Public attitudes towards flooding and property level flood protection (PLFP) uptake

Seth Owusu

Submitted for the degree of Doctor of Philosophy

Heriot-Watt University

School of Energy, Geoscience, Infrastructure and Society (EGIS)

November 2014

Abstract

The number of residential properties at risk from flooding is predicted to rise as a result of the impacts of both climate change and increasing urbanisation. The flooding of residential properties comes with various impacts ranging from significant financial costs to less tangible social impacts, which are often lasting and of greater concern to flood victims. At the same time, it is now clear that large scale flood defence schemes are not always favourable due to their high cost, and there is an increasing onus on property owners to protect their own properties. The research reported here therefore aimed to investigate public attitudes towards flooding and property level flood protection (PLFP), and their willingness to pay (WTP) for such measures to reduce their exposure to flooding.

This research employs different methods. An extensive stakeholder consultation in the form of questionnaire survey and focus group activities were used to collect primary data on flood experience and PLFP. Financial analysis of varying packages of PLFP products was carried out to assess the cost and benefit of using resistance and resilience products. Finally, a consultation with institutional flood risk management (FRM) stakeholders was undertaken to help contribute to the evidence needed to improve the uptake of PLFP measures.

The stakeholder survey finding has highlighted significant financial impacts of household level flooding similar to previous studies, and suggests that flood education campaigns have been effective in raising the awareness and uptake of PLFP products. Again the findings have shown that more people are willing to contribute towards the cost of protecting their properties in order to reduce flood impacts, which appears to be at odds with past studies. The mean total WTP was £795, and was strongly linked with a number of factors including the scale of flood impacts and household income. In addition, the benefit cost ratios (BCR) of various PLFP products indicate that such measures are generally cost beneficial, and the manual resistance products in particular have higher (BCR>5) returns. Further analysis of models of incentivised PLFP scheme has demonstrated material benefit for both small scale and national level schemes, and signifies an opportunity to invest in a large scale PLFP projects. These findings are key and will provide valuable information needed to guide the development of strategies to encourage the uptake of PLFP products and improve community flood resilience.

Acknowledgement

The author would like to express his inordinate appreciation to some key individuals who have made some form of contribution to the success of this project, right from the inception to the writing up stage. I am indebted to my supervisors: Dr. Grant Wright and Dr. Scott Arthur for their excellent supervision, continuous encouragement, guidance and support throughout the years of this research. I also acknowledge the opportunity I was given to run laboratory tutorials and public engagement activities, under the auspices of my supervisors.

Professor Garry Pender and Dr. Gina Netto were also influential in my study, by providing useful information particularly in the data collection stage of my project. I am also thankful for the assistance I had from Conor Price and the Scottish Borders Council, for providing data for my research. The author would like to thank the members of public who participated in the consultation phase of this study, and Stuart Prodger from the Scottish Environment Protection Agency and Paul Hendy from the Scottish Flood Forum for their help in publicising the research. Many thanks to Councillor Stuart Marshall for his assistance in organising the Hawick flood group to contribute to this research.

I would also like to thank individuals from the Scottish Government and Scottish Environment Protection Agency who were consulted on various issues of the research, particularly Debi Garft who was very instrumental in providing views on the role of property flood protection in the national flood risk management strategy.

Without the financial support from the School of Energy, Geoscience, Infrastructure and Society (EGIS), Heriot Watt University, this project would not have gone ahead. I am thankful to the entire EGIS management board for awarding me the prestigious James Watt Scholarship, thereby giving me the opportunity to pursue this research.

Special thanks to my family, particularly my lovely wife Kyerewaa, and our son Jeshurun, for their support and sacrifices. I cannot forget my pastor, Dr. J. K. Baisie, for standing by me throughout these years. Most importantly, I would like to thank the Almighty God for all His provision and for bringing me this far; I am forever grateful.

ACADEMIC REGISTRY
Research Thesis Submission

Name:	Seth Owusu		
School/PGI:	School of Energy, Geoscience, Infrastructure and Society (EGIS)		
Version: *(i.e. First, Resubmission, Final)*	Final	Degree Sought (Award **and** Subject area)	PhD Civil Engineering (Water Management)

Declaration

In accordance with the appropriate regulations I hereby submit my thesis and I declare that:

1) the thesis embodies the results of my own work and has been composed by myself
2) where appropriate, I have made acknowledgement of the work of others and have made reference to work carried out in collaboration with other persons
3) the thesis is the correct version of the thesis for submission and is the same version as any electronic versions submitted*.
4) my thesis for the award referred to, deposited in the Heriot-Watt University Library, should be made available for loan or photocopying and be available via the Institutional Repository, subject to such conditions as the Librarian may require
5) I understand that as a student of the University I am required to abide by the Regulations of the University and to conform to its discipline.

* *Please note that it is the responsibility of the candidate to ensure that the correct version of the thesis is submitted.*

Signature of Candidate:		Date:	27/11/2014

Submission

Submitted By *(name in capitals)*:	SETH OWUSU
Signature of Individual Submitting:	
Date Submitted:	

For Completion in the Student Service Centre (SSC)

Received in the SSC by *(name in capitals)*:			
Method of Submission *(Handed in to SSC; posted through internal/external mail)*:			
E-thesis Submitted (mandatory for final theses)			
Signature:		Date:	

Table of Contents

Lists of Tables

Lists of Figures

Lists of Abbreviations

AAD	Annual Average Damage
ABI	Association of British Insurers
AEP	Annual Exceedance Probability
BCR	Benefit Cost Ratio
CBA	Cost Benefit Analysis
CEC	City of Edinburgh Council
CM	Choice Modelling
CRED	Centre for Research for Epidemiology of Disasters
CV	Contingent Valuation
DEFRA	Department of Food and Rural Agriculture
DT	Dundee Tables
EA	Environment Agency
EU	European Union
FHRC	Flood Hazard Research Centre
FRM	Flood Risk Management
K	Thousand (£1,000)
LA	Local Authority
MCM	Multi Coloured Manual
NFF	National Flood Forum
NFRA	National Flood Risk Assessment
NPV	Net Present Value
PLFP	Property Level Flood Protection
RT	Return Period
SBC	Scottish Border Council
SEPA	Scottish Environment Protection Agency
SFF	Scottish Flood Forum
SG	Scottish Government
SoP	Statement of Principle
UK	United Kingdom
WAAD	Weighted Annual Average Damage
WTP	Willingness to Pay

Chapter 1: Introduction

1.1 Background

Floods remain the most frequent natural hazard, and the global economic damages associated with flooding are increasingly significant. In 2007 alone, almost 200 major floods were reported throughout the world which resulted in over 8,000 fatalities and the incurred costs were over £40 billion in direct financial damages (Pitt, 2008). Although in Europe, flood deaths have not been as high as is often the case in Asia, the economic damages are significant; the insured losses of flooding in Europe between 1998 and 2002 were almost €25 billion (EEA, 2003). In the UK, over 5.5 million properties and 2.4 million people are at risk of flooding, and current annual average damages are estimated to be more than £1 billion (Evans et al., 2004; ASC, 2012). Moreover, climate change and the urbanisation of our societies are increasing the risk of flooding (POST, 2007b; Houston et al., 2011). In particular, there now appears to be clear evidence that climate change will lead to an increase in the frequency and severity of extreme precipitation and other extreme weather events (IPCC, 2007); for the UK this may well result in wetter and stormier winters (UKCIP, 2009). As such, it is predicted that the risk of fluvial and coastal flooding will at least double by the 2080s, and that annual average damages will soar to some £27 billion (Evans et al., 2004; Ramsbottom et al., 2012).

In addition, urbanisation poses a major challenge as this further increases the growing risk of urban flooding. Whilst around 50% of the world's current population is said to live in urban areas, it is predicted that about 70% of the global population will live in the urban areas by 2050 (UN-HABITAT, 2010). Moreover, within Europe, the situation is worse given that three quarters of Germans, Dutch and Britons live in urban areas. What this means is that flood impacts could become higher given the traditionally higher concentration of population and assets found in the urban environment (UNICEF, 2012; Jha et al., 2012). Furthermore, urbanisation and climate change will affect the natural water cycle, resulting in more surface runoff and reduced infiltration which is compounded by the increasing proportion of impermeable urban surfaces. These factors pose further threats of flooding, and urbanisation in particular is predicted to have a far more significant effect on pluvial flooding than climate change given the rate of urban growth (Houston et al., 2011).

On a more local level, the direct financial damages related to the flooding of residential properties can be significant. Figure 1.1 shows the scale of flood impact on building (a) and household contents (b) from recent incidents in Scotland. Depending on the floodwater depth, it is estimated that the costs of flooding can be between £10-50k for a single residential property and its contents (Bowker, 2007). For example, insurance claims of the widespread 2007 floods in England ranged from £23-30k for flooded household (Environment Agency, 2010). Additionally, flooding at the household level can result in less direct, insurance-related impacts, with premiums and flood-related excesses typically increasing following a flood event (Ball et al., 2012). Flood excesses of £10,000 are relatively common for UK households who have experienced repeated flooding, and such households have often had difficulty in getting insurance cover afterwards (Werritty et al., 2007; O'Neil et al., 2012).

(a) Building fabric damaged in Fife floods in 2012 (© Gall, 2012 – Daily Record website)

(b) Household content damaged in Stonehaven floods in 2012 (© Cruden, 2012 – STV website).

Figure 1.1: Flood damage from household level flooding

Existing problems could well be exacerbated in the near future due to the dynamism of the flood insurance market. Generally, flood insurance plays a critical role in compensating for flood losses, but flood policies have changed over the years and it is difficult to predict what the flood insurance market will be like in future. For example, in the USA, flood cover is provided by the National Flood Insurance Programme (NFIP), and largely subsidised by federal government for properties who are part of defined flood risk zones, known as Special Flood Hazards Areas (SFHA) (Swiss Re, 2012). In Germany, flood insurance is provided by private companies as supplementary to standard building and contents insurance. Perhaps because homeowners are not obliged to participate in the arrangement, the market penetration has been very low. This has called for the state's intervention in paying huge reimbursement for flood losses, particularly in the 2002 floods (Thieken et al., 2006). On the contrary, the UK has traditionally provided flood insurance cover as a standard feature of household insurance policies through the Statement of Principles (SoP) which is an arrangement between the Association of British Insurers (ABI) and the UK Government (Crichton, 2005). This approach has been purely market-based, in that neither local nor national governments subsidise flood premiums, but instead, the SoP has ensured that flood insurance for properties in flood prone areas are essentially cross-subsidised by those in low risk areas, as the key element of the agreement is to make flood insurance cover available and affordable (ABI, 2011a). However, this agreement expired in July 2013 but will continue to run until 2015 when a new replacement scheme the Flood Re takes effect. Failure to replace the SoP with a more sustainable scheme could have led to insurance premiums and excesses increasing towards the true market price (Ball et al., 2012; DEFRA, 2013). This may make more properties essentially uninsurable and across the UK, the current estimate of the number of such properties is 200,000 (ABI, 2012; O'Neil and O'Neil, 2012).

In addition to financial costs, flooding also has other less tangible and often longer lasting "social" impacts (e.g. the stress of the flood event, worry about future floods). Although little emphasis has historically been put on such impacts, presumably due to a general focus on direct financial impacts and difficulties in quantifying less tangible impacts, previous research suggests that social impacts are of great significance to flood victims (RPA, 2004; Tunstall et al., 2006; Werritty et al., 2007), with survey respondents often "scoring" such impacts higher than the direct financial impacts of flooding.

Furthermore, flood management strategies have largely concentrated on traditional large scale structural measures. Large scale flood defences can be effective in reducing widespread flood risk; however, such developments are costly, both in terms of time and financial resources (Pitt, 2008; Jha et al., 2012). Consequently, cost benefit analysis does not always yield a favourable result for large scale defence schemes, and the extensive flooding that has occurred within the UK has strengthened calls for greater use of property level flood protection (PLFP) measures (Pitt, 2008). Such measures are often temporary, demountable, and simple to install (Wingfield et al., 2005), and are generally classified as either resistance or resilience measures (DEFRA, 2008). Typical examples of flood resistant products are shown in Figure 1.2, and they include airbrick covers, door guards and demountable flood barriers. Resistance products either totally prevent floodwater from getting into a property, or "buy time" for the householder to move valuable possessions to safety, while resilience measures are those with the ability to minimise flood damages when floodwater actually enters a property (Wingfield et al., 2005; Joseph et al., 2011).

(a) Door barrier (© Floodgate product)

(b) Community demountable barrier at Bewdley (© EA)

(c) Non-return valve for sewage (© Flood Ark product)

(d) Airbrick covers (© Aquobex product)

Figure 1.2: Flood resistance and resilience measures

Significant benefits have been associated with the use of resistance and resilience flood products. Whilst floods cannot be stopped completely, using flood protection products helps to minimise internal flood incidences, and consequently can reduce both the financial loss and social impacts of floods. Previous assessments of flood protection products based on limited studies have shown that they can be cost effective, and when used appropriately they can reduce the insurance claims costs by 50-80% (ABI, 2006; Thurston et al., 2008). In addition, a recent study of a PLFP project undertaken by DEFRA suggests a benefit cost ratio of 5 to 1; this implies that for every £1 spent, £5 of benefits can be achieved (JBA, 2012a). Although these findings provide useful insights of the benefits of PLFP, there is limited study on the financial incentivisation for PLFP and how to improve greater uptake to help reduce flood impacts.

The problems associated with increased future flood risk, coupled with a lack of resources to fund the construction of large scale flood defence systems and potential changes to flood insurance cover, are likely to shift the onus of flood protection even more onto individual property owners. However, the uptake of PFLP measures in residential properties remains stubbornly low (DEFRA, 2008), with one study finding that only 16% of households and 32% of SMEs in areas of significant flood risk have taken practical steps to reduce their exposure to flood damage (Thurston et al., 2008). Common reasons for the low uptake of PLFP include underestimation of flood risk, a lack of understanding about flood protection responsibilities, concerns over the costs and aesthetics of such measures, and also the lack of perceived benefit of insurance premiums (Werritty et al., 2007; Thurston et al., 2008; ABI, 2011b). Moreover, the low level of awareness of PLFP products has been a major obstacle to their increased use, and it is commonly accepted that many property owners are unaware of the options, benefits and costs of such measures (DEFRA, 2008; Thurston et al., 2008).

1.2 Research Aim

It is expected that climate change and urbanisation of our societies will increase the risk of flooding of residential properties. This will result in greater demand for sustainable flood management strategies at the household level, including the adoption of PLFP measures. In view of this, the study will investigate PLFP measures and financial incentivisation for such schemes to help improve uptake and mitigate flood impacts. The main aim of the research is to gain a better understanding of public perception of flood risk in general and PLFP in particular, and hence contribute to the evidence base needed to inform the effective promotion of PLFP products to increase community flood resilience.

1.3 Research Objectives

In order to achieve the project aim, the following clearly defined objectives were set out:

- Undertake an extensive literature review on flood risk and impacts, and flood risk management approaches with particular emphasis on PLFP and the benefits.

- Develop a flood database of significant floods within Scotland to serve as a benchmark for the selection of case studies.
- Assess household attitudes towards flooding and PLFP products, and their willingness to pay (WTP) for such measures.
- Assess the costs and benefits associated with a range of PLFP packages, using a case study area in Scotland.
- Undertake institutional stakeholder consultation on PLFP strategy.
- Draw relevant conclusions from the research, to inform decision makers in promoting the uptake of PLFP products.
- Disseminate the research outcome.

1.4 Outline of Research Methods

In order to achieve the specific objectives of the research, the following approach, combining five key activities have been employed in the research:

- Literature review to understand the problem of flood risk and its impacts as a result of climate change and urbanisation challenge, and to explore the available evidence relating to the use of PLFP measures.
- Development of a flood database within Scotland to help determine appropriate case study areas for the research.
- Stakeholder consultations in the form of questionnaire surveys and focus groups to investigate public attitudes towards flooding and PLFP measures.
- Financial analysis to assess the relative benefits associated with the use of varying degrees of PLFP measures.
- Semi-structured interviews with institutional flood risk management stakeholders to provide guidance on PLFP uptake.

1.5 Justification of the Research

There is a growing need for further research into the use of PLFP, because climate change and urbanisation of our societies is expected to increase the severity and frequency of flooding. This means that more residential properties will be exposed to flood risk and hence vulnerable to the social impacts and financial losses associated with household flooding. In addition, it is now clear that a significant number of properties in high flood risk areas could face difficulty obtaining insurance cover, and the dynamism of the insurance market means that future flood insurance could be competitive and risk-reflective and could worsen existing problems (O'Neil and O'Neil, 2012). Moreover, the dependency on large scale structural flood defences which are often 'hard' engineering solutions may not be adequate as such measures are not always economically feasible and hence cannot be used in all situations (Pitt, 2008).

Recent initiatives, including the DEFRA consultation on the use of PLFP, indicate these measures are now being considered in a similar light to large scale structural flood defences in terms of government funding (DEFRA, 2008; DEFRA, 2011). The Scottish Government (SG) also identifies the role of PLFP as part of its flood management plans, and seeks to encourage people to take proactive measures to protect themselves (Scottish Government, 2011). In view of this, there is the need to better understand the costs benefits of PLFP measures and the economic impact of incentivised schemes, which will help provide the evidence needed to guide the development of strategies to promote such alternative solutions to help minimise flood impacts.

1.6 Delimitation of the Research

The proposed project focuses primarily on residential properties and does not include commercial properties; the motivation for taking up PLFP measures could be far different from that of individual residential owners. Also, the stakeholder consultation will involve mainly the general public and key institutional stakeholders who play important roles in flood management in Scotland, namely the SG and SEPA (Scottish Environment Protection Agency). In addition, the questionnaire surveys and focus groups will be limited to appropriate case study areas given time and resource availability. Nonetheless, the research outcome is envisaged to be beneficial to various flood management authorities, and the wider community who will gain improved knowledge in the field.

1.7 Anticipated Research Impact

It is expected that the findings from the research, including the outcome of the stakeholder surveys and the financial analysis of PLFP scheme will have key implications in several areas. The cost benefit analysis of PLFP measures will inform government policy towards the funding and promotion of such alternative schemes, particularly incentivised projects which usually have greater uptake. In addition, the research will provide useful information that will enable local authorities and the public to assess the costs and benefits of PLFP options, which will guide them in their implementation of local flood risk management plans under the Flood Risk Management (Scotland) Act 2009.

Moreover, the outcome of the research which will be publicised should help transform the public perception about the use of PLFP measures as they will be better informed about the benefits of such products. By this, the institutional flood risk management community will be in a better position to fulfil their statutory duties to reduce flood risk, the insurance industry should see their financial risks decrease and the product manufacturers should benefit from an improved understanding of their marketplace. Overall, this transformation is important to ensure that society can meet the additional demand presented by climate change and urbanisation.

1.8 Thesis Outline

The overall thesis is covered in seven chapters, describing how the project was undertaken. Chapter 1 has provided an introduction to the entire thesis, giving a brief background of the research and justification. It has presented the research aim and objectives, and a summary outline of the methods used in the study.

Chapter 2 is a review of relevant literature to help put the research into context. It presents the problem of growing flood risk and thus evaluates the current approach to flood risk management. It also discusses the role of key stakeholders at different levels of flood risk management, followed by a review of flood insurance policy and its role in flood mitigation. By considering the problems of flooding, it discusses the potential of PLFP uptake to help reduce the extra demand that climate change places on flood defences.

Chapter 3 documents the various research methods employed in the study and the rationale behind them. These include the selection of case study areas, the development of flood database and undertaking stakeholder consultations. It also details the financial analysis of PLFP packages.

