct powerful mapping and spatial analytics, helping a variety of organisations to use their data more effectively, including commercial, governmental and manufacturing industries (Esri, 2017b).

Story Maps, created by Esri, are online resources, accessed via the Story Maps website. They can be created using several pre-set designs that require no coding, or creators can develop their own Story Map designs using Esri's open source code (Esri, 2017c:1). Esri states "Story Maps let you combine authoritative maps with narrative text, images and multimedia content. They make it easy to harness the power of maps and geography to tell your story" (Esri, 2017c:1).

Many Story Maps have a map or several maps as their centrepiece. The maps can contain a combination of base maps, thematic maps, tabular data and pop-ups amongst other options (Esri, 2012a). These maps are easy to create on either standard desktop ArcGIS or Esri's free ArcGIS online, although certain restrictions apply to the latter, allowing everyone the opportunity to create maps, in an environment that suits them. Furthermore, ArcGIS online supports data sources created in Excel spreadsheets on local computers and then loaded into online Story Maps, allowing flexibility in data input (Kerski, 2013 and Wright, 2016).

During development and creation of the Story Map there is the opportunity to use text and a variety of multi-media mediums including, videos and images, charts, graphs and more, from Youtube, Flickr and Google+ or via a URL. Other more advanced options include an auto-play feature that allows the application to run without user interaction and many other widgets. Once completed Story Maps can be published as web apps on online gallery or onto user's webservers (Kerski, 2013). For example, Vallui and Gérald (2017) have created a Story Map and a website to teach French school children about the risks of flooding. This is one of a limited sample of Story Maps that are used for flood hazard and risk communication.

Thus, it seems important to investigate Story Maps, as they could be potentially useful hazard and risk communication tools. Story maps' novelty means few other studies from the fields of Geography, GIS or education technology have examined them or their potential (Strachen, 2014). Additionally, none have investigated them in a hazard and risk context; instead research often focusses around proof of concept studies or studies that provide examples of researchers' Story Maps and their development (Brigham, 2016, Kerski, 2016 and Ivanov, 2015). Story Maps do seem however to have some distinct advantages which might make they useful communication tools. Firstly, they can integrate data analysis with supercharged technologies including GIS, the web, mobile communications and the cloud, overtaking traditional maps in terms of capability (ESRI, 2012a and 2012b). Secondly, these resources grant the author greater creativity that helps convey their message, which would not be achievable with one map or a textual document (ESRI, 2012a and Graves,

2015). Thirdly, as Story Maps attempt to convey stories and draw users into involvement with data, this helps viewers to invest and engage in what they are viewing, making learning easier (Harvey and Watkins, 2012, in Jobst, 2012) Fourthly, their development has accelerated at an enormous pace and more and more complicated subjects are being tackled by Story Maps, with some Story Maps explaining and exploring spatial analysis with viewers on complicated subjects (Wright, 2014).

Finally, Story Maps present a novel, mixed media approach to presenting flood hazard and risk information (Drewitt, 2016). They allow for mapped flood hazard and risk data to be combined easily with other resources, to enhance both the map's content and communication of flood hazard and risk information. The use of different media and the interactivity of Story Maps offers a variety of benefits and the opportunity to accommodate varied learning preferences e.g. visual, auditory and kinaesthetic (Drewitt, 2016). This ability to accommodate varied learning preferences potentially makes this digital platform useful for flood hazard and risk communication. Moreover, mixed media approaches are not fully utilised within flood hazard and risk communication, but some examples exist. One mixed media communication example is the National Flood Services *FLOOD Ed.* website, which utilises various images, text and video testimonies from flood victims to discuss flood risk (National Flood Services, 2016). It also has an interactive flood calculator where individuals can insert their homes square footage, the number of floors their home contains, estimated value of possessions and level of flood water (National Flood Services, 2016). Another example is the *Focus on Floods* website, presenting text, images, videos and educational resources to help individuals understand flooding (Nurture Nature Foundation, 2012). This however is predicated, much like *FLOOD Ed,* on a text heavy approach across multiple pages. These resources, unlike Story Maps, seem to lack the holistic interface, where mixed media can be utilised in a single space alongside interactive mapping.

These features within Story Maps therefore make them seem like valuable communication resources and thus it seems valuable that further research is conducted not only on Story Maps as a whole, but also to assess their usefulness as communication resources. This dissertation begins this investigation.

1.5: Aims and research questions

To investigate how Story Maps could be effectively utilised within flood hazard and risk communication, the following research questions (RQ's) were devised.

RQ1: What are the current issues within the St Blazey area and to a wider extent Cornwall, in terms of flood hazard and risk and its communication?

RQ2: Using the issues ascertained in RQ1, what considerations must be made when creating a Story Map to attempt to overcome these issues?

RQ3: What benefits, limitations and potential uses for Story Maps can be identified by using St Blazey as a case study?

RQ4: How do the elements of a Story Map help individuals understand flood hazard and risk information and what design preferences are expressed by those viewing Story Maps?

1.6: Study area context

This study uses links with the STARR project (St Austell Bay Resilient Regeneration Project) to create a case study, focussing on the St Blazey region. The St Blazey area, located in the county of Cornwall, includes several Cornish towns such as Par, St Blazey, St Austell, Tywardreath and Luxulyan. Figure 4 provides further detail.

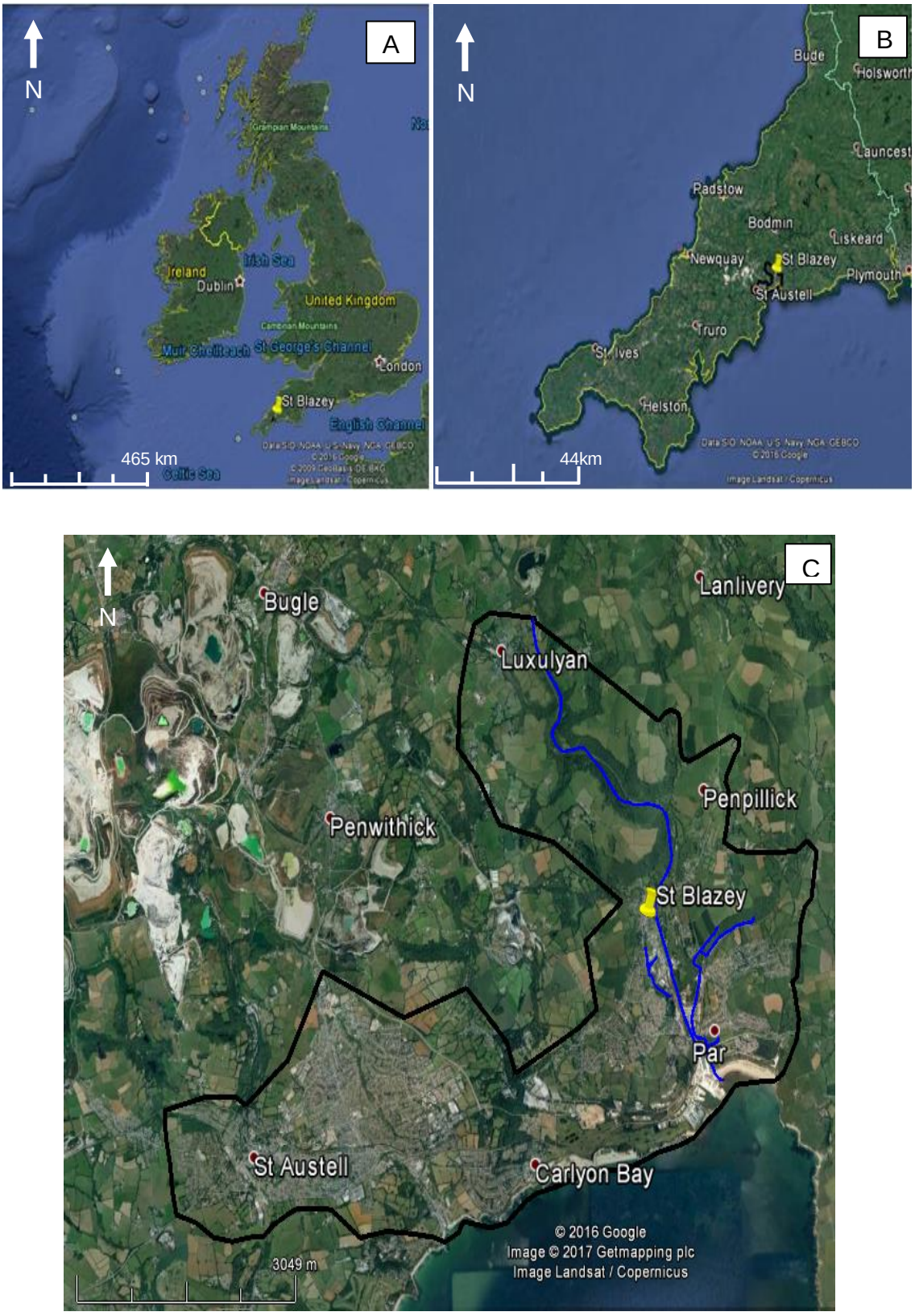

Figure 4: Study area in the UK and within Cornwall. A) Study area in the UK, B) Study area in Cornwall, C) The area STARR broadly operates in. St Blazey (pinned in these images) is an area of particular interest to this research, alongside the blue lines which highlight the major waterways (Source: Google Earth).

The STARR project is a >£30 million flood alleviation and regeneration scheme led by Cornwall Council and involves several other organisations e.g. South West Water (Cornwall Council, 2016a). It aims to reduce flood risk to communities living and working in the St Austell Bay area, especially those in Par and St Blazey (Cornwall Council, 2016a). The STARR project is an example of a multi-agency approach. It is attempting to collaborate with many stakeholders to create effective flood risk management (FRM) plans and ensure the interests and insights of different groups are discussed, debated and addressed. Multi-agency approaches to flood risk are explored further in Section 2.2.3. The areas covered by STARR suffer from flooding as they are mostly coastal towns and are in a highly active catchment, which sits at the interaction of two river catchments, the Par and Sandy rivers, leading to flood risk from riverine, surface, tidal and groundwater (R5, Table 4, personal communication; 9th March, 2017). The STARR project endeavours to use natural FRM, defined by the Government as "the alteration, restoration or use of landscape features to reduce flood risk" and often includes soft-engineering solutions to manage flood risk (Prescott and Wentworth, 2011:1). Moreover, the STARR project aims to: create conditions for regional economic growth, improve the natural environment, create a better living environment in Par and St Blazey and create widespread community awareness and ownership of FRM (R5, personal communication; 27th February, 2017). The University of Exeter is involved with the STARR project. This presented the opportunity to work alongside STARR to gather real world data surrounding flood hazard and risk communication. The St Blazey area within the STARR project was utilised as the focus for the created Story Maps and data collection.

Rachael Bice (Strategic Environment Manager: Cornwall Council, 2016b) states that the St Blazey region "is really susceptible to flooding with damaging events occurring (every) 1-2 years" and that in 2010, damages reached £20 million. It was also reported that 55 properties in St Blazey alone were flooded, as drainage became overwhelmed due to persistent rainfall and surface water run-off (Cornwall Council, 2016b and R5, personal communication; 9th March 2017). Furthermore, vehicles were damaged and major roads were flooded.

Further statistics reveal that Par and St Blazey have 700 properties at risk from fluvial or tidal flooding and 900 properties potentially at risk from surface water flooding (Cornwall Council, 2010). These at risk properties are displayed in Figure 5.

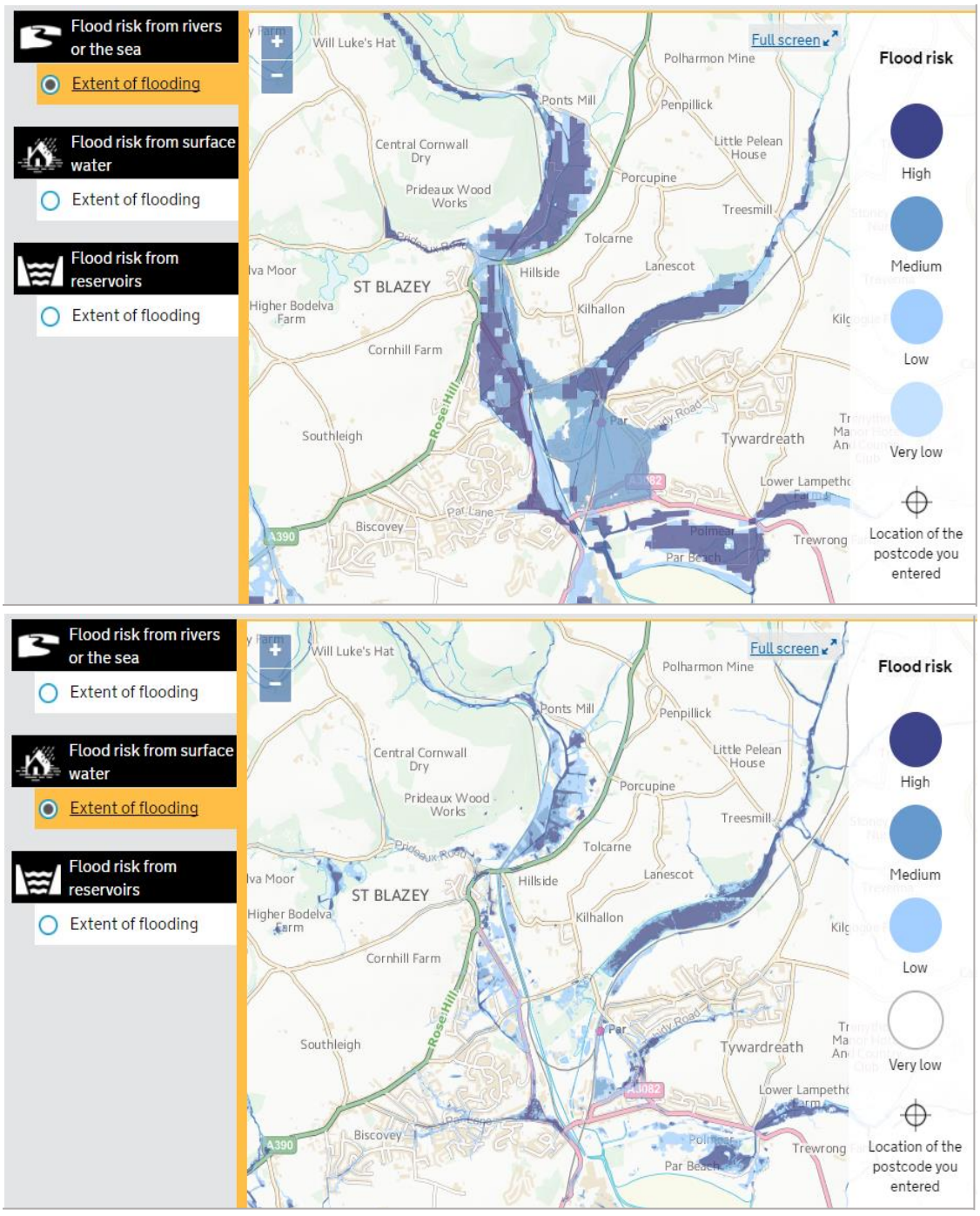

Figure 5: EA flood risk maps. A) Flood risk from rivers and sea for St Blazey and Par. B) Flood risk from surface water for the same area. (Source: Environment Agency, 2017).

Climate change is likely to compound this issue. In 2100, climate change is likely to cause 75 more properties in St Blazey/Par to be at flood risk (Environment Agency, 2012). Figure 6, shows St Blazey/Par's flood risk compared to the rest of Cornwall, alongside the impacts of climate change on future flood risk.

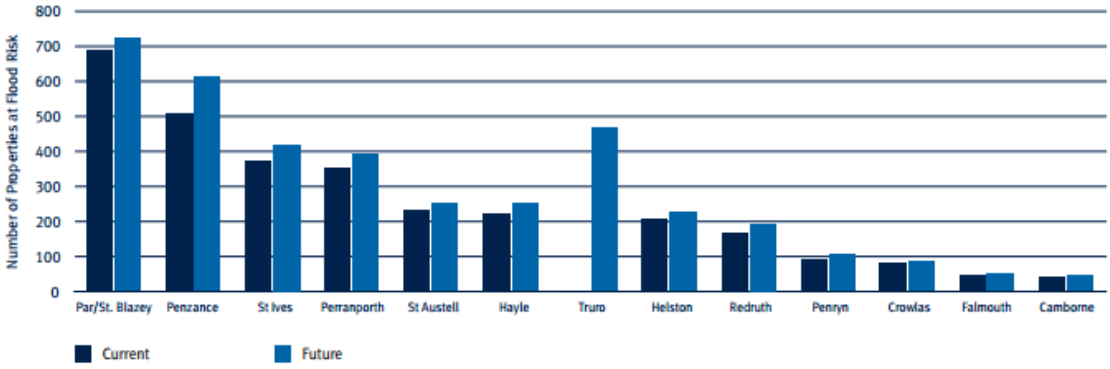

Figure 6: Current and future (2100) flood risk to properties from a 1% annual probability risk flood, accounting for current flood defences. (Source: Environment Agency, 2012).

The figure demonstrates St Blazey/Par's and St Austell's high flood risk compared to the rest of Cornwall. This indicates that the area is an appropriate study site as a significant quantity of the population is at risk of flooding. This community therefore, would have valuable insights into whether a Story Map is a good communication tool to discuss flooding, the issues they face and the STARR flood alleviation strategy.

To summarise, this dissertation and the Story Maps produced by the research, have particularly focused around St Blazey/Par as the area has the greatest number of properties at risk from flooding within the STARR project area.

1.7: Overview of dissertation structure

The following sections detail the literature surrounding flood hazard and risk management and its communication and the new sphere of research developing on Story Maps. Following this, the data collection methods and their justifications are explored. The results and discussion section then examine the insights gathered from the research and positions them within the context of existing research.

Finally, the research questions are answered and an assessment of whether Story Maps could be useful resources to conduct flood hazard and risk communication is completed, before suggestions are presented on potential future research.

2.0: Literature Review – Part 1

2.1: Opening remarks

This literature review initially investigates FRM conduct in the UK, detailing its history and current practices, whilst examining issues with the UK's current approach. Secondly, the communication of flood risk, a key element within the UK's FRM strategy, is addressed. Following this communication theme, an in-depth analysis of flood hazard and risk communication literature is completed.

2.2: UK flood risk management

Over the past few decades, a shift in UK FRM has occurred. The UK's previous FRM system was dominated by a 'flood defence' and 'keeping water out' mentality, reliant upon top down governance and large scale, cost intensive engineering and technical measures. This system has transitioned towards a strategy where sustainability and 'living with water' is the priority (Begg *et al.,* 2015). This re-evaluation of FRM has also been extensively adopted throughout Europe, leading to a recognition of numerous factors. The importance of soft engineering and management solutions that co-operate with natural processes have been documented (Butler and Pidgeon, 2011 and Krieger, 2013). Additionally, the redistribution of responsibilities, where citizens and communities take responsibility for personal FRM, to help build resilience and promote increased bottom-up governance within FRM, has been acknowledged (Butler and Pidgeon, 2011 and Krieger, 2013). This shift within FRM is the product of multiple influences, which will be discussed below, including:

- The failings of hard defences.
- The increasing need to address the three pillars of sustainability (economic, social and environmental).
- The transition towards localism and a multi-stakeholder approach in governmental thinking surrounding FRM.
- Better communication surrounding flooding, its impacts and FRM.

2.2.1: Brief history of the UK's FRM strategy

To thoroughly assess the UK's changing FRM strategy, it is necessary to investigate its history.

From the end of World War II until the late 1970's, FRM focussed on land drainage and hard engineering solutions to ensure farm profitability, increased productivity and protection of urban assets, with responsibility firmly in the hands of central government (Begg *et al.,* 2015, Johnson and Priest, 2008 and Watson *et al.,* 2009). During the 1980's and early 1990's, FRM shifted to primarily defending against flooding and to ensuring water was excluded from areas using structural engineering (Begg *et al.,* 2015, Johnson and Priest, 2008 and Watson *et al.,* 2009). These priorities explain the thousands of kilometres of flood embankments and the hundreds of kilometres of flood walls across Britain, meanwhile, soft-engineering options, if considered, were local initiatives (Begg *et al.,* 2015 and Rickard, 2009 in Ackers *et al.,* 2009). This 'defend' approach, that relied on structural defences, had its limitations. These include, the recognition that structural defences only reduce the probability of flooding up to specific magnitudes and have an in-built risk of failure related to maintenance condition, whilst often displacing flood risk downstream (Butler and Pidgeon, 2011, Crichton, 2011 in Lamond, 2011 and Lane *et al.,* 2011).

Furthermore, climate change, is causing future flood risk to become increasingly uncertain. Changes in location, frequency and magnitude of floods are predicted, leading to rising defence costs, which affect current and future generations, with recent extreme flood events emphasising that some floods cannot be defended against (Butler and Pidgeon, 2011, Nye *et al.,* 2011, Johnson and Priest, 2008, Ball *et al.,* 2013 and Crichton, 2011 in Lamond, 2011). Finally, the 'defend' mentality has led to some undesirable outcomes, including adverse effects on natural water retention spaces and creation of a false sense of security for individuals living near defences (Krieger, 2013 and Crichton, 2011 in Lamond, 2011).

Since the 1990's, with the rise of sustainable development, there has been growing alertness that FRM must fulfil the three pillars of sustainability and these factors require consideration when altering flood risk in a catchment and shoreline wide approach (Pitt, 2008, Nye *et al.,* 2011 and Johnson and Priest, 2008). This culminated in 2005, with the creation of England's 20-year FRM policy called *'Making space for water'*, fully implemented in 2008 (DEFRA, 2004).

This policy supports sustainable FRM by promoting increased use of soft engineering methods e.g. floodplain management, re-afforestation and effective land use practices over flood defences, where appropriate (Johnson and Priest, 2008, Lane *et al.,* 2011 and Ball *et al.,* 2013). Furthermore, it specifically stated that resilience (defined as the ability of individuals, communities, services and infrastructure to detect, prevent, withstand and recover from hazards e.g. floods) was increasingly important in UK FRM and indicates a transition of power for FRM to the local scale (Ball *et al.,* 2013 and Medd *et al.,* 2015).

Improvements and additional recommendations have been derived from a series of further UK and EU policy documents. Firstly, the '*Pitt Review*' (2008) encourages councils to strengthen their technical capabilities so they can lead local FRM strategies and called for higher quality flood warnings. Secondly, '*The Flood and Water Management Act*' (2010) provides several responsibilities for councils, including; applying and monitoring a local FRM strategy, co-operating with other *'Risk Management Authorities'* and maintaining a register of local structures/features likely to be significantly affected by flooding. Finally, European legislation, such as, The EU *'Floods Directive'* (2007), required member states to undertake preliminary flood risk assessments, prepare flood hazard and risk maps and FRM plans. Europe's influence, however, is likely to change in the face of Brexit.

The UK's FRM strategy has clearly undergone a significant shift over the last two decades, with increasing attention upon the three pillars of sustainability and an understanding that hard flood defences are prone to failure. To further investigate the UK's FRM strategy, three other parts will be discussed sequentially in the following sections, these include;

- Responsibility for FRM transitioning from central government to local citizens and communities. These members have been empowered to conduct and improve their understanding of property level resilience measures alongside awareness of their flood risk and centrally managed structural and technical measures (Johnson and Priest, 2008, Butler and Pidgeon, 2011, Nye *et al.,* 2011 and Watson *et al.,* 2009).

- Increased momentum to conduct holistic multi-stakeholder FRM, where participation and engagement is encouraged throughout the disaster cycle and the planning and implementation of FRM to improve resilience (Begg *et al.,* 2015, Wachinger *et al.,* 2013 and Walker *et al.,* 2010). Furthermore, to ensure this approach is attained, increased trust and legitimacy of local stakeholders in public administration and decision making is required (Thaler and Levin-Keitel, 2016).

- Increased communication between all FRM members that is clear and transparent, has been recommended in research and public documentation. This ensures that the public and other stakeholders has increased awareness of flood risk/coastal risk and their respective responsibilities. It is also important that these stakeholders clarify their positions in the decision-making process and communicate this (Nye *et al.,* 2011 and Butler and Pidgeon, 2011).

2.2.2: Localism in FRM

Some changes to the UK's FRM strategy, show alignment with new localism ideals within governmental thinking, which, in recent years, have become a popular and relevant trend in policy discussions (Thaler and Priest, 2014). Localism is the decentralisation of government favouring the 'local' level as the place where decisions and problems are best dealt with (Begg *et al.,* 2015). This approach is evident in the '*Pitt Review*', whereby local authorities are encouraged to lead and co-ordinate FRM, this has been continually reinforced throughout the ensuing period (Penning-Rowsell and Padroe, 2015 and Pitt, 2008). Localism is also evident in new 'Partnership Funding' mechanisms for FRM, whereby those at risk raise some funds to be spent locally, which complements government investment (Thaler and Priest, 2014). The benefits and limitations of localism in FRM are examined below.

Localism is associated with a variety of advantages including improvements in active citizenship, community empowerment and local democracy, with citizens providing more varied services, information and capabilities (Featherstone et al., 2012 and Painter *et al.,* 2011). Furthermore, localism enables improved reflection of diverse local perspectives and 'lived experience' in policies created (Walker *et al.,* 2010 and Thaler and Priest, 2014).

Thus, localism potentially provides improvements in trust, communication and collaboration between actors (Wachinger and Renn, 2010 and Kuhlicke *et al.,* 2012). These features are vital for developing improved community resilience when faced with risks and threats, in the instance of UK FRM, from flooding (Wachinger and Renn, 2010 and Kuhlicke *et al.,* 2012).

There are criticisms however, of the localism approach in FRM. For example, the government still 'steer' policies and actions of lower level stakeholders by setting agendas and targets, thus limiting the ability for stakeholders to work independently (Begg *et al.,* 2015 and Painter *et al.,* 2011). Furthermore, each individual community possesses differing levels of resources and capabilities to handle the new responsibilities of FRM (Begg *et al.,* 2015 and Painter *et al.,* 2011). This can reinforce existing patterns of deprivation and social exclusion, leading to unequal flood protection, mitigation and resilience across communities (Thaler and Levin-Keitel, 2016 and Penning-Rowsell and Pardoe, 2015. To help avoid the reinforcement of existing deprivation, partnership funding formulae prioritise the protection of deprived communities (Penning-Rowsell and Pardoe, 2015). Overall however, there is suggestion that differing levels of resources and capabilities will continue to exist.

Johnson and Priest (2008) state that urban/economically dense areas are more likely to receive government investment, as the impacts of flooding will be larger and the cost-benefits analysis is favourable, which provides them with greater resources and capabilities to conduct FRM. This contrasts with rural communities, which potentially receive little or no government investment, as impacts are perceived as less significant and the cost-benefit analysis is unfavourable. These communities will thus be forced to self-fund FRM efforts or be left with diminished FRM, leading to questions of fairness (Johnson and Priest, 2008). Currently, local authorities pay for FRM, not those at risk, so this issue is minimised. If this situation changes however and rural communities are required to forward their own money for FRM, whilst urban areas continue to receive government funding, this becomes a more pressing issue (Penning-Rowsell and Pardoe, 2015).

This question of fairness also encompasses whether vulnerable members of society should be compelled to accept the increased burden upon themselves to conduct personal FRM, whilst already dealing with the variety of issues they

face (Johnson and Priest, 2008). Personal FRM can involve: raising awareness of personal flood risk, creating a flood plan, moving furniture and belongings to safe places, purchasing, storing and maintaining temporary (which will require deployment) or permanent household flood defences and insurance.

Finally, although citizens and communities are encouraged to take responsibility for FRM and its implementation, Rouillard *et al.* (2015) established that this can only be effective if there is local interest. Even if interest is evident, there can be misunderstandings about what counts as *effective* FRM. For example, Wamlser and Lawson (2011), identified the tendency of homeowners to view insurance cover as a successful system to deal with flood risk and thus used this as their only FRM method. Insurance therefore, is misunderstood or conceptualised as a simple 'solution' to flood risk, whilst providing no preventative protection. This understanding causes friction in opposition to the conducting of personal FRM by property owners (Ball *et al.,* 2013). Furthermore, even if people understand and want to take responsibility for FRM, many participants in Butler and Pidgeon's study (2011), felt that they had limited power and any effective action was dominated by governing and private organisations. Nye *et al.* (2011) states that if this sentiment continues, living with water will be unsuccessful.

Thus, it seems that localism presents opportunities for individuals to become increasingly responsible for their own FRM and to have greater power to communicate with those responsible for FRM decisions and conduct. Localism however, present issues of unequal FRM due to differences in resources and capabilities of different communities and individuals, exposing issues of whether this approach is fair and safe for UK citizens.

2.2.3: Multi-stakeholder approach in FRM

The previous section, investigated the shift towards localism in FRM and how responsibility for FRM is becoming a 'personal' matter. Although this shift has begun, there still exists an important multi-stakeholder network that holds varying FRM responsibilities. The stakeholders, who are responsible for conducting and implementing FRM policy include: DEFRA, EA, Internal Drainage Board, Local Authorities, Highways teams, Insurers and Sewer undertakers (Pitt, 2008 and Butler and Pidgeon, 2011).

The EA are a major stakeholder within FRM. They are not legally obligated to manage flood risk from main rivers but are empowered to do so, thus, they do not have a *duty* to undertake flood defence or prevention work but will do what they consider is reasonable (Lane *et al.,* 2011 and Johnson and Priest, 2008).

These agencies are responsible for co-operating, negotiating and decision-making regarding flood risk governance and the workings of FRM (Johnson and Priest, 2008 and Butler and Pidgeon, 2011). This network also adheres to the ideals of 'advanced liberalism', which is a "form of governance thus relying on complex distributions of responsibility as well as mechanisms for ensuring accountability" (Butler and Pidgeon, 2011: 534). Thaler and Levin-Keitel (2016), declare that multi-stakeholder engagement is effective at managing issues, leading to a more successful consensus surrounding political discussions and solutions to problems. Figure 7 is a simplified diagram, the different stakeholder's interactions and their responsibilities.

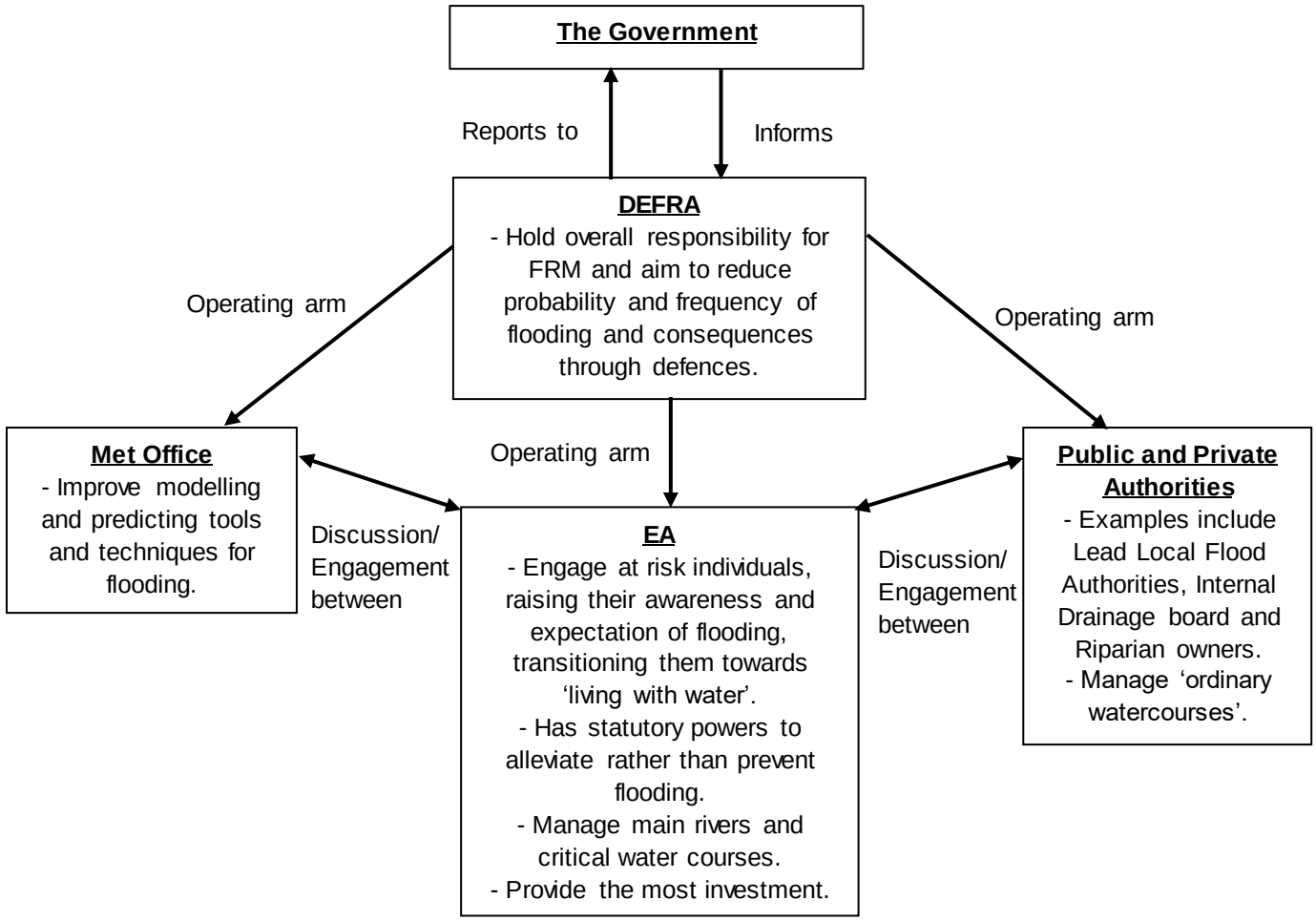

Figure 7: Simplified diagram of key FRM stakeholder's roles and responsibilities. (Information Sources: Pitt, 2008, Johnson and Priest, 2008, Lane *et al*., 2011 and Butler and Pidgeon, 2011).

There are issues however with this multi-stakeholder approach. Firstly, the overall shift in FRM may conflict with stakeholders' longstanding duties and engrained ideals. For example, transitioning an agency (EA) towards soft engineering and partnership building, when its history and organisational ideology was produced by engineers, is challenging (Nye *et al.,* 2011 and Krieger, 2013). The agency has, for a long time, relied on concrete pourers and dredging machines, so the new ideas aforementioned, are viewed as 'avant-garde' and thus members sometimes disregard these ideas and continue in the traditional way, which is problematic (Nye *et al.,* 2011 and Krieger, 2013).

Secondly, conflicts in ideologies exist between stakeholders, whilst fulfilling different roles and responsibilities. Insurers advocate for hard defences to safeguard their profits and regard soft defences as 'temporary' solutions that provide hard to quantify reductions in flood risk, by contrast, the EA promotes soft-engineering and behaviour change solutions (Ball *et al.,* 2013, Thaler and Levin-Keitel, 2016, Thaler and Priest, 2014 and Krieger, 2013). These conflicts are exacerbated between stakeholders, as their individual monetary contributions differ and the quantity of the contribution is linked to the balance of power in FRM selection (Thaler and Priest, 2014). FRM failures, including missed EA targets and ignored planning guidance, are potentially the result of these conflicts, which shows a lack of co-ordination and co-operation between the different agencies involved in UK FRM, as their roles and responsibilities are separate and lack cohesion (Butler and Pidgeon, 2011, Thaler and Levin-Keitel, 2016 and Krieger, 2013). These failures, often attributed to the EA, weaken the EA's position within FRM, which diverts increased power to 'local' institutions (Krieger, 2013). This diversion of power allows 'local' institutions to follow their own self-interests, rather than pursuing a holistic agenda (Krieger, 2013).

Thirdly, FRM still follows a top down, tiered approach, which restricts discussion and engagement of different stakeholders (Nye *et al.,* 2011). This is evident in the EA's practices. The EA engages initially with consultees and partners, then progresses to a more 'ad-hoc' approach where they liaise with other stakeholders (Nye *et al.,* 2011).

Public involvement only begins when decisions are at the appraisal stage, therefore, failing to effectively engage with the localism agenda, the complex nature of FRM decision making and with all stakeholders at every stage of the decision-making process (Nye *et al.,* 2011). This tiered approach is likely a product of the link between financial contribution and level of participation in FRM, with greater financial contribution related to increased participation and power in FRM. Therefore, with the national government still contributing 93% of the flood defence budget, their interests are considered paramount. Whereas, the limited contribution by citizens and other non-state stakeholders reduces their engagement in decision-making processes (Thaler and Priest, 2014).

Finally, public administrators often experience a lack of institutional support for organising and dealing with stakeholder engagement. This is caused by a lack of communication, information sharing and resources from other stakeholders, which is particularly problematic in the mass participation approach, advocated for UK FRM (Thaler and Levin-Keitel, 2016). Even if public administrators can overcome these issues and create good multi-stakeholder interaction, it can be very difficult to implement the recommendations of public participation, failing those involved (Thaler and Levin-Keitel, 2016).

The new localism and multi-stakeholder approach adopted in UK FRM therefore, has its benefits and limitations, but for FRM to be effective communication is required. This involves communication between stakeholders to ensure FRM decision making is effective, but also with the public, to ensure FRM strategies can be successfully implemented. As communication between stakeholders is important, Story Maps present a tool that could be utilised to start discussions between these members, enabling them to present their ideas clearly and concisely, whilst providing a space where ideas can be debated.

2.2.4: Communication and the UK's FRM strategy

To ensure the UK's FRM strategy is effective, communication is required. For example, the *Environment Agency's National Assessment of Flood Risk* (2009), emphasises the need to strengthen flood warnings, by improving accuracy, coverage and timeliness.

It additionally, encourages the communication of flood risk to businesses and households, using flood maps to show potential flood severity and locations at risk (Ping *et al.,* 2016). Moreover, the '*Making Space for Water*' report and the '*Pitt review*' included extensive discussion on the need to communicate flood risk to the public to raise awareness and knowledge of flood risk (DEFRA, 2004 and Pitt, 2008).

Flood hazard and risk communication helps people change how they think about FRM and aids peoples understanding of why adaptive approaches must be utilised over hard defence strategies. Adaptive approaches are adjustments to human or natural systems, in response to actual or expected climatic stimuli or their effects, which moderates harm or exploit benefits and are slowly being adopted worldwide, alongside mitigative actions (UNISDR, 2009a and Sayer *et al.,* 2013). These adaptive actions are traditionally associated with behaviour changes or non-structural solutions including; planning controls in flood risk areas, improved warning and evacuation planning and utilisation of the best forecasting technology (Sayers *et al.,* 2013). Within the UK, these non-structural approaches are being taken seriously, with the EA primarily responsible for developing and delivering communication on flood risk, which often involves advocation of adaptive approaches (Sciencewise, 2016).

Typically, flood risk communication has been conducted using technical and statistical language and complicated interpretations of flood risk, but Cotton *et al.* (2014) and others now suggest these present barriers to effective communication. To address some of these failings, the EA conducted a communication research project with other organisations e.g. The Met Office. The project, titled '*Flood Risk Communications: Public Dialogue Project*', ran from 2013-2015 and explored messages about flood risk and developed innovative methods and techniques to help people understand their flood risk (Sciencewise, 2016). This project was in response to the EA's increasing awareness that their flood risk maps required updating and their supplementary flood information was inadequate to help those 'at risk' (Sciencewise, 2016). It led to several recommendations, including:

1. Think about the needs of different audiences.
2. Don't assume a little bit of information will scare people – telling the truth about risk and impacts is more likely to lead to action.

3. Stop talking about probability and risk in mathematical language as it means very little to a lot of people.
4. Be very clear with people on what is happening before, during and after a flood, and what actions they should take.
5. If you are asking people to take individual action, tell them in the same communication what local/national organisations are doing too – this shows that we're all in this together.
6. Focus on making information local, with historical context.
7. Don't just focus on the negative impacts of flooding - focus on what people can do about it

   (Recommendation Source: Environment Agency, 2015:1).

Finally, although not specifically related to the project, the UK government has acknowledged that those at risk are a non-homogenous group and thus communication must be tailored to different groups and conducted through multiple channels (Cotton *et al.,* 2014). Similar recommendations are expressed in the literature, for example O'Sullivan *et al.* (2012) and are discussed in Section 2.5.

In 2014, the EA began to integrate many of these endorsements into their communication practices and had started producing mock-ups of flood risk maps (ScienceWise, 2015 and Environment Agency, 2015). They then continued their work on flood risk communication in 2015 by improving web access and information, revising flood risk maps, making simple documents to clarify roles and responsibilities and producing new communication documents based on feedback (ScienceWise, 2015 and Environment Agency, 2015). These ideals have been implemented in several online resources, including the EA's blog, Facebook, Twitter page and #FloodAware, alongside their Youtube channel, *Environment AgencyTV*. Additionally, paper resources including their '*Floods Destroy, Be Prepared'* campaign, focus around the impacts of flooding, rather than traditional technical and statistical approaches (Environment Agency, 2014).

It is however, too soon to understand whether the EA's changes have improved flood hazard and risk communication, due to the limited timespan following the implementation of recommendations. Ping *et al.* (2016:5), nevertheless, does

present limited support for improving UK flood hazard and risk communication, stating there has been an 'overall evolution of flood risk communication' over the last three decades, towards the ideals of the EA's '*Public Dialogue Project*'.

These communication changes are products of the UK's transition towards localism and a multi-stakeholder approach which defies conventional top down, deficit model communication approaches. These changes produce new challenges and opportunities for flood hazard and risk communication, alongside other persistent issues that plague this complicated practice. The following sections investigate flood hazard and risk communication literature, presenting the challenges associated with communication, before addressing further recommendations on this type of communication, of which some align with the UK's changing communication practices.

2.3: Science and flood hazard and risk communication

2.3.1: The deficit model and the complexity of creating *effective* communication

Communicating information is a complex process and this complexity is compounded when dealing with scientific topics. Traditionally, but still present, is the issue of how to communicate science to the public. Science communication often follows an expert to lay person knowledge transfer model, which lacks any knowledge sharing/co-production of knowledge between these groups. This model, created in the 1980's, is referred to as the 'deficit model' (Dickenson, 2005). This model has various parts including the assumption that communication is from 'smart' scientists and follows a linear, one-way process of knowledge transfer, without significant alteration, to the passive, ignorant and hostile public, where the knowledges of these two parties is distinctly separate (Bucchi, 2008 in Bucchi and Trech, 2008). The deficit model supported a technocratic attitude in which the ignorant public were unqualified to participate in decision making processes (Bauer, 2009).

The model also argued that the public are sceptical about science and technology, but this was due to their lack of scientific knowledge (Dickenson, 2005). Hence, it was important to fill people's 'knowledge deficit' so individuals better understood science and technology, viewing them as good practices (Dickenson, 2005). It also enveloped the idea that if individuals understood a

problem, they would take rational action e.g. accept and conduct behaviour changes or support policy decisions (Moser and Dilling, 2007 and Whitmarsh *et al.*, 2011).

The deficit model however has many issues, for instance, it relies on a one-way communication approach, based on the Shannon and Weaver (1949) encoder-decoder model of signal transmission, Figure 8 and involves three stages:

1) Sender encodes risk message.
2) Transmission of that signal over a channel to a receiver.
3) Receiver successfully decodes risk message from background noise.

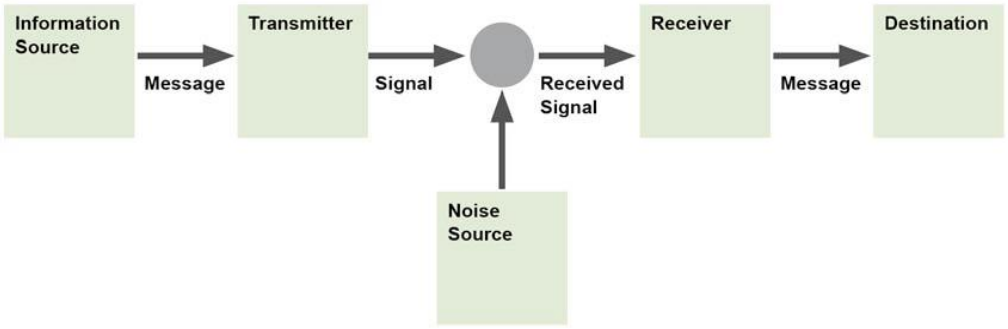

Figure 8: Encoder-Decoder model of signal transmission. (Source: Höppner *et al.,* 2010).

This model however, has many issues, which can cause transmission breakdowns and inadequate or incorrect decoding, which causes some of the deficit models failings. For example, when communicating flood risk, communicators use return periods (an estimate of the likelihood of an event occurring – 1 in 100 years) as an encoding system. When this information is decoded by the public however, there is evidence suggesting that this concept and other jargon causes widespread confusion (Bell and Tobin 2007 and Highfield *et al.,* 2013). This is particularly evident in Ludy and Kondolf's (2011) study, which investigated various flood risk concepts in the Sacramento-San Joaquin Delta, California. Their study revealed that only 34% of individuals surveyed were familiar with the 1 in 100-year concept and furthermore, only 2.6% defined the term correctly.

The deficit model also has many other failings. Especially problematic is the model's lack of appreciation for 'non-experts' even though these individuals have valuable information and conduct more informal science daily. This lack of appreciation for 'non-experts' is evident in the Wynne (1992) study, in which scientists ignored specialist sheep farmers' arguments and insights after the Chernobyl incident. This was due to scientists understanding that 'scientific insight' could only come from themselves. Moreover, with the rise of localism, these 'non-experts' want a voice within decision making processes that form part of their everyday lives (Brown, 2009).

Furthermore, the model's simplistic assumption that communicating information promotes proactive and rational action is flawed, as people base their actions and understandings on many factors other than scientific fact. These factors include; ethical, religious, cultural or historical beliefs and personal experience (Brown, 2009). This insight shows similarities to the competition between hazard and risk communication and risk perception factors (Table 1). Moreover, the presentation and framing of information can influence whether it will be accepted and understood, discussed further in Sections 2.4.2 and 2.6. Figure 9 presents the deficit model in simplistic form, alongside the new dialogue model, which includes multi-stakeholder interactions and is being implemented to address some of the deficit model's failings.

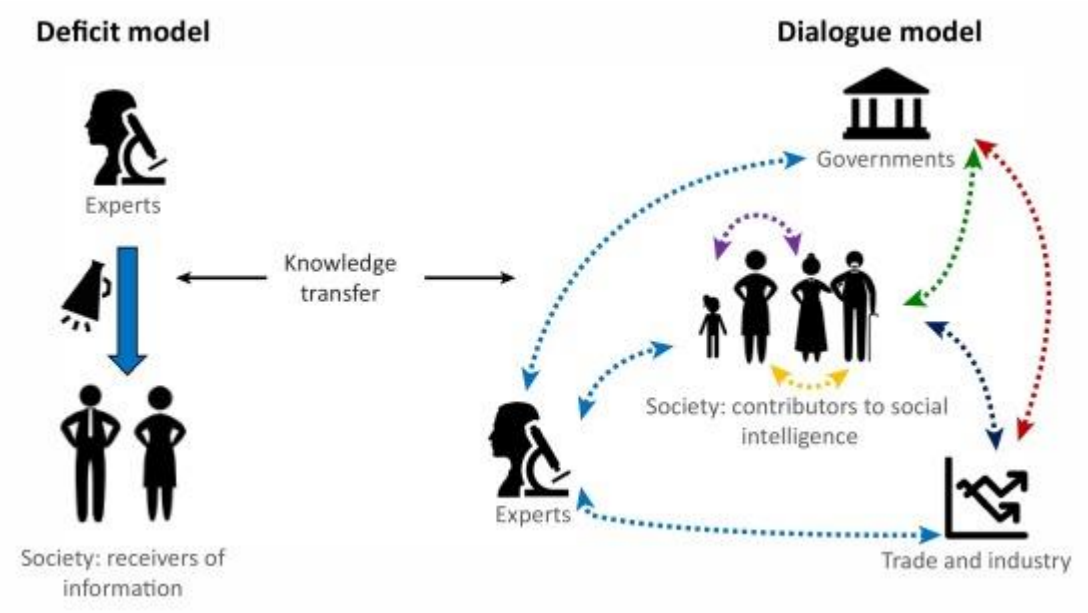

Figure 9: The deficit model and the new dialogue model. (Source: Courchamp *et al.*, 2017).

Flood hazard and risk communication is unfortunately plagued by 'deficit model thinking' as its failings were not understood, and thus traditional communication is littered with attempts to address individuals 'knowledge deficits', which is the case within the UK. Throughout much of the UK's FRM history, central Government has been responsible for communication. McEwan *et al.* (2016), suggest that the Government and its 'experts' therefore understood UK flood hazard and risk and relied on deficit model ideals whilst informing the public on FRM strategies alongside flood hazard and risk. Flood hazard and risk communication thus, has been an ineffective, one-way process, where the government has utilised technical and mathematical language, only fully understood by their experts, to communicate with the public to fill their knowledge gaps (Cotton *et al.,* 2014). Moreover, they have informed the public on what FRM to utilise and how to use it, leaving little room for discussion and two-way communication. This has caused past flood hazard and risk communication to fail, as outlined in Section 2.4.

Despite the deficit model's failings and the endorsement of a multi-stakeholder approach, in principle, in '*Making Space for Water*' (2004), the '*Pitt Review*' (2008) and finally the '*Public Dialogue Project'* (2014-15), there continues to be evidence that the deficit-model of communication has a "zombie-like longevity" (Irwin, 2009 in Holliman *et al.,* 2009:8). This is due to the absence of skills and tools necessary to develop more iterative forms of engagement (Irwin, 2009 in Holliman *et al.,* 2009). This sentiment is similarly reflected within scientific communication, with communicators accepting the need to reject deficit model ideal and change its governance structure, but continuing to resist and unintentionally promote these ideals (Stilgoe *et al.,* 2014). For example, people cannot keep up with the latest science to educate themselves as access to journals is hidden behind a pay wall, alongside publishing. Moreover, there is a lack of promotion of where to find scientific information, so unless scientific insights appear in the media, interaction with this information is limited. These practices, intentionally or not, justify science communication's top-down knowledge deficit ideals.

Nevertheless, examples exist of public engagement events that have opened up science communication, generating productive and interesting discussions about politics and the purposes of science, with the insights taken seriously

(Stilgoe *et al.,* 2014). Stirling (2008) suggests public engagement has grown from individual projects and programmes to wider fields including environmental planning, regulation and governance of 'technological risk', with the '*Public Dialogue Project'* extending this to natural risks. Science and technology are increasingly being seen as open to individual's creativity, collective ingenuity and stakeholder interactions, by enveloping this public engagement paradigm (Stirling, 2008). These engagement exercises however, are often consultation events, which only gather people who are already interested, or have an opinion, on the topic being discussed, resulting in many individuals ideas/preferences being missed (Irwin, 2006). There are also examples of 'two-way communication' events, which include engagement events, being utilised in entirely opposing ways to that which Stirling (2008) describes. These activities have been utilised to stop vital debates in contentious areas and as tools, to an extent, to reach a consensus by bending peoples will (Stilgoe *et al.,* 2014).

Public consultation, or 'two-way communication', is also perceived as a method to eliminate other opinions and change people's minds, winning them back from their scepticism of government and science (Irwin, 2006). This is present in policy debates, where governments justify their choices on unfathomable science (Stirling, 2008). In these debates, any scepticism provided by defendants about specific technologies is viewed as anti-technology and is ignored as 'misguided' or 'incorrect' sentiments (Stirling, 2008). Irwin (2006), presents an example from the genetically modified organisms debate. In this study, ten myths about public responses to genetically modified organisms, likely collected during these 'participation' approaches, were all contradicted by focus group participants. These subversions of the two-way communication approach seem to cling onto deficit model ideals and not those surrounding new communication theories.

Moreover, dialogue and two-way communication attempts are typically conducted only in an experimental sense, to understand if these approaches work. These trials are dwarfed by the continuous churning of science production and governance that does not adhere to new communication ideals (Stilgoe *et al.*, 2014).

Regardless of all these challenges with implementing new two-way or multi-stakeholder approaches to science and communication, this method is beginning to be utilised. These new approaches should be interactive, promote long term discussions and open dialogue about where, how and what information should be communicated, with this being especially necessary within natural hazard communication, including flooding (Feldman *et al.,* 2015, Kellens *et al.,* 2013 and Irwin, 2009 in Holliman *et al.,* 2009). This form of communication, as stated, presents new issues and compounds the complexity of science communication. Following this idea, an analysis of three major issues present in science communication, particularly natural hazard and risk communication, are presented.

2.4: Failings of current communication methods

2.4.1: The problems with uncertainty

Uncertainty, in a natural hazard and risk context, can be understood as, "the possibility of more than one outcome resulting from a particular course of action, the form of each possible outcome being known but the chance or probability of one particular outcome being unknown" (Gregory *et al.,* 2008:779). It is a concept that requires understanding and effective communication to ensure that risk information is appropriately utilised to inform choices and evaluations of different mitigation options for flood risk reduction and their evaluation afterwards (IOM, 2013 and Hill *et al.,* 2013).

Uncertainty, however, is a persistent problem within science and is especially problematic when communicating natural hazard and risk information, such as flood risk. Flood hazard information is less adversely affected by uncertainty, than flood risk material, as the factors that influence flood events are reasonably well understood. Nevertheless, unaccounted factors or local differences exist, in terms of topography, rainfall and drainage, allowing for uncertainty. Flood risk information, including risk estimates however, suffer significantly from uncertainty, as the factors that interact to create risk are varied and create difficult to predict outcomes. These factors include social components such as age, level of education and class, alongside the uncertain impacts of climate change, with estimates and predictions getting harder the further into the future you try to project (Smith and McAlpine, 2014).

For example, precipitation affects flooding, it's risks and magnitude, but in the future, is likely to be influenced by climate change. The IPCC (2015), presents a complicated message for precipitation and flood risk initially. It suggests high magnitude one-day precipitation events, which can cause flooding, will increase in frequency, but other precipitation events are likely to decrease. When this is paired with the IPCC's uncertainty about whether these changes will occur and exactly where, the complexity is compounded. Uncertainty is such a pervasive issue in climate change that the IPCC has had to adopt language such as low, medium and high confidence, to address this issue.

Regardless of the difficulties in communicating uncertainty, it is required and is frequently conducted in flood hazard and risk communication. Uncertainty is communicated through risk estimates, presented in the form of probabilities e.g. 1% chance of flooding in any one year (1 in 100-year concept) (Morgan, 2009). Probabilities are, however, notoriously difficult to communicate to lay persons, thus it is important to consider the appropriate method to communicate probability, utilising either a numeric, verbal, or graphic approach (Spiegelhalter *et al.,* 2011).

To compound matters, uncertainty remained absent in the public domain until the 1990s. When it was finally discussed, public understanding of science changed dramatically, viewing the practice as complicated and uncertain, having detrimental impacts (Stilgoe and Wilsdon 2009 in Holliman *et al.,* 2009). For example, the Climate Gate email scandal (2009) is an instance where uncertainty in scientific discussions was leaked publicly, with damaging effects. In the event, leaked emails, data files and data processing programs, discussing the uncertainty inherent within climate change went public. It led to suggestions that climate change was not a human induced phenomenon and caused increased climate change scepticism. This events and others, has caused distrust and scepticism to spread, with uncertainty a persistent issue in current arguments such as; genetically modified crops, nuclear power, climate change, alongside flood hazard and risk (Stilgoe and Wilsdon 2009 in Holliman *et al.,* 2009). Moreover, uncertainty is now utilised by individuals to sow confusion, delay important action or even advocate for a lack of action in the face of threats such as climate change and flooding (Pidgeon and Fischoff,

2011). Thus, certainty in science has been undermined, creating issues when communicating scientific information.

To add further complexity, a disjuncture exists between scientific and public understanding of uncertainty. Scientists view uncertainty as a fundamental part of a system which can be expressed in a probability. The public however, view uncertainty as science being unclear with its predictions and scientists being ambivalent about their activities. To combat uncertainty being utilised as a weapon, communication should build trust and aim to bridge gaps in knowledge about uncertain between scientists and the public (Pappenberger and Beven, 2006).

Thus, communicating uncertainty is a complicated, but essential part of science, including natural hazard and risk communication. Uncertainty needs to be transparently assessed, honestly reported, and effectively communicated so all parties can scrutinise it and there can be uptake of effective risk reduction actions (Hill *et al.,* 2013). The relationship described by Hill *et al.* (2013), however is complicated by other factors. Even if uncertainty is better understood and scrutinised, other factors affect the uptake of effective risk reduction actions including; available resources, perceived control and trust in the agencies responsible for managing flood risk (Whitmarsh, 2008). There are also various socio-economic and psychological factors that also affect whether people will act, including, but not limited to; home 'ownership', age, income, perceived lack of responsibility for actions, fear and worry about flooding (Bubeck *et al.,* 2012).

The above-mentioned discussion presents the difficulties caused by uncertainty, but also emphasises that it requires communication. Currently, guidance is lacking on successful methodologies to communicate uncertainty, presenting opportunities for new solutions to be trialled, which could include Story Maps (Pappenberger and Beven, 2006).

2.4.2: Cognitive barriers to effective hazard and risk communication and promoting action

Psychology plays an important role in the understanding of flood hazard and risk, alongside how it is communicated, thus it seems relevant to address three psychological theories that affect how individuals understand information and

their issues. The three theories addressed are the Cognitive Dissonance Theory, the Construal Level Theory and Goal Setting Theory.

Cognitive Dissonance Theory, which is well supported, was developed by Festinger (1957) and suggests that if individuals feel psychologically uncomfortable they will be motivated to reduce the feeling of discomfort to restore mental balance, Figure 10. This theory links with the Selective Exposure Theory, in which people actively avoid situations and information that continues or increases their dissonance (Freedman and Sears, 1965). People will instead find information favourable to their current ideas to restore mental balance (Freedman and Sears, 1965).

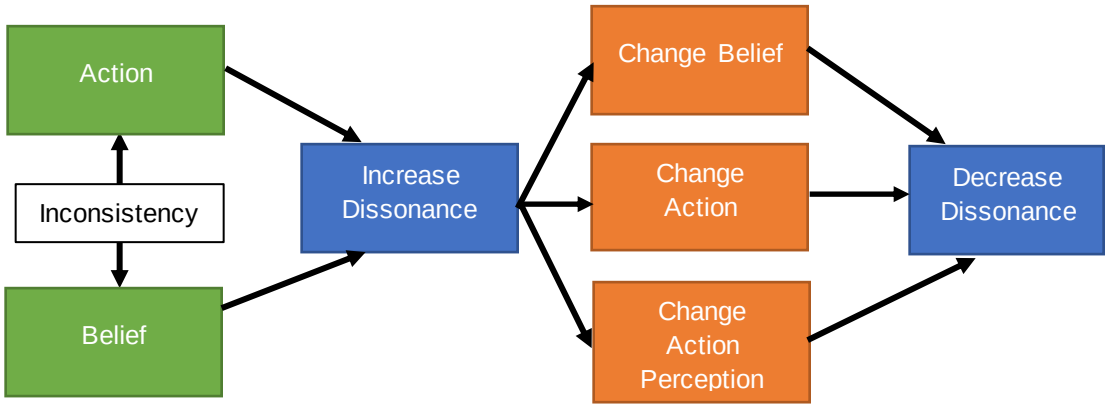

Figure 10: Festinger's model of cognitive dissonance.

There are criticisms of this theory, with suggestions that, although people seek out dissonance reducing information, they do not necessarily avoid dissonance increasing information (Freedman and Sears, 1965 and Brehm and Cohen, 1962). These theories of dissonance and selective exposure have been presented as reasons why attempts to use the media to change attitudes and opinions have failed (Case *et al.*, 2005).

Research has identified that representational barriers are utilised by individuals to ensure their existing assumptions about the world are maintained and to prevent hostile representations perturbing this understanding (Harries, 2008). Thus, when flood hazard and risk is communicated, it is potentially blocked by this barrier to maintain an individuals' mental balance, meaning individuals can believe flooding is not an issue and can continue their lives as normal (Harries, 2008).

Hence, it might be important to consider the type of information being communicated and attempt to co-produce flood hazard and risk communication to ensure individuals are engaged in the process. This approach means information production transitions from deficit model understandings and ensures individuals attend to flood hazard and risk communication and adopt any suggested FRM solutions.

Secondly, the Construal Level Theory (CLT) and the Goal Setting Theory (GST) present psychological considerations for flood hazard and risk communication. CLT, originally devised by Liberman and Trope (1998), specifies that individuals process information on different levels, depending on psychological distance, expressed in four dimensions. Figure 11 illustrates the theory.

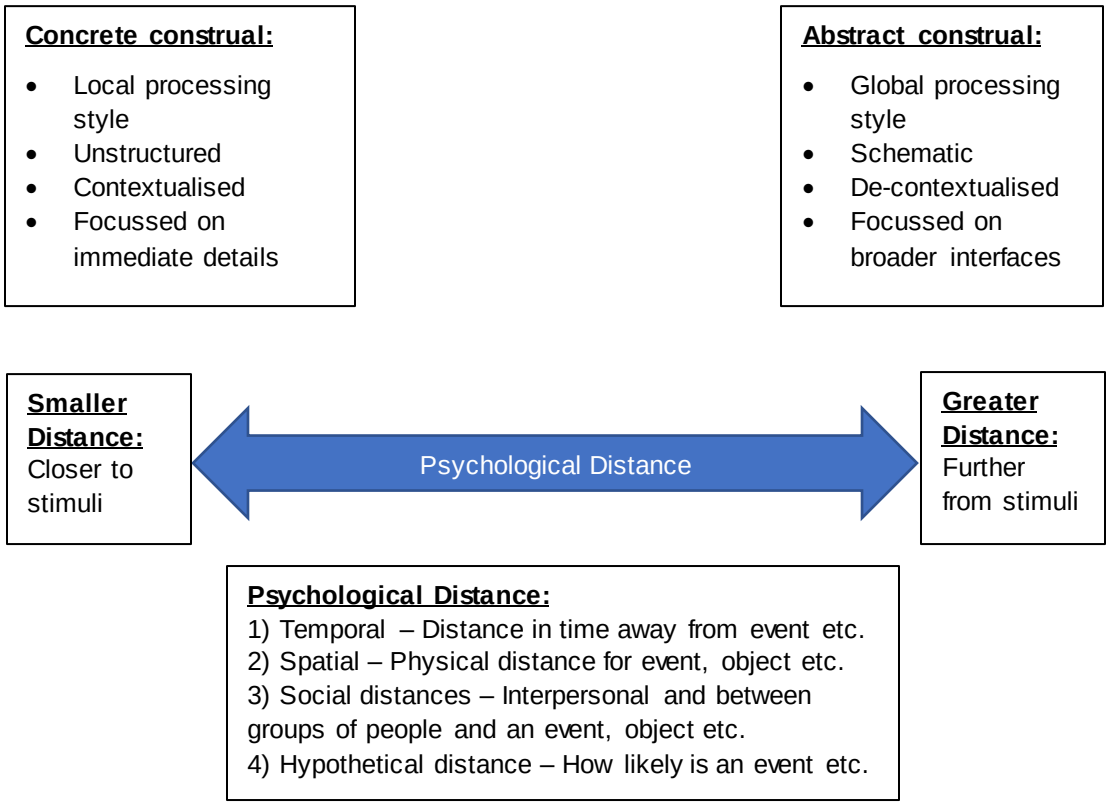

Figure 11: Schematic of the CLT. Psychological distance is an important concept in this model and plays a significant role in information processing. (Adapted from Kaufman and Flanagan, 2016).