Chapter 4 reports the results from the stakeholder consultations consisting of questionnaire surveys and focus groups. The findings are presented under a number of themes such as flood experience, flood impacts, flood protection, and willingness to pay for PLFP. The results are discussed alongside findings from related previous studies.

Chapter 5 discusses the findings from the financial analysis of PLFP in respect of the outputs of the financial model. It presents the costs benefits of various packages of PLFP measures. Chapter 6 discusses the consultation with institutional stakeholders to provide guidance on PLFP uptake. It highlights government plans to improve awareness and uptake of PLFP products.

Chapter 7 presents the conclusions made from the study, by reviewing the aim and objectives of the research alongside the main findings from each aspect of the project. It discusses the implications of the research and also the limitations of the research.

Chapter 2: Flooding and Flood Risk Management: Literature Review

2.1 Introduction

In a general sense, flooding means inundation caused by water; an example is rivers overflowing their banks. This results in a condition where land areas which are normally dry are temporary covered in water (Ward, 1978; Rackhecha and Singh, 2009). While flooding results from a combination of weather extremes and hydrological factors such as intense precipitation and flows, they can be exacerbated by human activities (Jha at al., 2012). Factors that are now known to compound the problem of flooding include the changing climate and urban creep of our societies.

Flooding is a worldwide phenomenon which causes widespread devastation, both in terms of economic losses and social impacts, and can result in the loss of human lives. It is now known that flood occurrences have become the most frequent natural hazard, and the number of reported floods has been increasing significantly (CRED, 2010). The number of people affected, and the economic losses have all increased. Globally, it is estimated that the total losses due to floods exceeded $40 billion between 1998 and 2010 whilst almost 178 million people were affected by floods in 2010 alone (Jha et al., 2012).

Developing an understanding of flood risk is a vital step in the risk management process; this provides the basis for decisions on flood mitigation measures. Flood risk is commonly described by the 'Crichton Risk Triangle', which explains that risk is a function of hazard, vulnerability, and exposure (Crichton, 1999). Hazard is defined as an event with the potential to cause harm (e.g. cyclones, floods and drought), whilst exposure is the degree to which a system is exposed to hazard. In terms of floods, exposure could refer to the density or value of property located near rivers which can be the source of hazard. Also, vulnerability refers to the susceptibility of a system or its resilience to hazard; for example, the design and construction of a property could determine its level of resilience. Flood risk is often expressed as the chance or likelihood of that event occurring in a year. For instance, a flood event with an annual chance of 1.3% has a 1 in 75 year chance of occurring in a year.

Flood management has undergone a paradigm shift in past years, in that the traditional approach to flood management, including the heavy reliance on large scale flood defences, has now shifted to include non-structural measures. A sustainable approach of FRM requires dealing with all sources of floods in an integrated manner, and thus requires collaborated inputs from various key stakeholders. Governments have a role to play, as well as environmental regulators, the insurance industry, and the general public in dealing with the additional demands for flood protection due to growing flood risk.

This chapter provides an extensive review of flooding and flood risk management. Section 2 discusses both the causes and sources of floods and explains the concept and elements that contribute to the increasing flood risk. Section 3 of the chapter discusses the impacts of floods in terms of the tangible and intangible impacts. Section 4 outlines the different characteristics of floods, and highlights their relevance in terms of the challenges they pose. The various stakeholders involved in FRM will be discussed in Section 5, while a range of FRM techniques including the use of large scale flood defences, property level flood protection, and non-structural measures will be reported in Section 6.

2.2 Risk, Causes and Sources of Flooding

An international database on disaster showing the current state of global flood statistics suggests recent increases in flood occurrence and related impacts, particularly across Asia (CRED, 2012). Asia has the largest share in natural disaster occurrence with an average of 40.3% of total occurrence in 2009, which rose to 45% in 2011 and caused almost US$274 billion damages (CRED, 2012). Of all the natural disasters, hydrological disaster consisting of floods (83%) and wet mass movement including landslides (17%) remains the most common disaster, and accounted for 53.7% of reported hazards, affecting over 57 million victims (CRED, 2010). Europe has a smaller share of global flood incidents perhaps due to the better preparedness, with records indicating that from 2000 to 2009 Europe’s share was almost one-third of that of Asia (CRED, 2010). Figure 2.1, compares flood occurrences with other common natural hazards that occurred from 2001 to 2010 in the world, and indicates that out of the 384 total cases floods were the most frequent event (175) followed by storms (104).

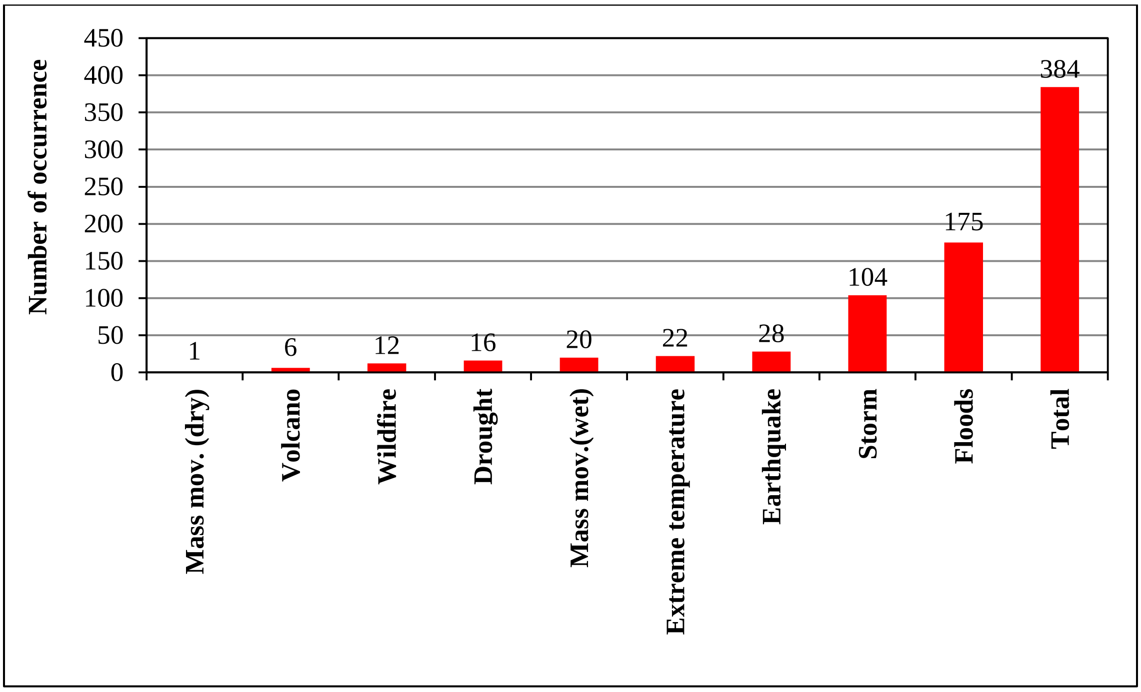


Figure 2.1: Natural disaster occurrence between 2001 and 2010 (Source: CRED, 2012)

2.2.1 Flood risk and probability

Risk is a term defined differently by different people, depending on the subject of discussion. The Oxford Dictionary defines risk as "a situation involving exposure to danger, harm, or loss". A number of components determine the extent of risk and this concept is best explained by the Crichton Risk Triangle, which gives a comprehensive and simple means of understanding risk assessment. It explains that the area of an acute-triangle represents the risk, and the three sides represent each independent component that contributes to risk, that is hazard, vulnerability and exposure (Crichton, 1999; Crichton, 2008a). These three constitute risk, and therefore, risk can be reduced by addressing any component of the triangle.

Flood risk is a function of the likelihood of a flood occurrence and the impact, and therefore a sound understanding of the likelihood of flooding occurring is essential in assessing flood risk. This has been conceptualised by the Source-Pathway-Receptor model (CIRIA, 2010). The source component of flood risk comprises any element which has the potential of causing harm (hazard), for example the source of floodwater such as rainfall, coastal, and snowmelt. The pathway represents the mechanism through which the harm is conveyed, and this can involve a breach of flood defence. Receptor or target is the final stage which comprises the people, property or infrastructure at the receiving end of the hazard (Figure 2.2). A fourth component is often included to describe the consequences of the hazard; that is, the damage and disruption caused to the receptor at the end (Jha et al., 2012).

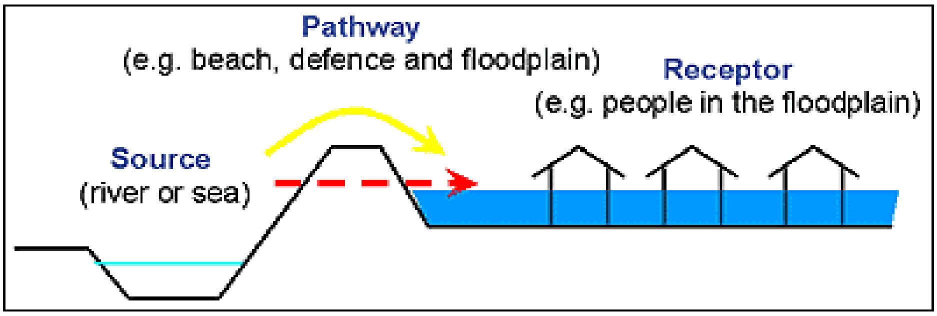


Figure 2.2: Schematic of the source-pathway-receptor model (Source: HR Wallingford, 2001)

Generally, flood hazard predictions are often determined based on computations, using historical data for the area of interest. To estimate the probability of a flood event, the return period (i.e. recurrence interval), which is defined as the average time between events of a given magnitude (this is catchment specific), needs to be known (Jha et al., 2012). Whilst the return period (T) refers to past flood occurrence, it is related to the flood probability (p) which is a future likelihood of an event and is expressed as the inverse of the return period $p = 1/T$. With this relationship, a flood event with a 200 year recurrence interval has a half percent chance of occurring every year, denoted as 1 in 200 year event or 0.5% likelihood. In the UK, the likelihood or chance of flooding occurring at a given time is classified into three different categories (Environment Agency, 2009a). Flood risk can either be significant, moderate or low, and they are often expressed as an annual chance or as a probability:

- **Low:** 1 in 1,000 to 1 in 200 chance (i.e. < 0.5%) in any given year.
- **Moderate:** 1 in 200 to 1 in 75 chance (i.e. 0.5% to 1.3%) in any given year.
- **Significant:** greater than 1 in 75 chance (i.e. > 1.33%) in any given year. This has been the threshold the ABI uses as the indicator for assessing flood insurance cover (ABI, 2008), and not what the Environment Agency (EA) or SEPA considers in flood risk assessment.

2.2.2 Causes of increased floods

Increased urbanisation

Global urban population has grown substantially over the last decade. In 1990, less than 40% of the global population lived in cities, but this rose to more than 50% in 2010 (UN-HABITAT, 2010). Further to this, population projections suggest that 70% of the global population will live in urban areas by 2050 (Jha et al., 2012). Meanwhile, current estimates of urban population growth show an extreme trend within the USA and Europe. It is now known that three-quarters of all Britons (49 million), Dutch (14 million) and Germans (61 million) are living in urban areas (UNICEF, 2012).

As urban settlements tend to concentrate people and infrastructure and other resources (Satterthwaite, 2011; Jha et al., 2012), the dangers of increased urbanisation of our societies include the impact on hydrological cycle which increases the exposure to flood risk (Houston et al., 2011). Increasing urban settlement has turned what are naturally permeable surfaces, into 'hard impermeable' materials, such as concrete and tarmac which tend to speed up the runoff rates from precipitation and add to the flood risk problem. Figure 2.3, describes the effect of urbanisation on stream flow levels, and shows how urban development can add to the risk of flooding by increasing both the volume and velocity of runoff directed towards the watercourse (Christopherson, 1997).

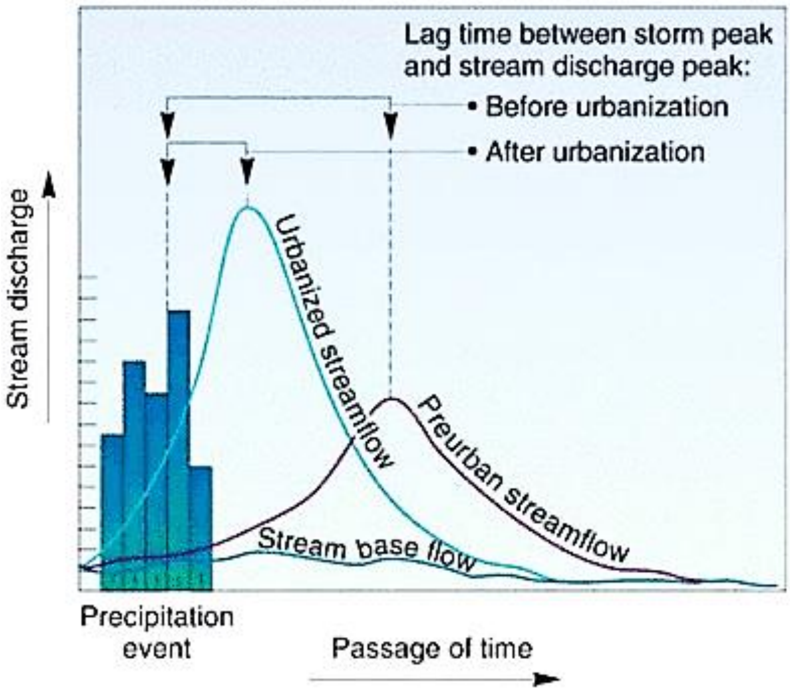


Figure 2.3: Effect of urbanisation on hydrology (Source: Christopherson, 1997)

Urban expansion alters the natural land use which can affect the soil conditions such as reduced infiltration and erosion problems, as well as modification to natural water storage (Jha et al., 2012). Urban expansion, particularly in floodplain areas can change the frequency of flood occurrence. For example, small floods such as 1 in 10 year might increase up to ten times with rapid urbanisation, whilst more severe floods (e.g. 1 in 100 year) might double in size if 30 % of roads were paved (Hollis, 1975; Jha et al., 2012). In addition, urban expansion results in growing pressure on drainage networks, and this coupled with the ageing condition of drainage and sewerage infrastructure are factors of increasing urban flood risk.

Flooding in urban areas can be very expensive to manage due to the sheer size of the population exposed, and the increasing number of homes susceptible to urban flood risk presents further challenges (Houston et al., 2011). Although it is impractical to stop increasing urban development, it is useful to acknowledge the bearing this has on the urban flood risk and act accordingly. For example, appropriate planning and development policies are needed to tackle the urban flood risk given that uncontrolled urban development can be a severe cause of flooding in terms of risk exposure and the scale of impact (POST, 2007a).

Climate change

Climate change has been defined by the United Nations Framework Convention on Climate Change (UNFCCC) as ‘a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods’ (UN, 1992). The Intergovernmental Panel on Climate Change (IPCC) has shown evidence of the observed increase in average temperature and thus concludes the role of human-generated greenhouse emission to this change (IPCC, 2007). In addition to the possible rise in global temperatures, the outcome of global climate change model scenario studies indicate that global annual precipitation will rise (IPCC, 2007). Further, a recent IPCC report concludes that the frequency of heavy precipitation, daily temperature extremes, intensity of droughts and sea level will increase (IPCC, 2011; Jha et al., 2012). Globally, the most affected regions are the least developed countries (LDCs) where there is low resilience capacity and the impacts of climate change could lead to more vulnerability to flooding and poverty (IPCC, 2007; UNFCC, 2012).

The UK Climate Projections 2009 (UKCP09) are projections of future changes of climate to the end of the century. The models are based on the IPCC standard three emission scenarios as described in Table 2.1, and they incorporate additional three probability levels, namely 10%, 50% and 90%; denoted as p10, p50 and p90 (DEFRA, 2010; DEFRA, 2012c). For the medium scenario (i.e. SRES A1B) in the 2050s, warming ranges from approximately 1°C to 3°C in winter, and from 1°C to 4°C in summer. However, there is a large uncertainty in the projected precipitation changes, particularly for the summer precipitation between the p10 (referred to as "p10 dry") and p90 (referred to as "p90 wet") projections (DEFRA, 2010; DEFRA, 2012c). For the medium scenario in the 2050s, the projected changes in summer precipitation averaged over administrative regions range from decreases of 20% - 40% (p10 dry) to increases of approximately 1% - 7% (p90 wet) (DEFRA, 2010; DEFRA, 2012c). Winter precipitation shows a more consistent signal of increase, from approximately 5% (p10 dry) to 30% (p90 wet). Although this is the case for all administrative regions across the UK, the uncertainty in percentage precipitation changes is generally larger in southern parts of the UK; the p90 shows larger percentage increases in the south as shown in Figure 2.4. Overall, an increase in the risk of flooding is widely reported as one of the most likely impacts of climate change across the UK (Evans et al., 2004; Werritty and Chatterton, 2004; Houston et al., 2011; DEFRA, 2012c), which is to be expected given that the UKCP09 models predict increased winter rainfall (especially in the north and west) and more intense and highly localised summer rainfall particularly in the south and east.

Table 2.1: IPCC Emission Scenarios (Source: IPCC, 2000)

Emission	**Label**	**Characteristics**
High	SRES A1FI	Fossil fuels intensive, very rapid economic growth, global population that peaks in mid-century then declines, rapid introduction of new and more efficient technologies.
Medium	SRES A1B	Balanced energy sources, very rapid economic growth, global population that peaks in mid-century then declines, rapid introduction of new and more efficient technologies.
Low	SRES B1	Emphasis on global solutions to economic, social and environmental sustainability, global population that peaks in mid-century then declines, rapid change in economic structures towards a service and information economy, reduction in material intensity, introduction of clean and resource efficient technologies.