A construal is our understanding of something in a particular way and CLT suggests there are two types of construal, these are concrete and abstract construals (Trope and Liberman, 2010). Liberman and Trope (2009) provide the example of a child playing basketball to explain the different construal levels. Concrete construals would be details such as the child's age, the ball's colour and the outside temperature. Whereas, abstract construals would simply be the child is 'having fun'. Abstract construals therefore, omit non-central features of something, in this instance what the child is doing, wearing etc. and a decision about the features central to something, that the child is having fun, is undertaken (Liberman and Trope, 2009).

Psychological distance affects how we construe something and is created through temporality, spatiality, hypotheticality and social distance (Trope and Liberman, 2010). Trope and Liberman (2010:1), state it "is a subjective experience that something is close or far away from the self, here and now". Essentially, concrete construals have a smaller psychological distance and as psychological distance increases our construals become more abstract and less well defined (Trope and Liberman, 2009 and 2010). For example, the effects of flooding on current generations would be very detailed and specific, whereas, the effects for future generations are more abstract i.e. there will be impacts somewhere (Trope and Liberman, 2009 and 2010). Psychological distance therefore, allows individuals to expand and contract their mental horizons and shapes how they construe something (Trope and Liberman, 2010).

In regard to action, Trope and Liberman (2010), argue that abstract construals and psychologically distant actions are more easily understood and likely to be acted upon. This is because activities processed as abstract construals only contain central, goal-related features, making them appear straightforward and easy to complete. Whereas, activities processed as concrete construals contain a multitude of peripheral and potentially goal-irrelevant information, thus making them seem complicated, discouraging people from completing them. This affect has been identified in research regarding the saliency of pros and cons of conducting an activity at different construal levels. For example, Trope and Liberman (2010) cite Eyal *et al.* (2004)'s experiment where participants were able to generate more pros and fewer cons with increasing temporal distance from an action.

Moreover, Trope and Liberman (2010), state that individuals seemed to have a better understanding of what they should do or should have done, if they remove themselves from the situation, by creating a large psychological distance.

Spence *et al.* (2012), bring this theory into a geographic context, stating that psychologically distancing climate change makes people feel there is still an opportunity to mitigate future effects and encourages them to adopt sustainable behaviours e.g. recycling. Potentially similarly effects might occur if flood hazard and risk information was framed in a comparable way. This is contested however, due to the significant impact of direct experience and proximity to a flood risk area on flood risk perception and action. Direct experience (small hypothetical distance/concrete construals) has been identified, in many studies, as influential in forming high risk perception and influences/ triggers those affected to adopt preventive actions (Plapp and Werner, 2006, Grothmann and Reusswig, 2006 and Siegrist and Gutscher, 2006). Furthermore, increased proximity to flood risk areas (smaller spatial distance) has been related to higher flood risk perception, with differences experienced even across the same area, with those in safer locations having lower risk perception than those in more unsafe areas (Brilly and Polic, 2005 and Ruin, 2007). This contrasts with CLT model understanding, thus creating a complicated picture of whether CLT, already applied to climate change communication, is effective in communicating flood hazard and risk.

GST presented by Locke and Latham (1990), critiques CLT and attempts to explain how psychological distance affects individuals' understanding of behaviours and actions i.e. FRM. It also criticises the CLT's understanding of how psychological distance affects individuals' ability to conduct behaviours and actions. The theory proposes that specifically detailed goals promote psychological closeness. A specifically detailed goal, for example, would be 'to be able to run a marathon, I will sign up to the event, bring my running kit to work and attend X gym to raise my running time by 5 minutes every week'. This specificity increases the likelihood of completing the activity, due to reduced ambiguity about what needs to be achieved (Locke and Latham, 2002 and Locke *et al.,* 1989). Whereas, ill-defined goals, e.g. to do ones best, are more

psychologically distant, abstract, lack guidance and an external referent, making them harder to attain (Locke and Latham, 2002 and Locke *et al.,* 1989).

Flooding and its impacts could be understood as psychologically distant phenomenon and thus the goals associated with conducting FRM might be similarly conceptualised e.g. I will buy flood gates before the next flood. This explanation provides a basis for why experience of flooding can actually lead to a rapid reduction in the psychological distance of flooding and its impacts (Kousky *et al.* 2010*,* in Michel-Kerjan and Slovic, 2010). Without the initial psychological distance existing, it would not be possible for the reduction of psychological distance through flooding experience. Experience of flooding also leads to increasing concern about an event happening again and the need to conduct mitigative or adaptative actions, which potentially leads to more specifically detailed goals that are likely to be undertaken (Kousky *et al.* 2010*,* in Michel-Kerjan and Slovic, 2010). Bubeck *et al.* (2012), found this affect across several reviewed papers, with flood experience promoting private mitigation behaviours, but states that this effect diminishes a few years after the flood event. This could potentially be as response to the increased temporal distance from the last flood event, increasing psychological distance and making thinking more abstract.

This is counter-criticised however in Burningham *et al.* (2008), with findings that suggest experience and knowledge of flooding does not necessarily prepare people for flooding of their own properties and many are either unconcerned or in denial about flood risk. Moreover, even if mitigation goals are construed in a more psychologically close way, there are other factors that affect an individual's decision to conduct protective actions, i.e. available resources, perceived control and trust in agencies responsible for FRM (Whitmarsh, 2008). GST is debated, as expressed, but if it is to be followed, flood hazard and risk needs to be communicated in a psychologically close way. It must present specific detail on which actions to take and how to complete them, to increase the likelihood that personal FRM will be conducted.

Although these theories seem to contradict each other, a combination of understandings from CLT and GST is suggested by Rabinovich *et al.* (2009) and Spence *et al.* (2012) to help promote useful climate change related activities.

Spence *et al.* (2012) suggest that risk communication should attempt to reduce psychological distance to help engage the public with climate change. At the same time, discussing very serious future impacts, that are thus psychological distant, could be useful to promote sustainable behaviours. This approach could be useful when communicating flood hazard and risk, as both topics suffer from similar problems in terms of psychological distance, leading to similar outcomes. One potentially useful tool to reduce psychological distance would be GIS software. GIS could reduce the spatial distance of flooding, as individuals can visualise where flooding is affecting their community and be able to see if their homes are within flood risk zones. There could however, cause denial as individuals refuse to accept their homes are in flood risk zones. It is thus essential to utilise this approach delicately, with discussions between communicators and those at risk, to mitigate against this impact.

To conclude, these theories help to provide psychological explanations for how flood hazard and risk information is understood, how it should be communicated and how it promotes action. Thus new tools and approaches should consider the psychological insights provided by these models.

2.4.3: The issue of trust in science communication

Trust, as aforementioned, plays a vital role in natural hazard and risk communication and many risk communication models. Longstaff and Yang (2008) found that a community's resilience, in the face of all crises (including natural hazards), is tied to the population having access to trusted information. The research suggested that if individuals have immediate access to information and trust the sender, they can act immediately without wasting time verifying it, with implications on the impacts of a crisis. Similarly, if trusted communication exists among emergency responders, including the media, a more immediate and effective reaction to crises occur (Longstaff and Yang, 2008). Paton (2007), explains further, stating that trust is particularly important in influencing the perception of other's motives, their competency and the perceived credibility of information they provide. Thus, it likely significant influences the acquiring and understanding of information and the motivation to take mitigative actions against natural hazards (Paton, 2007).

Inversely, distrust and low confidence in authorities providing information, often compounded by the media, can lead to a diminished response to flood risks and a lack of uptake of mitigation or adaptive solutions (O'Sullivan *et al.*, 2012). As trust is a crucial element within natural hazard and risk communication, and with science providing much of the information and communication about this topic, an investigation of the public's trust in scientists and experts seems appropriate.

There is currently an issue with the public's trust in scientists, which Ben Page effectively summarised when he stated, "blind faith in the men in white coats has gone and isn't coming back" (Page, 2004:31 cited in Holliman *et al.,* 2009). This 'trust gap' formulated during the 1990s for a variety of reasons. For example, the poor handling of communication about 'mad cow' disease and the measles, mumps and rubella vaccine caused public distress and reduced the public's confidence in science (Stilgoe and Wilsdon, 2009 in Holliman *et al.,* 2009). This 'trust gap' is also evident in how science struggles to continuously deliver trustworthy, accurate information. Fang *et al.* (2012), reviewed all 2,047 biomedical and life-science research papers indexed by PubMed as retracted on May 3, 2012 and identified that false statistics and scientific misconduct including fraud/suspected fraud was present in 67% of them as the reason for their retraction.

To compound matters, society is transitioning towards a 'post-truth' mentality, where facts are disregarded, lost, or overwhelmed by information that appeals to emotions and personal beliefs, exacerbating the issue of communicating research to the public (Gewin, 2017). This post-truth world flies directly in the face of science, which aims to produce more understandable, credible, relevant and accessible information to help inform decisions and is deeply unsettling for scientists leading to anger, confusion and angst (Lubchenco, 2017). To overcome this situation, Lubchenco (2017:3), states that science and scientist must better intertwine with society and move themselves from their "loft perches above society" and instead, serve society in a fashion that responds to society's needs and is embedded in everyday life. This complex issue of trust surrounding scientists creates a barrier to conducting flood hazard and risk communication effectively, which utilises information from these individuals and thus becomes embroiled in the same issues.

With scientists already struggling to maintain or gain the public's trust, the media's input can be unhelpful. It has sometimes presented the scientific process as uncertain, leading the public to believe that researchers are unsure about what they are doing, undermining faith in science (Hsueh, 2015). The media also highlights scientific misconduct, often stating that a single individual is at fault who is brought to justice (Franzen *et al.,* 2007). In covering these cases however, they create a misleading image of deviant behaviour in science, reducing trust (Franzen *et al.,* 2007). Furthermore, the media provides an effective way for scientific institutions, journals and researchers to communicate with the public, thus there can be a "craze for publicity" (Lawrence, 2003:259). This is because there is gratification for scientists if their work is presented in a leading journal and then reported in the media (Lawrence, 2003). For the media to report on science however, researchers sometimes need to create a 'buzz' around their research, so universities modify findings to achieve this, which are often identified by readers, leading people to distrust future information (Hsueh, 2015). Even with these potential drawbacks, the media is a valuable tool to deliver scientific information. It is used by many individuals daily and could be an important method to more effectively communicate information, including flood hazard and risk information. The media, although a valuable resource, still compounds the issue of trust in science communication.

This issue of trust in scientists and the media further undermining trust, presents issues for flood hazard and risk communication. This form of communication, requires information from scientists to be utilised, but if these individuals are regarded as untrustworthy, so too will their information and data. Flood hazard and risk communication thus becomes enveloped in the trust issue, with questions arising, such as, 'can flood hazard and risk communication be trusted, if scientists deliver it or it utilises information and data collected by scientists?'. This presents a significant problem for flood hazard and risk communication.

To address this 'trust gap', trust building projects are being attempted. For example, the *'Public Dialogues Project'* mentioned in Section 2.2.4, investigated how the public wanted flood risk discussed, which lead to a collaborative exercise and a trust building environment (Sciencewise, 2016).

Moreover, the WeSenseIt project, with case studies in Italy, UK and the Netherlands, is attempting to create an environment where authorities and citizens collaborate to share knowledge about flood risk and participation in planning, decision making and governance (WeSenseit, 2016). This promotes an environment of trust amongst members, some of which will be scientists providing information (WeSenseit, 2016). The project is in response to major drawbacks present in traditional approaches to observing earth's water cycle and an awareness that situations (flooding) and crisis management are conducted through official communication channels, leaving citizens out of the loop. (WeSenseit, 2016). These examples are part of continuous efforts to build trust between citizens and scientists, but the process is slow.

Story Maps thus present a new platform that could continue to help build trust between stakeholders. They present the opportunity for local people and stakeholders to collaborate on FRM decisions and create a space for debates and discussion. Using the resource in this way, helps create a dialogue and trust between agents.

2.5: Recommendations for flood hazard and risk communication

As highlighted earlier in Section 2.3.1, the 'deficit model' has been widely criticised and has instigated the transition towards a multi-stakeholder communication model, taking account of externalities affecting people's understanding of a topic (Brown, 2009). Furthermore, as referenced, UK FRM communication is progressing towards this multi-stakeholder approach, where multiple agents collaborate (Ping *et al.,* 2016). Ping *et al.* (2016) state that their respondents exhibited mixed views surrounding the current level of interaction between themselves and government authorities but indicated progress toward this multi-stakeholder communication model. This process is complex however and transitioning to this system has difficulties, as outlined.

Within this multi-stakeholder model, natural hazard and risk communication will inevitably become more complex (Renn, 2005 and Höppner *et al.,* 2012). It will require an exchange of knowledge and views to be conducted throughout the risk cycle, from prevention/preparation through to the recovery stage and must promote participation and co-production of knowledge (Renn, 2005 and Höppner *et al.,* 2012).

Debate continues however on how best to incorporate principles from the multi-stakeholder communication model within natural hazard and risk communication and thus no generic document specifically outlines legal requirements on the communication of natural hazard related risks, at least within Europe (Höppner *et al.,* 2010).

There are however attempts to make generic documents for those involved in natural hazard and risk communication. For example, the Geological and Nuclear Sciences Ltd (GNS) and Auckland Council Natural Hazard Risk communication toolbox, helps ensure all councils, stakeholders, politicians and communities in Auckland, New Zealand, deliver communication in a similar way (Auckland Council, 2014). This document includes brief and detailed explanations, alongside visual representations and case studies, where they exist, of language utilised within natural hazard and risk communication to ensure understandings of concepts are standardised (Auckland Council, 2014). Another example comes from UNISDR (2009b), which has produced a training handbook for media professionals involved in natural hazard and risk communication. This handbook presents definitions of key concepts in the field, work sheets and exercises to help these professionals produce excellent media resources and case study examples of effective media already produced (UNISDR, 2009b). A final example is a recent publication by Shaw *et al.* (2017), which presents 40 case studies on how multi-stakeholder and participatory approaches have been applied to disaster risk reduction. This document contains case studies from all levels (regional, subnational and national) and attempts to provide examples and guidance on how to utilise the new multi-stakeholder approach required in hazard and risk communication.

Although there are examples of generic documents on natural hazard and risk communication, the debate continues on how to conduct this form of communication, which is evident from the number of papers that provide guidance on this activity. Faulkner and Ball (2007), O'Sullivan *et al.* (2012), Bradford *et al.* (2012) and Höppner *et al.* (2012), all present varied recommendations for flood hazard and risk communication, with Parker *et al.* (2009), supplementing these, with more specific emphasis upon flood warnings.

This complexity surrounding the issue of effective communication recommendations arises from 'good' communication being dependent upon the standpoint from which communication is judged (Demeritt and Nobert, 2014). Table 2 presents recommendations from these various papers.

Table 2: List of recommendations based on various research papers.

Research Paper	Recommendations
Faulkner and Ball (2007)	1) To improve the language and efficacy of risk communication. 2) To ensure that the communication content is balanced more towards the benefits of learning to live with risk rather than the more threatening (risky) tone often implicit in risk communications. 3) To improve the joint (mutual) ownership of the embedded uncertainties of risk assessments in communication. 4) To embrace emerging technologies for real-time assessments of emerging risk. 5) To work to ensure that risk communication continues to grow as a reflexive process. 6) To improve trust, which includes enhancing social capital and creating overlapping social networks that include better communication. 7) To embrace what capacity there is in society to shift strategies towards these ideals, for example, to include topics and technologies in school curriculums that allow society to engage in detail with an improved public discourse about risk.
O'Sullivan *et al.* (2012)	***Core:*** 1) Develop and raise awareness of current flood information sources. 2) Develop understandable statements on flood risk. 3) Provide information on how to prepare for a flood. 4) Make responsibility of authorities clearer to the public. ***Supplementary:*** 5) Use multiple channels of communication for flood warnings and information. 6) Create lines of communication between authorities and the public.
Bradford *et al.* (2012)	1) As awareness is increased by previous flood experience, capturing knowledge from experienced flood victims can be used as a resource in flood risk communication. 2) Providing understandable statements on risk will lead to recognition that structural protection measures will be exceeded for events greater than the design capacity, thus, reducing the issue of residual risk.

	3) Preparedness information needs to be tailored to those who are at risk, but have no direct experience of floods or whose experience is based on events from some time in the past. 4) Including personal accounts from flood victims in ongoing communications can serve to highlight adverse impacts of floods, reinforcing the need to take alleviation measures. 5) Locally tailored information that identifies safe routes and appropriate actions in times of flood should be provided. 6) Providing specific information on easily implementable mitigation measures will increase confidence, especially in women, in personal ability to protect property. 7) As worry does not increase preparedness, communication strategies should not aim to evoke fear in vulnerable communities.
Parker *et al.* (2009)	1) Successful public education campaigns: (a) raise questions creating uncertainty; (b) offer fairly simple answers, and, (c) feature authorities to provide additional information and reinforce the message. Raising uncertainty can reinforce non-formal learning opportunities. 2) Individuals are not generally motivated to change their behaviour by being told by others what they should or should not do. They are however, more likely to change their behaviour, if they feel ownership for the behaviour change strategies and if they develop solutions themselves or with their peers with helpful information from specialists. 3) Individuals do not usually think in probabilities. Typically, the human thought process is binary (i.e. a flood will or will not happen) and elaborate efforts to provide probability estimates of flooding are unlikely to change this fundamental… 4) Ensuring that individuals and communities feel ownership of flood warning response and self-protection is very important. Publicly-provided flood protection is vitally important, but it is also associated with the message that the responsibility for protection can be delegated by the individual to the public authorities. It is therefore, crucially important to reinforce the message that flood risk management is a partnership… 5) Learning-by-doing, in which floodplain users are engaged in flood risk management activities, is likely to be a very useful means of non-formal learning which may increase people's responses to flood warnings. The paper contains further recommendation, but due to limited space, they are not presented here.
Höppner *et al.* (2012)	Due to this paper's quantity of recommendations and examples of good, readers are encouraged to refer to the paper.

There are, however, recommendations that appear to be ubiquitous within the literature:

Firstly, information must be clear and simple, not relying on purely technical or statistical terms and probabilities, thus avoiding misunderstandings arising from technical terms, such as the 1 in 100-year concept (Höppner *et al.*, 2012 and Ludy and Kundolf, 2014). Moreover, probabilities are insufficient to encourage individuals to act as further factors influence this decision such as: beliefs, recent experiences, preferences and political views (Parker *et al.,* 2009). Thus, Parker *et al.* (2009), suggest that the information provided should use questions that ensure individuals think and question their environment and encourage them to discuss these question with friends and family, thus partaking in non-formal learning. These questions should however have simple answers and authorities which will provide additional information and reinforce the message.

Secondly, populations at risk are non-homogenous, with varying social and demographic profiles, alongside various interests and stakes, thus utilising the same means to communicate universally, is inappropriate (O'Sullivan *et al.*, 2012). Parker *et al.* (2009), state therefore that potentially targeted communication for specific audiences is required to address this non-homogeneity. This could also be achieved by utilising several means of communication simultaneously to ensure all those at risk have appropriate means to collect information. Wachinger *et al.* (2013) support this, stating exposure to various media types is correlated to better recollection of hazard warnings. The use of varying media can be achieved through traditional means e.g. radio, television and newspapers, alongside recent innovations, including: the internet, social media or virtual reality (Kreibick *et al.,* 2009). Within this same study, survey results revealed that participants found it less important to receive pre-emptive communication about the issue of groundwater flooding through public involvement activities, roadshows and seminars. This contrasts however with the aforementioned ideals of a more participatory approach to flood hazard and risk communication, but this dichotomy cannot be explored further, as reasoning for this stance by participants is not provided. Höppner *et al.* (2012) also highlight the importance of using multiple tools to communicate information, as it offers an effective way to build long-term communication strategies.

By adopting a multiple tool approach, these strategies can include differing communication modes, which reinforce each other and have the versatility to accommodate the specific context of hazards, alongside changing communication needs, because of shifting positions within the hazard cycle (Höppner *et al.,* 2012). This approach also accommodates the differing needs of community members, facilitating stronger relationships and dialogue between and within those involved in FRM, alongside providing platforms to facilitate peer to peer sharing (Höppner *et al.,* 2012). An issue however, is that although information is communicated through multiple mediums, its penetration is low, thus it might be important to consider the timing of these methods to maximise their effectiveness (O'Sullivan *et al.*, 2012).

Thirdly, it is important to provide those at risk with easily implementable mitigation activities and advice on how to behave during a flood/hazard event, thus increasing confidence and self-efficacy (Bradford *et al.,* 2012 and Höppner *et al.,* 2012). Furthermore, to ensure these mitigation activities are conducted, individuals must understand why they are required, that FRM is a partnership between different agents and that self-help/self-protection measures are integral to this partnership (Parker *et al.,* 2009). Moreover, Bradford *et al.* (2012) state that if risk statements are made more understandable, individuals can better comprehend the limits of structural defences. Conceivably, this dispels the false sense of security associated with structural methods, which often acts as a barrier to the implementation of self-protection measures (Höppner *et al.,* 2012 and Harvatt *et al.,* 2011). Finally, if risk communication outlines the roles and responsibilities of different agents, clearer boundaries of responsibilities are created between agents, enabling individuals to understand their need to conduct self-help and self-protection (O'Sullivan *et al.*, 2012). Thus, successful communication, must empower individuals to act and raise awareness of current information sources on FRM, rather than forcing them to act without them understanding why (O'Sullivan *et al.*, 2012).

Fourthly, participation in the communication process is important. Parker *et al.* (2009) state that individuals generally do not change their behaviour when being ordered to, as they feel the actions are not their own. They are more likely to, if they are engaged with and assisted in creating their own solutions, with specialist information.

Similarly, for many years, Burningham *et al.* (2008), state that enhanced FRM, has employed a local flood risk perspective and involved people in developing and delivering local strategies using creative, informal systems and social networks. The River Thames Scheme presents an FRM strategy that follows this stance. It has involved the public through drop-in discussion groups and workshops, or through email correspondence, which has ensured the scheme adhered to local ideas and enveloped local strategies (Environment Agency, 2016). Furthermore, community resilience advisors have been created to work with residents and community groups involved with the scheme, to prepare them for flooding. Höppner *et al.* (2012) also support a participatory approach, identifying consistent evidence that two-way risk communication has positive effects on an individual's ability to establish and maintain trustful relationships. It also supports development of communication skills vital for networking and co-operation amongst individuals and organisations (Höppner *et al.,* 2012). This participatory process, promotes knowledge exchange between public and authorities, assists two other recommendations. It improves trust in authorities and experts, meaning when important information is provided, it is taken seriously and acted upon (Wachinger *et al.,* 2013). Also, it helps shift individual's attitudes towards personal agency and self-protection, promoting action (Wachinger *et al.,* 2013). These points have been discussed in Section 2.2.4.

Finally, trust is essential for communication and was assessed earlier. Faulkner and Ball (2007) suggest improved trust in risk communication is required and communication should enhance social capital, whilst creating overlapping social networks for greater interconnected communication between stakeholders. Parker *et al.* (2009), supports this, transparency in decision-making and communication of decision-making shortcomings should be communicated to build trust and people should trust the flood warning process. Furthermore, trustworthiness of flood risk communicators and an individual's trust in authorities is important, with these playing a significant role in promoting understandings of flood hazard and risk, how to reduce flood risk and the adoption of risk reduction measures (Paton, 2008, Heitz *et al.,* 2009 and Wachinger *et al.,* 2013).

These are just a handful of the vast array of risk communication recommendations, but each hazard, community and situation will likely require a different approach to communication. Thus, an awareness of this myriad of recommendations is valuable to begin the process of creating effective risk communication. It also presents the need to continuously trial new communication methods, such as Story Maps, to deal with varying situations, which require differing communication methods.

2.6: Is there a pedagogical issue in natural hazard and risk communication?

It is clear, from the previous sections, that natural hazard and risk communication is complex and suffers from an array of issues including: uncertainty, psychological barriers, a lack trust in hazard and risk communication and a lack of fundamental recommendations for its practice. Thus, novel and innovative solutions that attempt to resolve this complexity are valuable. Story Maps present such an opportunity, as a new and innovative way to present and communicate flood hazard and risk information.

Some of the complexity however, could also be potentially resolved through utilisation of insights from pedagogical literature. Before this is approached, it is important to consider the current pedagogical system utilised for natural hazard and risk communication. It could be argued that this communication type is potentially pedagogical biased towards uni-sensory methods, which are not appropriate for all learners. For example, in the UK, flood risk communication conducted through the EA, utilises one sense extensively, this being the visual sense, with learning completed either through reading or viewing information. This is evident in the EA's flood risk maps on their website[2], which rely intensively on viewing information and interpreting it. Another example is the EA's *'Floods Destroy, Be Prepared'* campaign, which relies on extensive written text, which relies on visual learning. This reliance on uni-sensory methods is potentially a product of the educational bias towards linguistic modes of instruction and assessment and to a lesser extent toward logical-mathematical modalities (Lunenburg and Lunenburg, 2014).

[2]Environment Agency Flood Risk Maps can be located at: https://flood-warning-information.service.gov.uk/long-term-flood-risk/map

The presents an issue though, as not all learners possess equally strong linguistic intelligence and thus struggle to understand information presented in this style (Lunenburg and Lunenburg, 2014). A transition therefore has begun, towards understanding that information should be presented in forms that are inclusive of all learning styles and learners. This transition could be important for natural hazard and risk communication.

This transition has resulted in multisensory teaching/learning, which has scientific endorsement. It is important to recognise that the human brain is programmed to operate in a multisensory environment, where our senses combine information to create an overall understanding of something. Evidence for theory is broad including; neuroanatomical, electrophysiological and neuroimaging studies that have demonstrated multi-sensory interactions occur throughout information processing, with many brain regions indicating interaction between the senses, providing different and complimentary information (Alias *et al.,* 2010 and Driver and Noesselt, 2008).

Multi-sensory teaching therefore uses different methods simultaneously. This means learners activate more brain regions, neural pathways and processing centres, which leads to multiple encoding and associated benefits (Shams and Seitz, 2008 and Seitz *et al.,* 2006). Alternatively, activation of multiple senses causes uni-sensory brain regions to work more effectively, having similar associated benefits (Shams and Seitz, 2008). Figure 12 explains how multisensory teaching methods facilitate multiple encoding.

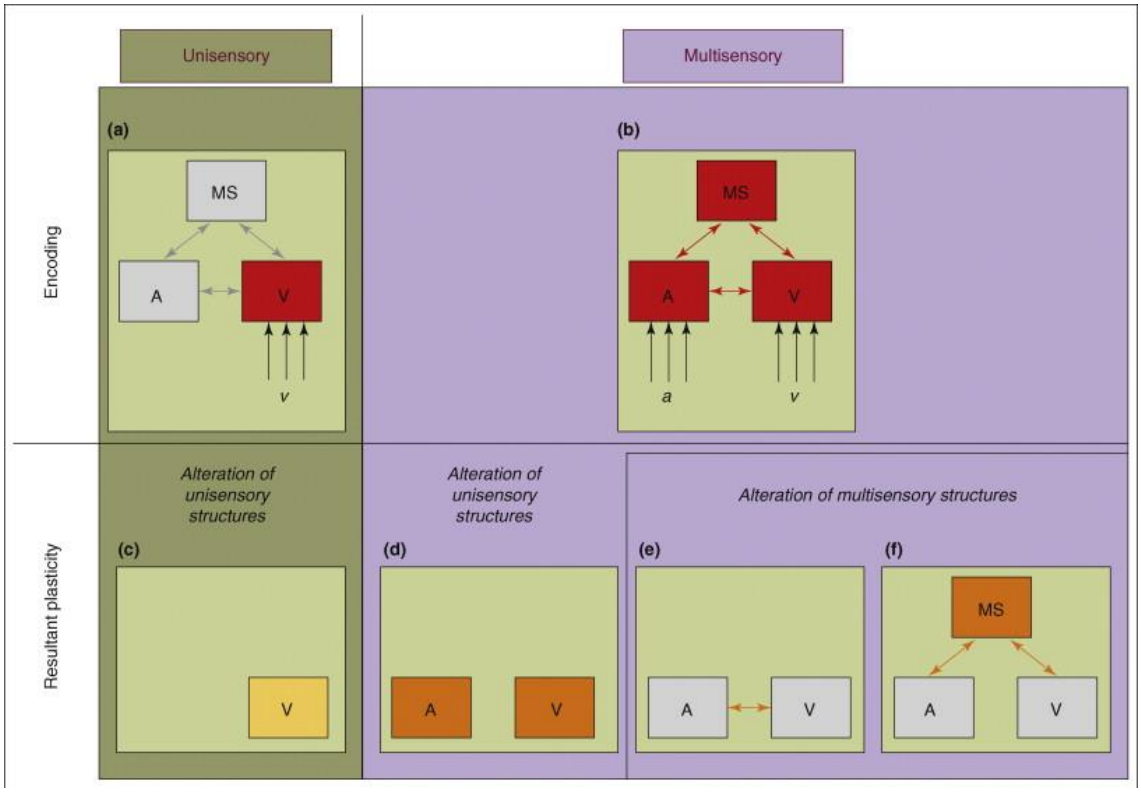

Figure 12: Schematic of multisensory vs unisensory learning processes. A) During encoding in unisensory teaching methods, only visual inputs are present and therefore only visual structures are activated (red box). B) Multisensory teaching methods provide visual and auditory inputs, thus a greater set of processing structures are activated, with the number of processing structures increased if kinaesthetic inputs are utilised. C,D,E and F offer different alterations that can result from learning and how learning information can activate or allow interaction between brain regions. D) Multisensory teaching methods can allow unisensory brain regions to work harder or multiple brain region interaction illustrated in E) and F). A, V and MS represent auditory, visual and multisensory brain regions. Brain regions and connections that undergo learning are shown in light orange. Orange and bright orange representing low to high degrees of plasticity respectively. (Source: Shams and Seitz, 2008).

The multi-sensory approach has various benefits including:

1) Faster learning time to master skills (Seitz *et al.,* 2006 and Shams and Seitz, 2008). This is consistent with multiple studies, including, Kim *et al.* (2008), in which superior learning was achieved in a visual task when subjects were trained with congruent audio-visual stimuli than when only presented with visual stimuli.

2) Activation of multiple brain regions helps individual's build strong neural networks, making information accessible, usable and transferable (Sprenger, 2008). An example is auditory-visual synaesthesia, providing superior memory capacity, through utilisation of sound to activate visual memory (Seitz *et al.,* 2006). Moreover, Thelen *et al.* (2014), suggests objects encountered in multi-sensory environments are more robustly remembered than those in exclusively visual or auditory contexts.

3) Improved accuracy of understanding, likely facilitated by a more thorough bank of information about an object or concept (Newell *et al.,* 2001 and Sumby and Pollack, 1954).

4) Greater precision when understanding stimuli when multi-sensory interaction occurs (Alias and Burr, 2004).

5) Aforementioned, multisensory teaching facilitates multi-sensory learning, meaning inclusion of all learners regardless of learning style (Lunenburg and Lunenburg, 2014).

Thus, a multi-sensory approach has various benefits, that could help with hazard and risk communication. Moreover, if all individuals' learning preferences were accounted for, its conduct would be more varied. This can be achieved with Story Maps, discussed later.

2.7: Final remarks from Literature Review – Part 1

The multitude of issues present within natural hazard and risk communication emphasises its complexity. Thus, it is valuable to consider solutions available to resolve these issues. The next section manoeuvres the discussion onto new opportunities to communicate flood hazard and risk. It investigates how GIS, especially Story Maps, present a potentially useful tool for flood hazard and risk communication and their strengths and limitations, expressed in the literature.

3.0: Literature review - Part 2

3.1: New ideas on communicating natural hazard and risk

Various new methods to communicate natural hazard and risk have been developed, over the last ten years. For example, the 'flood box' is a telephone box, redesigned during the Flood Scan project, into a touring exhibition including audio points with features about local flood hazards and preparation advice (Hagemeier-Klose and Wagner, 2009). Another example includes the gamification of knowledge, with the Stop Disasters game by UN/ISDR educating individuals on disaster protection measures, including flooding measures, but also the difficulties faced by decision makers (UN/ISDR, 2016). Figure 13 and 14 display these two innovative ideas.

This review however, focusses upon the internet and GIS technologies as new communication tools that are being utilised to visualise flood hazard and risk and to warn/inform the public, which is supported by Hagemeier-Klose and Wagner (2009) and Charrière *et al.* (2012). Advances in computing and internet capabilities have provided new GIS tools and programs that have been applied to flood hazard and risk communication. Pender and Neélz (2007), state that; recent developments in GIS, accessibility to accurate digital terrain models and improved graphic computer interfaces have made outputs from computer models on flood inundation more easily accessible to stakeholders and are now regularly utilised. Moreover, Tran *et al.* (2009:167), state that "new technology and capacities derived from GIS and remote sensing must quickly become an essential element in community-based disaster management projects".

This section investigates GIS, ArcGIS and Geo-apps, before critically evaluating the potential of ArcGIS Story Maps as communication tools for flood hazard and risk.

Figure 13: The ‘Flood Box’ touring exhibition. (Source: FloodScan, 2009).

Figure 14: Stop Disasters game. This screenshot displays the floods game. There are also games for wildfires, earthquakes, tsunamis and hurricanes. (Source: UN/ISDR, 2016).

3.2: What is GIS and how does it work?

GIS is a complicated term, with a multitude of definitions. For this dissertation, GIS is defined as a three-component system comprising of: 1) a computer system, 2) that uses spatially referenced or geographical data and 3) which can conduct various management and analysis tasks (Heywood *et al.,* 2011). It has experienced growing popularity since its creation and is now utilised daily to; inform people, locate services, alert in case of emergencies, support decision making and to communicate (Marta and Osso, 2015). Examples of its use include: planning placement of nuclear waste sites, land use planning in areas of natural beauty, mapping the impacts of disasters and co-ordinating relief efforts (Heywood *et al.,* 2011 and Esri, 2016a).

Furthermore, with free downloadable GIS desktop programs e.g. GRASS GIS, QGIS and online versions, including Esri's Online ArcGIS, the number of GIS users is expanding. Online GIS is however reported to be easier and more accessible than conventional desktop GIS, requiring less time and commitment to master (Strachen, 2014). Online GIS, like desktop GIS, is particularly beneficial for communicators of natural hazard and risk, as geographic concepts can be easily represented. It however, presents easier opportunities to disseminate this information to the public, through the internet.

3.3: Story Maps, web-apps and geo-apps

The development of online GIS has led Esri to create geo-apps/web-apps, which can fulfil various purposes including: comparison analysis, crowdsource polling, and impact summaries. Esri's online ArcGIS system has an assortment of web-apps, which are defined as applications combining ArcGIS output within an online framework, allowing for HTML/Javascript to be utilised along with a variety of customised or pre-created widgets and templates (Esri, 2016b). These apps can fulfil a range of purposes, including data collection, analysis and presentation. These apps have some usage within hazard and risk, with examples at: http://www.Esri.com/services/disaster-response.

Examples of this type of approach, mostly utilised by American communicators include; monitoring wildfires through online mapping, tracking and monitoring exposure to tropical cyclones and up-to-date maps with current and forecasted precipitation, stream gauges and flood warning information alongside

geotagged Flickr pictures and Youtube clips (National Weather Service, 2016, Wildlandfire.com, 2016 and MarineCadastre.gov, 2013).

Story Maps, as explained in Section 1.4, are one of these web-apps, often referred to as geo-apps and have begun to be utilised by American organisations to present natural hazard and risk information. For example, key institutions such as the National Oceanic and Atmosphere Administration (NOAA), Direct Relief and the U.S. Fish and Wildlife Service have utilised this software.

NOAA have utilised Story Maps to detail the evolution of the 2010-2015 Texas Drought. It presents a detailed written account of the drought events and pairs this with informative maps, videos and images about the spread of drought, linking it to geographic concepts such as El Niño and La Niña. They have also utilised it to help present research about Californian flash flood event modelling, attempting to simplify and improve public engagement with research. Direct Relief, a health and disaster relief non-profit charity, employed Story Maps to investigate Hurricane Matthew, September 2016, and those at risk. The Story Map focussed specifically on four vulnerability factors, which were mobility, poverty, health and language. They explain these factors and their impacts using maps to explain where these factors were present and particularly problematic within the storm path of Hurricane Matthew. Finally, the U.S. Fish and Wildlife Service utilised Story Maps to present where their projects are located and what they hope to achieve, as they create a more resilient Atlantic Coast, after the effects of Hurricane Sandy.

There is however no research on the effectiveness of these resources at assisting with communication of hazard and risk information. Strachen (2014) nonetheless states that Story Maps are potentially effective at communicating information, as they utilise a storytelling framework, which has been a highly effective communication method for centuries. This storytelling method could be helpful when communicating about natural hazard and risk. Furthermore, they simultaneously combine multiple different media elements, supporting a multi-sensory approach, as discussed in Section 2.6, which could also make them useful communication resources.

Natural hazard and risk Story Maps are decidedly lacking within not only UK hazard and risk communication, but within communication worldwide and thus, this research partly aims to raise awareness of them and address their potential as natural hazard and risk communication tools. The following sections detail some potential benefits and limitations of utilising Story Maps for communication, before concluding the literature review.

3.3.1: Location centred information and decreasing psychological distance

Story Maps' utilisation of maps could be vital to decreasing the psychological distance of flooding, which is very important, as outlined in Section 2.4.2, although this is debated. Story Maps allow users to investigate interactions and changes occurring in various spatial locations including their homes, local community, or country (Kerski, 2013). Story Maps could be exploited in flood hazard and risk communication to ensure individuals can see their homes and identify their own level of flood risk. This should decrease the spatial psychological distance of flooding and cause more concrete understandings of flooding and its risks in their local area. This, in turn, should encourage individuals to mitigate or adapt to their flood risk, following GST.

Support for this approach mostly originates from climate change research and is relatively unexplored in natural hazard and risk communication. Spence and Pidgeon (2010), found that framing climate change mitigation locally made participants more positive in their attitudes and this encourages them to adopt mitigation solutions. Similarly, O'Neill and Nicholson-Cole (2009), identified that clearly defining the local impacts of climate change and using action images e.g. individuals conducting adaptation and mitigation efforts, made climate change locally relevant and empowered people to adopt behaviours to assist in halting climate change. Furthermore, Brügger (2013), revealed when climate risks were localised, support grew for individual behaviour intentions within the public of the UK and Switzerland. Moreover, it is possible that when issues and effects are made more spatially close, individuals are more likely to support mitigation (McDonald *et al.,* 2015). This is not only for self-serving reasons, but because the impacts also appear psychological closer on other dimensions, such as the hypothetical and temporal (McDonald *et al.,* 2015).

The situation therefore it not helped when public communication often presents impersonal, future global impacts e.g. future sea level rise, making climate change temporally and spatially psychologically distant (Linden *et al.,* 2015). Linden *et al.* (2015), state that policy makers should emphasise climate change as a present, local risk (specific localities and communities) and should highlight the tangible gains of immediate action and appeal to long-term motivators. This is supported Scannell and Gifford (2013), who suggested that information framed locally, improved individuals' receptiveness to the information and thus, personal relevance of information should be a guideline for effective climate change communication. Using these insights from climate change communication, it seems appropriate to utilise GIS to decrease the psychological distance of flooding, which should create the aforementioned effects and improve communication practices.

Brügger *et al.* (2015), however critiques localising information, stating that individuals relate to a place on various spatial scales and this affects concern about a subject. For example, an individual who is predominantly concerned with the local scale, should be presented information on the local consequences of flooding as this would decrease the psychological distance of flooding for them. Whereas, another individual may be more concerned about global consequences and thus, locally framing the consequences of flooding would not decrease the psychological distance of flood for them or increase their likelihood to conduct mitigative actions (Brügger *et al.,* 2015).

Moreover, psychologists suggest that bringing an issue psychologically closer can trigger defensive mechanisms, which helps individuals reduce their negative feelings, but does nothing to help individuals reduce the threat itself (Brügger *et al.,*2015). Furthermore, if there is an over-emphasis on fearful representations presented about a locality and its risks, it is likely to distance and disempower individuals, as it causes a strong emotional reaction, leading to helplessness or becoming overwhelmed (O'Neill and Nicholson-Cole, 2009).

Additionally, if psychological distance is decreased, the salience of a hazards impacts increases, alongside clarity of other factors such as cost and inconvenience of mitigative and adaptive actions, which decreases the likelihood of people taking these steps (Fujita *et al.* 2014 in Van Trijp, 2014).

These findings are reflected by Shwom *et al.* (2008), which found that information presented either at a national or regional level about the predicted impacts of climate change had no influence on climate change support. To connect these finding to flood hazard and risk communication the following example is provided. If flood risks are expressed in a local manner, impacts gain greater clarity, but so does the clarity of mitigative and adaptive actions e.g. cost of flood gates or flood barriers and this discourages individuals from taking these steps.

Finally, McDonald *et al.* (2015) highlights that the science around psychological distance and climate change is incomplete, with little research examining how people perceive the psychological distance of climate change. Moreover, they state no studies systematically examine the effects of psychological distance across different mitigation and adaptation actions or examine the effect of psychological distance across all its dimensions.

The helpfulness of localising information is thus a debated field, as expressed. Localisation of information could be addressed by using GIS to decrease the spatial distance of flood hazard and risk and this could be achieved within a Story Map. Its impact however remains absent within much of the literature surrounding natural hazard and risk communication and needs to be further addressed to understand its importance in creating effective communication.

3.3.2: Design capabilities of Story Maps

When creating a hazard and risk communication tool, design is important and the variety of options within Story Maps help produce an effectively designed product. An important design element is the map interface, which contains a collection of important information for natural hazard and risk communication. Within flood hazard and risk communication, research suggests that the layout and level of detail of flood risk maps influences the transfer of information (Fuchs *et al.,* 2009 and Spachinger *et al.,* 2008).

Flood risk maps are a visual component of a Story Map and therefore, need easily understandable content, a self-explanatory and easy-to-understand interface, and links to further information, provided by the creator (Hagemeier-Klose and Wagner, 2009). Furthermore, the map's background must be brightly coloured to increase the contrast with informative elements, helping prevent information overload and assists with guiding individuals' attention[3] (Fuchs *et al.,* 2009). Moreover, insights from flood risk mapping suggest maps require; a sufficiently large visible legend, to the right of the map, that is easily accessible, has a conservative amount of information, is comprised from one colour range and arranged in decreasing values (Fuchs *et al.,* 2009). Finally, the legend needs to be visible, accessible and easily recognisable, with colour and written text drawing individual's attention (Fuchs *et al.,* 2009). This all culminates into a conceptual map, displayed in Figure 15.

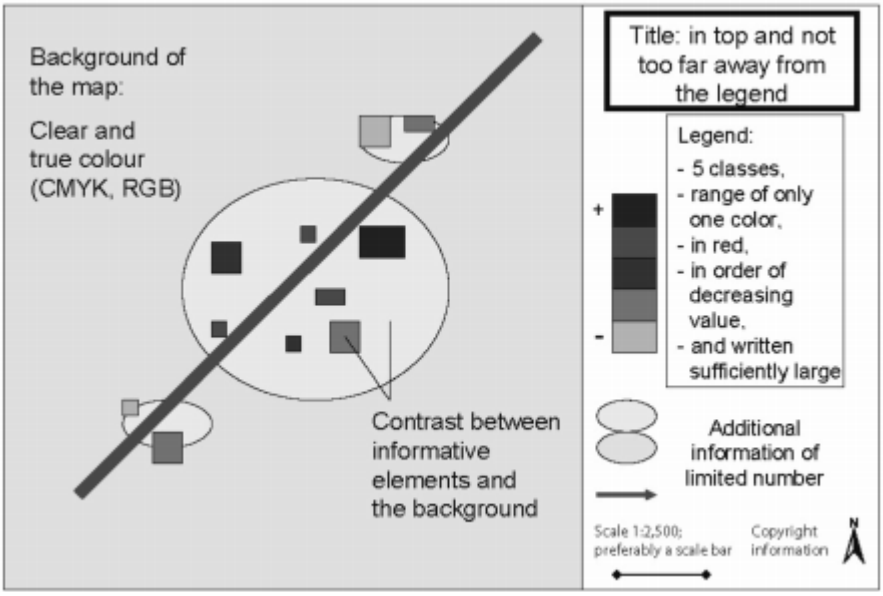

Figure 15: Conceptual flood risk map with all the elements above represented. The diagram provides a representation on how to design a flood risk map for maximum effectiveness. (Source: Fuchs *et al.,* 2009).

All the aforementioned suggestions can be applied by using Story Map tools. They also go further than traditional flood risk maps, as the online maps, within Story Maps, can have pop-ups embedded within them with extra information. Furthermore, there are an assortment of colour schemes and layouts to utilise

[3] This analysis of design will be focussing on visuality, as Story Maps have many visual elements. Specific design requirements therefore, for people with visual or auditory impairments, are not discussed here.

and extra features such as widgets, videos, images, and web links that help produce a professional flood risk map and overall communication product, which potentially helps individuals engage with information. Other opportunities to experiment with design can be attempted, due to the variety of Story Map templates available.

Examples include ‘Story Map Tour’ where discussion follows a set path as you move through an environment, Figure 16 (Esri, 2016c).

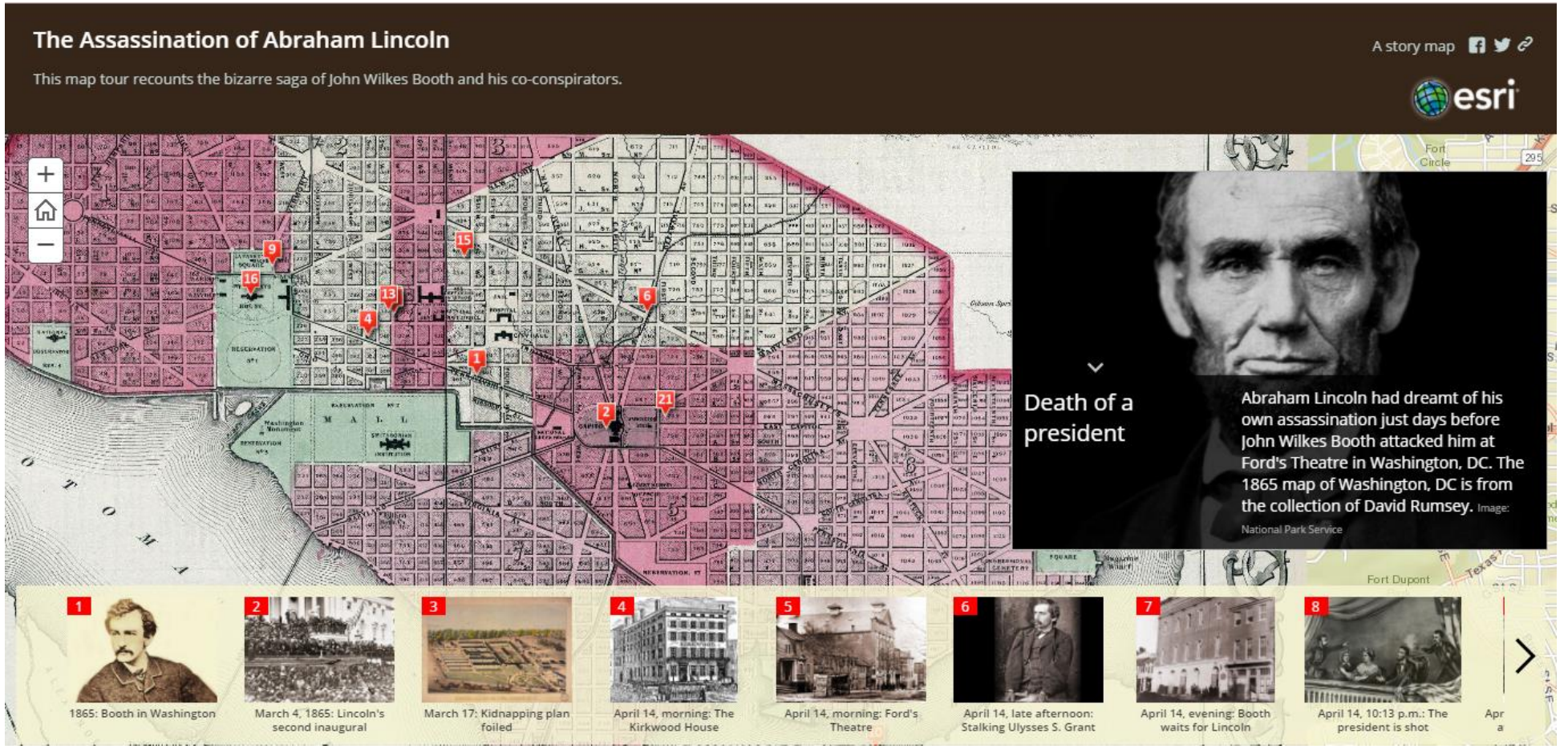

Figure 16: Story Map Tour Example discussing the assassination of Abraham Lincoln. (Source: Esri, 2017d).

‘Story Map Swipe’ where an area can be compared before and after an event, Figure 17 (Esri, 2016c).

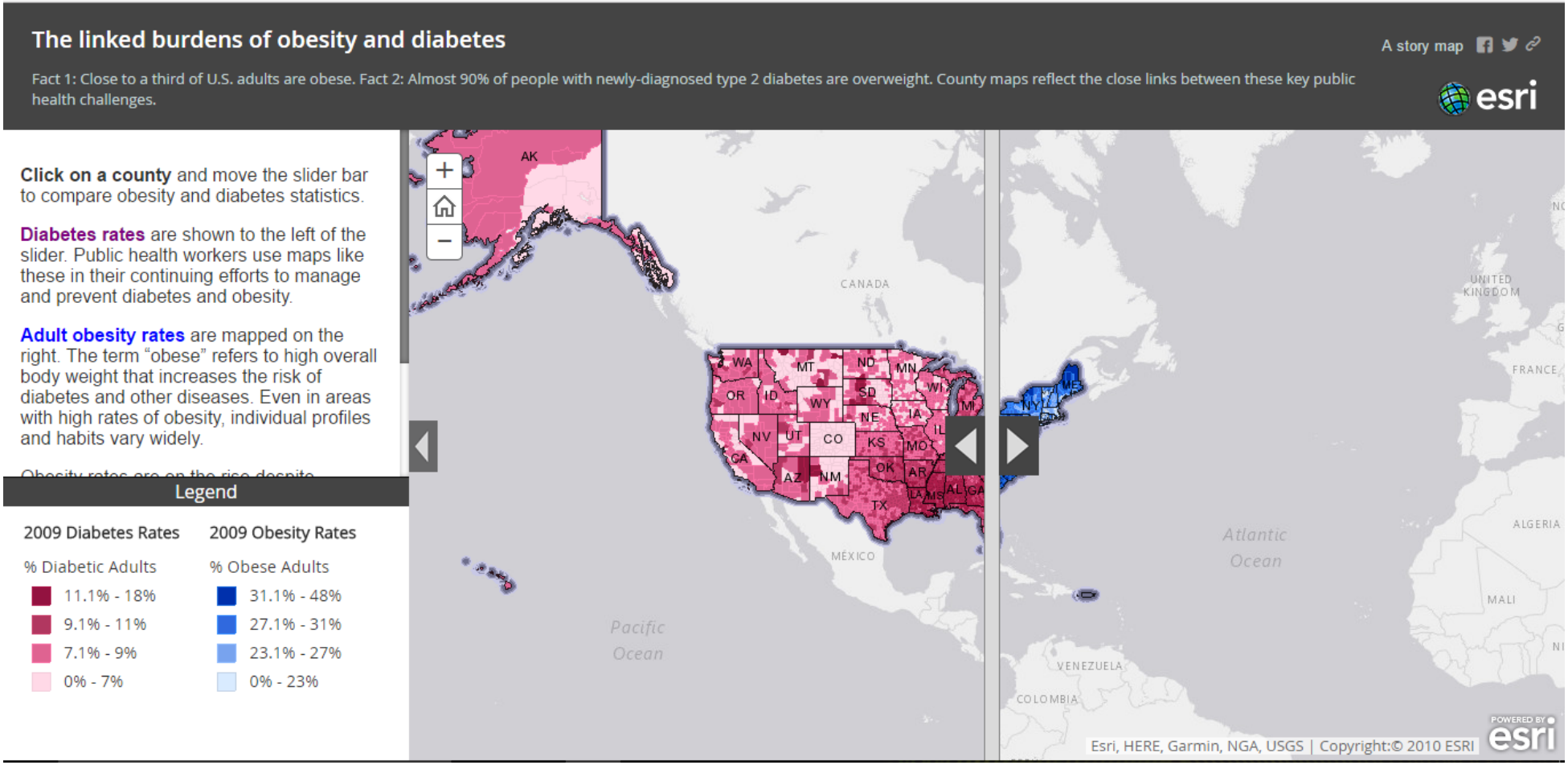

Figure 17: Story Map Swipe example explaining the linked burden of obesity and diabetes in America and Canada. (Source: Esri, 2017e)

And finally, the ‘Story Map Journal’ where an in-depth narrative, in sections, can take individuals through an issue or an environment, Figure 18 (Esri, 2016c).

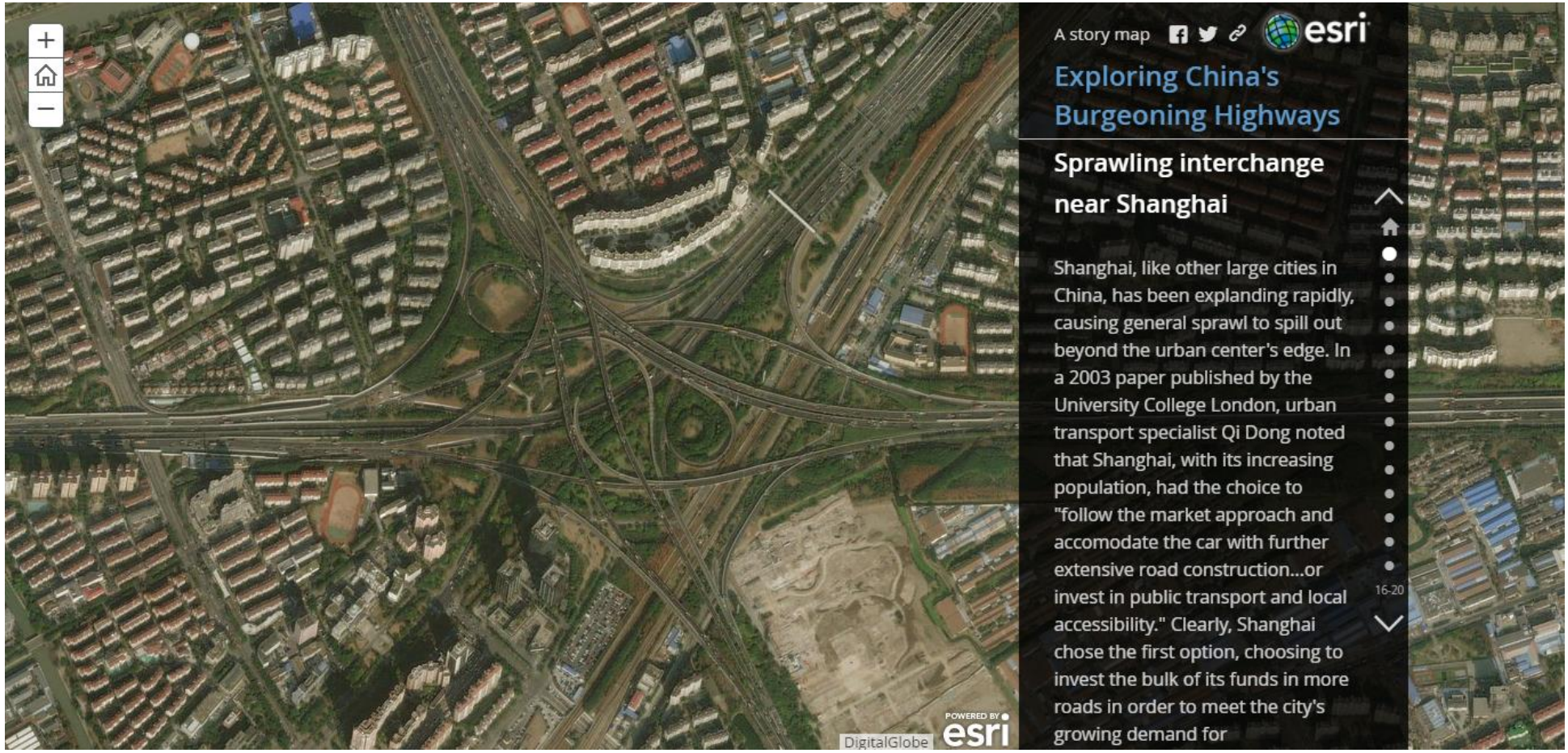

Figure 18: Story Map Journal example exploring China’s highway system. (Source: Esri, 2017f).

The tools within Story Maps, alongside the map/s, help create an interaction with flood risk information that goes beyond that achieved by flood risk maps alone, such as those provided by the EA. Story Maps can present the spatiality of flood risk, with critical supplementary information, in various formats, that guides users through numerous topics focussed on flooding e.g. flood risk, adaptation, mitigation and flood chronology. They can also simultaneously explain the flood risk maps presented and their key terms e.g. What is "flood risk zone 1 or 2" and their differences. This holistic view makes the topic of flooding and flood risk maps more accessible to users, enhancing their ability to learn and understand these subjects. This approach is possibly an improvement on approaches, such as the EA's, where maps are presented without supplementary information. This means users must already understand flood risk maps or undertake arduous research e.g. web-searching. This approach likely dissuades users from engaging with flood risk and flood risk maps. To fully ascertain whether Story Maps improve flood hazard and risk communication, through their innovative design, research must be conducted to fill this gap in understanding. This dissertation begins to address this gap.

3.3.3: Story Maps as a pedagogical tool: An emerging idea

The design capabilities of Story Maps might help them be effective flood hazard and risk communication tools, but they also show the potential to communicate effectively, due to their pedagogical underpinnings. In 1981, Story Maps were developed as a reading comprehension tool to used alongside written text (Fox, 2016). These educational Story Maps therefore were "a unified representation of a story based on a logical organisation of events and ideas of central importance…and interrelationships of these events and ideas" (Beck, 1981: 914 cited in Fox, 2016). In particular, Fox (2016), drawing on evidence from Reutzel (1986), suggests that Esri's Story Maps fit into the Cloze Story Map, which focusses selective attention, provides periodical checks for comprehension and attempts to present structured summaries of content. This educational tool has now been re-designed by Esri as an innovative communication tool.

Esri Story Maps, have many perceived psychological benefits that make them excellent education and communication resources. Firstly, storytelling, an element of Story Maps, involves audiences in what they are viewing, by tying emotions and people's imaginations together, allowing information and

concepts to be more easily assimilated and conveyed (Marta and Osso, 2015). The impacts of storytelling are pronounced and Gottschall (2012) cited in Wright (2016), suggest that over the last several decades' psychological studies have repeatedly shown that attitudes, fears, hopes and values are heavily influenced by stories. Secondly, multimedia increases the likelihood of sustaining an individual's attention, aiding comprehension of materials presented and helps entertain and involve audiences (Marta and Osso, 2015 and Graves, 2015). Finally, maps can communicate spatial stories across linguistic and cultural divides, whilst stimulating people's imagination and inspiration, capturing their attention (Strachen, 2014, Marta and Osso, 2015 and Kerski, 2013). Through the combination of storytelling, multimedia and maps, Story Maps have a stable groundwork to effectively communicate and educate, meaning they are becoming a popular tool for creating excellent visually appealing geographic narratives and placed based stories (Sinha *et al.,* 2016 and Nelson and Robinson 2015).

Limited work, mostly conducted within the education sector, has been completed to quantify whether Story Maps present a useful communication or pedagogical tool. Marta and Osso (2015), comment that storytelling, with maps, is a useful educational tool that captures student's attention. Kerski (2013) solidifies this stance, suggesting today's web mapping technologies, which envelopes Story Maps, provide a variety of easily accessible data and tools for educators and students, to explore key 21st Century issues, at scales from local to global. These new web maps and applications have attracted people from varied disciplines to convey instruction, assist learning and express research (Kerski, 2013). The issue presently is that teachers lack training with web-based mapping and geo-technologies, meaning these tools are being employed insufficiently within the education sector (Marta and Osso, 2015). In terms of hard statistics, only user's comments have been collected. Individuals commented on the user-friendly, interactive and engaging nature of Story Maps with staff members, suggesting that students would enjoy using the technology and that Story Maps could present material to academic standards (Strachen, 2014 and Kerr, 2016). Moreover, teachers have expressed their excitement at the availability and frequently updated content on ArcGIS online, meaning it has become a go-to resource for many teachers and those completing their practicum or student teaching placements (Kerr, 2016).

In terms of creation however, web mapping and navigating ArcGIS online were viewed neutrally, with staff/students preferring to use pre-made Story Maps over personal authorship (Strachen, 2014). Furthermore, for these resources to be employed effectively, institutions must have the technological capability to enable enough internet bandwidth to support web mapping, through many browsers, by multiple students simultaneously (Kerski, 2013).

At present, there is inadequate evidence to assess the usefulness of Story Maps as educational resource and thus further investigation is required. Information presently suggests however, that their unique pedagogical approach could be valuable and helps them to communicate information effectively. This approach therefore could support flood hazard and risk communication.

3.3.4: Story Maps: Distance learning and self-education

Pedagogically, Story Maps can employ a storytelling approach, but they also support a distance-teaching method, which would be important, as many individuals would be expected to complete their own self-education about flood hazard and risk. This type of teaching is conducted or communicated from a location, spatially distant from the student, requiring communication through technologies (Moore and Kearsley, 2011). This type of teaching has many benefits from the learner's viewpoint. One benefit is that learners can exercise control over their learning, engaging with information at a comfortable pace, in a time and location that is convenient (Levine, 2005 and Means *et al.,* 2009). These traits are valuable in a world where individuals learn at different rates and the pace of life continues to increase, forcing activities to become increasingly convenient (Kerski, 2013). Distance teaching also presents opportunities to reach learners worldwide and has capabilities to support both real-time and asynchronous communication between communicators and learners, among different learning groups (Means *et al.,* 2009). Meta-analysis has suggested that distance learning is equally as effective as many traditional face-to-face teaching methods and earlier forms of online distance learning have now outperformed previous efforts as innovation has brought improvements (Zhao *et al.,* 2005 and Machtmes and Asher, 2000).

This method however has imperfections. For example, there are issues with individual's engagement with distance learning resources as teachers are not physically present, thus individuals must be self-motivated to learn (Levine, 2005). Furthermore, a loss of connectivity to teaching sessions and faulty communication technology presents issues (Bender, 2003). Moreover, motivation is challenging for struggling individuals, although teachers have facilities to help them, but these are limited by spatial distance (Levine, 2005). Thus, using Story Maps as distance-teaching flood hazard and risk communication resources, means individuals must be motivated to engage with them and they must work effectively to keep individuals attention and motivation. Whilst communicators can encourage this interaction, through many means e.g. social media and interactive activities, data on who is interacting with a Story Map is not attainable.

Moreover, electronically mediated discussion, utilised by distance education programs has many issues including misinterpretation of facts or words, which can lead individuals to the wrong conclusions (Bender, 2003). Thus, the language utilised within flood hazard and risk communication, is further complicated when it is communicated through Story Maps, due to these reasons and this affects the likelihood of individuals performing appropriate actions. Furthermore, visual cues are lost with online communication and text alone cannot "communicate the nuances of the human voice which can convey the tone of the conversation" or alternatively information conveyed about an issue (Tiene, 2000:33 cited in Wang and Woo, 2006). These issues could be overcome through careful construction of Story Map resources and effective management of communication technology. Moreover, utilisation of multi-sensory teaching methods, accommodated within Story Maps, removes the need to communicate persistently through text, overcoming some of the issue associated with the misinterpretation of facts and words.