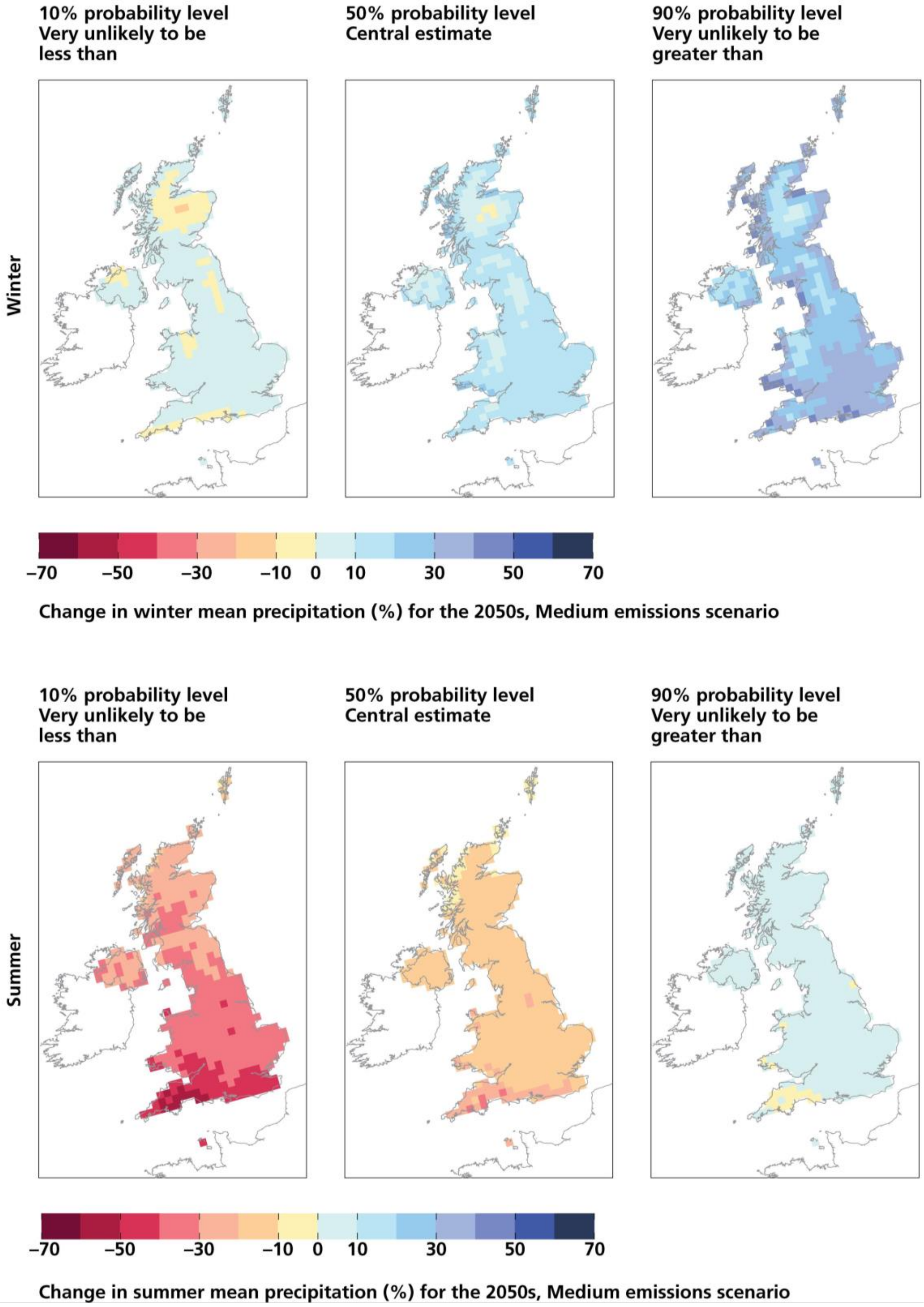


Figure 2.4: Projected precipitation change in winter and summer by 2050s under medium emission (Source: DEFRA, 2012c)

Additionally, the UK Climate Change Risk Assessment (CCRA) based on the UKCP09, provides assessment of the potential risk to the UK that could be caused by climate change in future (Ramsbottom et al., 2012). This study highlights findings including those impacts identified in the floods and coastal sector, which could pose significant challenge to livelihoods. The number of flood related deaths is projected to increase from the present number of 18 per year to between 30 and 120 by the 2080s, whilst flood related injuries could increase from 360 per year to between 550 and 2,350 by 2080s (Ramsbottom et al., 2012). Further, those who might suffer from flood related mental stress problems could rise from the present figure of between 3,000 and 5,000 to between 9,000 and 24,000 by the 2080s (Ramsbottom et al., 2012). The most vulnerable groups to flooding include the elderly group (over 75), people with mobility or cognitive constraints, and those with pre-existing mental health conditions. These people in particular and those on low incomes could face extreme difficulty during floods, hence it will require a greater support to manage such effects including adopting resilience measures to protect those vulnerable.

For Scotland, the CCRA findings suggest key implications of climate change based on a different methodology to that of the UK, reflecting the lower availability of geo-referenced environmental and socio-economic data across Scotland. Based on the CCRA findings, some key threats to Scotland have been highlighted (HR Wallingford, 2012; Ghimire et al., 2012), and these imply the need for adaptive strategies to cope with the impacts of climate change particularly, the impacts of coastal flooding and erosion which demand more resilient coastline actions and preparedness. The four main threats to Scotland are as follows:

- Changes in coastal evolution affecting people, property, infrastructure, landforms, habitats and species.
- Increases in flooding both on the coast and inland affecting people, property, infrastructure, landforms, habitats and species.
- Increases in insurance losses, ICT disruption and transport network disruption resulting from an increase in the occurrence of extreme weather events.
- Increase in the number of people at risk of death, injury or mental health problems as a result of flooding.

2.2.3 Sources of flooding

The history of flood incidents in the UK suggest that the major types of floods often experienced are fluvial, followed by pluvial and costal or sea floods (Environment Agency, 2009a). While other sources include sewer flooding and groundwater flooding, these are less common in terms of both their frequency and magnitude. In Scotland, history of repeated flooding has predominantly come from rivers or surface water (pluvial flooding). Figure 2.5 shows the main sources of floods in Scotland. Irrespective of the main sources outlined, floods can also occur as a combination of incidents such as rainfall filling rivers, breach of coastal flood defences and overloaded or blocked drains (Office of the Deputy Prime Minister, 2003; Samwinga, 2009).

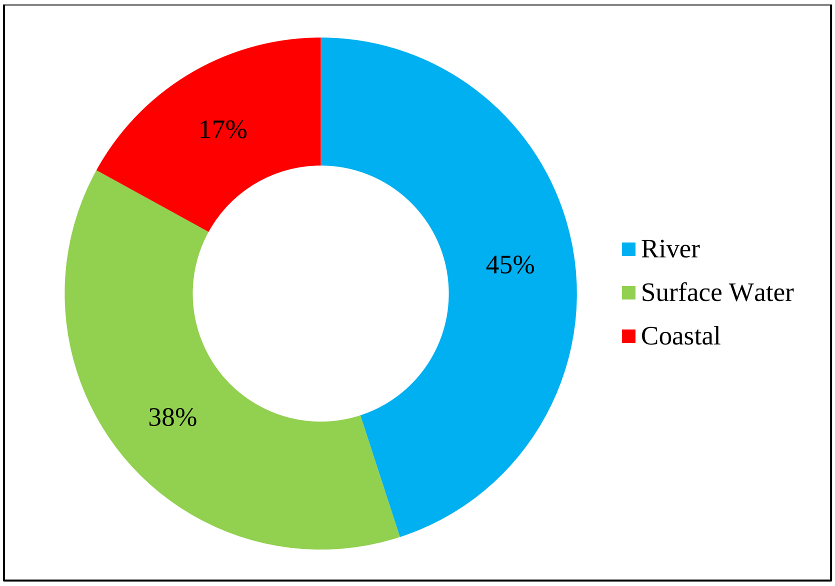


Figure 2.5: Main sources of flood risk in Scotland (Source: SEPA, 2011)

Fluvial flooding

Fluvial flooding usually occurs in the floodplain of rivers when the capacity of watercourses cannot cope with the water draining into it from the surrounding land, due to high rainfall intensity or snow and ice melt within the catchment area. In such a situation, rivers may overtop and burst their banks and floodwaters which sometimes carry with it large debris of objects and can cause other problems. Moreover, high river flows alter the natural river morphology and sediment transport which in every consequence will result in more rivers breaching flood defences resulting in flood inundation (Werritty and Chatterson, 2004).

A number of fluvial floods in the recent past have been reported given the risk due to greater settlement of floodplains. In 2000, the River Uck in South East England flooded. Fluvial flooding is also reported to have caused the bulk damage of the July, 2007 summer floods in England the Severn and the Humber in Hull overflowing their banks. Similarly, Scotland has a long history of fluvial flooding. These include River Teviot in Hawick (2005), River Lossie in Elgin (2009), River Devon (2009), River Cowie and Carron in Aberdeenshire (2009) which have flooded, inundating many properties.

The increasing frequency of fluvial flooding in recent years is also revealed by findings from several studies (RPA, 2004; Werritty et al., 2007). According to a household survey undertaken by Werritty et al. (2007), fluvial flooding was found to be the common source of flooding to residents (85.4%), followed by pluvial flooding (9.9%), whilst coastal flooding was the least (4.7%) based on flood data provided for the study locations. Further threats from fluvial flooding are expected in the future, and more households are likely to suffer flooding as rainfall intensity is predicted to increase due to the changing climate (UKCIP, 2009).

Coastal flooding

Coastal flooding may arise as a result of high tides, storm surge, wave action, or a combination of these factors (Ball et al., 2008; Ghimire et al., 2012). Though not as common as fluvial flooding, coastal flooding continues to pose further threats to lives and livelihoods. For instance, the impact of the 1953 coastal floods in the East coast of UK claimed 307 lives (Spalding, 1954), affected over 24,000 homes and caused 1,200 breaches along 1,000 miles of coastline. Additionally, the Scottish coastlines including the Solway Firth, Moray Firth and the Firth of Clyde have experienced significant coastal flooding in the past (Ball et al., 2008).

Although the risk of coastal flooding in Scotland is not expected to be as significant as in other parts of the UK, given the more resistant geology of the Scottish coastline (Evans et al., 2004; Zsamboky et al., 2011), there are clear concerns about current and future problem with coastal flooding and erosion in Scotland (Ball et al., 2008; Ghimire at al., 2012). Almost 30% of the Scottish population live in coastal areas (SEPA, 2011), and the risk of coastal flooding and erosion is one of the most serious challenges faced in the country, particular with respect to climate change (Ghimire et al., 2012). This highlights the need for adequate preparedness in the event of unexpected future risk. In view of the potential risk of coastal flooding, greater awareness and preparedness is necessary, especially following the storm that hit the North of UK in 2005 and affected many areas including the Scottish Western Isles coastline (Ball et al., 2008). This incident in particular raised further questions about the risk of coastal floods, and necessitated future investment in coastal flood protection schemes (Ball et al., 2008).

Pluvial flooding

Pluvial or surface water flooding is another common type of flood; this is often complex and affected by many factors (Pitt, 2008). It normally results from rainfall-generated overland flow before the runoff enters any watercourse or sewer system, or when the runoff cannot enter because the system is full to capacity (Falconer, 2009). While pluvial flooding is usually associated with high intensity rainfall events, it can also occur with lower intensity rainfall or melting snow where the ground is saturated or has low absorbency. The problem of urban pluvial flooding is exacerbated by overloaded or outdated drainage infrastructure (RIBA, 2009). These factors tend to limit the amount of water that can get into sewers, and this can potentially contribute to a fluvial flooding situation when the floodwater makes its way to a river.

Much of the 2007 widespread floods in England was pluvial flooding, resulting from short torrential rainfall and runoff of surface water, especially in Yorkshire and Gloucestershire (RIBA, 2009). Similarly, Pitt (2008) found that 50% of the 2007 floods occurred away from Environment Agency floodplains with 60 to 70% due to pluvial flooding. Furthermore, current estimates show that about two million people in urban areas (with a population with a greater than 10,000) face a 1 in 200 year chance of pluvial floods (Houston et al., 2011).

Further, Houston et al. (2011) estimated that the UK urban population at risk from pluvial flooding could substantially increase to 3.2 million by 2050, with the main factor being population growth. In addition, climate change will worsen the case by the accounting for the 25% of the estimated figure. Although both climate change and urban population growth are crucial factors that will affect urban flood risk, the lack of permeability of land surfaces in urban areas could pose further threats, resulting in more localised pluvial flooding cases which are often difficult to forecast (Jha et al., 2012). At the same time, a study of urban pluvial flood victims suggests that people are often ill prepared and uninformed, as well as confused about their responsibility before, during and after such events (Douglas et al., 2010). This is a source of concern and needs urgent solution, otherwise it can be particularly disturbing given other contributing factors.

Sewer flooding

Sewer flooding occurs when sewerage systems are overwhelmed by heavy rainfall and their capacity is exceeded. Most sewer flooding incidents are as a result of overloaded sewers, blockages in the sewerage network and infrastructure failure. Also combined sewer systems are highly susceptible to pluvial flooding, with a typical example being the case of the Glasgow 2002 floods which led to the Metropolitan Glasgow Strategic Drainage Plan (MGSDP, 2012). Current records show that there are over 7000 cases of sewer flooding every year in the UK, and overloaded sewers typically account for some 50% of flooding problems in large cities (ABI, 2011a). While this situation is partially due to aging sewerage systems, it is worsened by urban creep which is the loss of permeable surfaces leading to increased runoff (UKWIR, 2010). This type of flooding can be difficult to predict especially from infrastructure failure, and where sewer floodwater happens to be combined storm and untreated foul water it can be very worrying for people. The latter has potential health implications on both people and the built environment (RIBA, 2009), and this arguably makes sewer flooding the worse of all flood types. In particular, internal sewer flooding can be severe and distressing to affected victims.

In addition, urban population growth and sewage increases put extra demand on aging sewerage infrastructure. As a result of this, the risk of sewer flooding has increased in urban settlements, and needs to be minimised (NOA, 2004; Lamond et al., 2012a). In view of this, the introduction of sustainable urban drainage systems (SUDS) which are a range of water management techniques designed to mimic the natural system, has been a vital in addressing drainage issues in urban areas (Ashley et al., 2007). Common practices including the use of detention and retention reservoirs, swales, permeable pavements and green roofing are all elements of SUDS which replicate the way rainfall drains in the natural system, and help to alleviate the growing demand on conventional drainage systems and reduce flood risk.

Groundwater flooding

Although groundwater flooding is rare in the UK, and particularly Scotland, it can be very severe when it does occur. This type of flood is most likely to occur in areas underlain by unconfined aquifers, when water levels in the ground rise above surface levels. One peculiar characteristic exhibited by this groundwater flooding is the duration of the event (Macdonald et al., 2008). Usually, groundwater flooding has long durations (from days to months) while other floods typically have shorter durations ranging from hours to days (Bowers, 2007). As a result of the longer duration of groundwater flood events there could be prolonged disruption and high damages where they occur.

A typical example of extensive groundwater flooding in the UK is the winter flooding in Southern England in 2000/2001. It is reported that these floods lasted for four months, affecting 700 properties in Hampshire (Jacobs, 2004). Due to their rarity, dealing with groundwater flooding is often seen as the most problematic. In most cases, engineering solutions are often limited because the source of groundwater flooding is not contained, and therefore difficult to trace to a specific source location. Moreover, groundwater flooding often involves dealing with high volumes of water which could also prolong the recovery process. Although there are limited options in managing groundwater flooding, the use of resilient measures could help minimise the risk of internal flooding in properties. For example, retrofitting or repairs using water resistant flooring materials such as concrete or ceramic materials are effective ways to improve the resilience of properties (Bowker, 2007). In some cases, groundwater can be pumped out to lower the water table and reduce flood risk, and the water can also be used for other beneficial purposes.

2.3 Impacts of Flooding

Floods are the most common natural hazards affecting infrastructure and human settlements. A regular publication of global disasters put together by the Centre for Research for Epidemiology of Disasters (CRED) indicates more frequent floods compared with other natural disasters such as volcanoes and earthquakes, with significant impacts (CRED, 2010). While flood events can result in substantial financial damages, less tangible impacts can also occur depending on the scale of the event itself (Meyer, et al., 2009), and can exacerbate the overall repercussions of floods.

Examples of flood impacts include damage to residential properties, important national infrastructure including energy, water, communication, commercial and transport infrastructure resulting in huge financial damages (Pitt, 2008; Jha et al., 2012). Table 2.2 shows the types of flood impacts, which are mostly categorised based on the form of damage, whether they are as a result of direct or indirect consequences of floods. Secondly, damages are categorised based on their measurement, whether they can be quantified in monetary terms or not (Smith and Ward 1998; Parker et al., 1987; Penning-Rowsell et al., 2003; Messner and Meyer, 2005; Messner et al., 2007). Often, the magnitude of such financial (tangible) losses makes them more recognisable, overriding the intangible impacts which are less quantified. Further, recent findings suggest that the intangible impacts of floods including the stress of flood and fear of future flood have gained growing recognition and that people place more importance on them than the financial losses (Tunstall et al., 2006; Werritty et al., 2007; Paranjothy et al., 20012).

Table 2.2: Categorisation of flood damage impacts (Source: Smith and Ward, 1998; Penning-Rowsell et al., 2003; Messner et al., 2007)

Forms of damage	**Measurement**	
	Tangible	Intangible
Direct	Physical damage to assets: Building Contents Infrastructure	Loss of life Health effects Loss of ecological goods Emergency cost
Indirect	Loss of industrial production Traffic disruption Emergency costs	Inconvenience of post-flood recovery Fear about future floods Increased vulnerability of survivors

2.3.1 Economic impact

The tangible impacts of flood, as the name implies are those impacts that can easily be assessed and quantified in monetary form (Penning-Rowsell et al., 2003; JBA, 2005; Meyer et al., 2009; FHRC, 2010). These impacts include damage to building fabric, the costs of clean-up after flooding, and the cost of living in temporary accommodation which can have implication on business. The direct economic consequence of flooding means that, such impacts are the most conspicuous and are often highlighted more in flood damage assessments. This perception has often influenced the course of policies and strategies towards FRM, whereas in most cases the less intangible impacts are regarded as immaterial and less significant (JBA, 2005).

Global flood impacts

The economic damages resulting from floods can be substantial, and their severity can differ from country to country. For instance, Table 2.3 shows flood occurrences in Europe between 2000 and 2009, and indicates that Romania alone recorded twenty five major floods which resulted in $1.7 billion damages, whereas the UK experienced just half the number of floods in the same period which resulted in damages of $16.6 billion (CRED, 2010). Probably, the extremely high damage for UK floods could have resulted from some high profile floods in the decade, including the widespread 2007 floods. Another record detailing European floods suggests that over one hundred major devastating floods happened between 1998 and 2002, including the catastrophic floods along the Danube and Elbe rivers in 2002, and caused at least €25 billion in insured economic losses (EEA, 2003). In addition, there were 200 major floods (i.e. catastrophic or life threatening flooding where structures may be completely submerged) reported worldwide in 2007; this affected 180 million people with the human cost being more than 8,000 deaths and over £40 billion worth of damage (Pitt, 2008).

Given the recent high level of floods and the increasing risk of flooding, flood related insurance costs could escalate if the situation does not improve. For example, records suggest that the global losses in the insurance market in the 1990s exceeded US$200 billion, whilst the insured loss from the 2002 European floods was €3.4 billion (Munich Re, 2005). In the UK the extensive 2,000 floods which generated insured losses of more than £1 billion (Environment Agency, 2000), and led the insurance industry to consult on a range of strategic options for the future (Green and Penning-Rowsell, 2002). In addition, recent findings from the Association of British Insurers (ABI) showed that between 1998 and 2005 the industry paid out £7.2 billion in weather related damage claims, £3.5 billion of this was for storm and flood damage (ABI, 2010b).

Table 2.3: Flood* occurrences in Europe between 2000 and 2009 (Source: CRED, 2010)

Country	Number of Floods	Number of people Killed	Number of people affected	Damages** (billion US$)
Romania	25	169	187,400	1.7
France	14	34	22,500	1.6
Greece	14	15	12,200	0.7
Italy	13	72	20,000	2.1
UK	12	26	379,500	16.6
Bulgaria	11	52	13,300	0.5
Hungary	8	1	45,800	0.2
Austria	6	14	61,400	3.8
Czech Rep	6	38	218,800	3.1
Germany	6	29	331,600	14.1

*Flash floods and storm surges/coastal floods not included   ** 2009 US$ value

UK flood impacts

Despite significant impacts from past flood events, there remains in the UK a greater concern over future floods impacts given the increasing vulnerability of many homes to flood risk. As a result of this growing burden, many flood studies have been carried out both at the national and local levels to understand flood risk exposure, and the most notable studies include the National Flood Risk Assessment (NFRA). Findings from the NFRA in 2008 indicate that over 5.2 million properties or one in six properties are at risk of flooding in England and Wales (Environment Agency, 2009a). A recent update suggests that the figures for properties at flood risk have increased to more than 5.5 million (Environment Agency, 2012). Approximately 2.4 million of properties at risk are related to flooding from rivers and the sea, and a further 2.8 million properties are susceptible to surface water flooding (Environment Agency, 2009a; O’Neil and O’Neil, 2012). The findings also suggest almost 500,000 of the total properties at risk are actually at significant risk of flooding (i.e. 1 in 75 year annual chance of flooding). In addition, the Foresight Future Flooding report estimates that the risk of flooding from rivers and the sea will at least double by 2080s (Evans et al., 2004). With this, the number of people at high risk of flooding in the UK will rise from 1.5 million to 2.3-3.5 million, and the annual flood damages to properties at risk from flooding will also increase from the current estimation of £1 billion to as high as £27 billion by 2080 (Evans et al., 2004; Ramsbottom et al., 2012).