Although distance education has its limitations, it also has many benefits and fits in better with societies move towards greater quantities of life being conducted digitally (Correa *et al.,* 2010). Thus, it seems appropriate that hazard and risk communication should further utilise this teaching method, which could be conducted through Story Maps. Story Maps can however be utilised in situations where individuals are present such as a classroom, meeting room or

lecture session. The ability to utilise distance education thus, presents an extra benefit, allowing individuals to conduct self-education about flood hazard and risk.

The contemplation of a communication tool as educational is novel and transitions communication away for deficit model ideals. It gains a new lens to view communication more as a discussion and dialogue, where knowledge is co-produced. It encourages communicators to assume a teaching role, where they pass knowledge onto others, who are, in a sense, students. This means communicators must ensure information is provided in an understandable manner to others and must help individuals understand the information. It also opens pedagogical questions, aforementioned, about the ensuring all individuals have resources that support their learning styles and assists their learning, dispelling ideas of blanketed communication being acceptable.

3.3.5: Accessibility: Cost, the elderly, economic status and rurality

In an economic accessibility mind-set, ArcGIS online and its associated web-apps, which includes Story Maps, are free to create for up to 60 days, before ArcGIS online requires purchasing or ArcGIS desktop must be utilised. Training costs are also eliminated, unlike traditional ArcGIS, through the variety of online tutorials that explain how to create Story Maps (Kerski, 2013). This resource is also shareable online, through a hyperlink, making them available to practically anyone. There are potential exceptions however, which are discussed, including individuals with poor computer literacy, namely the elderly, and those without internet-enabled devices. These issues might deter hazard and risk communicators from using the resource.

It is a commonly held belief that the elderly cannot use computers and the internet, meaning they cannot access Story Maps, make them ineffective communication tools for these individuals. This sentiment is supported, with evidence suggesting that, within the UK, 3.2 million individuals, <45% of the 7.1 million individuals who have never used the internet, were <75 years old (ONS, 2013). This attitude has been challenged in recent years however, with reports suggesting elderly people now represent a large user group, with numbers steadily growing since the year 2000 (Pierce, 2009 cited in Maaß, 2011 in Trepte and Reinecke, 2011).

Furthermore, in the UK, 1.5 million individuals <75 year old have utilised the internet to some extent (ONS, 2013). Moreover, within the U.S. and Western Europe, the internet adoption rate for adults <50 years old, has outpaced that of young adults (Kohut *et al.,* 2006). Figure 19, shows that increased age does lead to slight decreases in the number of individuals using the internet, but that over 80% of 75+ still utilised the internet within the last three months (ONS, 2013).

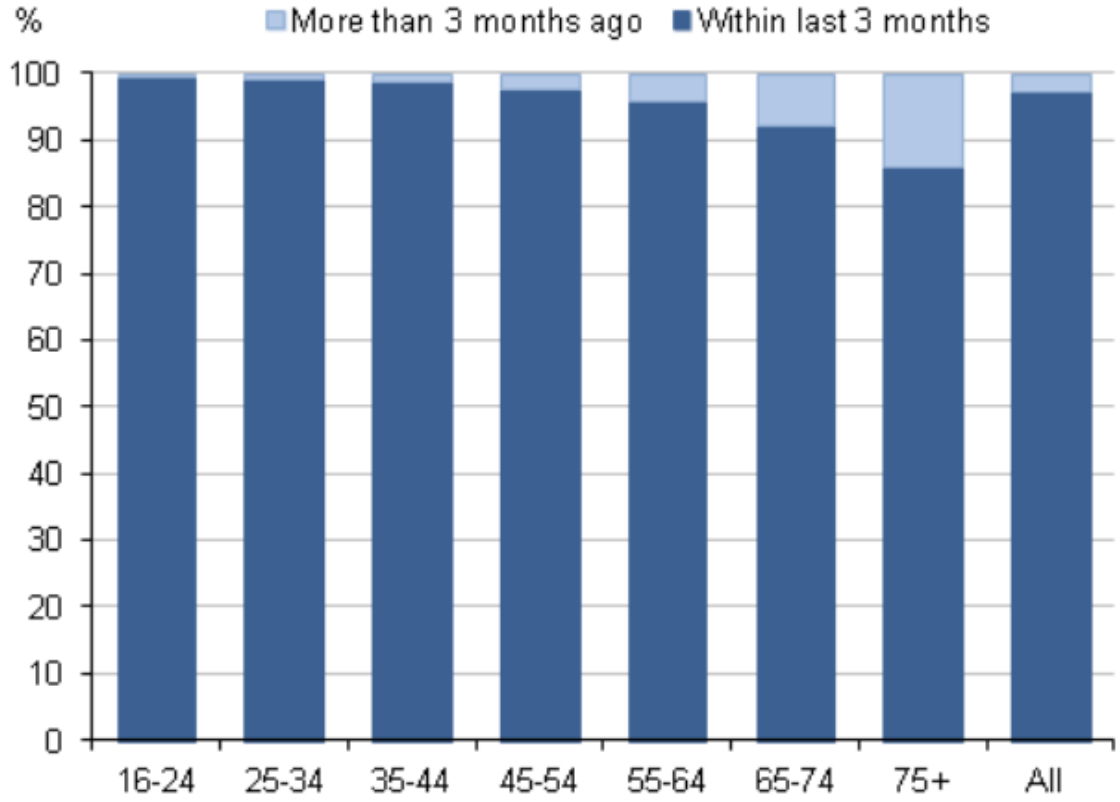

Figure 19: Percentage of individuals in different age groups that have used or not utilised the internet within the last 3 months. (Source: ONS, 2013).

These changes can be attributed to training programmes for elderly people, to teach them about computers and the internet. In the UK, these programmes include, the Barclays Digital Eagles scheme, Which? guides and the Age UK's computer training course. These programmes are dissolving the UK's age digital divide very rapidly. Ofcom (2010), reported that internet uptake grew 7% among 65-74 year olds and 6% among 55-64 year olds, compared against the 3% uptake by the general population, a more thorough review is provided by the Nominet trust (Milligan and Passey, 2011). Furthermore, elderly people use the internet primarily to talk to people and to locate information (Milligan and Passey, 2011). Thus, Story Maps might provide the perfect location to place

hazard and risk information for elderly people, as they are already using the internet to locate information. The age digital divide still exists but is dissolving as more elderly people are getting online, which is important in ensuring Story Maps are universally useful hazard and risk communication tools.

There are other groups who suffer from the digital divide. These include those in the global digital divide, which is the divergence of internet access between industrialised and developing nations and those in the democratic divide, the difference between those who do and do not use digital means to engage in public life (Norris, 2001). The causes of these digital divides are multifaceted with economic, political, social, cultural and institutional reasons, but most research concludes the overwhelming importance of economic factors in both digital divides (Chinn and Fairlie, 2007 and Crenshaw and Robinson, 2006). The importance of economic factors regarding internet access helps to explain, to some extent, why there is a split internationally between *More Economically Developed Countries* (MEDC) and *Less Economically Developed Countries* (LEDC) and why as economic wealth increases so does internet access[4] (ITU/UNCTAD, 2007). This argument is supported by evidence that, in 2011, the average broadband connection rate for MEDC countries was around 174.9 million people compared to 24.4 million for the entire of Africa and 42.2 million for Middle Eastern regions (Curran and Poland, 2011). This means many individuals, in LEDC and *Newly Industrialised Countries* (NIC) countries, are 'disconnected', presenting an issue to communication using Story Maps. This is not the case in many MEDC countries, due to adequate internet access.

The digital divide is potentially being resolved. Since the 1990's, the global digital divide has been closing due to many initiatives including: the InfoDev programme (1996), the Millennium Development Goals (2000) and the International Telecommunication Union's continuous work, which have all broadened efforts to implement the internet worldwide (Epstein *et al.,* 2011). In 2012, these efforts mean that <2.4 billion people, 1/3 of the world population had internet access (Dutton *et al.,* 2014). Recent statistics by the World Bank and the International Telecommunications Union, displayed in Figure 20 and 21, highlight the effort to close the digital divide since the millennium. Figure 21 also

[4] A deeper review of the digital divide can be found in Billon *et al.* (2009) and Epstein *et al.* (2011).

puts into context which locations could easily employ Story Map communication and which areas would struggle to employ Story Maps.

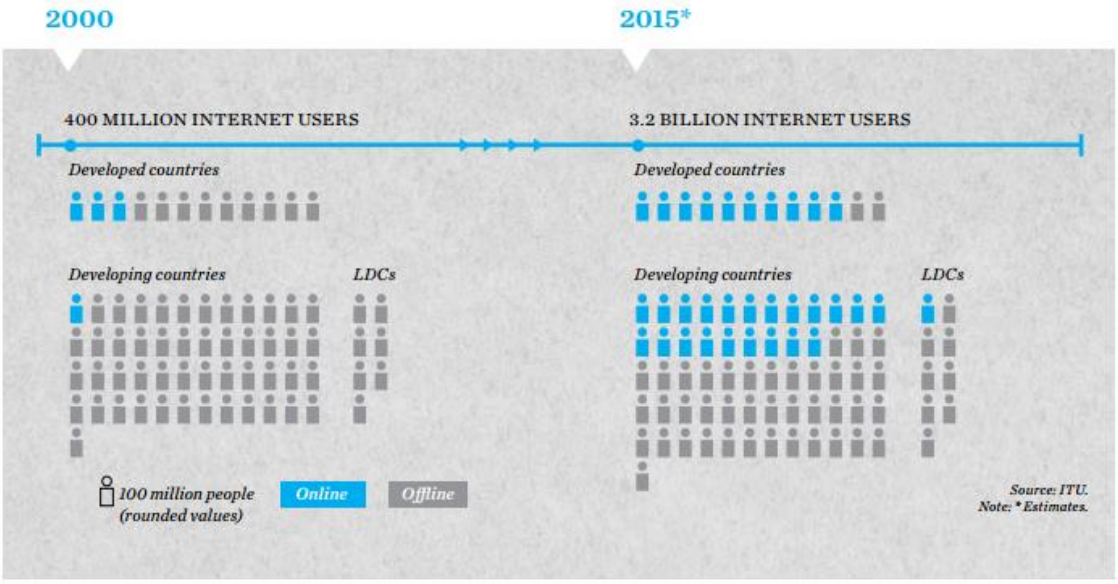

Figure 20: Improvements in internet access over 2000-2015. (Source: International Telecommunications Union, 2015).

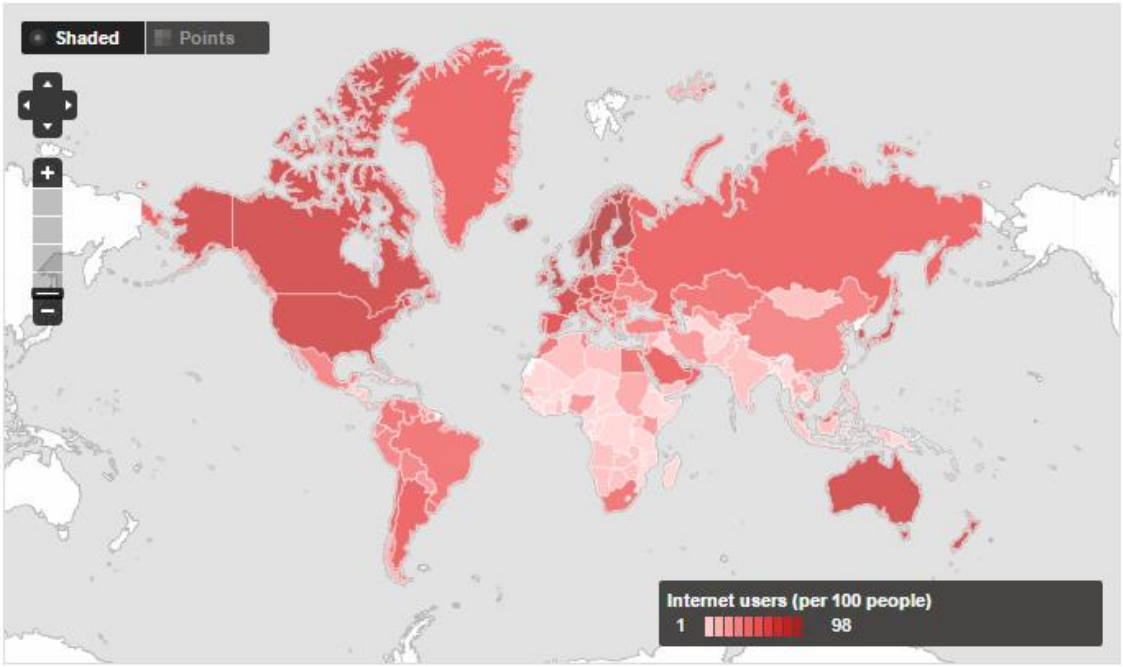

Figure 21: Internet users (per 100 people) across the world. An internet user is anyone who has used the internet over the last 12 months. (Source: The World Bank, 2014).

The digital divide is also a local issue, with divisions between rural and urban areas, caused by the cost of getting online, the availability of fast broadband and economic viability. Prieger (2013) states that within the US, there is a rural/urban divide in broadband, leading to fewer mobile and high-speed broadband providers in rural communities compared to urban areas. This is similarly reflected by Townsend *et al.* (2013), which state that rural isolation is being amplified by the internet, with rural communities being unable and unwilling to access broadband technologies. Additionally, in 2012, around a third of the UK population did not have broadband access and this problem was more likely to affect those living in rural areas (Townsend *et al.* 2013). Furthermore, in the recent Ofcom (2016) *Economic Geography* report, it was found that 3G/4G operators with good coverage were higher for urban than rural areas, with the divide greater for 4G than 3G.

To investigate the factors causing the digital divide, it seems appropriate to start by discussing Ofcom (2012), which stated that the most cited reason for not adopting broadband was lack of interest and cost. This is particularly important, with remote/sparsely populated areas requiring costly wireless technology such as satellites, which can lead to slower broadband speeds and increased monthly costs (Townsend *et al.,* 2013). These rural populations are also likely to have lower incomes levels and thus, are unable to afford the cost of the internet (Townsend *et al.,* 2013). Affluence, often lower in rural areas, is also linked with a better probability of receiving good 3G and 4G service, with a difference in the probability of receiving these services being, 9% (4G) and 7% (3G), between low and high affluence (Ofcom, 2016). This digital divide presents rural areas with disadvantages both in social and economic terms and this gap is widening as urban areas benefit from improved technologies (Townsend *et al.,* 2013). Thus, this divide between urban and rural internet access, is likely to present further issues to the use of Story Maps, but will likely close over time.

Although internet connectivity is required to access Story Maps and this presents a barrier to global communication of flood risk through these means, there is evidence that digital divides are closing. Thus, Story Maps could potentially be utilised by all, for a variety of purposes, including flood hazard and risk communication.

3.3.6: The trustworthiness of the internet and its impact upon Story Maps

Recent statistics highlight that the internet is becoming the primary source of general science and technology information for the public and this is likely to happen within other subjects soon (Akwaka, 2013 and National Science Board, 2012). This makes sense, as the internet has helped combine different channels of communication into one body and has made finding information easier than other mediums (Case, 2012). The internet therefore, is a valuable resource to communicate hazard and risk information, "but is it trustworthy?". This is one of the pre-requisites defined earlier. If the internet is trustworthy, then Story Maps, as a result, will be viewed as trustworthy and the advice they provide will likely be accepted and utilised. If the internet is untrustworthy, then information provided by Story Maps could be viewed as untrustworthy, potentially limiting their effectiveness of hazard and risk communication tools.

Trust in the internet is a mixed affair. Dutton *et al.* (2014), suggests individuals trust the internet, but a quarter of individuals were also very concerned about misinformation online and 65% were, to some extent, worried about online information. This is reflected in Bartlett and Miller (2011), which highlighted that the quality of online information can be imperfect, with 'unprecedented' amounts of mistakes, mistruths, propaganda and misinformation, leading individuals to doubt online information.

Recently, trust in the internet has also been affected by 'fake news'. It has become a pervasive phenomenon, with the BBC forming a team to fact check and debunk misleading and false stories that seem like genuine news articles (Jackson, 2017). Furthermore, an assessment of the recent 2016 U.S. presidential election suggested that fake news stories favouring Trump were shared a total of 30 million times on Facebook, with Clinton leaning stories shared 8 million times, affecting people's opinions (Allcot and Gentzkow, 2017). Moreover, the average American adult saw one or more fake news stories the month before election, with just over half of those believing the information (Allcot and Gentzkow, 2017).

The aforementioned statistics and the fake news issue however, are debated by YouGov (2011), with survey results indicating that, within the UK, 55% of people trusted the internet. Moreover, Lebo (2011), suggests 79% of American internet users trust information found on government websites and established media

outlets and 45% had some, or a lot, of trust in the internet. These findings are broadened to a global scale, with Dutton *et al.* (2014), suggesting trust in online information was almost identical to that of traditional media and one in two users trust online information written and edited by many people. Table 3 presents some further statistics.

Table 3: Levels of trust in various sources of information. (Source: Dutton *et al.*. 2014).

"To what extent do you trust the following sources of information?"	% who trust*	Mean
1. Online news sites	56.8	4.65
2. Results of an online search engine	56.1	4.65
3. Online information written and edited by many people (e.g. Wikipedia)	52.2	4.47
4. Social media	43.2	4.17
5. Citizens' blogs	39.2	4.02
Valid N listwise (10514)		
* Percentage of people who answered 5, 6 or 7on a 7-point scale		

Offline Sources

"To what extent do you trust the following sources of information?"	% who trust*	Mean
1. Television news	58.4	4.67
2. Radio reports	56.4	4.62
3. Newspapers	56.3	4.61
Valid N listwise (10761)		
* Percentage of people who answered 5, 6 or 7on a 7-point scale		

This debated trustworthiness of the internet might present a barrier to communication efforts using Story Maps, as the internet is not a 100% trusted source. Trust in the internet is however, reasonably high and many individuals utilise the internet to collect information daily, often believing the information. This potentially means that, even though the internet, as a unit, might not be 100% trustworthy, Story Maps might still be believed, even though they are located online.

3.4: Literature Review conclusion

This literature review has focussed upon many themes. In Part 1, there was an investigation of UK FRM and current communication efforts being conducted. Discussion then transitioned onto the issues with conducting hazard and risk communication and recommendations for effective communication. Following this, a debate was opened on whether hazard and risk communication has a pedagogical issue and how multi-sensory communication might provide some useful insights.

In Part 2, GIS and Story Maps were explained and investigated with their strengths and weakness discussed, in areas including; their ability to localise information, design considerations, pedagogical uses, accessibility (digital divide) and trust in the internet. The following section will address the methodology utilised for data collection to answer the following research questions:

RQ1: What are the current issues within the St Blazey area and to a wider extent Cornwall, in terms of flood hazard and risk and its communication?

RQ2: Using the issues ascertained in RQ1, what considerations must be made when creating a Story Map to attempt to overcome these issues?

RQ3: What benefits, limitations and potential uses for Story Maps can be identified by using St Blazey as a case study?

RQ4: How do the elements of a Story Map help individuals understand flood hazard and risk information and what design preferences are expressed by those viewing Story Maps?

4.0: Methodology

4.1: Introduction

As previously mentioned, in Section 1.6, this study focusses on the St Blazey area. This area is prone to flooding from multiple sources and the community have thus had vast flooding experience. They are therefore likely to provide useful and nuanced insights into flooding and its communication. The following sections thus investigate how these insights were collected utilising telephone and face-to-face interviews with key stakeholders, a presentation to a student body, ethnographic notation at community meetings and finally, a semi-structured survey with local residents.

4.2: Interviews

Interviews were conducted with several stakeholders to understand their opinions on current issues surrounding flooding, methods utilised to communicate associated information and their opinions on Story Maps. Interviewees were selected to represent a spectrum from local insights through to regional insights, whilst keeping discussion focussed, where possible, on St Blazey. Interviewees were gathered using a snowball strategy, with emails sent out asking if they would be interviewed and then interviewees presenting ideas on further individuals to interview. The emails contained two Story Map hyperlinks so participants could view a Story Map before they were interviewed. These Story Maps were about flooding, so were centred around the same ideas as the research project.

Opinions on flooding and its communication were collected to begin with. Following this, Story Maps were discussed, with interviewees asked to assess their suitability as resources to communicate flood hazard and risk and how these stakeholders might utilise them within their roles. The interviews were semi-structured, conducted either over the telephone or face-to-face and ranged from 20-45 minutes, depending upon the willingness of the participant and the extent of their knowledge. The telephone interview questions utilised are presented in Appendix 1. Table 4 outlines the jobs/roles held by respondents and methods utilised to conduct the interviews.

Table 4: List of respondents, jobs/positions and methods of contact.

Scale	Respondent No.	Job/Position	Interview Method
Local	R1	Tywardreath and Par Parish Councillor	Telephone
Regional	R2	Cornwall Community Flood Forum	Telephone
N/A	R3	Esri Employee focussed on higher education	Face-to-Face
Local	R4	Retired, member of Cornwall Emergency Planning group and PL24 Community Association	Telephone
Local/Regional	R5	Critical STARR project officer	Face-to-Face (Informal)
Regional	R6	Cornwall Council Strategic Environment Team member	Telephone
Local	R7	Cornwall Councillor St Blazey	Telephone
Local/Regional	R8	Cornwall Community Link Officer	Telephone

Interviews are particularly useful for gathering individuals' attitudes and values and provide better insights than questionnaires into participants' understandings, experiences and opinions, which are integral elements within this research (Byrne, 2011 in Seale, 2011). The use of interviews is also widely incorporated as part of a mixed-methods research methodology. In this research, this equates to the triangulation of information from interviews, survey/questionnaires and a pilot application of the Story Map with community members and students, where ethnographic notations were taken (Flowerdew and Martin, 2005 and McDowell, 2010 in DeLyser *et al.* 2010). Semi-structured interviews were selected as they allow greater flexibility in data collection and for the research topics' complexities to be explored, leading to interesting and nuanced understandings (Galletta, 2013). Additionally, a semi-structured approach allows attention to be focussed on the lived experiences of participants, yielding valuable insights, which the researcher would be unable to otherwise attain (Flowerdew and Martin, 2005).

Telephone interviews offer a variety of benefits, which made them appropriate for this research. Firstly, they are a cost-effective method for data collection, avoiding travel and other expenses and allows information to be collected from an extensive spatial area, thus expediting the research process (Novick, 2007 and Trier-Bieniek, 2012). Secondly, they allow for higher levels of anonymity and privacy, providing a more comfortable environment for participants, with the

telephone interview scenario acting as a shield (Farooq, 2015). This decreases social pressure inherent in face-to-face conversation and aids the building of rapport with the participants (Vogl, 2013 and Farooq, 2015). This more comfortable environment helps interviewees open up and reveal more personal or revealing insights (Holt, 2010). This study also conducted face-to-face interviews where appropriate, to show individuals how the Story Map worked, allowing for a different type of discussion.

Critics would attempt to attest that the telephone interview procedure provides an impoverished data source compared to face-to-face interviews. This is because there is a lack of face-to-face contact that supposedly restricts development of rapport and causes the encounter to feel unnatural (Irvine *et al.,* 2012). It has been identified however, that telephone interviews are equally as effective as face-to-face interviews at gathering information. Sturges and Hanrahan (2004), found no difference in nature and depth of responses across interview methods and Vogl (2013), found no difference in participants' motivation and level of rapport achieved, whilst interviewing.

Face-to-face interviews have their own unique set of advantages and for this study were particularly useful for providing detailed responses about the Story Map, which complimented those attained in the telephone interviews. Face-to-face interviews help create a more 'natural encounter', where interviewer and interviewee can build rapport and generate a relaxed friendly attitude, encouraging the interviewee to speak openly and thoroughly about the research topic (Farooq, 2015, Gillham, 2005 and Shuy, 2003 in Holstein and Gubrium, 2003). These benefits were important when encouraging interviewees to discuss openly the sensitive issue of flooding and enabled an in-depth interaction with the Story Map to take place, as the interviewer was physically present to assist the interviewee with the resource. This approach therefore led to detailed, articulated insights regarding the effectiveness of the resource as a communication product.

Furthermore, face-to-face interviews enable the interviewer to provide visual signals and utterances that encourage the interviewee to elaborate and crystallise their intended observations, providing more carefully considered responses (Shuy, 2003 in Holstein and Gubrium, 2003). Moreover, the

interviewer can constantly manage the interview, so the research needs, and interests are constantly the focus of the interview (Stephens, 2007).

In this instance, these visual cues and utterances were utilised by the researcher to entice measured opinions on whether the resource was effective at accomplishing its aim of flood hazard and risk communication. It also facilitated the extraction Story Map benefits and limitations, according to the 'informed' interviewees[5]. After each interview was conducted, responses were transcribed using Express Scribe Transcriber and then key themes were selected and discussed further within the results and discussion section.

4.3: Story Map demonstration to a student body

To conduct a deeper investigation of Story Maps, a design study was also devised. This study aimed to reveal insights into Story Map design, such as, the types of information to include and where to position critical information and the effect this had on participants understanding of flood hazard and risk. This information was collected by creating a Story Map consisting of ten 'slides', of which nine contained information relating to St Blazey flooding. Each 'slide' was designed with mild variations in terms of layout and content. These variations removed any effects caused by boredom, as the new stimuli assisted in keeping participants focussed on the task. Table 5 outlines the various designs. Figures 22, 23 and 24 provide screenshots of slide designs 1,4 and 7, to aid understandings of the Story Map design.

[5] Further discussion on telephone and face-to-face interviews is located in Irvine *et al.* (2012).

Table 5: The nine Story Map slide designs created for St Blazey flood hazard and risk communication.

Slide No.	Sequential order of information/mediums on left-side of Story Map		Mediums on right-side of Story Map
1	Sentences with information regarding flooding in St Blazey.		ArcGIS map of St Blazey's flood risk with properties highlighted.
2	Video of flooded Station Road.	Sentences bullet pointed.	ArcGIS map of St Blazey's flood risk with properties highlighted.
3	Sentences bullet pointed. Specific terms highlighted in blue.	St Blazey flooded home image.	ArcGIS map of St Blazey's flood risk with properties highlighted.
4	Sentences bullet pointed. Quote from local resident.	St Blazey town flooded image.	Video of flooded Station Road.
5	Sentences with information regarding flooding in St Blazey. Specific terms underlined.		Video of 2010 flooding around Cornwall.
6	Sentences bullet pointed. Quote from local resident.	Video of 2010 flooding around Cornwall.	St Blazey flooded home image.
7	Sentences with information regarding flooding in St Blazey. Specific terms highlighted in blue.		St Blazey town flooded image.
8	Sentences bullet pointed. Specific terms underlined.	Video of flooded Station Road.	ArcGIS map of St Blazey's flood risk with properties highlighted.
9	St Blazey flooded home image.	Sentences bullet pointed.	ArcGIS map of St Blazey's flood risk with properties highlighted.

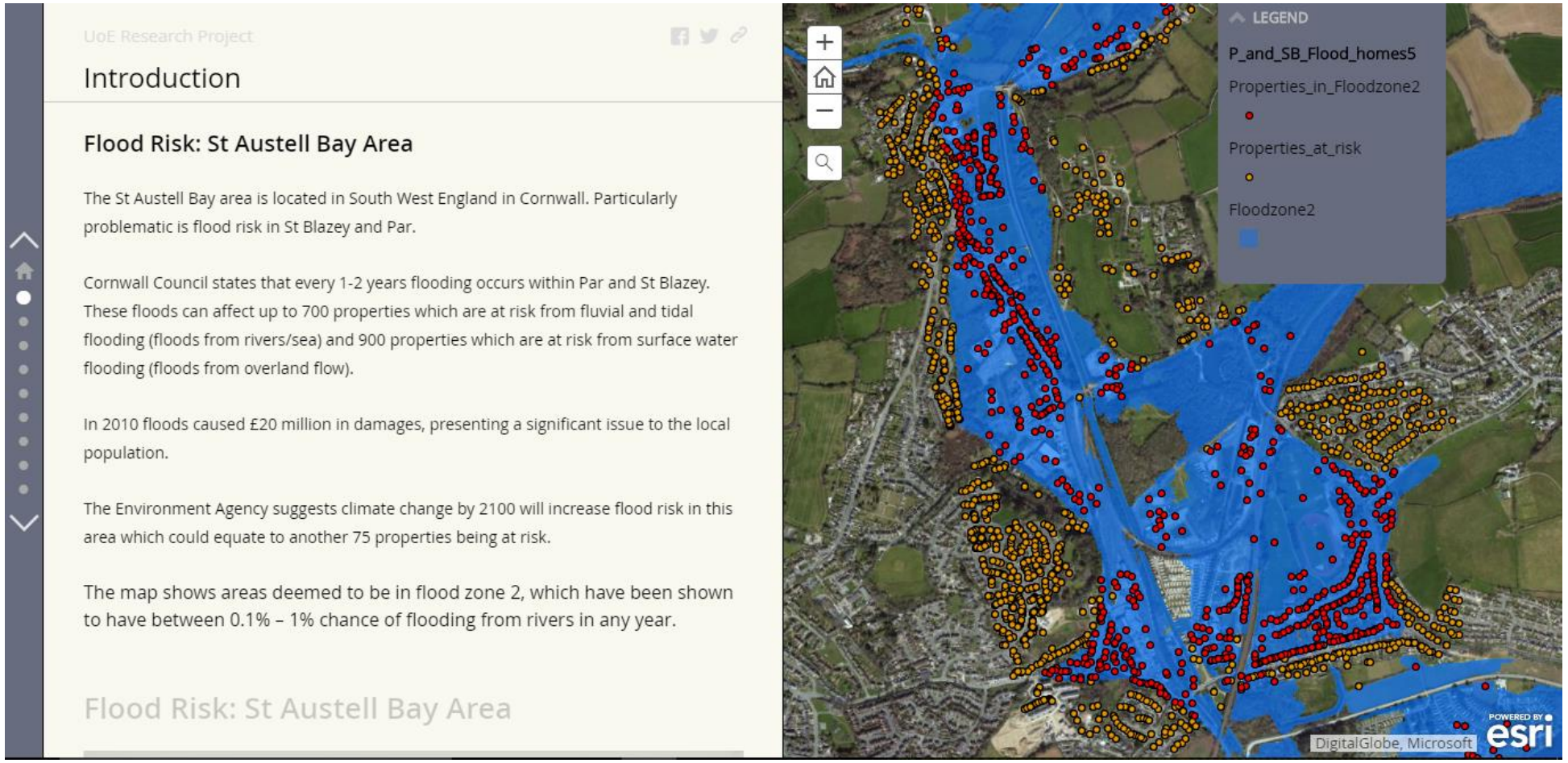

Figure 22: Screenshot of Slide Design 1. All information on flood risk is provide in sentences with an ArcGIS map that shows properties at risk of a 1 in 100-year flood and other properties at risk of floods with a greater return period.