The impacts of floods have caused much disruption to the lives and livelihoods of people across the UK (Pitt, 2008). Some typical devastating floods that have occurred in the past include the Scotland floods 2002, Cumbria floods 2005/2009, Cornwall floods 2010, and the widespread summer floods in 2007. The Cumbrian 2009 floods alone affected 1,800 properties, resulting in the evacuation of 200 homes (Smith, 2010; O'Neil 2012). While the economic damage of the Cumbrian floods was estimated to be around £276 million, the Cornish floods were found to have caused approximately £12 million worth of damages (House of Commons, 2010), given the relatively smaller scale of the event. In addition, the Pitt review of the 2007 floods reported the economic costs of the floods to be £3.2 billion (Pitt, 2008). In spite of the major infrastructure that were affected by the floods, the findings confirmed the vulnerability of residential properties and businesses to flood risk impact, as they formed almost two thirds (£2.1 billion) of total economic costs incurred.

Flooding of residential properties has serious consequence (RPA 2004; Werritty et al., 2007). First of all, the tangible impacts of floods could be substantial financial losses (Meyer et al., 2009). This is demonstrated by a number of studies; for example, one significant study for DEFRA estimates that the economic damages of household level flooding could range from £10-50k for an entire building and its contents, depending on the flood depth (Bowker, 2007). In addition, Werritty et al. (2007) surveyed flood victims in Scotland and determined that buildings and contents losses were £31,980 and £13,552 respectively. Moreover RPA (2004) reported that the mean total losses (insured buildings and contents, and uninsured) for a flooded property in England was approximately £30k, while another study suggests that the insurance claims following the 2007 floods in England were found to be £23-30k (Environment Agency, 2010). Although these findings highlight the extent of economic impacts on residential properties, the potential increases in the severity of future floods as a result of climate change and urbanisation problems mean that the economic damages of household floods could rise (Evans et al., 2004; Houston et al, 2011).

Along with the rest of the UK, many properties are increasingly at risk of flooding in Scotland (SEPA, 2011). Environmental regulators including SEPA produce their own flood risk information to help planning and decision making, and the insurance industry is also a major owner of flood risk databases which they use in assessing risk and premium levels (DEFRA, 2010). Prior to the recent 2011 publication of the Scottish

National Flood Risk Assessment, SEPA indicative flood maps were the main source of flood risk information, giving a general indication of areas expected to be inundated during a particular flood event. The maps do not give accurate prediction of actual flood, or account for the combined effect of river and coastal flooding at the same time, except for a few key locations (SEPA, 2011), and this implied the need for SEPA to provide more accurate maps. Despite the limitations, the maps showed that almost 100,000 properties in Scotland were either at risk of fluvial flooding or lie within coastal flood zones (Scottish Executive, 2007). A breakdown of this figure indicates that the fluvial zone affects the majority of the properties which is almost three quarters, and represents 3% of all properties in Scotland, while the coastal flood zone affects the remaining quarter of properties and forms 1% of all properties in Scotland (Werritty et al., 2002; Scottish Executive, 2007).

With the inception of the NFRA for Scotland, more data on the current state of flood risk is now available, indicating that almost 125,000 properties (both residential and businesses) are now at risk from flooding (SEPA, 2011). This represents 1 in 22 residential properties at flood risk compared with 1 in 6 homes for England and Wales. At the same time, 1 in 13 non-residential properties are found to be at flood risk. With these figures, the average annual cost of flood damages is estimated to be between £720 -£850 million using NFRA methodology (SEPA, 2011), which is comparable to almost £1 billion for England and Wales.

Similar to flood experience in England, some damaging floods have occurred in Scotland in recent years, resulting in damaging impacts. Examples of such events include: Tay 1993, Strathclyde 1994, Edinburgh 2000, Elgin 1997 and 2002, Glasgow 2002, and Hawick 2005, which resulted in high economic losses. The estimated losses arising from the Tay/Earn flood of 1993 was £30 million, whilst those related to the Strathclyde flood of 1994 was £100 million (Werritty et al., 2002). Moreover, in Elgin, the severe flooding suffered in 1997 and 2002 inundated over 600 residential and 170 commercial properties, and affected key transport infrastructure. The combined economic damages of both flood events were in excess of £100 million (Scottish Government, 2008).

2.3.2 Intangible impacts

Intangible flood impacts are those which are more difficult to quantify and hence are often less represented in the economic appraisal following flood event (RPA, 2004). The stress of flood events, the loss of sentimental items, the loss of community spirit, and anxiety of future flooding are considered intangible and are often underestimated (RPA, 2004; Werritty et al., 2007). This also implies that they are less often or not accounted for in economic appraisal of environmental schemes, as it can be extremely difficult quantifying the true costs of these impacts (RPA, 2004; JBA, 2005). In spite of this, various studies have shown the growing awareness of these flood impacts as floods continue to threaten many homes and residents (RPA, 2004; Werritty et al., 2007; Paranjothy, 2011).

Studies on flood victims, including those affected by the summer 2007 floods in England, have reported evidence of social impacts of floods, and showed that the psychological and mental health impact of flooding is a serious growing public concern (Paranjothy et al., 2011). Flooding effects can also challenge the psychological resilience of people, and can pose substantial social and mental health problems that may last for long periods (Stanke et al., 2012). In another study by RPA (2004), flooding was found to cause short term physical effects as well as short and long term psychological impact; the extent of health impacts is influenced by factors including socio-demographic factors, flood characteristics, and post flood events .This finding concurs with that by Werritty et al., (2007) which found that the intangible impacts of flooding can have immediate or lasting effects on their victims or those who may have been witnesses to the traumatic event. The most significant impact was the immediate intangible such as discomfort or stress, followed by the lasting-intangible impacts which may be related to financial impacts as well and include worry about future flooding; both impacts were ranked higher than the financial impact. Again, this outcome highlights the relevance of the less tangible impacts to flood victims, and suggest the need to account for them in damage assessments.

Flood fatalities

Flood fatality is the most serious direct consequence of floods, and this can occur when people lose their lives through drowning or through sustained physical injuries, with the most vulnerable victims being those mobile at the time of flooding (Jonkman and Kelman, 2005; DEFRA, 2006; Werritty at al., 2007). Past records from 1986 to 1995 suggest that natural disasters killed 367,000 people in the world, of which more than half (55%) were due to flooding (MR-G, 1997). Across Europe alone, it has been noted that floods caused some 700 fatalities and displaced about half a million people between 1998 and 2002 (EEA, 2003). Also, more recent findings show that 1309 flood deaths were reported to have occurred across Europe between 1980 and 2009 (CRED, 2010), whilst eight thousand people were killed by floods in 2010 alone (Jha et al., 2012). Elsewhere in Australia, at least seventy-three flood fatalities occurred between 1997 and 2008 as a result of the direct impact of floods, with the 2010/2011 Queensland floods resulting in the deaths of 35 people (FitzGerald et al., 2010; Hancock and Rea, 2013).

The above figures are alarming and underscore the significant fatalities related flooding across Europe. Although flood deaths have been very rare in the UK, the aftermath of recent extreme floods has shown that flood fatalities may become more common. Information from the Emergency Events Database (EM-DAT) suggests that the number of people killed by UK floods from 2000 to 2009 was 26 (CRED, 2010); the 2007 summer floods alone killed thirteen people (Pitt, 2008), while an earlier flood in January 2005 recorded three deaths in Northern England.

Whilst limited information exists on the flood mechanisms surrounding flood fatalities, understanding the circumstances can provide invaluable information to reducing such incidents. Previous studies estimate that one-third of direct flood deaths were as a result of physical trauma and heart attack, while the majority (two-third) were caused by drowning (Jonkman and Kelman, 2005; Jha et al., 2012), a finding could indicate the dangers associated with the depth of moving floodwater. Moreover, it is known that most flood deaths are likely to occur as a result of high speed floodwater (e.g. flash floods), rather than slow moving flood water (Du et al., 2010; Jha et al., 2012), which also implies the relevance of floodwater speed and its flood impact. In another study exploring this subject, Ramsbottom et al. (2003) has compiled some circumstances where flood deaths are likely to occur. These include:

- High floodwater velocities.
- Floodwater depths are high (deep).
- When flood onset is sudden as in flash floods.
- When natural or artificial protective structures fail by overtopping or collapsing.
- Large low-lying areas without proper evacuation.

2.4 Flood Characteristics

When a flood event occurs, the extent of damage caused is influenced by the flood inundation characteristics. Flood characteristics play a vital role in the estimation of flood damage, and the most primary element is the inundation depth (DTLR, 2002; Soetanto and Proverbs, 2004; Messner and Meyer, 2005). However all flood inundation parameters including flood velocity and duration are equally considered in flood damage assessment. In some cases, a combination of factors such as depth and velocity parameters of floodwater is useful in assessing the severity of floods fatalities such as deaths and injuries (Ramsbottom et al., 2003). Table 2.4 illustrates the significance of each flood characteristic.

Table 2.4: Flood inundation characteristics and significance

Flood characteristics	Significance	Source
Area/extent	Determines which elements at risk will be affected.	Meyer et al., (2007)
Depth	Has perhaps the strongest influence on the amount of flood damage.	Green et al.,(1983); Nicholas et al., (2001); DTLR,(2002); Soetanto and Proverbs, (2004); Lancaster et al., (2004); Meyer et al., (2007)
Duration	Has influence on the damages of building fabric, long duration can cause much impact.	Green et al.,(1983); Nicholas et al., (2001); DTLR,(2002); Soetanto and Proverbs, (2004); Lancaster et al., (2004) ; Meyer et al., (2007)
Velocity	High velocities can lead to increased damages; very relevant in flash flood areas or areas near dike breaches.	Green et al.,(1983); Nicholas et al., (2001); DTLR,(2002); Soetanto and Proverbs, (2004); Lancaster et al., (2004); Meyer et al., (2007)
Rise time	Influence on damage reducing effects of warnings and evacuation.	Meyer et al., (2007)
Contamination/ Water quality/ Sediment	Floodwater containing pollutants will pose a greater risk to health and safety. High sediments and debris can increase additional greater health risk and more infrastructure damage.	Green et al.,(1983); Nicholas et al., (2001); DTLR,(2002); Soetanto and Proverbs, (2004); Lancaster et al., (2004); Meyer et al., (2007)

2.4.1 Depth of floodwater

Floodwater depth is the most important factor in flood damage assessment, and the scale of flood damage to properties depends largely on the depth of water they are exposed to (DTLR, 2002; Soetanto and Proverbs, 2004; Bowker, 2007). Generally, flood damage increases with increasing floodwater depth (Nichloas et al., 2001; Soetanto and Proverbs, 2004). For example, Table 2.5 describes potential flood damages based on floodwater depths, and shows that if the depth of floodwater is below ground floor level, minimal damage to the main building will occur. At the basement, any items below the level of floodwater such as electrical sockets, carpets, other fittings and possessions will be affected. On the contrary, a floodwater depth above ground floor level could cause major internal damage (e.g. floors, walls, kitchen appliances, and furniture) in addition to the damage to the main building (Garvin et al., 2005; Samwinga, 2009).

In view of the damaging impact of floods resulting from flood depth characteristics, the normal practice has been flood protection against such impact. Alternatively, there is a growing demand for the adoption of resistance and resilience measures in helping to improve the resilience of properties to flood impacts, to complement existing solutions (Bosher, 2008; Pitt, 2008). This practice helps to avoid or reduce the amount of floodwater that gets into a property by blocking all apertures into buildings. Techniques involve covering airbricks or vents openings, doorways, windows and drain networks with water resistant materials (Bosher, 2008).

Table 2.5: Flood damage for a typical residential property (Source: DTLR, 2002; Wingfield et al., 2005)

Flood depth	Damage to building	Damage to services and Fittings	Damage to personal possessions
< 0m	Minimal damage to main building Water may enter basements, cellars and floor voids Possible erosion beneath foundations	Damage to electrical sockets and services in basements and cellars Carpets in basements and cellars may need replacement	Possessions and furniture in basements and cellars damaged
Up to 0.5m	Damage to internal finishes such as wall finishes and plaster linings Floors and walls becomes saturated and will require drying out Chipboard flooring likely to require replacement Damage to internal and external doors and skirting	Damage to downstairs electricity meter and consumer unit Damage to gas meters, low level boilers and telephone services Carpets and floor coverings may need replacement Chipboard kitchen units likely to need replacement White goods may need replacing	Damage to sofas, furniture and electrical goods Damage to small personal Possessions Food in low cupboards may be contaminated
>0.5m	Increased damage to walls and possible structural damage	Damage to higher units, electrical services and appliances	Damage to possessions on higher shelves

2.4.2 Velocity of floodwater

Floodwater velocity is related to the depth of floodwater as well as the distance from the flood source (Soetanto and Proverbs, 2004) which also influences the transport of materials during floods. Typically, the further the distance from flood source, the lower the floodwater velocity and its ability to transport sediments (Xu et al., 1998; Soetanto and Proverbs, 2004). In the same way, deep floodwater with high velocity has the tendency to transport sediments (Nicholas et al., 2001; Soetanto and Proverbs, 2004). The relationship between velocity or depth and their impact on the dangers of flood hazard is shown in Figure 2.6. This demonstrates that an increase in either velocity or depth will escalate the risk of hazard; for example, a flood with velocity of 3 m/s and depth exceeding 0.3 m presents extreme danger to all.

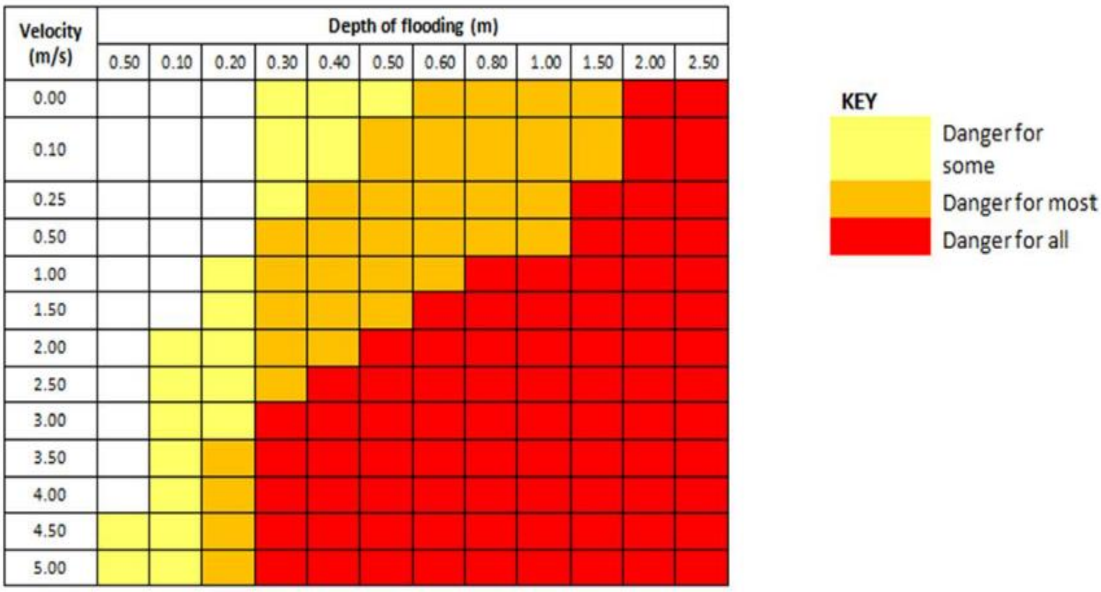


Figure 2.6: Depth-velocity matrix of hazard (Source: Priest et al., 2008; Alexander et al., 2011)

The rise time of floodwater in a property also determines to a large extent the damage caused. While slow rising floodwaters can give more warning time for people to move their possessions to safety, fast rising floodwaters demand more rapid response and could easily take victims by surprise. A previous study examined people’s perception of floodwater and found that what was of greater concern to most people was the velocity of floodwater onset (23%), followed by the dirtiness of flood water (22%) (RPA, 2004). The significance of floodwater characteristics including velocity will be examined later as part of this research, when exploring the flood experience of flooded households through questionnaire surveys.

2.4.3 *Duration of flooding*

The duration that floodwaters remain within a property is another key factor which determines the level of flood damage. Logically, longer duration flooding results in increased flood damage and vice versa (Soetanto and Proverbs, 2004). Furthermore, the duration of the floodwater will determine the entire recovery process. Generally, short duration floods are easier to remediate and require less recovery time. Floods lasting over 24 hours can cause greater damage to the building element (Garvin et al., 2005). In practice, typical durations for floods resulting from overland flow and infrastructure failure can last for hours, whereas fluvial and coastal floods have a longer duration extending from days to weeks (Bowker et al., 2007). However, groundwater floods pose the greatest risk in terms of duration (Macdonald et al., 2008), and can last for several months, resulting in protracted recovery processes.

Flood duration is an important factor and it is said that this has more influence in assessing production losses due to floods, though it impacts on the direct damages as well. In flood damage appraisal, the Multi-Coloured manual (MCM) which provides flood depth-damage database and guidance for damage assessments in the UK, classifies flood damages under both short duration (<12 hours) and long duration (>12 hours). Figure 2.7 shows the damage curves for both durations, and suggests relatively higher losses for long duration flooding often resulting from damage to internal flooring, and plumbing and electrical costs (Penning-Rowsell et al., 2003).

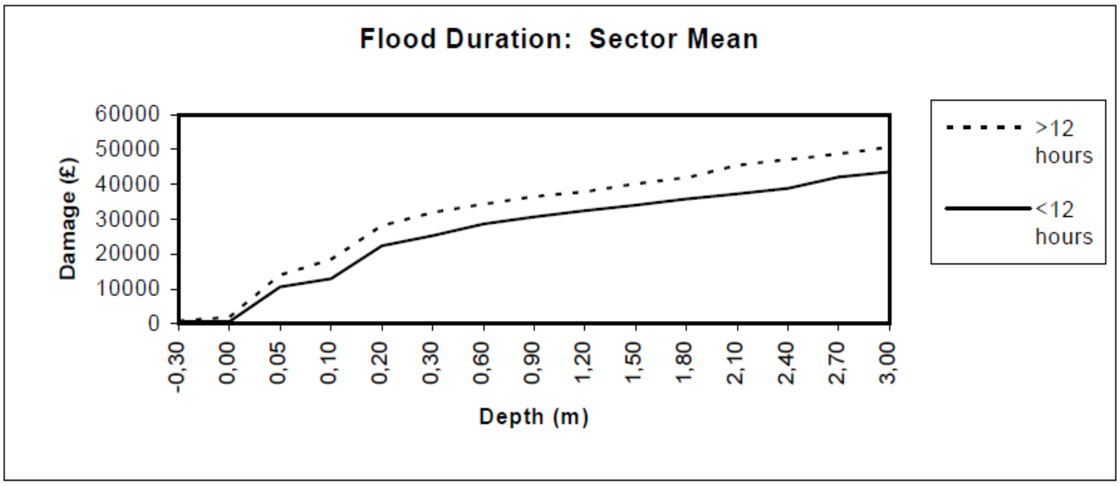


Figure 2.7: Depth-damage differentiated by duration (Source: Penning-Rowsell et al., 2003)

2.4.4 Floodwater constituents

Floating debris and other foreign materials such as organic and inorganic chemicals can pollute floodwater. Floodwater pollution is conspicuous, generally experienced by most flood victims (RPA, 2004; Werritty et al., 2007), and can impact flooded households. Among the reasons why this characteristic is important is the influence it has on the drying time of materials as well as the impact on building property and contents (Nicholas et al., 2001; Soetanto and Proverbs, 2004). Depending on the contamination or the pollutant being carried, floodwaters could cause corrosion to building materials and its contents (Garvin et al., 2005), resulting in higher repair costs. In the case of flooding from sea water, it is found that saltwater can cause corrosion to metal fittings and can increase flood damage repair costs by almost 10% (ABI c.f., DTLR, 2002; Soetanto and Proverbs, 2004). In addition, floodwater contamination by chemicals and other waste can add to the cost of cleaning and disinfecting flood affected buildings (Samwinga, 2009).

Where sewers carry trade effluents, chemicals can be carried into the floodwaters and the risk associated with this will depend upon factors such as the type of chemical, its concentration, the volume of spillage and dilution effect (Smith and Fewtrell, 2006). Contact with such contaminants can result in detrimental mental health impacts, physical effects and infection. Sufficient evidence of infectious diseases associated with flooding exists; floodwater carrying sewage contamination can cause serious diseases such as Salmonella, Tetanus, Polio and Hepatitis (Atkinson and Price, 2005). In another study, there have been reported higher concentrations of dangerous chemicals including phosphorus and copper in sediments gathered from the Szczecin lagoon after flooding from River Oder in Poland (Glasby et al., 2004; Smith and Fewtrell, 2006).

In the UK, some complaints of chemical pollution have been made in several flooding cases. Following the 2000 flooding of the River Severn, a number of chemicals, including arsenic, were believed to have contaminated the floodwater. Although there were some health complaints from affected areas, and analyses of floodwater and silt collected from the area showed the presence of some chemicals, there was no evidence of significant pollution to homes (Smith and Fewtrell, 2006). However, in spite of the evidence on the impact of floodwater contamination, such impacts are often ignored in flood damage assessments (Nicholas et al., 2001; Soetanto and Proverbs, 2004), with just a few studies appraising the health and stress impact of floods (Bower et al., 2000; RPA, 2004). This effectively means that the true impact of floodwater contamination is not quantified and hence, less evident in the flood damage evaluation.

2.5 Flood Risk Management (FRM) Stakeholders

FRM strategies in the UK and worldwide have historically been based on flood defences and flood warnings (Environment Agency, 2009a). With more growing awareness of flood risk, the approach has gradually shifted towards sustainable flood management which involves integrated approaches to reduce the risk of flooding (Hall et al., 2003; Werritty, 2006; Jha et al., 2012). Across Europe, the principal driver of this change has been the EU Floods Directive (EU, 2007), which has been transposed into individual member state's flood policies and strategies. The enactment of the EU Floods Directive means that flood risk management has become a shared responsibility at various designated levels (EEA, 2007). Unlike previous forms of flood management, recent developments have devolved flood risk responsibilities, and government institutions and relevant stakeholders now have obligated roles in minimising flood risk. Accordingly, the UK, like any other EU country, has delegated tasks for its stakeholders at their level of duty in the pursuit of an integrated approach to flood risk management.

In the UK, several FRM Acts have been implemented to help achieve sustainable flood risk management through integrated and holistic approach (Scottish Government, 2011; DEFRA, 2010). For example, the new Flood and Water Management Act (FWMA) 2010 in England is expected to provide more comprehensive management of flood risk to properties, with its success dependent on flood authorities contributing to sustainable development in discharging their flood risk management responsibilities (DEFRA, 2012a). Similarly, the Scottish Flood Risk Management Act (2009) introduces an integrated approach to flood risk management which requires all stakeholders to deliver their delegated responsibilities (Scottish Government, 2008). In view of this, various organisations including Central Governments, Environment Agencies, Local Authorities and Water companies have vital roles to play, while non-governmental organisations, including Community Flood Groups, Flood Activists, and homeowners also have shared responsibility managing flood risk at their level.

2.5.1 Stakeholders in UK

Central Governments

In England and Wales, DEFRA is the lead government department responsible for flood and coastal erosion management policies, and in Scotland a similar role is ensured by the Scottish Government (SG). As a primary responsibility, Central Governments provide funds through grants to enable the implementation of FRM projects in addition to other national assignments. In the recent past, DEFRA has invested enormously in flood and coastal flood risk management schemes; £664 million was spent on flood defences during the period of 2010/2011 (House of Commons, 2012). Elsewhere, the SG invested as much as £462 million grants in major projects including flood protection schemes between 2009 and 2010 (Scottish Government, 2010). Despite huge investments in flood risk management, there have been further recent calls to increase flood expenditure due to more pressing needs (House of Commons, 2012). Consequently, alternative funding sources are highly sought after including levies from LAs to help sustain the levels of funds for flood protection schemes in England (DEFRA, 2010). In view of this challenge, the introduction of the new partnership funding approach of flood mitigation schemes provides some solution. This scheme seeks to fund cost-effective flood protection options, including PLFP which are likely to be implemented on a large scale. This subject will be further examined in this research, and the SG will be interrogated on its strategy to promote PLFP uptake as part of its FRM plans.

Environmental Regulators

The Environment Agency (EA) and the Scottish Environment Protection Agency (SEPA) have instrumental roles in managing flood risk in the UK. Similar to most countries, the EA and SEPA have tasks including developing policies, implementing and monitoring national strategies for management of coastal erosion and all sources of flood risk (Scottish Government, 2008; DEFRA, 2012a). At the district level, SEPA is responsible for District Flood Risk Management Plans which set out the national framework for FRM in Scotland. This in turn sets out the framework for local level FRM Plans. In England and Wales, the EA is responsible for Catchment Flood Risk Management Planning, where PLFP are now being integrated into the catchment management process. For example, the Thames Catchment Flood Management Plans

(CFMP) incorporates a range of plans towards sustainable flood risk management which include flood proofing properties and infrastructure in floodplains, to improve their resilience and resistance to mitigate flood impacts (Environment Agency, 2009b). In addition, PLFP are being considered with respect to short and long term flood management options; where there are no existing flood defences short term solution will improve resilience in all new developments, whereas long term strategies could include refurbishment of existing buildings to increase resilience and resistance to flood (Environment Agency, 2009b). In Scotland, the introduction of the new FRM Act places additional responsibility on SEPA, central is the delivery of information and coordination of flood risk management (Scottish Government, 2009). In some cases, the responsibilities of environmental regulators may overlap with various authorities, such as LAs and utility companies, and this implies greater need for stakeholders to work in collaboration and close partnership to achieve the overall goal of sustainable flood risk management.

Local authorities (LAs)

LAs have more localised responsibility for managing floods in Scotland. Although they have seen increased responsibilities in recent years, their primary duty remains developing plans for local FRM that are consistent with the national strategy. They perform local level flood risk assessments and management in supplement to the district plans, and with additional requirements under the Flood Risk Management (Scotland) Act 2009, LAs are to provide Lead Local Flood Authorities (LLFA) to undertake particular tasks for each Local Plan District (Scottish Government, 2009). These LLFA are responsible for preparing and implementing Local Flood Risk Management Plans as well as developing local FRM strategies for their areas and coordinating activities between the various LAs (DEFRA, 2012a).

There have been some successes by LAs in implementing local FRM strategies, but this has not come without collaborative working partnerships with relevant stakeholders at various levels of the FRM cycle. Apparently, a good working relationship with the national level and other management bodies has led to successful implementation of flood risk reduction strategies at the local levels. An example of such project is the Eddleston Water which was carried out to improve natural flood management, and it involved a number of partnerships including the Scottish Borders Council (SBC) and

Dundee University, led by the Tweed Forum (Werritty et al., 2010). As a matter of fact, working closely together with other stakeholders has been the message from recent strategies in FRM, and SEPA for instance continues to highlight the importance of this tool (Scottish Government, 2010).

Utility companies

UK flood management policies clearly require water utility companies to assess flood risk from potential sources and implement measures aimed at reducing flood risk and their impact on the public (Scottish Government, 2009; DEFRA, 2010). For the Water and Sewerage companies, their main roles include maintaining and managing their water supply and sewerage systems to reduce the risk of flooding as well as making sure their systems have appropriate levels of resilience to flooding. Ofwat, which is an independent economic regulator of the water industry in England and Wales, has a statutory duty to minimise sewer flood risk to its customers among other duties. Following the 2007 floods which recorded countless incidences of sewer flooding, the Pitt review made key recommendations including the need for water and sewerage companies to keep sewer flooding registers, which help form the evidence base on flood risk (Pitt, 2008). These data combined with other flood information will help relevant parties to be more effective in delivering their FRM responsibilities as they work jointly and share data.

In Scotland, Scottish Water (SW) has a primary responsibility for managing flood risk from surface water and sewer systems, and the approach taken to reduce potential flood risk is through its capital investment programme (Scottish Water, 2012). This strategy also points out the need for coordinated effort from relevant bodies including SEPA and LAs once surface water flood risks are identified. In addition, the economic regulator of the SW, the Water Industry Commission (WIC), plays a critical role in the partnership to help reduce pressure on sewer system and alleviate flood risk. Both the SW and WIC have duties to deliver sustainable flood management solutions, and given the complexity of factors involved in surface water flooding means that an effective working partnership between them and other responsible organisations is critically essential (POST, 2007a). These factors, including the rising number of buildings and people in our towns and cities, have over-burdened drainage systems (RIBA, 2009). As a result, managing flood risk from drainage infrastructure within our densely populated societies has been extremely difficult; hence the SW alone cannot bear such responsibility (Scottish Water, 2012). However, SW has the mandate to lead in the assessment of surface water management issues in general, while LAs are tasked with the assessment of flood risk from sewerage system (Scottish Government, 2009). At the property level, homeowners need to ensure their property is maintained in good condition to avoid the possibility of contributing to sewer flooding problem.

A typical example of a successful close working partnership in managing flood risk is the Metropolitan Glasgow Strategic Drainage Partnership (MGSDP). The MGSDP which consists of several bodies including SEPA, Scottish Water, Scottish Enterprise and Glasgow City Council, has the aim of providing a long term urban drainage strategy for Glasgow (MGSDP, 2012). The 2002 floods that inundated Glasgow was a primary motivation for forming the MGSDP, and since then the partnership has taken proactive measures to tackle flooding problems. For instance, the success of the White Cart Flood Prevention Scheme that now protects thousands of properties was down to collaboration between various stakeholders, and has produced an exemplary approach to managing surface water flooding in the city (MGSDP, 2012). In particular, the MGSDP has reduced flood risk to over 7000 properties, and has invested over £40 million in sewers to improve and protect water quality (MGSDP, 2013).

Emergency services

Emergency response is a vital element under the disaster management cycle. Figure 2.8 shows the cycle and illustrates the sequence of disaster management, with emergency response being crucial to recovery from flood event (Atkinson et al., 2006; HR Wallingford, 2008). Emergency response is a public task which requires all stakeholders, including the emergency authorities. The Civil Contingencies Act (CCA) provides legislation on civil protection. This Act applies to the whole of the UK including devolved administrations, and defines responsibilities in dealing with emergencies such as flood hazard (HM Government, 2005). Under the CCA, emergency is defined as “an event or situation which threatens serious damage to human welfare in a place in the UK, the environment of a place in the UK, or war or terrorism which threatens serious damage to the security of the UK” (HM Government, 2005). The Act provides the basic framework for emergency response, and it places responsible authorities in two categories. The first responders are those organisations at the core of emergency response, and include emergency services such as Police, Fire Brigade, LAs, Government agencies (SEPA and EA), and Health bodies.

The EA and SEPA have a task to issue timely flood warnings in the event of floods, and also work in cooperation with other professional partners to provide integrated response to flood incidents. Likewise, LAs have a duty to work with the police force and rescue teams to coordinate the response flood emergencies, while the fire service also work with the police and others to plan for flood emergencies, and their most important task include rescuing trapped people. In all, flood emergency response procedure needs to be quick and effective in order to be successful, hence a good working partnership is vital (Lumbroso et al., 2008).

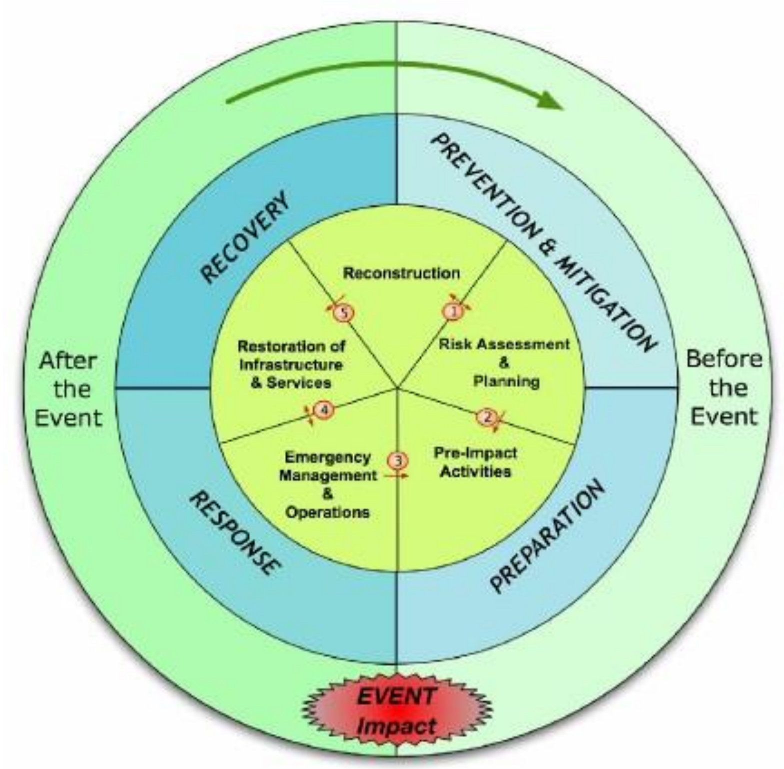


Figure 2.8: The disaster risk management cycle (Source: HR Wallingford, 2008)

Non-governmental organisations

The role of non-governmental organisations in achieving the goal of sustainable flood risk management is crucial. These organisations include community level flood groups, flood wards or volunteers and individual activists. Their primary responsibilities include flood education campaigns, that promote both better preparedness for floods and uptake of flood protection measures to reduce flood risk exposure (NFF, 2011; SFF, 2012). In the event of floods, these groups have often been seen helping with emergency assistance to affected homes. The largest of community based non-governmental organisation in the UK is the National Flood Forum (NFF), funded by the EA (NFF, 2011).

A subsidiary organisation in Scotland is the Scottish Flood Forum (SFF) formed in 2008, and funded by the SG. Together, these community based organisations have helped flood risk communities to be more aware and prepared for floods. Through establishing flood action groups within flood risk communities, and instilling flood consciousness and resilience in them, they contribute to flood risk reduction. In Scotland alone, sixty-one community flood groups were established by 2012 through the collaboration with SEPA, SFF, local authorities, water companies and Emergency Planning Agencies (SFF, 2012).

Although the specific operations of community flood groups differ from area to area, depending on the demands, the core aim remains making flood risk communities more resilient to flooding and assisting in flood recovery. Typical examples of such groups are the Cockermouth Flood Action Group and Morpeth Flood Action Group who have had extensive impact on their communities through creating flood awareness, by promoting and sharing flood knowledge. While these groups play a pivotal role in reducing flood risk at the community level, there is a limitation to their scope of operation and they do not assume individual flood risk responsibilities. It is therefore imperative that individual stakeholders make efforts to complement the work of the community flood groups.

Homeowners and individuals

Despite the role of government bodies and non-governmental organisations in fighting floods at the community level, significant numbers of homes still remain at flood risk. The need to minimise the dangers of flooding at the household level has necessitated a delegated responsibility at this level. Under the integrated approach to flood risk management, the role of homeowners in reducing flood risk exposure at their property is explicit – "homeowners are responsible for flood risk management at their property level" (Scottish Government, 2009). Thus, homeowners and individuals are expected to be more involved by being both fully aware of flood threats and prepared for such events. This is an essential task for homeowners to protect their properties; however, this responsibility has been neglected by householders for various reasons (Werrittty et al., 2007; Terpstra and Gutteling, 2008), and this will be investigated in this research.

It appears that householders often put the responsibility on governments to fully provide protection for their homes. This perception is somehow based on the fact that governments have the overall responsibility to ensure adequate protection for their citizens, and perhaps people may feel this overrides their personal obligations. However, floods cannot be stopped entirely and there has always been the problem of residual risk at the property level after the implementation of large scale flood protection schemes. In such situations, the onus rests on homeowners and individuals to protect their property from floods, and this burden is bound to increase given that future flood risk will rise. This implies that homeowners could be more concerned about their homes flooding, and the use of property flood mitigation measures can be instrumental in alleviating future risk (Bowker, 2007; Langdon, 2011; Royal Haskoning, 2012). The attitude of people towards using PLFP products, including their preparedness to pay for such measures is examined in Sections 4.5 and 4.6.

2.5.2 Stakeholders in other developed countries

United States of America (USA)

In the USA, FRM is a shared responsibility between the Federal, state and local agencies. A number of stakeholders are involved, including the Federal Emergency Management Agency (FEMA), and the U.S Army Corps of Engineers (USACE) who operate various programs to assist states in reducing flood risk vulnerabilities (USACE, 2013). For example, the state and local government determines and regulates how land is used in floodplains, and their decisions in turn inform federal programs to help mitigate flood risk. FEMA has the overall responsibility to lead and support flood disaster emergency protection, preparedness, recovery, and mitigation (FEMA, 2009). Their work is to help reduce the loss of life and property damage by protecting the country from flood risk. Figure 2.9 shows the forms of flood risk management and stakeholders related with each activity.

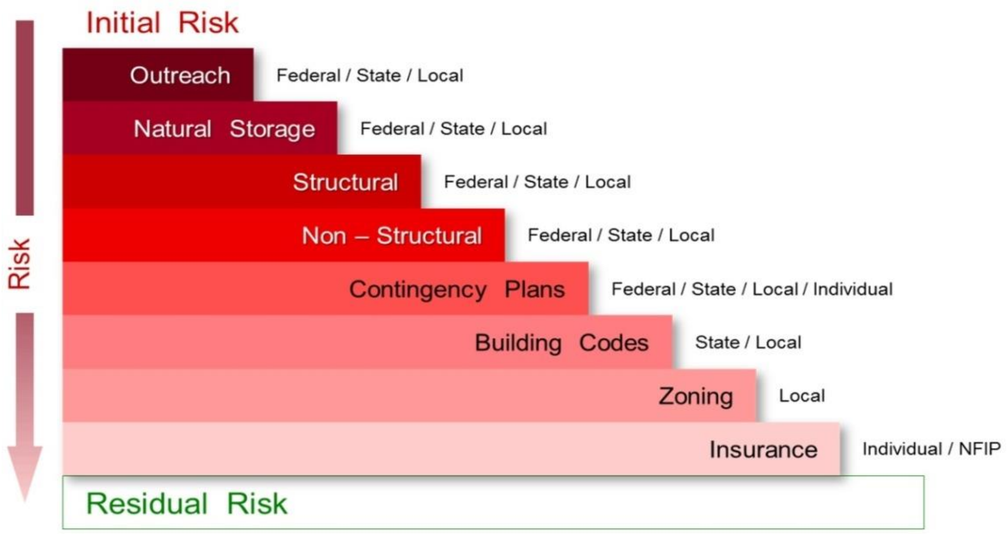


Figure 2.9: FRM stakeholders in USA (Source: USACE, 2013)

Specific tasks with respect to the construction, operation and maintenance of flood control dams, hydroelectric facilities and other water control measures is handled by the USACE (Natural Hazard Mitigation Plan, 2009). In addition, this group provides assistance in floodplain management planning, and also ensure adequate measures to reduce the impact of natural hazards. Their role at the community level is to provide advice to communities and property owners on flood mitigation measures. Due to the number of agencies and established programs involved in the management of flood risk, both USACE and FEMA lead the coordination of the various activities (USACE, 2013). Inter-agency coordination takes place at the national, regional, state and local level to ensure effective communication of activities as well as knowledge transfer in minimising flood risk (USACE, 2013).