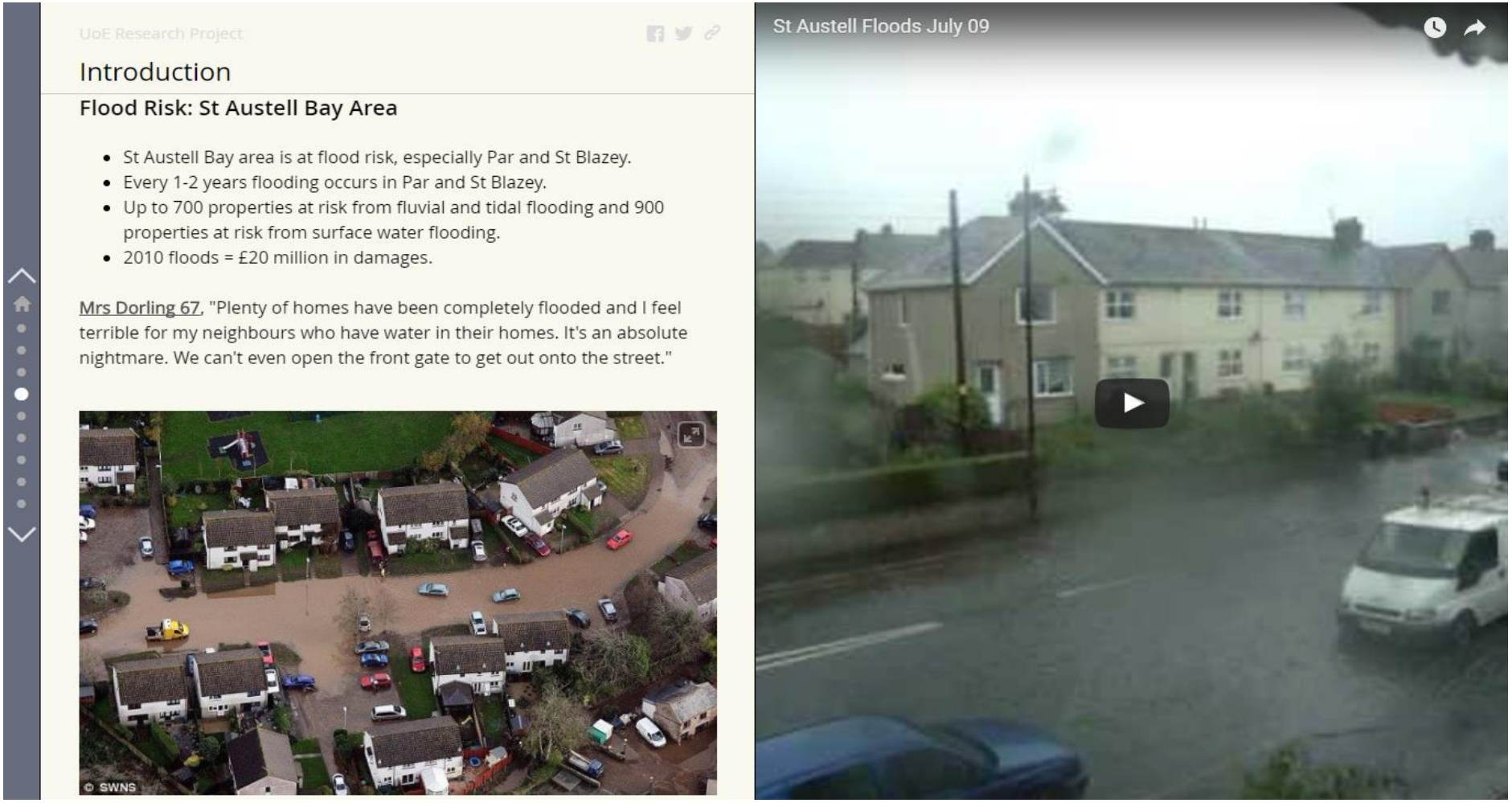

Figure 23: Screenshot of Slide Design 4. This utilises a different approach from Slide Design 1. In this slide design, the sentences have been converted to bullet points, a quote from a local resident about flooding has been added and a picture is also presented. There is also a video on the right-hand side to show how rapidly flooding can affect the area.

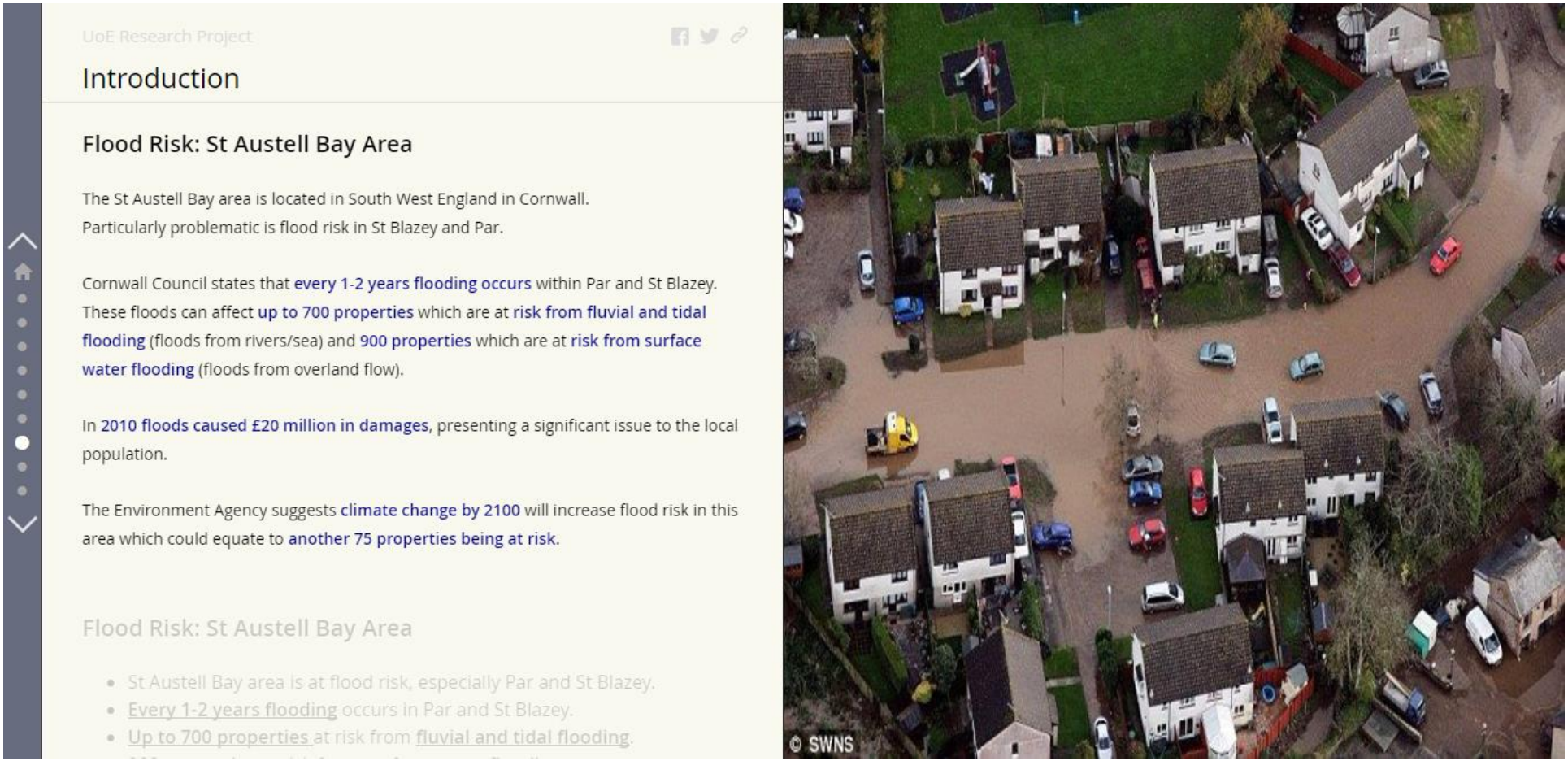

Figure 24: Screenshot of Slide Design 7. This slide utilises a design more closely related to Slide Design 1. In this design, key information has been highlighted in blue and the ArcGIS map has been changed to an image of flooded St Blazey.

This study was conducted in Penryn Campus' Seminar Green and DDM Seminar C, with 15 Geography undergraduate students and one mathematics undergraduate. Four masters students also participated, who had degrees from different fields. They were encouraged to participate through a Facebook event created by Geogsoc and various culinary enticements. The sample therefore, consisted of 19 students split into 12 males and seven females of age range 18-22. These participants have been assigned a participant number (P.no.) to anonymise their responses, presented in Table 6.

Table 6: Student participant details and participant numbers.

Participant No.	Age	Gender	Studied Geography?	Degree Level
P.1	21	Male	Yes	Undergraduate
P.2	21	Male	Yes	Undergraduate
P.3	20	Male	Yes	Undergraduate
P.4	20	Male	Yes	Undergraduate
P.5	19	Male	Yes	Undergraduate
P.6	19	Male	Yes	Undergraduate
P.7	19	Male	Yes	Undergraduate
P.8	20	Male	Yes	Undergraduate
P.9	20	Male	Yes	Undergraduate
P.10	20	Female	Yes	Undergraduate
P.11	19	Female	Yes	Undergraduate
P.12	19	Male	Yes	Undergraduate
P.13	20	Female	Yes	Undergraduate
P.14	21	Male	Yes	Postgraduate
P.15	22	Female	Yes	Undergraduate
P.16	22	Female	No (Marine Biology)	Postgraduate
P.17	18	Female	No (Mathematics)	Undergraduate
P.18	21	Male	No (Biology)	Postgraduate
P.19	22	Female	Yes	Postgraduate

Participants were presented with three 'slide' designs, asked to pick their favourite and to provide reasons for this choice, before taking a short break to consider their answers. The researcher detailed the changes for each slide to ensure participants were engaged with the task. This was completed twice over and then participants viewed all 'slides' again in a quick run-through before selecting their overall favourite. Participants were then asked questions, found in Appendix 2, on topics including, whether they liked the resource and whether they found the multiple different mediums helpful. This method ensured attentional resources were focussed on the Story Map, enhancing data

collection. Participants recorded their response on a paper survey, which were collected after the session. It was compiled into Excel for safety, before basic trends were extrapolated and identification of the 'best' Story Map ascertained. Participant's comments were also analysed, with interesting insights and quotes extracted for discussion. These findings are addressed, in Section 5.6.

4.4: Ethnographic notation and community member discussions

Data was collected during various meetings with community members. One of these meetings was the St Blazey Flood Group meeting (10th March, 2017). Twelve community members attended, alongside various key interested parties. This group of individuals included: an EA representative, the county councillor and the communities chief flood warden. This meeting primarily focussed on teaching residents about flooding, the towns flood plan and how to become a flood warden. At the end of the meeting, the researcher was given the opportunity to complete a question and answer session on the Story Map, shown in Figure 25 and 26. They were offered the opportunity to interact with the resource after the meeting concluded. All insights gained from this meeting were collected through ethnographic notation. This methodology was also applied to the STARR progression meeting, which contained key community members such as: the town mayor and the leader of the significant PL24 group.

These insights were combined with those collected during St Blazeys Big Lunch event (June 3rd, 2017). At this event, the researcher and the research assistant, demonstrated the same Story Map, to community members, to test whether it could be utilised to communicate flood hazard and risk information in St Blazey. In total, this resource was demonstrated to twenty participants, who were then asked questions from the semi-structured survey, presented in Appendix 3. The survey asked participants numerous questions about the resource to ascertain their opinions on it and its usability as a communication resource. Questions included: whether it held their attention, was easy to use and had an appropriate level of language, amongst others. To increase convenience for participants, no demographic information was collected, and their question responses and other comments were gathered by the research assistant, using a tally system. Tallied responses were converted into percentages, presented in the following section.

Figure 25: Screenshot of the historic Story Map. This part focussed on changes to upper St Blazey and their impact on flooding.

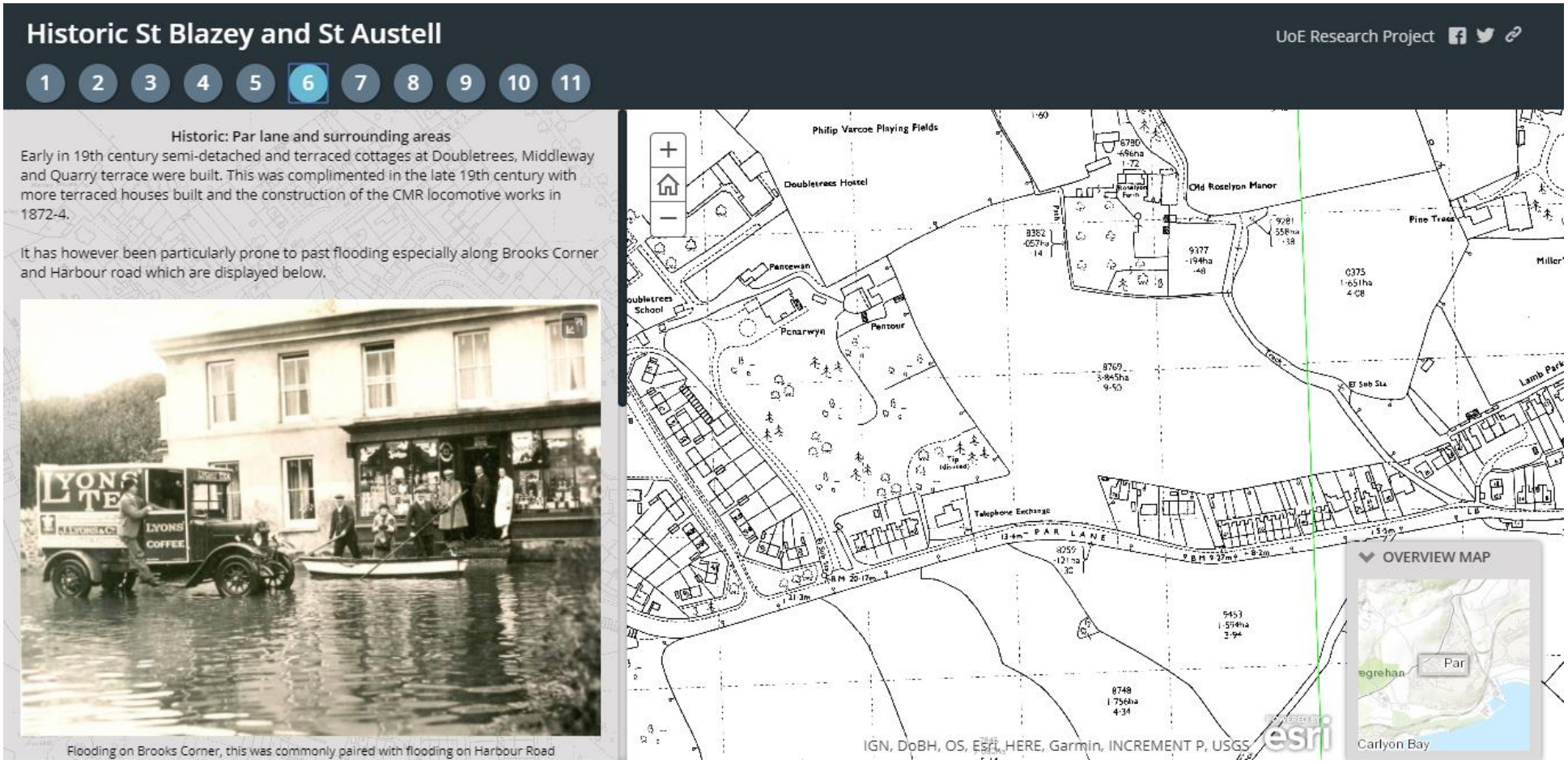

Figure 26: Screenshot two of the historic Story Map. This section focussed on Par Lane and the surrounding areas, which have been prone to flooding.

4.5: Research question methodological justifications and section conclusion

For RQ1, interviews were conducted with informed individuals, whose roles focused on flooding and communication, where possible, these individuals had associations with St Blazey. These interviews enabled an in-depth understanding of these subjects to be ascertained. Furthermore, these individuals fully understood current topical issues within flooding and communication, thus provided a top-down view of these topics, which could be compared later with community member's responses. Many of the interviewees also regularly interacted with the community, meaning they could understand and present the community's concerns to the researcher. A more invasive methodology therefore was not required, simplifying the research process. The insights gathered for RQ1 were investigated thoroughly by the researcher and their ideas and thoughts provided answers to RQ2.

Similarly, RQ3 was answered primarily using interviews, as the informed participants were already completing their own communication methods and had ascertained understandings on the opportunities and challenges present within flood hazard and risk communication. They were thus best suited to provide opinions on the benefits, limitations and potential uses for Story Maps as communication resources and their applicability to the research community. Survey results also helped answer RQ3 as they allowed a different user group the opportunity to present their own ideas, which could be compared against the interviewees.

For RQ4 however, a presentation and semi-structured survey methodology was more appropriate. This method ensured participants focused specifically on the Story Maps design and provide them with the opportunity to fully interact with the resource, yielding valuable results, not obtainable through interviews. The survey questions presented to participants also helped break the Story Map into its constituent parts, so they could be thoroughly assessed, and participants could provide their opinions, with justifications. This approach also meant the researcher could guide the participants through the resource and this ensured they understood the resource's various element and the exact part they were assessing, during each question, improving the accuracy of results.

Finally, ethnographic notation was utilised as a support methodology for all RQ's, helping create a rounded understanding of flooding within St Blazey and Story Maps as communication resources. It enabled the researcher to become more embedded in the community, especially with groups that discussed and dealt with flooding on the ground and provided the opportunity to assess the situation as it was unfolding. It was especially useful to find overlooked or missed thoughts and attitudes towards flooding in St Blazey and Story Maps, which were not possible to ascertain by using interviews alone.

Ethically, this methodology utilised University of Exeter's A route, as the research did not involve children, vulnerable groups or ethically sensitive topics and any impacts due to communication of flood hazard and risk were assessed as limited by the ethical committee.

In conclusion, this multi-faceted methodology aimed to create a holistic picture of St Blazey's flood hazard and risk situation and Story Maps as communication resources, by investigating the situation from several angles using a range of viewpoints and participant groups. This methodological approach ensured an assortment of data was collected, presenting many interesting findings. These findings are discussed in the following section, alongside accompanying insights from the literature.

5.0: Results and Discussion

Many insights were gathered through investigation of qualitative and quantitative data and these are discussed in this section. The insights fit into four themes, which are; communication considerations and current practices for flood hazard and risk, behavioural responses to this form of communication, the abilities of Story Maps and the role of design. This section concludes with a short discussion on interviewees potential uses for Story Maps and other ideas presented by the researcher.

5.1: Communication considerations and current practices

This section investigates some communication considerations, including; the role of delicacy and the issue of the 1 in 100-year concept, before examining current communication practices within the St Blazey area and to a wider extent Cornwall.

5.1.1: Delicacy in communication

R1, R2, R4 and R7 discussed delicacy of communicating any information about flooding, especially as it has perceived links with people's homes and insurance cover.

R2 explained the issue of delicacy perfectly in an anecdote about Portreath, where the EA and Cornwall Council worked collaboratively to create a flood plan for Portreath. They subsequently received significant backlash for highlighting the risk to stakeholders and R2 assumed that similar approaches would receive similar backlash in St Blazey.

> R2: When they went to launch the flood plan a large element of the community literally went up in arms, because they felt that through highlighting this, their properties were being blighted.
>
> They [thought] various property sales would fall through and homes would be devalued and all the rest of it and they insisted anyway that there was no risk of flooding here in Portreath.

Like Portreath, the issue of delicacy is present within St Blazey. Past flooding has led insurance companies to view the area as being at risk. This meant that recent flooding caused price increases for those with insurance already and is hindering others from getting insurance, which the following quotes express.

> R1: The fact that I live in PL24 means they try and make my house insurance higher because they say I am liable to flood. I am not going to flood as I live on the hill… but because I have a PL24 postcode, because there is flooding, it makes it like that.
>
> R7: (After recent flooding) Some individuals in St Blazey were being asked for four figure sums for their insurance premium, plus four figure sums for their excess. These figures are clearly unattainable for most [and this was leading to] some people not renewing their insurance and that meant they weren't covered for anything.

With this in mind, many interviewees expressed that communication of flood hazard and risk in St Blazey must be delicate, otherwise it would simply exacerbate the insurance issue. If any form of communication, including Story Maps, were not delicate, it would likely lead to R2's perceived backlash and is also presented in R4's quote.

> R4: People are very strongly concerned about flooding.... [as it causes] insurance problems for their properties… and [residents] are already struggling with insurance [and] will not thank you for advertising [flood risk]!

R1 also suggests that delicate communication is required, as residents believe that flood hazard and risk information will cause property devaluation, or the hindrance/ loss of property sales in the area, which displeases them.

> R1: As a member of the community it wouldn't be uncommon for people to say the earlier comment of [delivering flood risk information] ... "How would you do that without ruining my house price?" ... Therefore, how much information [to provide regarding flood risk] to make sure that you're not damaging people's property [prices], or their chances of selling.

R6 relates this sentiment to "a flood Story Map", which must be "very careful when talking about flooding" to ensure it does not "blight a particularly property" and lead residents to state that they "can't sell [their] house because they say it is at flood risk". The need for delicate communication leads onto questions about litigation, with R1 stating that they did not want to be "subject to litigation because I have cost [residents] money", due to an ill-conceived Story Map. This concern would similarly be voiced by both those developing Story Maps and those using them to communicate. It thus presents a complicated issue with law, which could discourage individuals from utilising Story Maps, but this could be circumvented.

This issue of delicacy has led R5 to ensure the STARR project is framed such that it exemplifies; the area's history, its archaeological importance, how it promotes plus assists with the area's restoration and the health and cultural benefits of living in a blue-green area. Communication on flooding and FRM specifically is back-benched in discussions with stakeholders. This is likely in response to its delicate nature, which might discourage the community from backing the STARR scheme.

This issue of delicacy, expressed by interviewees, was however criticised during interactions with residents at St Blazey's Big Lunch. The Story Map, which, to an extent, was delicately designed, acted as a platform to open discussions on flooding and the area's history. Participants provided detailed accounts about where it flooded, the impacts of floods and historical flooding events, when presented with the Story Map. It also presented an excellent opportunity to converse about how best to alleviate the town's flooding and STARR's plan for St Blazey's FRM, which many residents seemed generally happy about. The importance of opening a dialogue about flooding and not simply providing flooding information was apparent when the researcher talked with residents and aided their understanding and acceptance of flood risk. This experience supports arguments, mentioned in Section 2.2.4, for a dialogue and participatory approach to be utilised for flood hazard and risk communication.

The issue of delicacy is also presented in the literature. Dickenson (2005), highlighted that excessive flood hazard and risk communication, indelicate in nature, leads people to become stressed, worried or concerned about flood events, which can lead to dysfunctional behaviour. Porter and Demeritt (2012) discuss the problem of insurance in their study, regarding flood planners, with respondents voicing similar concerns. Furthermore, the issue of hindering home sales and property devaluation is presented in Lamond *et al.* (2007) and Soetanto *et al.* (2008) in Bosher (2008). Bosher (2008) also outlines that home ownership, in England and Wales, is one of the most significant financial commitments made by individuals and therefore, concerns about property devaluation are important.

Thus, delicacy is a guiding principle for the creation of flood hazard and risk Story Map communication resources, as it likely affects the successful implementation of these resources into communities.

5.1.2: The issue of the 1 in 100-year concept and technical language

Continuing this communication theme, R1, R4, R5, R6 and R8 raised concerns about the use of language and definitions when communicating flood risk. They were particularly concerned with the 1 in 100-year concept, which is complicated and difficult to understand.

> R1: It is you know obviously, this [flooding] doesn't happen that often, we are technically a 1:100 flood risk. That's not saying that floods happen every 100 years, its means there is a 100th of a chance it's going to happen every year.
>
> R4: [St Blazey residents] didn't understand that if they were in a 1 in 100-year area, they could get flooded for 3 consecutive years.
>
> R6: [We must be] very careful when talking about probabilities (1 in 100-year concept) of flooding to the public as they would say, "it flooded last year so then I have 99 years till it floods again".

Finally, R8 stated that during STARR discussions they use "1 in 25 and 1 in 50-year storms, but people can't really visualise what that is and understand it". These quotes, clearly exemplify how complicated this concept is to understand and thus, R5 suggested that discharge or volume of water might be an easier way to present flood risk.

Being aware of these issues, the Story Map avoided using the 1 in 100-year concept and kept other written elements short and simple. Any terms not understood by students or residents when using the Story Map, were explained by the researcher. This approach led to feedback, from students, that the text was appropriate and understandable. Furthermore, 100% of residents surveyed, stated that the Story Map's level of language was good and understandable.

The 1 in 100-year concept is also an issue present in the literature. It is a complicated concept that individuals find difficult to understand and can lead to inaccurate mapping of flood risk. Highfield *et al.* (2013), highlight that 1 in 100-year designations are unable to capture the likelihood of property damage and potential loss of life, leaving millions of individuals unaware of flood risk and unprepared for flood events. Furthermore, Ludy and Kodolf (2012) identified that many individuals did not understand the term and even those who stated they did, were found mostly to provide incorrect definitions. Extending this issue slightly further, De Bruin and Bostrom (2013), state that experts present

needlessly complex jargon on flooding, creating challenges for non-experts and use the 1 in 100-year flood concept as their example. It is important therefore to consider the language utilised within a Story Map and its presentation, to ensure individuals understand what the resource is trying to teach or communicate.

5.2: Current methods for flood hazard and risk communication

This section concludes the communication theme, by discusses current communication practices utilised in St Blazey and Cornwall.

5.2.1: St Blazey flood hazard and risk communication

Within the St Blazey area, R1, R4 and R7 helped identify a few communication methods. These methods included: their Facebook Page *'Par and St Blazey Community Flood Group'*, discussions with the EA regarding flooding and home visits where the flood group re-asserts phone numbers to call during a flood event. In terms of in-house communication, there is a consideration of creating a WhatsApp group to co-ordinate the flood group and the jobs they should complete in a flood event. It appeared, however, that communication was a second-rate issue that was not properly addressed, which was expressed by interviewees.

> R1: [Communication is] really a bit we are still working on and is pretty much a work in progress at the moment.
>
> R4: There isn't a lot done to communicate directly with the community about what is going on… [the community] know there is a flood issue but don't understand exactly where it comes from.

R7 continued this sentiment, suggesting communication happened only through the flood group and a few Facebook posts on the local flood risk page. Further communication could therefore be completed in St Blazey, using other resources, such as Story Maps, which would likely be appropriate.

5.2.2: Cornwall wide flood hazard and risk communication

R2 and R7 helped extend how communication was conducted, from St Blazey specifically, to the Cornwall region. R2 stated that the *Cornwall Community Flood Forum* has a Facebook page and Twitter feed dedicated to flood

information and a website, hosted by Cornwall Council, which "isn't brilliant but is free".

Moreover, during the Cornwall pathfinder project (2013), the forum created a video called *'Reginald Flood'*, hosted on their Facebook page, which was a "tongue and cheek style sort of 60's public information film which received pretty good reception". Finally, during this project, the Cornwall Council produced an A5 booklet detailing how to stay safe and respond to flooding, which came with a plastic credit card sized card with key phone numbers and safety information. This was provided to practically every at-risk property, in Cornwall. Interestingly, R2 revealed that this booklet "went out branded as the *Cornwall Community Flood Forum*", which could suggest, that the council were apprehensive about conducting flood hazard and risk communication, delegating responsibility to the *Cornwall Community Flood Forum*, to avoid any reaction to the booklet.

R7 added that the *Cornwall Community Flood Forum* has an annual conference, which many towns and parishes get involved in, which is "quite a useful dissemination event, it does spread information around". Moreover, R7 stated, there is a regional flood committee who also disseminate flood hazard and risk information, but from their response, it was unclear whether these events were for those already involved in FRM or for everyone.

Communication of flood hazard and risk is developing in the St Blazey area and Cornwall, but, R4 revealed it "tends to be more of a 'reactive force' than a 'proactive force'". This was apparent on the St Blazey Facebook page, dedicated to flooding information, with communication happening only when flood events occur. R7 similar adopts a reactive stance to communication, stating that "you don't want to be on about [flood hazard and risk] all the time, as there's no point to that". Thus, it appears that communication resources exist, but more resources could be utilised. Furthermore, the resources that already exist could be used more, as they are only utilised when flood events occur and for a short time afterwards. This means there is little long term pre-emptive communication about the causes of flooding or how to deal with risk, a common phenomenon as the literature expresses.

Bosher *et al.* (2007), states that within the building sector, although increasing quantities of guidance, information and legislation on flood risk is being created, suitable guidance focussed on proactive flood mitigation measures is lacking,

leaving buildings vulnerable to flooding. Furthermore, this study revealed that the lack of guidance on how hazard mitigation considerations should be integrated into the building phase, hinders the development of resilient built environments and appropriate re-construction of flood affected properties.

In terms of response, similar issues are present. For example, in America, the disaster risk reduction policy and actions are reactive and short-sighted, dealing with the natural hazard problem as they occur (Cutter *et al.,* 2013). They therefore, fail to foster sustainable disaster resilience, which Cutter *et al.* (2013), relates to a various factors including; legislation focussed on response, state and local governments irresponsibility by allowing building in high risk zones and an absence of public opinion or political will to make tough decisions regarding disaster risk. This is leading to an increasing frequency of billion-dollar disaster events and loss of life (Cutter *et al.,* 2013). Finally, in flood risk communication, there is often ample discussion of flooding and flood risk during and after the event, noticeable in the media, but this quickly fades and successive communication is lacking.

Thus, it is important to consider using Story Maps for flood hazard and risk communication prior to an event and afterwards. This would be achieved, in a Story Map, by informing people of their flood risk well before an event occurs, providing them with information and opportunities to adopt personal FRM and get prepared. This should help ensure their safe during an event and hopefully will have prompted them to adopt appropriate FRM, reducing the negative impacts of flooding, including; loss of life or property damage. This approach could encourage individuals to transition from being reactive to proactive in the face of flooding and move communication into a similar realm. After an event, they could be useful resources to showcase an event's chronology and what lessons can be learned.

5.3: Behavioural responses to flooding and communication of flood hazard and risk

Having investigated considerations to be made prior to conducting flood hazard and risk communication, alongside current practices in the study area and Cornwall, discussion transitions into examining behaviours associated with flooding, flood hazard and risk communication and Story Maps.

5.3.1: Denial

Denial and an unwillingness to act before flood events occur are issues associated with flooding and were identified in interviewees comments.

> R2: [Even when] EA highlight to the community that they are at risk of flooding there is a significant amount of denial, that it won't happen to us and an unwillingness to act.
>
> R7: Don't want to know about flooding necessarily.… they don't want to be associated with [flooding]. (This response falls into behaviours such as denial).

Principally interesting, in terms of denial, was R7's account of individuals within St Blazey, who decided not to tell their insurance companies about recent flooding, due to potential repercussions, such as price hikes, as examined earlier. This response seems counter-intuitive, as the insurance company would have paid out to deal with the recent floods impact. It appeared however, that the repercussions were too much for some residents, leading them to deny that flooding had occurred.

> R7: One other thing I should add is a lot of people didn't want to have a label of flooding on their property, even if they were flooded, they didn't claim insurance, simply because they didn't want to have that label. Now, I don't know how effective that was in terms of increases in insurance premiums, but a lot of people simply had flooded properties but denied it. That was quite obvious at the time, but unexpected I have to say.

The issue of denial is similarly pervasive in the literature. Denial is called a non-protective response, potentially helping individuals with high (detailed) risk perception to cope and reduce their negative emotions in response to flooding (Bubeck *et al.,* 2012). R2's comment is similarly identified in Demeritt and Nobert (2014), Grothmann and Reusswig (2006) and Burningham *et al.* (2008), where denial led to a lack of uptake of FRM strategies, likely because flood hazard and risk information was understood but placed to one side as individuals denied they were at flood risk. This discussion also highlights why flood hazard and risk communication must be delicate, as indelicate communication potentially leads individuals into the denial trap, where they reject 'scary' or 'harmful' information delivered and thus fail to uptake FRM strategies.

Evidence collected during this research however, suggests that denial, in the St Blazey community, is possibly not a pervasive issue, in contrast to the

information collected from interviewees. It was potentially avoided by using the Story Map and a discussion format. Many residents questioned during the Big Lunch event, discussed flooding and its impacts openly and attend to, without denying, the flood risk information provided in the Story Map (75% of resident's surveyed attended to the information constantly, with 25%, at times, drifting off). Moreover, rather than denying the information presented, 82% of residents surveyed, suggested their understanding of local flooding had improved and they felt more informed. The remaining 18% were long-term residents, therefore, they had ample knowledge about the flooding issue, but they did learn some new facts. These results suggest that potentially Story Maps can engage residents and hold their attention. This stops individuals from simply ignoring or denying flood hazard and risk information and instead allowed them to engage in discussions about the local flooding issue.