The National Advisory Council (NAC) is responsible for developing national preparedness goals, the National Incident Management System, and other plans which are meant to help advise the delivery of all aspects of emergency management by FEMA (Natural Hazard Mitigation Plan, 2009). Local Emergency Communications Committees (LECCs) work in collaboration with the State Emergency Communication Committee (SECC) to provide assistance at the community level, while the Environmental Protection Agency (EPA) remains the enforcer of environmental regulations. The EPA responds to disasters by providing technical assistance, clean-up, and information of flood protection measures (EPA, 2012). It also provides financial support to fund environmental campaigns including wetland protection and restoration of watershed.

Flood warnings form a critical part of natural disaster management, and this is supported by a number of public bodies in the USA. The National Weather Service (NWS) alerts the public about dangerous weather conditions, as well as implementing safeguards against such disasters (Natural Hazard Mitigation Plan, 2009). Also, the NWS provides information on weather conditions which helps the Emergency Alert System (EAS) to produce localised warnings and forecasts about natural disasters (National Weather Service, 2009). The EAS is a national public warning systems which can also be used by the state or local authorities to propagate emergency information.

France

In France, a total land mass of about 22,000 km^2 is vulnerable to flooding, potentially affecting 2 million people. Damages from past floods are said to represent 80% of all damages from natural hazards, and this amounts to €250 million, with recent examples including the 2000 Somme floods and 2004 Gard and Aude floods (CRUE, 2007). The annual budget for flood and coastal protection is estimated at €500 million (compared to around £600 million for the UK), and the need for FRM has been driven by concerns for the various climate types, torrential rainfall, and climate change problems.

FRM in France is also a shared responsibility between the State and communes, and the primary role of the state includes flood risk awareness and implementation of flood prevention and control measures. The mayors of each commune play a central role in flood prevention as they remain fully responsible in administering building and construction permits, as well as being in charge of urban land use planning (CRUE, 2007).

Like other EU countries, there exist various levels of stakeholder involvement from the national to the local level. FRM at the national level resides with the Water Direction (DE) and the Pollution and Risk Prevention Direction (DPPR), which are within the Ministry of Ecology and Sustainable Development (MEDD), and are tasked to ensure the prevention and reduction of flood risk as well as ensuring communication with local authorities and relevant state organisation. At the regional level, the Regional Agencies of Environment (DIREN) have the responsibility of implementing flood risk legislation, whereas at the community level, residents along the riverside have a duty to maintain the river and participate in flood risk prevention works.

Germany

Germany is a federal republic made up of sixteen Länder (States), with large river network including international river basins such as the Rhine, Danube, and Elbe. Having suffered major flood incidents including the 2002 and 2006 floods, flood management in Germany has been predominantly flood protection (DKKV, 2004). In addition to the prevalence of flash floods, flood management strategies have been guided by climate change concern and the storm surges from the North Sea, and in view of the EU Flood Directive, different agencies have responsibilities in implementing FRM.

The Federal Government has transposed the EU directive into the Germany national law (as well as Federal Ministry of Interior) by amending the Federal Water Act in 2009, and this came into force in 2010 (LAWA, 2010). At the national level, the implementation is undertaken by the joint Working Group of the Federal States on water issues (LAWA), which coordinates between the German Federal States. Overall, the German Federal States have the responsibility to put together flood protection plans based on 100 year flood where such plans do not exist.

FRM is a shared responsibility at the administrative regions, districts and municipalities, with the water administration coordinating activities from the various stakeholders including region and municipal planning agencies, agriculture ministries, emergency services and insurance bodies (CRUE, 2007). The Department for Water Management with the Federal States is responsible for implementing policies, and other roles such as planning and maintaining flood defences, and flood warning systems. The Federal Government co-finances flood defences while the maintenance of such measures is funded by the respective states. In terms of flood warning and forecasting, the German flood protection unit is involved and gives information on water levels of the river network (Flood Protection Unit, 2009).

Netherlands

The important sources of flooding in the Netherlands include coastal and fluvial flooding, with major flooding occurring in 1995 and 1998. While flood defences remain a requirement for livelihood in Netherlands due to the vast extent of flood risk, other factors that influence FRM include increase in population and urbanisation issues as well as the changing risk perception level (CRUE, 2007).

Different levels of government are involved in FRM, and at the Central Government level, the management of water and flood risk including implementation of policy and legislation is done by the Ministry of Transport and Public Work and Water Management. Also, the Ministry of Housing, Spatial Planning and Environment and the Ministry of Agriculture, Food Quality and Nature are all responsible for flood risk management and water policy. Moreover, the Minister of Interior Affairs is in charge of disaster management actions at the national level.

At the regional level, twelve Provinces are involved in FRM with the task of formulating strategic and operational water and FRM policy within the national policy framework (CRUE, 2007). In addition to this, they draw regional plans and policies for expansion of residential units and industries within towns and cities, are responsible for groundwater issues and have authority to delegate powers to Water Boards. Given their role in issuing development permits, they also help in spatial planning and reduction of development on floodplains. At the provincial level, disaster management and responses is handled by the Royal Commissioner.

Water Boards are one of the oldest and independent authorities in FRM, and there are twenty six of them with vital roles of ensuring surface water quantity and quality, including the maintenance and management of dike systems to safeguard the country from flooding (Water Board, 2010). Their operation is backed by the Water Embankment Act (1996) aimed at providing protection against flood risk and was introduced in all geographical units consisting of 53 dike ring systems. To help meet the future demand of water management, a new governance agreement was signed in 2011, and the Water boards were tasked with the maintenance and reinforcement of dikes and dams, with the central government often providing financial assistance for this work.

At the municipal level, there are 483 municipalities involved in FRM with the task of constructing and maintaining sewerage system. These authorities prepare local regulation and have both the legal power and financial resources to implement their plans and decisions (Water Board, 2010). However, at this level, municipal authorities may work together with other bodies including the Water Boards such as is usually required to implement and enforce environmental regulations.

2.5.3 Stakeholders in developing countries

Bangladesh

Countries in Asia including Bangladesh and Indonesia have been severely flooded in the past. Bangladesh, which is a densely populated country with low topography, has three major rivers: Ganges, Brahmaputra and Meghna which have been linked with floods. The country has experienced seasonal flooding as well as many tropical cyclones, and the common types of floods are flash floods and river floods (SDC, 2010). Catastrophic floods include the 1988, 1998 and 2004 incidents, with the later causing 750 deaths and made 20 million people homeless (Khan, 2008). Flood management practice in the past has predominantly been flood control through structural measures, and factors that have influenced flood management in Bangladesh are the effects of climate change and the fast growing population of the country (SDC, 2010).

There have been numerous national plans and policies towards flood management in Bangaldesh, including the National Water Plan 1 in 1986 and the recent Climate Change Strategy in 2008 by the Ministry of Environment and Forests (MoEF, 2008). However, the challenge has been the implementation of such policies, which is said to have been ineffective in most cases. The Flood Action Plan (1989-95) sponsored by the World Bank, was implemented after the disastrous floods in 1987 and 1988, initiating a culture of disaster management and risk reduction (SDC, 2010). Given the lack of resources and funds to implement flood management schemes in developing countries, the World Bank has supported many initiatives including the Flood Forecasting and Warning Centre (FFWC) in Bangladesh (UNDP, 2014). The FFWC which was established in 1972 has been improved through the UNDP and DANIDA assisted projects under the Flood Action Plan, where forecasts are now being made in many locations and dissemination of such warnings are through government and NGO initiatives.

In terms of recent plans, the Bangladesh government has a regulative framework for disaster management, which is being seriously pursued following the Hyogo Framework for action 2005-2015 (SDC, 2010). The framework includes the Disaster Management Act which forms the basis to protect life and property and manage long term risks from hazards. There is also the National Plan for Disaster Management which provides overall guideline to relevant sectors and disaster management committee at all levels (SDC, 2010). With the shift in disaster management, from response and relief to risk reduction practices, Bangladesh has seen few lives and livelihoods destroyed by natural hazards unlike the past (UNDP, 2014). However there are still clear problems with local risk management as disaster management committees at the local levels do not have sufficient supports and funds to carry out their responsibilities (SDC, 2010). There are also concerns about broad-based ownership of plans, resulting in stakeholders implementing plans in many different ways.

There exist a number of stakeholders at the national level, with the Ministry of Food and Disaster Management (MoFDM) being responsible for coordinating disaster efforts. Under the MoFDM, the Disaster Management Bureau (DMB) is tasked with creating public awareness of flood risk and formulation of programmes that will better prepare at-risk communities and public officials to mitigate the impacts of disasters (DMB, 2010). The Directorate is responsible for effective liaison between government agencies, donors and NGOs to ensure maximum cooperation and coordination in all aspects of disaster management (SDC, 2010). At the local level, the Local Government Division which is under the Ministry of Local Government, Rural Development and Cooperatives acts as the focal point in disaster preparedness activities (DMB, 2010; SDC, 2010). Despite the promising efforts by the government, there are challenges including inadequate funding, poor coordination and slow or ineffective implementation of initiatives as previously indicated. In fact, regional coordination with neighbouring countries is still weak and not institutionalised, and the existing coordination between government and donor agencies is said to be much of a response to disasters rather than preparedness (SDC, 2010).

In view of the need for proactive actions in disaster management, some organisations have been influential in community engagement activities in Bangladesh. For example, the UNDP has contributed to building mangrove greenbelts along vulnerable coasts by working with the government and local residents in the southern delta (UNDP, 2010).

This is an important step to flood management at the local level, as the project is expected to protect 5,000 families from storm surges and coastal waves. Similar community level practices have been employed elsewhere in Indonesia, where UNESCO together with local government institutions and NGOs, put together activities to strengthen flood resilience of vulnerable communities in Jakarta, following the devastating floods (UNESCO, 2004; Jha et al., 2012). Lessons learned from these initiatives should encourage LDCs to embrace such cost effective actions to help the poor and vulnerable communities improve their flood resilience.

Mozambique

Mozambique is one of the poorest countries in Africa, with almost 50% of the population living in extreme poverty. Extreme climate conditions have affected this country's development, and since 1980 at least seven major floods affected many people (Hellmuth et al., 2007). The worst floods were in 2000 which affected more than 2 million people and killed 700 people, whilst the Zambezi River flooded in 2001 affecting 500,000 people and caused 115 casualties (Hellmuth et al., 2007). Although the high incidence of floods in Mozambique are largely by the tropical cyclones from the south-western Indian Ocean, the country is a low-lying land with major river systems and also vulnerable to climate change making it more susceptible to flooding (Hellmuth et al., 2007; INGC, 2009).

Flood management has evolved in the country and the turning point was the 2000 floods, where risk reduction became a priority. The Department for Combating Natural Disasters established in 1997 was replaced by the National Policy on Disaster Management Institute, following a change in the approach to disaster management from reaction to preparedness (Hellmuth et al., 2007). This new policy of preparedness encouraged early flood warning system which is coordinated by the National Institute of Disasters Management (INGC), established under the Ministry of State Administration in 1999. Ahead of the rainy seasons in the country, seasonal forecasts are made and experts meet to assess preparedness for the predicted weather. At the river basin level, Regional Water Administrations monitor water levels and provide information to the National Institute of Meteorology who also collect data from their meteorological stations to use in their periodical forecasts.

The Regional Water Administrations issue flood warnings when necessary to district governments and local authorities and also to the media (e.g. radio and television). The district governments and local authorities (and sometimes Red Cross and NGOs) are involved in disseminating flood warnings at the local level, and the evacuation of people. Unlike in the developed countries, flood warning messages could take longer to reach vulnerable residents considering the processes involved and the lack of modern technologies to facilitate effective warning systems. Clearly, the 2000 floods showed some shortcomings not only with the technical and institutional capacity of the country but also, the need for effective flood communication to vulnerable groups which is generally a challenge in LDCs.

Some improvements have been made to early flood warning systems and flood management practices following the floods in 2000 (Wiles et al. 2005; Hellmuth et al., 2007). In fact previous flood experiences led the government to set up flood management structures at various levels, from central to local, with effective cooperation between the structures as well. Regional cooperation was improved and this is critical, particularly for countries with international river basins like Mozambique (Wiles et al. 2005; Hellmuth et al., 2007), since what happens domestically is largely influenced by weather events in neighbouring countries. This cooperation is facilitated by the Southern African Regional Climate Outlook Forum, which meets yearly for information exchange and to prepare seasonal forecast for the Southern African Development Community (Hellmuth et al., 2007). Further, a National Disaster Management Strategic Plan was adopted in 2006, with the aim to reduce the risk of disasters in line with the national priorities for poverty reduction (Hellmuth et al., 2007). However like other LDCs, the poverty of most Mozambicans adds to their flood risk vulnerability and the country rely on international support in most of its initiatives.

Flood risk analysis was undertaken to identify vulnerable areas and people in Mozambique, which found that 40 out of 126 districts are prone to flooding, representing 5.7 million people in those districts (Hellmuth et al., 2007). This figure signifies a high portion of the Mozambique population (~20 million) is at-risk of flooding, and implies greater need for flood mitigation in those areas. Although community based disaster risk management programs are in several locations, including the Buzi District of Sofala Province, there are still large vulnerable communities where flood awareness raising and capacity building is needed to help people prepare better for floods.

Ghana

Ghana has experienced flooding in the past decade particularly in the Northern Savannah belt, among other natural disasters such as storm surges, landslides and coastal erosion. In 1995, major floods inundated the country and reports suggest over 17 casualties, with over 1000 families said to have been displaced in the process (Aboagye, 2012). More recent floods in 2007 affected over 325,000 people in the northern region with almost 100,000 people helped to recover from the event (GFDRR, 2014), and similar situations occurred in 2008 and 2011 (Lamond et al., 2012b). Although floods are serious problems, the country's development dynamics and demographic changes put more people at risk of flooding (GFDRR, 2014). These factors include increasing rural poverty, rapid urbanisation and growing urban and coastal neighbourhoods, which are contributing to flood risk vulnerabilities.

Managing floods is a challenge in Ghana and national institutions including the Water Resources Commission (WRO), Hydrological Services Department (HSD) and the National Disaster Management Organisation (NADMO) have roles to play. NADMO is the government agency responsible for disaster management and emergencies, established within the Ministry of Interior in 1996. NADMO functions include preparing national, regional and district disaster management plans for preventing and mitigating disasters, and establishing facilities for technical training as well as coordinating local and international support for disaster (NADMO, 2012). Although NADMO has played vital roles in relief support to victims of disasters, flood reduction initiatives are very minimal or non-existent and the institution face major problems primarily with insufficient funds and resources to function more effectively. NADMO is therefore handicapped in its ability to develop capacity for the implementation of adaptation and mitigation strategies, and it is said to be preoccupied with top-down approach where devastation occurs before actions are taken (Otteng-Ababio, 2013).

In view of the lack of strategies and mechanisms to integrate disaster risk reduction into national policies and local development policies, there has been the need for national disaster risk management plan which has been supported by donor agencies including

UNDP (GFDRR, 2014). NADMO and its international partners are currently working to strengthen the government's capacity in disaster preparedness and risk reduction. Their activities include training programs for staff, which is critical for the success of risk reduction operations given the lack of sufficient training and capacity building within NADMO (GFDRR, 2014). Another area that the national plan seeks to address is the need to increase public flood awareness, which is an essential part of the flood management practices, as discussed in the following sections. Successful flood risk reduction plans should involve key stakeholder participation especially at the local community level, but this is often neglected in Ghana and most flood affected communities are continuously exposed to the disaster without any preparedness (Otteng-Ababio, 2013). Targeting vulnerable groups and raising awareness of flood risk, and taking up proactive measures are key areas LDCs could invest to help mitigate flood impacts in future.

As part of the changing approach to flood management in the country, there has been recently completed disaster preparedness and watershed management projects. This project involved flood hazard assessment for the White Volta and development of an operational flood forecasting system (GFDRR, 2014). The risk assessment and flood forecasting information are being used for flood warning by the national agencies including HSD and NADMO. Although this is a good initiative, particularly for communities along the White Volta who could benefit from early flood warning, there is greater need for investment in early warning system to improve wider operation to benefit most communities.

2.6 Flood Risk Management Techniques

2.6.1 Large scale flood defences

The prevalence of floods has called for a holistic approach in managing flood risk, and this demands balancing current and future needs sustainably. The strategy has usually required the implementation of both structural and non-structural mechanisms in reducing flood risk (Jha et al., 2012). Figure 2.10 shows the classification of flood management tools, including the structural and non-structural measures and the techniques involved. Structural measures are normally physical features or hard engineering solutions designed to control flood water. For some good part of human history, flood control has involved the construction of traditional large scale flood defences, typically in the form of embankments, walls, weirs, sluices and pumping stations, and dams or reservoirs (Environment Agency, 2012b). These flood defences are often permanent structures made of concrete, metal or construction materials, and have been useful in protecting national assets, properties and the environment from the damaging impacts of floods.

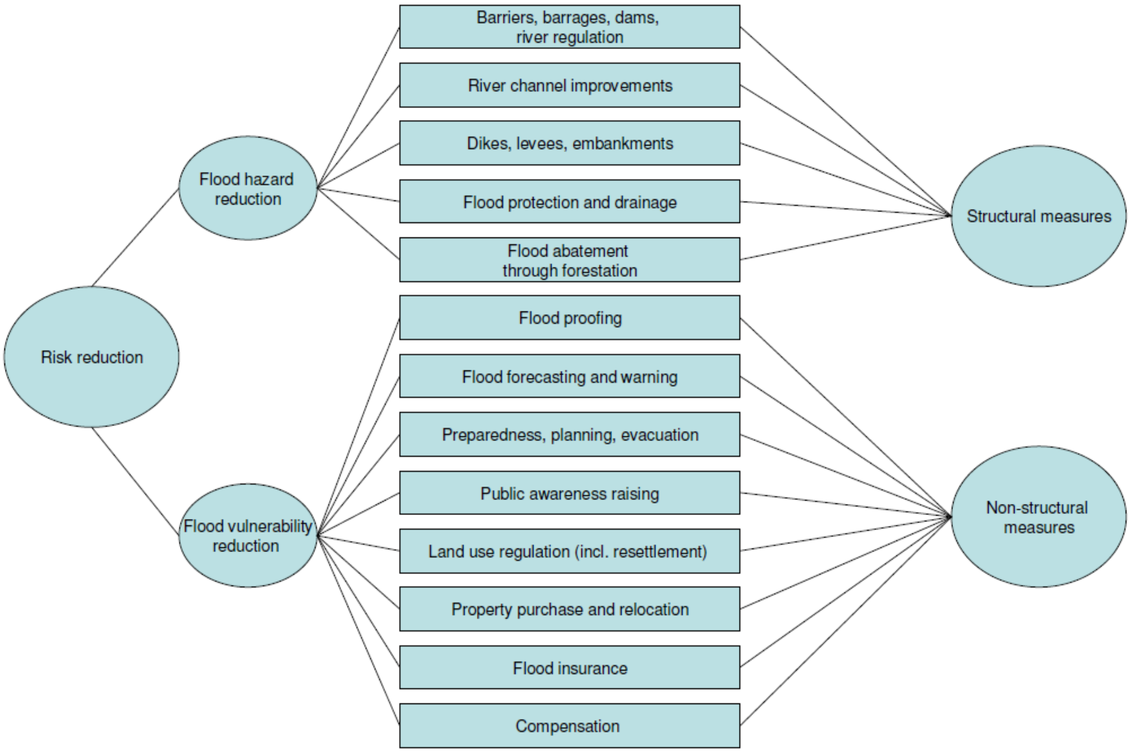


Figure 2.10: Classification of structural and non-structural measures (Source: Parker, 2007; CRUE, 2008)

There are innumerable cases where structural defences have been used extensively, both across Europe and elsewhere. For instance, in the Netherlands, many homes would be vulnerable to flooding if not for structural flood defences (Jongejan et al., 2008). The country is largely protected by natural dune, dikes and storm surge barriers (Roode et al., 2011), and without them almost 65% of the most densely populated areas would be flooded daily (Van Stokkom et al., 2005). Another example is the Cologne flood prevention in Germany system which covers 67 km along the Rhine's bank, and protects over 150,000 residents (Brandenburg, 2011; Jha et al., 2012). Elsewhere, the UK has over 24,000 miles of flood defences and 46,000 structural flood defences protecting properties and assets from fluvial and coastal floods; the replacement costs of these assets is estimated to be £20 billion (House of Commons, 2007). The Thames flood defence alone protects 125 km^2 of vital assets and properties in central London from flooding caused by tidal surges (Environment Agency, 2011).

Generally, structural flood defences are costly to design and maintain, and they require continuous investments over a long time. There is evidence of increased funding for flood defences, with almost 40% rise between 2002 and 2007 (House of Commons, 2007). Recent figures suggest that the UK spends close to £600 million annually on flood defence projects, compared to previous figure of £400 million for 2007/2008 (Environment Agency, 2009a; House of Common, 2013), and the costs of most individual flood defence schemes in the UK have been very high. An extreme example is the Thames flood barrier which cost nearly £535 million to complete, with an annual maintenance and operational cost of around £8 million (Environment Agency, 2010). The cost of the Cologne flood prevention system in Germany was around $600 million, which also highlights the high investment of such large scale schemes (Brandenburg, 2011; Jha et al., 2012). On a relatively smaller scale, the costs of flood defences in Scotland include £53 million for the White Cart Water Prevention Scheme in Glasgow (Glasgow City council, 2011) and the ongoing Elgin flood defence scheme is budgeted for £86 million (Scottish Government, 2011).

Despite the substantial investments in structural flood defences, the state of flood defences in the UK still demands much improvement (House of Commons, 2007). The demand is evident in the recent appeal for further annual investments of £20 million in flood defence projects to keep flood risk at current levels (House of Commons, 2013). Since this call, some additional £120 million was made available in autumn 2012 to fund increases in flood defences in the next few years, as shown in Figure 2.11; but this is largely recognised as a partial attempt that addresses the shortfall in funding.

The partnership approach to funding new schemes means that more projects including PLFP are likely to be funded, unlike in the past where some schemes have received 100% funding and others nothing. Funding levels will depend on the number of households protected and other benefits, and households in most deprived areas will qualify for more funding than those in less deprived areas (DEFRA, 2011; Environment Agency, 2012a).

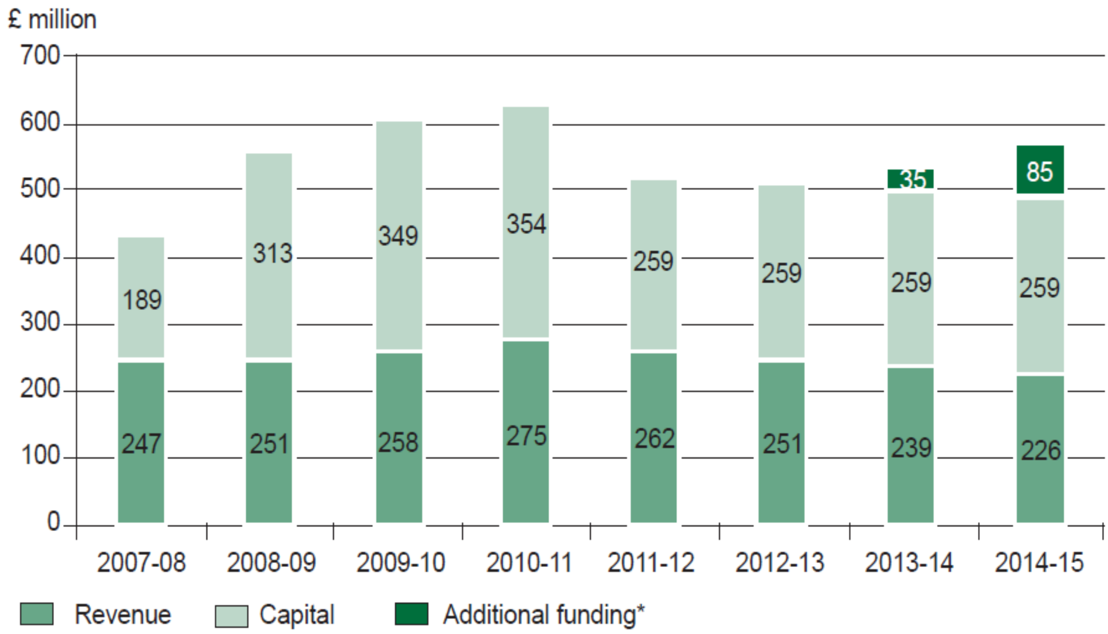


Figure 2.11: Flood and Coastal Risk Management funding level (Source: House of Commons, 2013)

2.6.2 Property level flood protection

Flood risk management at the property level has become significant due to the increasing risk of residential properties and the severe impact of these floods on householders (DEFRA, 2011). Whilst large scale flood defences can be extremely effective in reducing widespread flood risk, such developments are costly, both in terms of time and financial resources (Pitt, 2008). Consequently, cost benefit analysis does not always yield a favourable result for large scale defence schemes, and the recent spate of devastating floods has called for an increased consideration of PLFP measures to curtail the extra demand of flood defences (Pitt, 2008).

Unlike large scale flood defences, property level flood protection measures are often temporary, demountable, and simple to install products (Wingfield et al., 2005). Such measures can be cost effective, easy (and quick) to deploy and can help to prevent or slow floodwater ingress (Bowker, 2007; DEFRA, 2008). Two main types of measures are used for property level protection – resistance and resilient measures.

Resistance flood products

As the name implies, resistance products are those that prevent or minimise the ingress of flood water into a property, thereby reducing the extent of damage caused to the building fabric and contents (Bowker, 2007; DEFRA, 2008). By sealing up entry points to a property, resistance products operate as a barrier between the property and flood water. In practice, two categories of resistant measures can exist – temporary and permanent measures (Bowker, 2007). While temporary or demountable products are usually designed to protect building apertures such as doors, windows and airbricks, permanent measures include barriers protecting one or more properties from flooding.

Resistance products either totally prevent floodwater from getting into a property or "buy time" for the householder to move valuable possessions to safety (DEFRA, 2005). They tend to be particularly effective for shallow floods (< 0.6m), and can remove or reduce many of the damages caused by flooding. Typical costs for a temporary, demountable property level resistance solution (door and window boards, airbrick and service duct covers) range from £2-4k. However, individual products such as airbrick covers can cost as little as £50, whilst floodgates for door openings start at around £330 (UK Floodgates, 2012).

The costs of more permanent resistance measures (water-proof doors, windows, and airbricks) range from £3-10k for a single property (Bowker, 2007). In terms of cost-effectiveness, it has been found that the correct installation of a total property level solution can reduce the insurance claim costs associated with a flood event by 50-80% (ABI, 2006; Thurston et al., 2008). In addition, flood resistance packages have been found to be cost-effective for households with an annual chance of flooding of 2% (i.e. 1 in 50 years) or above, with the largest savings being residential properties subjected to an annual risk of flooding of 4% (i.e. 1 in 25 years) or greater as shown in Table 2.6 below (Thurston et al., 2008). While these findings suggest significant benefits of PLFP, they do not account for barriers to greater uptake of such measures or the financial incentivisation of PLFP scheme.

Table 2.6: Benefit-cost ratios for PLFP measures for semi-detached property (Source: Thurston et al., 2008)

Annual chance of flooding	Return frequency (years)	Resistance (temporary)	Resistance (permanent)	Resilience without flooring	Resilience with flooring	Resilient repair without flooring	Resilient repair with flooring
20%	5	10.6	8.4	3.7	3.7	6.7	5.5
10%	10	5.8	4.3	2.1	2.0	3.9	3.0
4%	25	2.6	1.8	1.0	0.9	1.9	1.4
2%	50	1.3	0.9	0.6	0.5	1.0	0.7
1%	100	0.3	0.2	0.1	0.1	0.2	0.2

Resilient flood products

At the other end of the protection spectrum, resilience measures are those with the ability to minimise flood damages when floodwater actually enters a property (Wingfield et al., 2005; Joseph et al., 2011). Such measures are normally permanent, and include replacing permeable floors with water resistant material (e.g. solid concrete), using waterproof wall plasters, replacing kitchen and bathroom units with plastic units, and raising electrical sockets (ABI, 2004; Bowker, 2007). Since the cost and disruption associated with the installation of resilience measures can be significant (e.g. £10-30k), they are often implemented during major renovation or repair works.

Resilience packages are considered to be more effective for deeper floods (0.6-0.9m) as corresponding resistant products are often overwhelmed at such depths (Thurston et al., 2008). In general, the higher cost of installing resilience measures makes them less cost beneficial than resistance products. However, in common with resistance products, implementing resilience measures can be worthwhile where the annual chance of flooding is greater than 2% (1 in 50 years). For buildings not already in need of repair or refurbishment, resilience measures are only cost-effective in areas with a 4% or greater annual chance of flooding (Thurston et al., 2008).

Uptake of resistance and resilience products

The current uptake level of resistance and resilience measures is very low (DEFRA, 2008, Kazmierczak and Bischard, 2010). A study found that only 16% of households and 32% of small and medium enterprises (SMEs) in areas of significant flood risk have taken practical steps to reduce their exposure to flood damage (Thurston et al., 2008). In addition, the reluctance of the public to contribute towards the cost of protection is further revealed by Werritty et al. (2007) where just over half of survey respondents were unwilling to pay additional council tax to fund flood protection measures, and even amongst those willing to pay, only 8.5% were prepared to pay £100 or more.

In assessing the willingness of homeowners living in flood risk areas in England to undertake property level protection, Kazmierczak and Bischard (2010) found that almost half of homeowners were concerned about climate change consequences on their homes, and were prepared to install airbrick covers and door guards for their homes. The median willingness to pay amount per household was under £100, which seems very low; even lower than the £200 that RPA (2004) reported as the sum of money householders in England were willing to pay to avoid the health impact of flooding. Another survey involving over thousand residents in Northern Ireland found that 74% of them were willing to make some adjustment to their properties to protect against flood damage, including tiled floors with rugs, resistant frame doors, and skirting boards. Overall, 65% of respondents were willing to pay towards flood protection measures, but just 16% were willing to pay the full costs and 49% were willing to contribute towards some of the costs of PLFP measures (Consumer Council, 2013). A similar survey of Dutch residents found that nearly two thirds of homeowners would be willing to invest in flood mitigation measures (e.g. water barriers) in exchange for discounted flood insurance with the mean willing to pay value being almost €120 per year (Botzen et al., 2009). Though this finding confirms the public's interest to take-up flood protection, the WTP value is low and there was a heavy preference for traditional sandbags as the majority (68%) of the people were willing to buy these products.

Common reasons for the low uptake of property level protection include the fact that homeowners often underestimate the risk of flooding of their properties, and are unaware of their responsibility in protecting their properties (Werritty et al., 2007). This problem has strengthened the need for flood education campaigns and, flood risk communication has been shown to be a source of motivation to individuals to undertake precautionary measures for flood events (Kreibich et al., 2011; Koerth et al., 2013). Other barriers to promoting PLFP is concern about the cost of implementing such measures are the physical appearance of such measures on their property (DEFRA, 2008; ABI, 2011c). Moreover, the low level of awareness of PLFP products is a major obstacle to the use of such measures (Kazmierczak and Bischard, 2010); some property owners are generally unaware of the options, benefits and cost of PLFP measures (DEFRA, 2008). Table 2.7 shows some of the common flood resistance and resilience products on the PLFP market, including basic products such as airbrick covers. Resilience options, including raising door threshold and resilient flooring are permanent measures.

Table 2.7: Property level flood protection measures

Products and measures	**Resistance measures**	**Resilience measures**
Airbrick and vent covers	●	
Flood guards on doors or windows	●	
Free-standing barriers	●	
Flood resistant skirts	●	
Flood walls and gate	●	
Water pump and sump system	●	
Non return valves on pipes	●	
Sandbags	●	
Toilet plugs	●	
Raised door threshold		●
Resilient wall plaster		●
Concrete flooring		●
Resilient kitchen (waterproof units)		●
Resilient bathroom units		●
Raised electrical sockets, phones, and TV points		●

Promoting the uptake of PLFP

To increase the uptake of protection measures, there is the need for homeowners to realise their personal responsibility to prepare for floods, and even greater need to promote awareness of property flood mitigation measures (Thurston et al., 2008). This message is also echoed by Pitt (2008) after reviewing the 2007 UK floods. In addition, recent findings from surveyed residents in Germany has highlighted that, providing homeowners with information on the effectiveness of flood mitigation measures and advice on the implementation of these measures can lead to increased flood precautionary behaviour (Bubeck et al., 2013). In carrying these messages forward, consumer organisations including the NFF and SFF in the UK have taken up the responsibility of advocating the uptake of PLFP measures. Although flood education could transform public perception to participate in flood protection, lessons learned from previous studies have shown that such campaigns coupled with grants or incentives to households are key measures to greater uptake protection measures (DEFRA, 2008).

In England, DEFRA has recently incentivised PLFP schemes to both help promote the benefits of innovative flood protection measures and to encourage further take-up (JBA, 2012a). This was a major initiative involving £5.2m projects delivered in two phases from 2009 to 2011, with over a thousand properties protected in 63 communities. The funding for individual property was limited to £5,700 and covered the costs of a property survey (£500), administration costs (£700), and the protection measures themselves (£4,500). Although the installed measures have not yet been tested by a flood event, the lessons learned from the scheme suggest that it has been successful with particularly high levels of participation; there was a 93% scheme uptake. Evaluation of the projects using six case studies, to understand whether they would have been funded under the Partnership Funding approach, showed that the project achieved a benefit cost ratio of 5 to 1.

In Scotland some local councils promote the uptake of PLFP measures by providing subsidies to residents. The Scottish Border Council (SBC) and the Dumfries and Galloway council have been exemplary in this initiative; these councils provide discount schemes on a range of protection products to householders and businesses whose properties are at risk of flooding. The maximum subsidy allocated to individual properties is £650, and the savings on basic products is 63%. The savings on floodgates are a little higher and are 66% for medium size (i.e. 975mm X 1405mm) under the SBC scheme and 76% for regular size (i.e. 890mm X 975mm) under the Dumfries and Galloway scheme (SBC, 2011).

Several overseas cases also highlight the need to incentivise flood protection products in order to promote take-up. For example, the Toronto City Council (Canada) ran an existing subsidy program to homeowners to reduce their risk of basement flooding due to the increasing flood risk related to climate change (Toronto City Council, 2012). The financial subsidy provided to homeowners is up to $3,200 per property to install PLFP measures including back-water valves and sump pumps (Sandink, 2013). In addition, several studies in Germany strongly advocate encouraging the uptake of flood precautionary measures based on their usefulness, particularly, following the high profile floods in Europe (Grothmann and Reusswig, 2006; Bubeck et al., 2012). Evidence of the effectiveness of flood precautionary measures in reducing the extent of damage has been shown; households with flood mitigation measures during the 1995 floods suffered less damage by far in comparison with the 1993 flooding (Bubeck et al., 2012). However, there exists a barrier to the wider use of flood protection measures which is the issue of affordability. In view of this challenge, the option of financial incentives to spur the uptake of flood mitigation measures has been recommended, and Bubeck et al. (2012) have also suggested incentives in the form of reduced insurance premiums which could help to improve the generally low uptake of flood cover and help reduce financial losses. On top of this, more recent flood in Germany has heightened the pressure for flood mitigation measures, and Meyer et al. (2013) has urged for a state subsidisation programme including construction or refurbishment to houses to withstand flooding.

2.6.3 Non-structural measures

Non-structural flood defence measures play a vital role, together with structural measures, in sustainable flood management. They are those measures that do not involve physical construction but use knowledge or practice to help reduce flood risk and impacts, for example through policies and public awareness raising (UNIDR, 2009; Dawson et al., 2011) The need for such solutions is more critical as it is notable no single approach can cope with the increasing demand for flood protection, and such structural measures are also found to be very costly to implement both in terms of time and financial resources (Pitt, 2008). In addition, structural measures are not always a suitable solution and in some cases, they may become a source of further risk in another location while being used to control flooding in a different area. Typical non-structural measures include flood risk awareness, flood warning and land use management which are the main foci of this section.

Flood risk awareness communication

Flood risk awareness is seen as the cornerstone of non-structural measures, and is designed to help people reduce their risk of flooding by staying aware and prepared for flood events. The need to communicate flood risk to the public is borne out by the reportedly high levels of public ignorance, even by inhabitants in floodplains (Jha et al., 2012).

Although flood risk communication is a tool found to cause behaviour change in people and encourage the preparedness of residents towards flood mitigation measures (Kreibich et al., 2011; Koerth et al., 2013), it needs to be effectively used in order to have impact. An effective communication process involves four stages, namely awareness, understanding, acceptance, and behaviour change (Jha et al., 2012). Raising awareness and explaining flood risk concepts in a way that the public understands, has been the priority of flood education, particularly the ongoing flood campaigns by the NFF and SFF in the UK. Also, interactive flood maps and information are now available to the public to aid increased understanding.

In addition, an evolving practice is to empower children to engage in promoting flood risk awareness at the grass root level, as they are among those usually affected by floods. A typical example of children's participation in flood education is the case of the Zambezia province in Mozambique where children aged between 12 and 18 have been largely engaged in promoting flood awareness (Dale et al., 2009; Jha et al., 2012). Children have been involved in various activities including an educational game called "The River Game", which is used to educate about disaster risk and encourage children to share their understanding with others members of their communities. This program is reported to have caused behaviour change among residents particularly along the Zambezi River and is said to have also increased the use of more appropriate responses to flood risk. Similarly, in Scotland, the SG and Education Scotland seek to encourage better awareness of flood risk and improve community flood resilience through the Curriculum for Excellence; a number of flood related activities are already happening in various schools across the country (Frame, 2014).

Flood forecasting and warnings

The long standing issue of flood risk has heightened the need some advance warning systems in an attempt to reduce flood loses (De Roo et al., 2003; Werner et al., 2005). The rationale behind flood warnings and emergency planning is based on the evidence that no matter how careful flood reduction efforts are, some risk will always remain (Handmer, 2001). There is clearly a need for flood warning systems that give timely warning to at-risk communities so that they can prepare for floods events (Carpenter et al., 1999), and this is particularly vital for effective deployment of PLFP. Examples of operational flood forecasting systems in the world and their inception dates are: the Community Hydrological Prediction System in the USA (2009), European Flood Awareness System (1999-2003) and the Flood Early Warning System in Sudan established in 1990 (Jha et al., 2012).

In practice, estimates of rainfall runoff and sea or river levels and flows are used as a basis to forecast flood events. Through the monitoring of rainfall and river levels in catchment areas, flood forecasting and warnings give people the time to prepare, protect their property and belongings before the onset of flooding (Patrick, 2002; Werner, 2005; Cloke et al., 2009). However, the challenge with flood forecasting and warning processes is to maintain the accuracy and precisions of its warnings. Common problems that can arise from such operational systems include flood warnings not reaching the public (Penning-Rowsell et al., 2000; Werner et al., 2005), or false warnings being disseminated to the public (Krzystofowicz et al., 1992; Werner et al., 2005). These situations can hinder public confidence in the performance of flood warning systems, and there is a need for improved and more advanced flood warning technologies to resolve operational issues (Pitt, 2008).