With denial a pervasive issue, although this study has some evidence to the contrary, Story Maps should address flood hazard and risk delicately as to not entice denial. It might be valuable to utilise Story Maps in a discussion format, with a speaker, so information can be explained and to allow recipients to have their questions answered to re-assure them. Furthermore, Story Maps should communicate the issues with denying flood hazard and risk and help those individuals to understand actions that will keep them safe and mitigative activities that reduce the impact of flooding.

5.3.2: Complacency: The challenge of deteriorating flood memory

Denial is just one of the behaviours associated with flood events and the delivery of flood hazard and risk information. There is also the issue of deteriorating flood memory, as day-to-day stressors envelope individuals lives', causing flood events to be forgotten or to seem like distant memories. This leads those at risk to become complacent that flood events will not happen again, allowing individuals to forget about flood risk. Structural FRM solutions exacerbate the situation, as individuals believe they cannot be flooded again as they are effectively 'defended' against floods. Complacency is presented in the following quotes, with R2 stating it is a "pressing" issue in their line of work.

> R2: The challenge we have is keeping people aware of flood risk when they haven't been flooded in the very immediate past.

> R2: Even in communities where they have flooding and the authorities have done some structural work within that community to make things better, and have made quite clear that things are now a lot better than they were, but the problem hasn't gone away completely, because the measures we have put in place only protect to a certain level, that complacency still comes back.

This issue of complacency and deteriorating flood memory also presents challenges to the successful implementation and longevity of flood groups. R2 revealed that flood groups often develop shortly after flooding events, to assist with future flooding, but begin to lose interest if flooding is absent for some time.

> R2: We've now had two fairly benign winters and even those community flood groups that came about as a result of that flooding are now basically starting to lose interest.

The issue of rapidly deteriorating flood memory and complacency is similarly reflected in the literature. Bradford (2012), states frequent events ensure that the perception of flood risk remains high, with Burn, (1999), stating that long periods without floods serves to diminish awareness. This relationship thus means individuals have short flood memories as they can quickly forget about flooding (Pfister, 2011). This means complacency can rapidly return to people's lives, leaving them unaware, surprised and unprepared for future flooding.

These above-mentioned issues could be alleviated by utilising Story Maps to ensure flood memory remains fresh in individual's minds. This could be achieved by placing them in various online locations, visited by community members, such as council websites, social media and flood forums. These Story Maps could be storage devices, where past flood events are recorded/ documented and safety information is presented. It should also include information about the weaknesses of structural FRM solutions, to confront complacency. This approach would mean individuals are re-reminded that the area is at flood risk and what flooding was like, helping them to remember their flooding experience and what they need to do before, during and after flood events. Thus, Story Maps could provide an alleviation method for this pervasive issue in individual's responses to flooding.

5.3.3: Responsibility and social responsibility for personal FRM and communication

Responsibility is a major issue within flood hazard and risk. The transition towards localism, explained earlier, encourages individuals to be increasingly responsible for FRM. They must also understand their social responsibility to conduct FRM, to benefit not only themselves, but for their community.

As previously discussed, structural FRM solutions can lead to complacency, meaning individual's believe they have no responsibility to conduct personal FRM. This sentiment was supported by R2, who stated they made it clear to individuals the expectations of the council during and after a flood event. They also however, had to "pull the punches" when telling people that they are also responsible for understanding and implementing personal FRM. R6 identified a similar tendency, stating that people become "a bit disgruntled to find out we are not there to fix all their problems". R6 believed individuals needed to understand their FRM responsibilities and which could be achieved through "educating" individuals.

R5 suggests this is related to a psychology, in the UK, that homeowners or individuals in flood risk zones do not believe they should respond to or be made to defend against floods, instead leaving it to outside agents. This is unlike America, where these individuals are flood first responders. R5 thus states the UK requires "behaviour change instead of structural options" to combat this responsibility and complacency issue. R5 is trying to avoid these issues by discussing STARR as "flood risk management" and not "flood defences". This should lead individuals to understand that STARR is not a structural defence scheme, which will simply defend against floods and instead promotes ideas of catchment wide thinking and the value of personal FRM.

The issue of responsibility is common within the literature. Grothmann and Reusswig (2006), state that reliance of public flood protection is a reason for people's inaction when it comes to flood damage prevention. Botzen *et al.* (2009), complements this, stating if there is available government compensation for flood damage and people perceive the responsibility for flood risk prevention to be governmental, it can negatively affect people's willingness to purchase sandbags. Joseph *et al.* (2015), similarly found that UK homeowners were unclear about their FRM responsibilities and were doubtful of whether personal FRM measures prevented flooding.

It is important therefore, that flood hazard and risk communication transitions towards discussing individual's FRM responsibilities. It should express why FRM helps people on a local scale and encourage messages of self-efficacy to complete flood risk reduction behaviours (Harvatt *et al.,* 2011 and Demeritt and Nobert, 2014). Story Maps should thus promote the importance of self-efficacy for FRM and provide helpful contact information. This could be completed by mapping the various stores to purchase FRM solutions or by providing links to online resources which provide information about non-structural flood management solutions. Further Story Map uses to support self-efficacy for FRM are presented in Section 5.7.

Helping people better understand their responsibilities seems important to ensure individuals understand the value of personal FRM and their social responsibility to conduct FRM, creating a 'community' response to flooding. R8 only became aware of social responsibility due to their experience with STARR where explanations were provided on how upstream changes affect flood risk downstream. Thus, R8 suggests this relationship between FRM actions and their impacts is not public knowledge and thus, people are unmotivated to conduct personal FRM as they lack understanding of how it helps themselves and their community.

> R8: I am far more aware of that yes [flooding] happens and if this happens, say something upstream and if they made that slight adjustment, that could have a massive effect on those being flooded. Now, not everyone has insider knowledge into the STARR project and I think if people did, their social conscience, I am sure not everybody, but many people, would think more widely about their ability to help those directly flooded.

If individuals better understood the impact of their actions, uptake of personal FRM might increase and individual's might stop pawning off their responsibilities to other agencies. This approach could potentially instil a sense of 'togetherness' or 'community' in combatting flood risk, further motivating individuals to adopt personal FRM. R8 stated that Story Maps could be utilised to this end, with the recommendation addressed in Section 5.7.

Matters are further complicated however, due to misunderstandings by the public about the responsibilities of different entities within FRM, as R2 mentioned earlier. R2 expands on this, stating that they are often contacted and

have to refer individuals to many other agencies, as they have come to the wrong place to get their issues resolved. The complex nature of responsibilities is clear in R6's comments.

> R6: Some things we [Cornwall Council] are responsible for, other things the Environment Agency are responsible for, it's not always clear who is responsible for what. Quite often it is also the landowner who is responsible.
>
> R6: [Many] aren't aware that quite often the issues are down to the owner of the land [to fix] rather than the council.

This complex nature of FRM was apparent in Figure 7, where multiple different agencies were responsible for FRM. This hinders individuals understanding of their own responsibilities and potentially stops them from conducting personal FRM. A Story Map communication resource, should therefore include a roles and responsibilities section for each organisation involved in FRM. This might stop confusion about FRM responsibilities, potentially encouraging individuals to conduct personal FRM as they understand that this is their responsibility.

Overall, responsibility for personal FRM is complicated by several factors, including: an understand that FRM is another entities responsibility, a lack of awareness of how personal FRM works, alongside inadequate understandings by individuals of their personal and social responsibility to conduct FRM. These issues could be overcome by using Story Maps in the ways above-mentioned.

5.3.4: Responsibility for Story Maps and longevity

The previous section investigated issues of responsibility in a general sense. This portion instead explores the potential responsibility issues for Story Maps and its impact on their longevity as communication resources.

Broadly speaking, if Story Maps are to be utilised for flood hazard and risk communication, an individual, group or organisation needs to take responsibility for them. This includes two levels of responsibility, with both hopefully being achieved:

1) Responsibility for a finished Story Map product, where the individual is responsible for the Story Map log-in details and utilising it for flood hazard and risk communication.

2) Responsibility for updating a Story Map regularly with the best information and data, whilst monitoring access and completing ArcGIS mapping, by purchasing ArcGIS online. The latter two points are discussed later in the discussion section.

When the issue of responsibility was presented at a community meeting, the researcher observed the residents/organisations 'shying away' from taking on responsibility for the resource. The attendees asked whether the researcher would maintain responsibility for the Story Map and seemed satisfied only when the researcher mentioned that the university might become responsible. There were multiple reasons provided by interviewees that explained why an individual, group or organisation would not want to be responsible for the St Blazey Story Map. These are likely applicable in other similar locations.

If an individual, group or organisation simply becomes responsible for a finished Story Map, interviewees were concerned mostly with the Story Map's ease of use. The meeting attendees and interviewees mentioned that a non-simple system, that the person responsible could not understand how to use or those they were interacting with could not use, would likely cause the resource to not be utilised. If the resource seemed unusable, people would be discouraged for taking responsibility for the finished Story Map, affecting the longevity of the resource.

> R1: If you have a program [Story Maps] you don't use often, it can be really challenging to then re-use…my husband, a flood warden… would struggle to use it.
>
> R1: We might get to use [Story Maps] in 18 months' time and have forgotten how and I'm not going to be in a position where I can you know [relearn and update the resource].

Counter to this argument, many respondents during interviews were impressed by the Story Maps ease of use.

> R2: I find [Story Maps] total intuitive and easy to use.
>
> R4: [Story Maps are] really user friendly.
>
> R7: If I can use it, and I am a bit of a dinosaur frankly, then it yes, it must be easy to use. (R7 found their home with no guidance, suggesting that the interface is easy to use).

Similarly, during the Big Lunch event, 100% of residents suggested the interface was easy to use, with many investigating the resource easily on their own. Thus, although ease of use could be presented as an argument against accepting responsibility, there are likely to be individuals to which this does not apply, who would potentially be willing to take responsibility.

If an individual, group or organisation becomes responsible for an evolving and developing Story Map there were several other issues presented. To develop Story Maps requires time, effort, economic resources and finally an understanding of ArcGIS, which many people do not possess and would need to be learned. This is already a significant amount to ask the person/s responsible for the resource, but there are also further responsibilities. These include: adding and managing content, allowing and restricting access and finally, ensuring the resource is developed. This significant body of work therefore, might discourage the adoption of Story Maps for communication, due to their difficult and time-consuming nature.

Some of these issues could be overcome however, by dividing tasks between a small team, but this presents its own issues. Thus, careful consideration must be given when deciding who is going to take responsible for the Story Map, to ensure it becomes are 'living documents' and not a 'glorified PowerPoint' with no development. It is also vital that succession planning takes place to ensure that someone is always responsible for the Story Map, ensuring its longevity.

These ideals have already been reflected by R1, but were also presented by many other interviewees.

> R2: [Story Maps look] quite time consuming even [with] my ability to learn how to do things...I suppose they are also time consuming to assemble.
>
> R6: [Story Maps] would enhance our flood investigation reports [but I] expect there is a lot of work involved [and thus] finding the time and the resources would be difficult.
>
> R7: It's difficult to find the time to do these things. (In response to creating a Story Map).

Finally, a lack of computer literacy, through any number of reasons, including having insufficient economic resources or being elderly, means that these individuals cannot access the resource or become responsible for them. This, at least in St Blazey, and probably other areas, significantly reduces the number of

individuals who could take responsibility for a Story Map, presenting another responsibility issue. The issue of computer literacy is more thoroughly examined in Section 5.5.3.

5.4: Participants' behaviours towards Story Maps

Finally, in terms of behaviour and communication, there were behavioural observations and opinions provided by respondents about Story Maps. The example Story Maps attached to emails, were viewed very positively by interviewees and their responses are displayed in Table 7.

Table 7: Interviewees responses to the Story Maps.

Interviewee	Response to Story Map
R1	*"Probably would be quite useful in the local St Austell Bay area".* The term 'useful' was expressed 17 times during the interview.
R2	*"Brilliant!"* *"Could be a very useful tool"* *"There are many people to whom [Story Maps] would be bang on target".*
R4	Story Maps: *"absolutely critical to get the right message over in St Blazey".*
R5	Commented on their usefulness and has begun spreading the idea of their use to STARR colleagues.
R6	*"It's easy to get into, interactive"* *"Enjoyed running through it"* *"An interesting resource".*
R7	Story Maps are: *"Interesting way to look at flooding",* likely *"a pool of people for who this is of interest".* *"Improve upon other means of communication and should be used alongside other methods, it would be good to use both".*

Utilising ethnographic insights, during the meetings with community members, a similar positive emphasis was present. Individuals seemed excited and interested in the Story Map. There were requests for the hyperlink to be provided to the community, so it could feature prominently on their councils' website and for PL24 to present it to other community members. Many were fascinated by the historic approach taken to flood risk and were particularly positive about the images. A few residents engaged with the resource, finding their homes using the search bar.

Further to this, 100% of residents questioned at the Big Lunch event, would recommend Story Maps to other residents, stating that they were effective communication resources. They also suggested that the Story Map model should be applied to other areas suffering from flood hazard and risk problems. A local county councillor added that they were "a really good tool, ideal to make issues more accessible and understandable in the local community". This positivity toward the Story Map was also present in their behaviours, as residents seemed engaged and interested in the resource, which helped open up discussions on flood hazard and risk. Together this myriad of positive inferences suggests Story Maps are a potential useful communication resource.

5.5: The abilities of Story Maps

5.5.1: Simplified and context aware interface

Story Maps simplified interface and context aware approach to information delivery was cited by R3 as a benefit and useful feature. R3 emphasised that, unlike other maps, e.g. EA flood risk maps, Story Maps present appropriate information at different temporally and spatially scales. This means that if an individual wants to move from one location to another, from a local to a regional perspective, or from one-time period to another, they are not overloaded by irrelevant information. The respondent also remarked that "rather than with a paper map, where the cartographer puts the emphasis on the biggest at-risk population" which makes it "more difficult for you to find your information", Story Maps present information that is "context aware".

This context aware approach is important, as it limits the amount of information individuals need to read and process at any one time. This approach fits with R3's comment that "nobody reads anymore" and the local county councillors statement that "people don't want to read anymore". This was similarly reflected by residents, with 0% of them finding text the most interesting or engaging element. Thus, Story Maps context aware approach, means information can be presented at the correct moment and scale, in a simple and concise manner, which makes users more likely to engage with them, unlike other communication resources.

A context aware approach is valuable to challenge the issue of information overload. Information overload is ever increasing in everyday life and is

exacerbated by the growth of the internet. This has led individuals to feel overwhelmed by information, causing behaviours including: anxiety, boredom, bad redundancy (repetition of useless information) and distraction (Savolainen, 2007). Moreover, individuals have limited attentional capacity and as information has proliferated at such an enormous rate, society has reached a point where attention is an extremely rare resource, which Story Maps must capture (Levy, 2008 in Himma and Tavani, 2008). This has led to theories that individuals are 'satisfiers' when it comes to information engagement and stop when they have information that is 'good enough', given a specific time constraint associated with a situation (Savolainen, 2007).

The context aware structure of Story Maps thus, is an enormous benefit as it ensures individuals limited attentional resources are focussed on smaller useful informational 'chunks'. This helps limit information overload and potentially increasing comprehension, potentially making Story Maps useful communication resources.

5.5.2: The value of online GIS

ArcGIS online, which provides an underpinning for Story Maps, has a variety of benefits that enable individuals to build and develop them easily. To exemplify the ease of ArcGIS online, R3 provided an anecdote of how mapping was conducted historically. They highlighted the various complicated steps which included: sharing information by PDF, struggling with HTML code and creating servers to share maps. ArcGIS online however, "removes all that stress", simply requiring users to "load your data into this folder and then we will turn it into a web-accessible layer" and provides tools to help create a GIS experience for non-GIS users. These benefits are important in creating a user-friendly experience with GIS and Story Maps.

Moreover, R3 stated that, "only now that we have web-maps that have reached a stage where they can be engaging and interesting resources [that] don't crash and are easy enough to put together" can they be utilised more effectively in communication. This easier to use interface potentially means individuals are more inclined to use Story Map software, either to create their own Story Maps or add to existing ones. This is supported by R2's statement that "If I had the time and was linked into whatever the Story Map was going to relate to, I would say that I could probably learn how to do that" and commented that certain

other St Blazey residents could create Story Maps. Thus, ArcGIS online potential increases the accessibility of Story Maps, allowing a wider base of users to learn GIS and utilise these resources for communication and other means.

Story Maps have some limitations however, due to their ArcGIS underpinnings. Firstly, GIS is often completed from a computer, miles away from the area being analysed, and this was presented as a limitation by R2 and R7. They stated that EA flood maps, but also appropriate for Story Maps as they both utilise GIS, generalise flood risk as they are primarily "desktop exercises". They present "a guide rather than an indication that you are liable to flood" and the only way to overcome this issue is if "somebody is going to go down at the street level, to property level and assess each property in turn". This approach is likely very time-consuming and unachievable. Story Map creators could potentially overcome this by having community members create Story Maps on smaller spatial scales such as their village or town. It would however, be difficult to achieve this level of detail, with a small team, working on large spatial scales, over short time periods.

Secondly, although Story Maps can be viewed on multiple online devices from phones to computers, their development is restricted to computers, likely due to their ArcGIS online underpinnings. Thus, Story Maps cannot be developed on the move. Data needs to be collected and accessed on a computer with internet, before ArcGIS online can be utilised to update the Story Map's maps, text, images and videos. These activities are complicated, technical and require specific skills, which raises responsibility issues already discussed. These issues potentially limit the usefulness of Story Maps in the field.

Thirdly, ArcGIS online requires time to learn and is potentially a complicated exercise which many might not want to complete. If ArcGIS is not learned, individuals/ organisations would struggle to utilise mapping, a critical Story Map element. Some of the difficulties with learning and utilising ArcGIS online, have led to "take up being reasonably slow" according to R3. Moreover, during and after the interview, R3 provided reasons for this, including that "the larger the potential pool of users, the bigger the headache for the admin".

Finally, ArcGIS online or desktop must be purchased if Story Maps are to be utilised, expressed briefly in Section 1.4. R3 comments that users "can sign up for a trial account, where you could create a Story Map" but that without purchasing ArcGIS online, your Story Map is "going to disappear in 60 days which would be annoying, you then lose all your analysis". This issue begins to raise questions surrounding the budget allocated by communities or organisations to conduct flood hazard and risk communication, possibly preventing the utilisation of Story maps. This could be overcome in many ways, for example, asking or going into partnership with an organisation who already utilises ArcGIS online or grant funding. R7 revealed that grant funding exists for individuals to "develop and deliver a flood plan [and] do things such as publicity, purchasing of items to help with the delivery of the plan… [with the] start up grant being £100 and then a completion grant of £400". If the costings of developing a Story map could be weaved into this, then funding issues are overcome. This could be problematic however, as the cost of ArcGIS online might exploit the entire budget, which is unsuitable.

Thus, ArcGIS online potentially expands the pool of users who can access and utilise GIS resources needed to create and utilise Story Maps. There are however many considerations to address, to ensure individuals can access, utilise and pay for ArcGIS online, a central underpinning of Story Maps.

5.5.3: Accessibility of Story Maps

Accessibility of Story Maps is important, as individuals must access the resources to receive flood hazard and risk communication, but also those developing Story Maps, need to consider who is accessing these resources. R1 and R4 presented questions about accessibility of Story Maps, their questions being "How would we link [Story Maps] to social media?" and "How would you restrict access to them?".

In answer to question one, Story Maps, once published within an organisation or publicly, can have a hyperlink created, which is publishable on all social media types e.g. Facebook, Twitter and Instagram, thus making Story Maps shareable on social media. When R6 and R7 were questioned on whether Story Maps could be used and shared, they stated this could be easily done. R6 stated if the Story maps were linked to the investigation reports they published, the Cornwall Council website could just "host the link" and then if individuals

wanted to view the Story Map related to a specific event “then we just post them a link or have it sitting on our website”. Moreover, R7 stated “I suppose you could send it to people through email” or “put the link on a Facebook group”. Overall therefore, Story Maps are highly accessible via social media and online. They can be accessed on many internet enabled devices, if internet connection is obtainable, this includes mobile data. Accessibility issues arise however if Story Maps require updating or changing, as expressed in Section 5.5.3.

In answer to the second question, there are two sides, restricting access to modify and restricting access to view. Restricting access to modify a Story Map is easily achievable. To access a Story Map account, individuals need the username and password of that account and thus, only the individual/s with this information could change the maps and information. If the issue is restricting access to view the Story Map, this is also attainable, to an extent, by not publishing the resource in the Story Map gallery and by providing the Story Map’s hyperlink only to specific individuals. Sharing the Story Map by social media however, might present issues, as anyone who has joined a group where the resource is published could view, or share it themselves. These groups could potentially contain individuals that others might not want their data and information on their homes shared with, which could cause the issues discussed in Section 5.1.1.

Another issue, mentioned by interviewees, also must be addressed regarding accessibility and this is insufficient computer literacy and access to the internet. If individuals lack these skills or access, they cannot utilise Story Maps, halting their ability to communicate flood hazard and risk. In St Blazey, with it’s elderly population and low economic status, some interviewees believed that insufficient computer literacy could make Story Maps ineffective communication resources, which the following comments express.

> R2: Quite a lot of the people, certainly that I speak to, are elderly in Par and St Blazey. They are in a fairly low stratum socio-economically and as such, are not necessarily the type of people who would engage with this medium.
>
> R4: St Blazey does not have a high level of computer literacy, and any digital offering to help communicate on flooding will have to be approached taking this into account.

Although comments on low economic status were not refuted, there were other insights that suggested the issue of low computer literacy in St Blazey's elderly population was not so problematic. Firstly, although the researcher was informed repeatedly about elderly people and low computer literacy, the organisations these interviewees belonged still utilising IT and online methods to communicate flood hazard and risk information, contradicting their argument. For example, these organisations utilise Facebook, their own webpages, WhatsApp and online videos. Secondly, R8 states "many [St Blazey elderly] residents use Facebook and emails right, so they can use the internet, so I don't see the reason to struggle with Story Maps?". If the elderly individuals can use internet resources, such as Facebook, they have the skills required to access a Story Map, to educate themselves about flood hazard and risk.

This issue of the elderly and computer literacy is not contained within St Blazey, it is also present in the literature and is similarly debated. As already mentioned the ONS (2013) revealed, in the UK, 3.2 million individuals <75 years old have never used the internet, representing 45% of those who have never used the internet. Although the number of non-internet users is shrinking, it still presents a major issue. There are other reports however stating, since 2000, 1.5 million individuals <75 years old have used the internet to some extent and internet adoption rates in the U.S and Western Europe by over 50's has outpaced that for young adults (Kohut *et al.,* 2006). The significance therefore, of the elderly and a lack of computer literacy, is not to be ignored, potentially presenting significant issues to the use of Story Maps for flood hazard and risk communication. Many of these individuals however, can use the internet to some extent, or can gain assistance and therefore, Story Maps would still be appropriate communication methods.

As mentioned, the comments on the areas' low economic status and its effects on computer literacy were not refuted and are supported by evidence from Cornwall Council. In 2013, they stated that GDP, since 2006, has been declining, causing Cornwall's GDP per capita to reach £17,600, 65% of the UK average, which leaves Cornwall as a 'less developed area' in the European context (less than 75% of the EU average) (Cornwall Council, 2013). It is likely therefore, that St Blazey residents lack the economic resources to purchase computers or attend classes to improve computer literacy skills, due to living in

a rural area and they also have higher internet costs. This lack of economic resources thus supports the claims by interviewees on lacking computer literacy in the area. This issue would similarly apply to other areas with low economic status, presenting an issue to using Story Maps, in these communities, for flood hazard and risk communication.

The evidence above suggests Story Maps are very accessible, as they are viewable on many internet enabled devices and can be easily shared via social media, websites or emails. There are also simple ways to restrict accessibility to modify Story Maps and with careful consideration, attempts can be made to restrict individuals ability to view them, which is a very useful feature. This argument must however be balanced against the issue of limited computer literacy in some age ranges and locations, leaving many individuals unable to access Story Maps, without support. This could limit the extent to which, Story Maps, could be utilised for flood hazard and risk communication.

5.5.4: The benefits of interactivity

The Story Map platform allows for excellent interactivity with information, which aids understanding and this was apparent in this research. To provide an example of how interactivity has improved in GIS and has helped make Story Maps successful, R3 provided an anecdote. R3 commented that “10 years ago” older “paper maps” and “geoPDFs” could be created but were “very dull” methods of communication and were difficult to use. Shared geoPDF maps struggled with interactivity with individuals having “no click on the map” and therefore, “didn’t get these pop-ups with information” or “they were very basic [pop-ups]”. This contrasts with Story Maps, which have much greater interactivity, as images, maps, videos and widgets give provide users with interactive elements and contain improved interactive pop-ups.

R3 also tied together Story Maps interactivity with the field of flood hazard and risk communication. They stated that if the maps, within the Story Map, were focussed on where people lived and were interactive “the first thing they are going to do is zoom in to where they live”. It was likely, in R3’s opinion, that individuals then assess maps more thoroughly and thus “understand that risk is not the same everywhere and that there are pockets of higher risk” and learn that risk varies within an area, potentially encouraging further investigation.

The value of interactivity was reflected by residents at the Big Lunch, with 100% of them suggesting Story Map's interactivity aided their understanding of the information and made the topic fun and interesting. The extra time and attentional resources provided by the resource's interface means individuals are likely to learn more deeply about flooding and personal FRM. Students also indicated that interactivity was an important Story Map element, expressed in Table 8.

Table 8: Students responses to a question regarding the Story Maps interactivity.

Theme	Examples (with participants i.d.)	Percentage agreement
The interactivity within Story Maps is useful.	Favourite Story map "Interactive and summed up with key points" (P.2) Liked Story maps because "its interactive and you can move it (the map and interface)" (P.3) Favourite Story map: "Map interactivity was good, plus underlined text easy to follow" (P.5) Liked the "interactive part of the map" in the Story map (P.6) Favourite Story Map was "more personal having the map that is zoom-able because you can see your own house" (P.10) "I like the interactive map and how the locations of things like the flood road…could be located on the map" (P.11) "The interactive map made it easier to understand which areas were at-risk" (P.13) Liked Story Map design as "The video really showed how flooding can happen, more interactive" (P.14) Liked Story Map because "It was interactive and has an easy legend to understand" (P.17) Story Maps present "Good design with opportunity to see loads of interactive information" (P.18)	52% of participants agreed with this statement.

The importance of interactivity has been identified in various studies. Several researchers consider interactivity as essential for effective and successful self-regulated learning within web-environments (Proske *et al.,* 2007). Interactive functions can contribute to "individualisation of the learning process, flexible use of learning material and media, active construction and communication of knowledge as well as increased motivation" (Prosike *et al.,* 2007:513).

In Frailich *et al.* (2008), interactive learning approaches embedded in an interactive website, provided students with opportunities to construct their knowledge regarding chemical bonding, helping them outperform the control group. Similarly, Evans and Gibbons (2007) utilised an interactive computer-based learning system to teach undergraduates about bicycle pumps. Students using the interactive system outperformed those using a non-interactive system in problem-solving tests and needed less time to complete both problem-solving and memory tests. These results agree with ideas that interactive systems facilitate deep learning by actively engaging learners in the learning process (Evans and Gibbons, 2007).

The inbuilt interactivity within Story Maps means they could be valuable resources for communication and learning about flood hazard and risk, by facilitating individualised deep learning, which individuals are likely to remember. This will potentially ensure personal FRM and knowledge of correct procedures to follow in a flood event are completed.

5.6: Story Map design: The value of various media

Story Maps allow the combination of multiple different media and mediums for communicating information. This is crucial, as discussed in Section 2.6, as individuals have different learning styles ways and multiple means of communicating information can help keep attentional resources. This section investigates participants insights regarding the various media and mediums utilised in Story Maps.

5.6.1: Map, video and image insights

There were many insights provided by participants about the maps, videos and images utilised. Tables 9, 10 and 11 display participants opinions about various Story Map elements.

Table 9: Examples of participants opinions on the maps within Story Maps.

Theme	Examples (with participants i.d.)	Percentage agreement
Maps are useful.	"Map is pretty important in my opinion" (P.1) "Think map is better than video" (P.2) "Really like the map" (P.3.) "Map is useful and allows you to gain a visual understanding of the spread of the risk" (P.4.) "Maps interactivity is good" (P.5) "The map seems the most informative for me" (P.7) "It made it more personal having the map that is zoom-able because you can see your own home" (P.10) "I liked the interactive map and how the location of things like the flooded road in the video could be located on the map" (P.11) "The interactive map made it easier to understand which areas were are risk" (P.13) "Maps make it less boring" (P.17) "I miss the map" (P.18)	79% of participants agreed with this statement.

Table 10: Examples of participants opinions on the videos within Story Maps.

Theme	Examples (with participants i.d.)	Percentage agreement
Video are useful	"Videos are important, I'm lazy and that's easy to take in" (P.1) "Videos are always a good way to show 'on the ground impact' (P.3) "Video added an element of visuality that was more engaging that just text. Shows what flood risk is to a greater extent" (P.7) "The video really showed how flooding can happen. More interactive" (P.14)	68% of participants agreed with this statement.

Table 11: Examples of participants opinions on the images within Story Maps.

Theme	Examples (with participants i.d.)	Percentage agreement
Images are useful.	"Image not too distracting but allows viewer to put into context the issues" (P.4) "Aerial photo added a nice touch….one large image on right [side] was clear and easy to interpret" (P.5) "Images are engaging because it shows impact of flood" (P.6) "The image was pertinent" (P.7) "The aerial picture helps summarise the information best, showing impacts on households" (P.8) "Picture shows impact to homes clearly" (P.12) "The photo is emotive and makes it more empathic" (P.16)	57% of participants agreed with this statement.

The data revealed that maps were participants favourite Story Map element, reflected by residents, with 45% of them stating they were the most effective element in the design. This is likely because maps help provide the spatiality behind the discussed flood issue and offers individuals something to view and investigate, as the map was interactive. Regarding images, residents at the Big Lunch followed a similar trend to students, with 35% of them thinking they were the most effective element. Unfortunately, asserting whether residents thought videos were effective is unavailable due to an on-site complication. The remaining 15% thought a combination of resources helped make the design effective. Videos and images therefore, scored slightly lower than maps, potentially because the maps gained a large amount of the participants attentional resources. They are very valuable however, as they help to contextualise the maps, which is important in aiding individuals understanding of the maps and other associated information. This context argument was present in P.3, P.4, P.8 and P.15's answers.

> P.3: Videos are always a good way of showing 'on the ground' impact.
>
> P.4: The birds eye image of the town gives some context to the flooding.
>
> P.8: The pictures help put everything in a real context.
>
> P.15: [The video provided] an interesting overview [which] put the topic in context.

It is also potentially important to have this map and image/video 'interface' as they provide different perspectives as P.3 stated. Maps are from a bird's eye view, but images and videos change the viewpoint from bird's eye to eye level, which combined, create a full picture of the flooding situation and the information provided. Finally, images and videos both seemed to do the same job so could be utilised interchangeably, which is a useful design feature.

5.6.2: Story Maps and multisensory learning

The aforementioned result indicate how useful and important it is to utilise multiple different media and mediums to communicate information in Story Maps. Participant's also highlighted the importance of creating Story Maps with a balanced design, that did not relying heavily on one media, as this helped comprehension and created an appealing design, as Table 12 presents.

Table 12: Participants opinions on the Story Maps balanced, mixed media design format.

Theme	Examples (with participants i.d.)	Percentage agreement
Balanced, mixed media approach is useful.	Favourite Story map: "Really like the map, and I think the amount of text is good, brief but informative" (P.3) "Most engaging Story Map designs… had the video to show impacts as well as interactive maps" (P.6) "A few of these [video, images etc.], aided with providing context, but too many sources were overwhelming" (P.8) "Didn't like when there was purely text on the left without quotes, images or videos" (P.10) Favourite Story Map: "It has all three elements, clear brief bullet point text, a news video to give an interesting overview and put the topic in context and a picture of someone's house to make it personal" (P. 11) Favourite Story Map: "Good balance of text, videos and pictures" (P.12) Favourite Story Map: "Good information without too much text which can sometimes lose peoples concentration…map which clearly shows flood zones and a video to show what happens when flooding occurs". (P.14). Favourite Story Map: "Mostly visual, concise, not info heavy, most aesthetically pleasing" (P.15)	84% of participants agreed with this statement.

This need for a balanced approach was also outlined in student's comments relating to text. Students thought that the best Story Map 'slide designs' were those with limited text, in a bullet-point format, where key information was underlined or bolded. This also follows earlier arguments about individuals not wanting to read anymore. Student's responses are presented in Table 13.

Table 13: Participants comments on the text within the Story Map.

Theme	Examples (with participants i.d.)	Percentage agreement
Key text underlined, bolded or coloured was useful.	"Underlined text is better…like blue over underline now" (P.2) "I did enjoy the highlighted points on the 3rd slide" (P.3) "Underlined text easy to follow" (P.5) "Underlining on writing…was the most engaging resource" (P.6) "Highlighted/underlined text is easier to read than the others" (P.7) "Blue/bold text aids reading and helps highlight the key ideas" (P.8). "I like bullet points (although highlighted in blue is better than bold)" (P.10) "The bold blue text made the key information easy to find" (P.13)	73% of participants agreed with this statement.
Text bullet pointed was useful.	"I like the bullet points" (P.3) "Bullet pointed text easy to follow" (P.5) "I also enjoyed the bullet point format" (P.9) "Preferred bullet point text – makes it easier to read" (P.11) "Easier to read bullet points…gets main points across" (P.12)	47% of participants agreed with this statement. Others picked their favourite Story Map as one containing bulleted text.

This preference for a balanced mixed media approach, was also present in the Story Map design that participants thought was the most effective. This design incorporated a mixed media, balanced approach, with simplified, easy to read text (blue box), a video to add context and an 'eye-level' view (green box) and finally, a map to display visually how flooding affects an area (grey box). These mediums work together to create a multi-modal interaction with flood hazard and risk information. The 'best' Story map is presented in Figure 27.

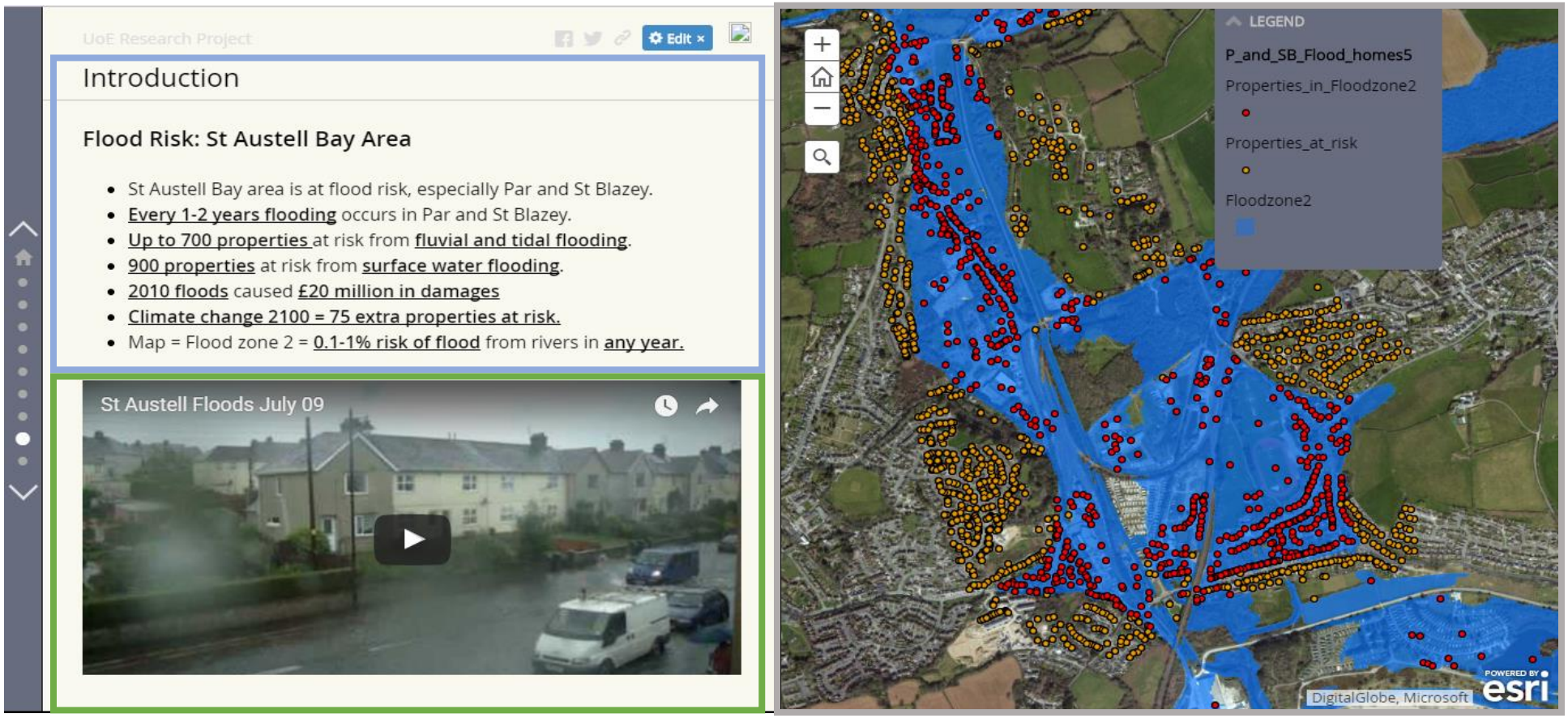

Figure 27: 'Best' Story Map design. The coloured boxes denote the various parts of the design.

This slide design falls into the category of multisensory or multi-modal teaching/learning, which has several associated benefits as expressed in Section 2.6. Thus, it could be suggested that this form of approach should be utilised more to communicate flood hazard and risk information as individuals seemed to enjoy and engage with this format.

5.7: Uses for Story Maps in flood hazard and risk communication

This section investigates interviewee's ideas about how Story Maps could be utilised in flood hazard and risk communication.

Interviewees stated that Story Maps could utilised to keep flood statistics and records of flood events. This record would include information on contemporary and past floods events, with information on flooding locations, transportation routes flooded and infrastructure affected, helping individuals to understand areas at risk. It would contain information on the towns history and changes to the town, which would help extend the audience who would view the Story Map. This approach could lead to Story Maps being a platform where the history of the area could be discussed alongside flooding, increasing flood hazard and risk knowledge for a wider audience. These ideas are expressed clearly in the following quotations.

> R1: It's an interesting way to display the information, it might be a way that from a community's perspective, it might be a way that we could display stuff after, to actually have a record of what has actually happened…It would also be useful to know the roads that are likely to flood so we know where we are expected to put the signs out.
>
> R2: If developed closely with authorities such as the Environment Agency and Cornwall Council… [Story Maps could] show infrastructure, areas vulnerable to flooding [and] pictures of when they had been flooded in the past.
>
> R7: I think it's a really good method and if you can get some people together it would be good to have it, it becomes a floor for discussion…It might also be interesting to people simply interested in the history of the place…Of course it is primarily about flooding in Par and St Blazey but there are other links there apart from flooding which are of interest.

There were also suggestions that Story Maps could be utilised as a NEETS training scheme, allowing individuals, in Cornwall and other areas, to learn valuable computer literacy skills. They could also provide skills in GIS and project management, as these individuals work towards the specific goal of making flood hazard and risk communication tools for different communities.

These skills would help these individuals get into education or the workplace and provides communities with a specific flood hazard and risk communication tool. These ideas are expressed in the following comment.

> R4: Now there is a thought, what about a training scheme, oh goodness me, could develop a training scheme that is available across Cornwall, to people, cause I mean this [St Blazey] is not the only area that floods really, but particularly for, dare I say it NEETS…where they become computer literate but also would have a part in the community.

Moreover, there was a proposal that Story Maps could support flood investigation reports, which are simple text documents that people probably do not read. R6 however, argued that they would have to serve as a "supplement rather than substitute" for conventional flood risk communication methods but could "enhance the reports". R6 also argued that flood events, without a "timeline", would be challenging to make a Story Map about, with R6 providing the example of rapid onset flooding in Falmouth and Redruth/Camborne. They suggested Story Maps would provide a "nice, simple visual approach" and would allow them to "[map] the locations where problems occurred". These ideals are presented in the following quote.

> R6: One of our [Cornwall Council's] obligations under the *Flood Water Management Ac*t is to follow up significant flood events and report on them and make that report publicly available… [A Story Map] could back them up as something the local community might find more interesting to [read] through [as they are] good for telling the story of what happened during an event.

As already mentioned, in Section 5.3.3, there was a proposition that Story Map could ensure individuals understood how their actions affected others and how upstream management could have impacts further downstream. R8 believed that people did not really understand this social responsibility for FRM. If Story Maps were utilised in this way, it might encourage people to adopt personal FRM actions, creating a platform to discuss flooding, helping the community to bond and alleviate flood risk.

> R8: Story Maps help individuals see the impact [their actions are] having [and helps] show people that they can make a difference…[whereas] if someone came and said to me, just by doing this you could make a difference to 10 properties, I couldn't visualise it. But you show me a screen (Story Map) where you can see how a bit of rainfall causes the river to swell and you can see the impact downstream…this could make a very powerful tool.

> R8: If the likes of the Environment Agency, Cornwall Council, South West Water or any other authority across the land use Story Maps to show people actually, this is the impact and direct effort of not your actions, but your lack of action if you like [this would be useful].

There are thus many uses for Story Maps, which should be investigated by those conducting flood hazard and risk communication. There are other potential uses that were not discussed by participants, which focussed more on adaptation and preparedness. Some examples are presented here.

Firstly, a Story Map could explain flood hazard and risk in a local area and present a variety of preparation and adaption methods. For example, it could guide users through completion of flood plans, could encourage them to download flood risk and prevention apps such as *"Flood Risk Finder"* or "*Flood Risk"* and/or put the flood-line number into their mobiles. It could also present the positives and negatives of various flood preparedness and adaptation methods, enabling users to make an informed decision on the methods they want to use for personal FRM.

Secondly, Story Maps could present the flooding situation to community members and could encourage them to become flood wardens. These individuals provide valuable assistance during flooding and help to spread the word about the importance of being flood aware and prepared for flooding.

Thirdly, Story Maps could be utilised as an education resource in schools, teaching children about flood risk in their community and how to mitigate against its effects. This might ensure, that from an early age, children understand flooding as an issue in their community and in the future might motivate them to conduct preparedness and adaptive behaviors. Moreover, children might inform their parents about these lessons, potentially encouraging them to consider their flood risk, prompting them to act.

Fourthly, a live Story Map which individuals can contribute to would be valuable, as this creates an interactive approach for the communication of flood hazard and risk. It helps make Story Maps active rather than static resources and allows community members to bring forth their own ideas on flood hazard and risk. It also represents the opportunity to showcase various preparedness and

adaptation methods community members are already using. This would create a knowledge sharing community, which could teach each other about flooding and allows them to share best practices for flood preparedness and adaptation. Furthermore, this interactive Story Map, could allow community members the opportunity to provide information spatially as flooding happens, helping to guide those involved in FRM and efforts to avert flooding.

Finally, Story Maps are an excellent location to provide opportunities for individuals to further investigate their local area's flood risk, alongside their own. This could be achieved by imbedding hyperlinks to interesting articles and websites, that would support their learning and understanding of their own flood risk situation, which might galvanise them to conduct flood mitigation practices.

5.8: Methodological critique and justification

Before concluding this results and discussion section, the methodology is critiqued to show that it effectively answered the RQ's but had issues, which were overcome.

One methodological issue was the use of students as research participants. These individuals were not the intended end users of the Story Map resource and thus, their insights might not be applicable to the St Blazey population that were being investigated. Further issues arise when this fact is considered alongside the difference in age between the two participant groups, with many residents in St Blazey being elderly. It is possible therefore that student's responses regarding design, might not be reflected by a more elderly population.

Similarities however, in responses between both groups that interacted with the Story Map, suggests this initial assessment might invalid. Moreover, the two research groups, were able to view the Story Map from different standpoints e.g. the students were younger than the community members, as expressed, and were more objective with their responses, as they felt no attachment to the place. These different standpoints provided a breadth of data that comprehensively answered RQ4. Furthermore, many student participants were completing Geography degrees, meaning they understood flood hazard and risk and its communication, like the community members interacted with during the Big Lunch event, although their understandings would have distinct differences.

The student participants, like the community members, were justifiably able to provide opinions on the resource's design, as it was primarily focusing of flood hazard and risk, even though the specifics were related to St Blazey.

Another methodology issue was the potential lack of community engagement during the Story Map's production, which might have presented other novel and interesting findings. Furthermore, community members could have helped guide the production of the resource, possibly increasing its effectiveness, which might have affected the results. This situation occurred due to the researcher's personal ideas and insights guiding the Story Maps' production, which limited the role community members could have during the resource's production.

This approach however, still managed to collect information that answered the RQ's effectively and helped to circumvent several issues. For example, it was likely that many community members would have wanted to become involved in the production of the Story Map and their ideas may have competed. This would have complicated the production process, delaying the researcher's ability to conduct research trials of the resource, presenting a significant issue, given the limited timescale allowed to complete the research. Secondly, the Story Map was dealing with a delicate topic specifically affecting the lives of community members. Thus, those assisting with the Story Map's production might have found this distressing and as impacts on research participants should be limited, the methodology utilised ensured this impact was minimised. Finally, some information that was utilised to produce the resource came from the STARR project. This information had to remain confidential until STARR stated otherwise. Thus, community members could not have been involved until the confidentiality period ended, which occurred late in the research process, after the Story Map was completed.

A further methodological issue is that a lack of embeddedness within the community, perhaps created issues when trying to gather research participants. This was evident during the Big Lunch event, with community members ignoring or avoiding the researcher as they were unaware of them and their work.
A greater friendliness and interaction with the community, would have potentially led to greater participant numbers and deeper, more nuanced insights into the Story Map resource and the flood hazard and risk situation in St Blazey. This approach could possibly have created opportunities to interview community members, which would have provided bottom-up viewpoints on the

research topic. These would have been compared with the top-down viewpoints collected from community leaders in St Blazey and those involved in flood hazard and risk communication.

Becoming embedded in a community is complicated however, especially within a short timeframe. Communities are often suspicious of outsiders and the building of trust takes time. The problem is further compounded if the community is being researched and understand this, as they are worried about how their data will be utilised and the researcher's motives, amongst other concerns. Thus, with more time, greater embeddedness would have been attainable, but for the scope of this study, it was adequate.

A final methodological issue was potentially a lack of participants. Although the combined methodology collected results from over 47 participants, gathering further participants could have been valuable, as many insights and opinions might have been missed. This is linked to the previous critique and would have been helped by the researcher becoming more embedded in the community. This could have presented more opportunities to discuss research with community members and opportunities to conduct research on different sectors of that community.

The in-depth interaction with participants however, potentially circumvents the need for more participants as the participants provided many ideas and insights, which were more than able to answer the RQ's. Also, as depth of understanding is more important the sample size, within qualitative work, this study's detailed examination of participants was appropriate and possibly circumvented the need for more participants, who might have not present any different insights.

5.9: Results and Discussion Conclusion

This section has investigated four broad themes, these are; communication considerations and current practices for flood hazard and risk, behavioural responses to this form of communication, the abilities of Story Maps and the role of design. It has also investigated potential uses for Story Maps and provided a critique of the methodology. The following section provides an overview of the conclusions and recommended practices for the use of Story Maps within flood hazard and risk communication.

6.0: Conclusions and Recommendations

In this concluding section, this study's insights will be related to the four research questions. There are many other points that could be considered when using Story Maps for flood hazard and risk communication, but this conclusion focusses on the evidence presented by participants. Once this is completed, a review of whether Story Maps show the potential to be useful flood hazard and risk communication resources will be discussed. Following this, a short statement will be presented about how this research has contributed to wider ideas. Finally, this section addresses further research that could be undertaken, before providing some concluding remarks.

6.1: Conclusions from RQ1

RQ1 attempted to answer what the current issues were within St Blazey and to wider extent Cornwall, in terms of flood hazard and risk and its communication. The issues were mostly identified through interviewee's responses and were also pervasive within the literature. These included:

1) The need for delicacy in flood hazard and risk communication. This is required as residents/homeowners feel this information can stop them from gaining insurance or their premiums would increase. This is alongside other fears such as, property price devaluation or the loss of home sales.

2) The continual use and misunderstanding of the 1 in 100-year concept.

3) That a reactionary, rather than proactive approach, is still intensely utilised when considering responses to flood hazard and risk and its communication. This links with issues of responsibility, which have many facets including: people's lacking desire to conduct proactive personal FRM and their lack of understanding about social responsibility.

4) An array of behavioural issues including denial and complacency when people are confronted with flood hazard and risk and its communication.

As these issues were all highlighted in the literature, it suggests flood hazard and risk management is still a complicated activity to complete effectively.

It is vital important therefore, to continue efforts to identify novel ideas and ways of conducting flood management and communication to resolve these problems. The introduction of Story Maps into flood hazard and risk communication could thus be a useful resource to trial, to alleviate these issues.

6.2: Conclusions from RQ2

Having addressed the issues present in St Blazey and to a wider extent Cornwall, this section discusses the considerations to make when creating a flood hazard and risk communication Story Map, so it avoids or overcomes the issues above-mentioned. These consideration points are:

1) Be conscious of the delicacy of communicating flood hazard and risk and pay attention to the information being provided. It might also be important to consider how to restrict access to this information, so it is only provided to relevant audiences. As Story Maps utilise ArcGIS, it is vital to communicate that any flood risk maps within them present a 'guide' to flood risk. Awareness of these issues should help avoid unsavoury behaviour.

2) Avoid the 1 in 100-year concept, as individuals are confused by its meaning. Also explain any technical language utilised so individuals understand the information. Videos and images can be utilised in the Story Map resource to present this form of information more effectively. This could involve including instructional videos on key terms or utilising accessible graphics to explain important ideas. Alternatively, using a discussion format where individuals can ask for key terms to be defined or fears to be addressed, is also encouraged.

3) Story Maps should attempt to provide proactive communication. This involves presenting information regularly, that discusses why individuals must conduct proactive FRM actions, alongside the structural and non-structural solutions open to them. This could be achieved by providing useful links to non-structural solutions and by presenting maps and recommendations on the best structural solutions and where to purchase them. Other ideas, within this bracket, were presented in Section 5.7.

4) Be mindful of the potential behavioural responses to using Story Maps for flood hazard and risk communication and attempt to help individuals understand why they must listen to and act upon information provided. The researcher found that when Story Maps were presented in a dialogue format, individuals could easily understand the information and could discuss any issues, misunderstandings or fears they had, which the researcher could then address.

By following these consideration points, flood hazard and risk communication, using Story Maps, can avoid some its conventional problems. Some of these issues could also be addressed through their innovative design and use in novel ways.

6.3: Conclusions from RQ3

Having investigated how Story Maps might help alleviate some of the study area's issues, this section presents the advantages and limitations of Story Maps before addressing how interviewees thought they could be utilised for flood hazard and risk communication.

1) Story Maps potentially suffer from a longevity issue, due to individuals unwillingness to take responsibility for them. Longevity is more likely for a 'finished' Story Map, rather than the preferred 'living document' ideals. This is due to the extra time, effort, energy and skill required for the latter, which will likely dissuade people from wanting to take responsibility, leading to its disuse. It is thus, important to carefully consider who is responsible for a Story Map and to complete succession planning.

2) Story Maps have an in-built, context aware approach, which, if utilised alongside the resources functionality, can present information when required, limiting information overload, potentially leading to better retention.

3) ArcGIS online presents the opportunity for increasing numbers of individuals to utilise Story Maps and online mapping, for many purposes, including flood hazard and risk communication.

   There are however drawbacks that must be considered including;

   - Story Maps require a paid subscription to ArcGIS online.
   - Updating and editing Story Map content requires a computer with internet access, making these resources difficult to use in the field.
   - ArcGIS must be learnt to fully utilise Story Maps, which is challenging.

4) Story Maps are very accessible internet resources, shareable via emails, social media and through links imbedded into webpages. This is important as many people obtain information online, so Story Maps seem perfectly placed to engage individuals with flood hazard and risk information.

   There are however two issues to be aware of:

   - Although shrinking, there are still individuals who cannot access Story Maps due to a lack of computer literacy, for several reasons, including: age, economic resources, excessive internet costs and location. It is thus vital that other communication is provided alongside Story Maps, so all individuals receive flood hazard and risk information.
   - It is necessary to consider who has access to view a Story Map and develop it. This is because of the perceived delicate nature of flood hazard and risk information and will help avoid backlash against a Story Map.

5) Story Maps interactive, streamlined and easy interface means they are much better than conventional attempts to utilise GIS to communicate information. They allow GIS information, e.g. flood maps/ flood hazard and risk information, to be more easily understood and interacted with, potentially increasing retention.

Story Maps therefore, should be utilised further, as they present the opportunity for previously difficult GIS information to be more effectively utilised to educate individuals.

Thus, Story Maps have various benefits and limitations that must be addressed when deciding whether to utilise them for flood hazard and risk communication and whilst utilising them.

There were also a variety of potential uses for Story Maps, within flood hazard and risk communication, expressed by interviewees and these are presented below. This list is not exhaustive however, and utilising Story Maps in other interesting and novel ways has been addressed in Section 5.7 and should be encouraged. Some Story Map uses include:

1) A recording system to keep contemporary and past flooding material. This could include data on areas at risk, including infrastructure and transport routes. If combined with a town's historical information, a wider audience could be engaged.

2) Develop Story Maps into a NEETS training scheme to help improve their computer literacy and other skills, enabling them to access work or education. If these schemes involved the development of Story Maps for flood hazard and risk communication, it creates a double benefit.

3) A supplement to flood investigation reports, which are asked for by the government. They could present an engaging visual tool to help people understand flood events, as currently, these reports are solid text, which might discourage people from viewing them.

4) To help individuals understand how their actions affect their community and to encourage upstream thinking about flood risk. This could help individuals understand their 'social responsibility' to complete personal FRM, helping create a community bond around combatting flood risk.

This section has presented the advantages and limitations of Story Maps, alongside their potential uses, as identified from participants comments.

6.4: Conclusions from RQ4

Having presented the advantages and limitations of Story Maps and their potential uses, this section addresses how various Story Map elements aid individual's understandings and some design preferences provided by participants, these are presented below:

1) Bullet-pointed text, with highlighted key terms, assists with reading and understanding. This approach is required as people have limited attentional resources. Thus, overuse of written information is likely to discourage users from interacting with a Story Map.

2) Images and videos help to provide context to the flooding issue. They can be utilised interchangeably and when utilised alongside maps, help to change the viewpoint, which aids in creating a rounded picture of flooding and its risks.

3) Maps are very useful and highly regarded by users. They support their understanding of flooding issues spatially and allow them to interact with the Story Map resource. This is likely to improve retention of information.

4) As previously mentioned, Story Maps' in-built interactivity is very important and enables individuals to engage with the resource, thus it should be fully utilised. For example, asking those at risk to identify their homes and level of risk could be a useful engagement exercise.

5) Using a balanced mixed media approach, to communicate flood hazard and risk information is important and helps alleviate information overload. It also potentially supports multi-sensory learning, which has associated benefits, as already explained.

This section has presented evidence to address the final research question. It seems appropriate therefore, to compile this evidence into an assessment of whether Story Maps have the potential to be useful flood hazard and risk communication resources.

6.5: Do Story Maps have the potential to be useful flood hazard and risk communication resources?

The evidence collected presents a case that Story Maps could be useful flood hazard and risk communication resources, but careful considerations must be made, in light of, the advantages and disadvantages of creating these resources and utilising them. Weight is added to the case for their usefulness when investigating the behaviours towards the Story Maps. Many interviewees commented on how interesting the resources were and how they could see it being valuable in their local area. When the Story Map about St Blazey flooding and its risks was presented to the community, similar positive comments were gathered. Participants actively engaged with the resource and a dialogue about flooding and its risks was attained. Similarly, participant's investigating the Story Map's design commented on how effectively the many elements interlinked to create a resource that seemed effective at conveying information. One participant even stated they thought 'Story Maps were much better than old paper maps'. It therefore, seems appropriate that further Story Maps are created on flood hazard and risk, as they appear to be useful communication resource and further evidence can be gathered on their impact.

To thoroughly investigate this question, it seems appropriate to ask where in the disaster risk reduction cycle these resources could be the most useful. Story Maps seem useful before and after flood events, but their use during the event is debatable.

Before an event, Story Maps can help individuals understand what a flood is, it causes, where there is flood risk, the terms used to discuss flooding and FRM solutions. Furthermore, Story Maps can provide information about what individuals must do during a flood and offers a space where key contact information can be placed. After an event, they can be an effective resource to inform the council/country which areas exactly have been flooded. They can also be reutilised in future flood events as a 'memory' or 'storage' bank to assist flood wardens and emergency planners in deciding where to focus their efforts. These resources can also ensure individuals remember their flood risk, by aiding recollection of flood memories.

During an event, however, there is potentially too much information being received, thus, processing and updating a Story Map might be challenging. Furthermore, for those dealing with flooding, Story Maps present an added

difficult to an already challenging situation, as they would have to constantly check the Story Map via the internet, to plan or receive their next steps. This is where other technologies such as phone calls, Twitter, Facebook and WhatsApp can contribute to help co-ordinate individuals, ensuring that flooding is dealt with effectively. Moreover, during a flood event, to rely only on a Story Map containing all important information, would be problematic, as power outages or lack of internet connectivity, means individuals cannot always access this information. Thus, other offline solutions for individuals to access information, if these issues occur, are required. These offline solutions can ease and speed of communication, as searching through a Story Map could cost vital time.

Story Maps thus do not represent a 'silver-bullet solution', as one participant suggested, but are still useful. They should be fitted into the methods already utilised for flood hazard and risk communication.

6.7: Contribution to the wider literature

In a wider sense, this research project has contributed to the literature by inspiring those involved in flood hazard and risk communication to consider how psychology can aid in providing better communication. It encourages these individuals to think of the influence cognitive models have on how people understand information and how communication can become more multi-sensory. It also re-evaluates communication as an educational practice where the communicator acts as a teacher, educating others on flood hazard and risk and allows for understandings from pedagogy to be intertwined with current thinking. It also presents a compelling case for utilising new mediums for communication and to continue to embrace online means as a communication method. Finally, this research project has provided a deeper understanding of Story Maps as communication resources by providing a greater understanding of their benefits but also critiquing them for their limitations. Furthermore, through investigating Story Maps as communication resources, there has been exposure of some of the issues that continuous plague flood hazard and risk communication.

6.8: Further Study

There are a few areas in which this research could be taken further. Firstly, if a more psychological approach was selected, an eye-tracking methodology could be employed. This methodology allows for eye movements and the trail of user's gaze to be recorded, revealing how attention and other cognitive processes are deployed (Nielsen and Pernice, 2010 and Mele and Federici, 2012 and Duchowski, 2007). This methodology would serve two purposes. Firstly, in terms of web-usability, it would reveal visibility, meaningfulness and placement of specific interface elements informing effective design of Story Maps for flood hazard and risk communication (Nielsen and Pernice, 2010). Secondly, eye-tracking helps reveal how attentional resources are deployed and begins to provide insights into the cognitive processes happening, for example, reading and scanning of a Story Map (Lorigo *et al.,* 2008, Bojko, 2006 and Mele and Federici, 2012). This is important as it can reveal if individuals are deploying attentional resources to learn, understand and engage with the Story Map. Furthermore, it could reveal the steps individuals complete when viewing a Story Map, which helps unveil exactly how individuals process them and could help inform Story Map design.

It would also be interesting to investigate whether Story Maps are useful for other natural hazards, besides flooding and whether they can be effectively applied to other regions, locally or globally. Where research is present, it is focussed around flooding, leaving all other natural hazards unexplored and this gap is important to fill. Furthermore, the usefulness of Story Maps could be affected by the type of natural hazard that is being communicated, but at present this is unknown. It is therefore, recommended that further study is completed on Story Maps to address these gaps and to investigate their usefulness further, in regard to, different natural hazard topics, different situations and with different communities.

Furthermore, research in this area should focus on further embedding the "research community" within the research process. Greater embeddedness could be accomplished by conducting community discussion sessions. In these session, community members could present the researcher with a more detailed understanding of the specifics, regarding flooding and how it should be communicated, guiding the Story Map production.

Moreover, interested parties could be presented with a workshop that shows how the Story Map has been produced, which would help them better understand the process and could reveal interesting insights. Moreover, online discussion groups on social media e.g. Facebook, Twitter, could be created to showcase the resource's progression, offering community members the opportunity to present ideas and changes to the researcher. This would help guide the resource's development, provides a space where the community can discuss the issue of flood hazard and risk, which might help them bond around the issue. By further embedding the community in the research process, novel and intriguing findings could be discovered. These insight would help to extend upon those presented in this dissertation and is a recommendation for further research in the area.

This research therefore, concludes that Story Maps present the opportunity to be useful flood hazard and risk communication tools and their use and research should be extended.

7.0 Appendices

Appendix 1:

Question 1:	*What is your job or position and what does this job entail for you?*
Question 2:	*What current methods are in use for people to understand flooding in their local area and how do you visualise the flood issue for those individuals?*
Question 3:	*How do you present flooding information to individuals and how does your outreach work?*
Question 4:	*What are the issues your organisation/yourself face when trying to communicate information regarding flooding?*
Question 5:	*Did you enjoy viewing the Story map and what made it appealing and interesting? What didn't you like about it?*
Question 6:	*Do you and how do you think Story maps could be used within your organisation?*
Question 7:	*Do you think Story maps are an appropriate method for communicating information surrounding flood hazard and risk and why?*
Question 8:	*Does the Story map present a different method for communicating flood risk and how does it compare to traditional methods e.g. is it a supplement, improvement etc?*
Question 9:	*Do you think Story maps could be effectively deployed to a wider community and how would this be accomplished?*
Question 10:	*Do you think Story maps could be used in an outreach/educational setting in terms of flooding and how might you use the tool in this sense?*
Question 11:	*Did you find the Story map easy to use and do you think others will to?*
Question 12:	*Would you be comfortable with some training to be able to create a Story map?*
Question 13:	*Do you think a Story maps present an improvement on some conventional means of flood risk communication e.g. leaflets?*

Appendix 2:

1) What is your age?

2) What is your Gender?

3) Which of the first three designs did you like the most and why?

4) Which of the next three designs did you like the most and why?

5) Which of the final three designs did you like the most and why?

6) Which one was your overall favourite and why?

7) Which design was the most clear and easy to understand and why?

8) Did the use of local's quotes, images and videos help keep your focus on the Story map and aid your understanding of the content, or did it confuse and complicate the message?

9) What did you like about the Story map and was there anything you didn't like?

10) Any further comments?

Appendix 3:

Questions on Story Map elements	Positive response	Neutral response	Negative response	Comment
Was the colour scheme effective?				
Was the language appropriate and easy to understand?				
Did the resource draw your attention?				
Was the resource easy to use?				
Would you recommend the resource to others?				
Did you learn anything from the resource?				
Did the resources interactivity make it:	Fun?	Interesting?	Easier to understand?	
Which Story Map element was the most interesting/engaging?	Maps	Images	Videos	Text

There must be loads of things that crossed your mind whilst I was showing you the Story Map that I haven't asked you about. Can you give me any other opinions or advice for the development of this resource?....

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