The conventional way of forecasting using the deterministic approach, which involves forecasts based on single model run is shifting towards a more reliable technique, the probabilistic forecasting (Pappenberger et al., 2005; Golding, 2009). This is because the deterministic forecasting can only be as good as other factors such as how good the models are and the skills needed in interpreting them. Usually this technique has short lead times (up to 2 days) which can hinder flood preparedness actions (Buizza et al., 1999: Dale et al., 2014). The key to longer flood warning times (beyond 48 hours) is probabilistic forecasting which relies on different numerical model runs (ensemble prediction) to establish the probability of event, and provides better understanding of uncertainty which can help save effort on flood incident actions (Buizza et al., 1999; Dale et al., 2014). Probabilistic forecasts provide better information to people and therefore increase the time available for decision making. Canada is one of the first countries to broadcast their probabilistic forecast of precipitation in percentages (Environment Canada, 2014). In England and Wales, the EA largely employs deterministic forecasting, whereby warnings are issued to areas where flooding is expected (Golding, 2009). However, substantial progress have been made to develop and implement strategy for moving towards probabilistic flood warning of both coastal and fluvial floods in the UK over the past years (Sene at al., 2007; Golding, 2009).

As a result of the important role of flood forecasting and warning as flood mitigation tools, and the increasing number of people who depend on such information, there has been a considerable investment in flood forecasting and warning system in the past few years (Environment Agency, 2009a; SEPA, 2010). There is now a network of over two thousand river levels and coastal locations being monitored daily to ensure accurate flood warning to flood risk households in England and Wales (Environment Agency, 2009a). The EA has established a national approach to forecasting and warning for England and Wales, and for flood forecasting there is the National Forecasting System (NFFS) which has been operational since 2005, and the majority of warnings delivered are for fluvial and coastal flooding (Werner et al., 2009). There is also the "Extreme Rainfall Alert" service, jointly developed by EA and Met Office, which takes into account pluvial flooding following recommendations from the Pitt (2008) review. Dissemination of flood warnings is done through the Flood Warning Direct, which delivers a larger number of warning messages through a wider range, including telephone, email and text messages (Werner et al., 2009).

In Scotland, the 1994 floods across Strathclyde called for more sophisticated approach to flood forecasting and warning, resulting in a national system called the Flood Early Warning System (FEWS) (Cranston et al., 2007; Werner et al., 2009). The government's commitment towards flood risk reduction has been demonstrated through the continuous improvements in flood warning services. An initial £8.6 million was invested in the SEPA Floodline project, with a further £ 1 million to help improve the scheme to benefit households (Scottish Government, 2010). A network of over four hundred rivers and rainfall sites were being monitored as at year 2010, and this new service, the Floodline, means that members of the public and businesses can now sign up for free flood warnings via mobile phones or landlines. Floodline messages are also published on the SEPA website (http://www.floodlinescotland.org.uk/service/), where customers can access more details on the predictions.

Land-use and management

Natural Flood Management (NFM) remains an integral part of sustainable flood management; this has been defined as 'working with or restoring natural flooding processes to reduce flood risk and deliver other benefits' (Scottish Government, 2009). Human activities such as agricultural practices, building in floodplains and urbanisation can alter the natural recycle of a catchment area rainfall. This can have an adverse effect on the land such as reduced soil infiltration and increased runoff and erosion problems. For instance, urbanisation causes disruptions to the natural drainage pattern while some agricultural practices can have an influence on the runoff and erosion generation process (MWO/GWP, 2007). In particular, floodplain developments have raised major concerns, and the scale of this problem has required government intervention in planning to help reduce flood risk (CLC, 2006; Wheater and Evans, 2009).

In assessing different approaches to flood risk management, the Foresight study suggests that better land use and catchment-wide water storage management can contribute to more sustainable solutions (Evans et al., 2004; POST, 2011). Unlike hard engineering solutions, NFM tends to have lower costs, and less environmental impact. This solution is also reiterated by Pitt (2008) who has heavily promoted working with the natural materials, in line with earlier recommendation by the DEFRA project on "Making space for Water (2005)".

In England and Wales, the concept of NFM is strongly enforced through the Flood and Water Management Act (2010), while in Scotland NFM has advanced since the implementation of the Flood Risk Management Act in 2009, which requires the mapping of natural features and the promotion of NFM strategies (Scottish Government, 2009). Common techniques of working with the natural environment to reduce flood risk include mimicking natural watercourses, restoring and regulating the functions of catchments, rivers and floodplains. Although these practices are considered a more sustainable approach to flood risk management, it is recommended they are used to complement traditional flood defences (Pitt, 2008), which implies that there is no single approach to flood mitigation and in most cases combination of different techniques could be useful.

Generally, the implementation of NFM strategies cannot be successful without a great deal of collaboration at all levels. Collaboration is required from stakeholders including policy makers, local authorities, and land owners, and effective cooperation from the communities involved is equally critical for the success of NFM projects (POST, 2011). Various cases exist where the implementation of NFM projects have been very successful, for example a study by the Flood Risk Management Consortium (FRMRC), highlighted that suitably-placed strips of trees in upland areas can improve infiltration of water into soils and also reduce flood risk for small catchment (~10 km^2) (Wheater et al., 2008). No significant benefits were observed for large catchments (~250 km^2), as they were found to be less sensitive to land management compared with small catchments. In addition, Nisbet et al. (2011) has established flood risk benefits related with the creation of woodland, where there was an average of 50% reduction in flood peaks for a small catchment (~10 km^2) of woodlands (POST, 2011).

2.6.4 Flood insurance

Flood insurance cover provides the means of indemnifying building damage, and clean-up costs in the aftermath of a flood (Platt, 1999, Kron, 2004; FEMA 2004; Thieken et al., 2006), which helps homeowners and businesses to minimise their financial costs. By means of insurance cover, householders are able to share their risk by a regular contribution of flood premiums in return for reinstatement costs should they be affected by floods (ICE, 2002). It is clear that flood insurance cover has been an effective tool in assisting the recovery and restoration of damaged properties to victims of flooding in the UK (Crichton, 2008a, Lamond et al., 2009).

A number of different insurance policies are available from country to country. Generally, flood insurance models, whether mandated by law or not, can be classified into four general categories: public and optional (e.g. USA), public and bundled (e.g. France), private and optional (e.g. Germany), and private and bundled (e.g. UK) (Swiss Re, 2012). In each case, flood insurance is either provided through the private market or public sector agencies. Several approaches exist in the delivery of flood insurance: there are the optional system and the bundle (package) system (Paklina, 2003). In the optional system, flood insurance is separate from other policies and insurers agree to offer flood coverage on payment of additional premiums. By comparison, under the bundle system flood insurance is available as part of a "package" together with other risks such as fire, earthquake, and hurricanes.

Overseas policies

Provision of flood insurance in the United States of America is by the National Flood Insurance Program (NFIP) which has been operational since 1968 and is administered by the Federal Emergency Management Agency (FEMA). It is a joint arrangement between the US federal government and the insurance industry to provide subsidised insurance to properties in flood risk zones termed "Special Flood Hazards Areas" (SFHA) (ABI, 2013). The flood insurance rate maps which display risk premium zones (SFHAs) are used in assessing eligibility for flood insurance cover for areas that would be inundated by a 100 year flood; these maps are legally binding and thus relevant for flood insurance premiums as well as damage mitigation by the NFIP (Platt, 1999; Thieken et al., 2006). In this provision an individual cannot access the NFIP without their community participating in the programme, and an eligible community must first volunteer to become an SFHA where their flood risk is at least 1 in 100 years (ABI, 2013).

Although the NFIP is well cited for its success, continuous reforms have been necessary due to some shortcomings. First, because flood cover is subsidised through the NFIP, and there has been limited inputs into the pricing of insurance beyond flood risks greater than 1 in 100 years, the programme is liable to exhaust its funds and become economically unsustainable, particularly after large flood events (ABI, 2013). For instance, the NFIP incurred a huge debt of $18 billion when Hurricane Katrina struck in 2005, which shows how the system tends to underestimate the accumulation of flood risk from storms (Swiss Re, 2012). In addition, the US system has been criticised for promoting adverse selection; only homeowners with a mortgage and at risk of 1 in 100 year flood are obliged to purchase flood insurance. This creates a situation where premiums are too high for those living on the fringes of a 100 year flood zone, and at the same time too cheap for those living in higher flood risk area (Swiss Re, 2012).

These are all major concerns which strongly advocate for the inclusion of private flood insurance market in the USA.

In Germany, flood insurance is offered by private insurance companies to homeowners as supplementary (optional) to building and content insurance (Vetters and Prettenthaler, 2003; Thieken et al., 2006). The insurance companies have developed detailed flood risk maps to assess premium levels in accessing premiums (called ZÜRS), made up of four flood risk categories. Properties found to be greater than 1 in 10 year zone are generally regarded to be uninsurable and cannot obtain flood cover. While the market penetration of standard building insurance is high, the penetration of add-on hazards insurance is generally low as most homeowners choose not to buy flood insurance. In many regions in Germany, flood insurance penetration is still below 10% (Paklina, 2003, Swiss Re, 2012), and this poor uptake presents a serious challenge for the government and insurers after a major flood incident. For example, this insurance system is not fully private unlike the UK model and the state's intervention has been critical as insurance only covered a fraction of flood losses in the past (Thienken et al., 2006). Following the recent floods in June 2013, the government paid compensation of €8 billion to property holders who suffered flood damage (Zurich Insurance Group, 2013), and in light of the huge costs of floods there are clear concerns for better incentives to improve insurance flood cover.

In France, the flood insurance pool is backed by the government but operated by the private sector. The scheme covers losses from natural hazards including floods, and homeowners who purchase fire and theft insurance are required to participate. The pool is funded by a levy on all property and motor insurance; the price of coverage is set by government, is uniform across the country and is not tied to individual property flood risk, but is set at a flat rate of 12% (ABI, 2013). There is also a standard flood excess of €380 applied to domestic property claims under this programme, which means that homeowners at higher risk areas benefit more from the system, whilst low risk homeowners pay relatively high premiums. However, the chief aspect of this system (as well as the Spanish model) is the fact that it takes flood insurance completely out of the private market, and this has made the programme very successful in attracting wide participation given its very high penetration rate (Swiss Re, 2012).

The UK policy

Unlike other parts of Europe, the UK provides insurance through the Association of British Insurers (ABI) as a standard feature of household insurance policies (Crichton, 2005). The penetration rate of the UK insurance policy is very high. For instance, homeowners are required to buy building insurance which includes flood cover in order to comply with mortgage lenders terms, and the take-up rate of this is 90% for owner-occupiers in UK (ABI, 2012; DEFRA, 2013). For contents insurance, take-up varies from 44% to 90% depending on household insurance.

The UK insurance scheme which has been running for over 50 years started with a “Gentleman’s Agreement” between insurers and the UK government in 1961 (O’Neil and O’Neil, 2012). This agreement loosely defined the responsibilities of each party, and established a bundled system for private insurance which makes flood cover available as part of buildings and contents policies, alongside other perils such as fire and theft. Since then a series of agreements have been made between the two parties, and the most current arrangement is the Statement of Principles (SoP) on the provision of flood insurance, which was revised in 2008 and extended to end in July 2013. The need for the SoP system was influenced by increasing flood incidents, with the tipping point being the 2000 flood where almost ten thousand properties were inundated at a cost over £1 billion to the insurance industry (ABI, 2009).

Under the current provision, the ABI which represents three hundred insurance companies who together sell almost 90% of all insurance products in the UK (DEFRA, 2013), agreed with devolved administrations to ensure that flood insurance is made available and affordable for majority of homes (ABI, 2008). The agreement obligates insurers to offer flood cover as a standard feature of household policy for most UK homes, and clearly outlines the commitments from both parties involved.

In view of the commitment of ABI member companies, they are obliged to make insurance available to domestic and small business properties in all areas that are not at significant risk of flooding. In contrast, insurers are not obliged to provide flood insurance cover for properties built after 1st January 2009, under the current arrangement (ABI, 2008); a position that is crucial given the intention to discourage new development in flood risk zones. However, for properties at significant flood risk, ABI members agreed to continue to offer flood cover for customers if there are plans in place to minimise the risk. In this case, flood policy is not guaranteed, and it implies that high risk properties can be exempted from flood cover.

The UK flood insurance policy has faced several challenges in achieving its primary goal, and the need for a new scheme has been necessary given the common problems including the insurance market becoming increasingly competitive and affordability of insurance not being safeguarded (Crichton, 2008b). For example, excesses as high as £10,000 have been charged by insurers, whereas annual premiums have soared by almost 70% in flood risk areas (Harries, 2010; Bell, 2011). These problems could lead to high flood risk homes finding flood insurance less available and affordable; current figures suggest that almost 200,000 properties could struggle to obtain flood cover (ABI, 2011c; Ball et al., 2012). As a result, the government and the ABI have agreed to replace the existing system with a more sustainable, long-term framework from 2015 (DEFRA, 2013).

Given the dynamics of the insurance market, it is difficult to predict what it might look like in future. There appears to be a high probability that insurance will move towards risk reflective pricing in the longer term (DEFRA, 2013), and if this happens, it may also be necessary to better incentivise householders to manage their risk exposure through the use of simple and cost effective flood protection products (DEFRA, 2011). It appears that the ABI are keen to promote PLFP in high flood risk properties (ABI, 2006; ABI, 2011d), and there has the need to incorporate the benefits of having to adopt PLFP measures in flood insurance policies which looks likely in future (Ball et al., 2012). Better incentives, including financial incentives on PLFP schemes could help generate greater uptake of flood protection, and this will eventually help to reduce financial losses due to floods and safeguard the insurance system.

Following extensive debate and negotiations, the “Flood Re”, a model proposed by the ABI has been slated to ensure that homeowners can continue to access affordable flood cover. Unlike the SoP, the Flood Re includes a cap on insurance premiums which indicates that flood risk homes in council tax bands A and B will have their premiums set at £210 while band G homes will pay a higher premium of £540 per annum (ABI, 2013b). The Flood Re scheme will operate as a non-for-profit flood insurance fund; the levy on each home is dependent on the council band, and it is estimated to be around

£10.50 per year (and this levy together with the premium income), will be used to buy reinsurance, pay claims, and fund the Flood Re operation.

It is expected that this model will provide additional coverage of vulnerable UK households when implemented, and also provide insurance for the almost 2% (200,000) of properties in high risk areas where it has become extremely difficult to find insurance cover in the open market (House of Commons, 2013; ABI, 2013b). This is vital, given the known problems with high risk homes, particularly with the affordability of flood insurance premiums under the free market. Moreover, it is estimated that the current average total home insurance for such high risk areas is £1400 for council tax band C, opposed to around £750 under the new Flood Re scheme (House of Commons, 2013) which is also positive for homeowners. Clearly, the level of affordable premiums is fundamental, and keeping the prices at an agreed affordable threshold is something that will determine the success of the scheme and will help safeguard the affordability of flood insurance policies.

Notwithstanding the above, the proposed scheme has come under criticism, primarily around the concern about the financial sustainability of the scheme. While the details of the proposed financial arrangement remains a subject of discussion, lessons learned from similar approaches have shown that such policies are prone to financial instability; for instance, the inability of some policies to survive after a single major catastrophic event (e.g. USA) (Swiss Re, 2012). In addition, there is concern that the new model will create perverse incentives for homes in high risk areas which will not encourage people to reduce flood risk and for developers to build in such areas which could make reinsurance (insurance purchased by insurance companies to offset their risk and allow trading) costs high. However, this argument has been dismissed by ABI with the stance that the scheme will not cover new homes just like the SoP (ABI, 2013b). In addition, the ABI has reaffirmed their commitment to encourage personal flood risk reduction practices by indicating that homeowners who improve their individual property protection could come out of the Flood Re and find cheaper cover in the free market, which is something most homeowners will welcome.

2.7 Flood damage evaluation

Flood damage evaluation is a decision making tool. Different techniques of damage estimation exist and depending on the type of the damage being assessed a suitable approach can be used, either financial or social damage assessment. This section reviews the different ways of estimating the damage associated with hazards, particularly flood risk. It also discusses the cost benefit analysis (CBA) concept as a tool widely used in the assessment of flood alleviation schemes.

2.7.1 Principles in damage evaluation

Flood damage evaluation is increasingly significant for decision making (Penning-Rowsell et al., 2003; Messner et al., 2007). The need to assess all benefits and costs of flood risk management policy, such as PLFP, is necessary in order to (Messner et al., 2007):

- Specify the risk situation (size of area or number of properties at risk).
- Determine the potentials of risk reduction and their respective costs.
- Compare the benefits and costs of risk reduction in terms of the benefit-cost ratio and/or the net.
- Compare the benefit-cost ratios of several policy fields dealing with risk reduction in order to decide where the tax money should be spent first.

In assessing the tangible or direct flood impacts, Meyer and Messner (2005) outlined some basic steps in the overall process. These principles include the selection of an appropriate approach. The decision of which method to use depends on a number of factors including the spatial level of the study (either national or local), the objective of the study, and the availability of resources and pre-existing data (Meyer and Messner, 2005). It is acknowledged that the flood damage evaluation process can be a laborious and time-consuming task, especially on a national scale. The next step of the evaluation principle involves the determination of the type of damage to be assessed, whether tangible or indirect damage (Meyer and Messner, 2005; Messner et al., 2007), and here it advisable that more attention is given to the damage which has greatest impact on the total cost. Thirdly, the necessary information is collected for the evaluation, such as inundation characteristics of the study area (Messner et al., 2007). As indicated earlier, flood depth information is the most vital parameter used to derive a damage function, and in the UK such depth-damage functions are further differentiated by flood duration as was shown in Figure 2.7. Elsewhere in the Netherlands, velocity is usually included in damage functions for residential properties (Kok et al., 2004). The last stage of evaluation process involves bringing all necessary information together to calculate the expected damage (Meyer and Messner, 2005), which also implies using the appropriate methodology to achieve the objective of the study.

Several examples of existing flood damage database are well known in Europe, which can be used for assessments. These include the HOWAS database in Germany (IWK 1999; Merz et al., 2004), which contains information on damages which occurred during nine events in the past, with around 3600 individual damages to buildings (IWK, 1999; Buck, 2004). The evaluation of damage associated with this data is by insurance damage adjustment and equates to replacement costs. The MCM, as previously mentioned, is a well known damage data for flood appraisal in the UK, developed by the Flood Hazard Research Centre (FHRC, 2010). This database is not derived from real flood data but has been synthetically generated; it provides absolute depth-damage function for 100 residential and more than ten non-residential property types (Penning-Rowsell et al., 2003; Messner et al., 2007). Prior to the current MCM, predecessor data including the Blue, Red and Yellow manuals have all been used for flood damage evaluation in the UK (Penning-Rowsell and Chatterton, 1977; Parker et al., 1987; Penning-Rowsell et al., 1992). The MCM database will be further explored in this study to assess PLFP schemes.

In flood damage appraisal, the MCM advises the use of the Weighted Annual Average Damage (WAAD) approach, especially where the appraiser has no information on the flood return period and depth distribution (FHRC, 2010), and it involves annualising flood damages using a range of flood frequencies and depth data for the study area. The driving data for the WAAD calculations in the MCM is based on the information in Figure 2.12, which was developed given the constraint of getting detailed data for flood appraisal (Penning-Rowsell et al., 2005; Messner et al., 2007). This figure shows the percentages of properties inundated at different depth bands for a range of flood frequencies for the case studies. For instance, the 5 year flood event shows very high proportion of properties which are flooded at low depths than the subsequent flood events. Such flood frequency depth distribution is essential for the WAAD method, and hence will be discussed further in the study.

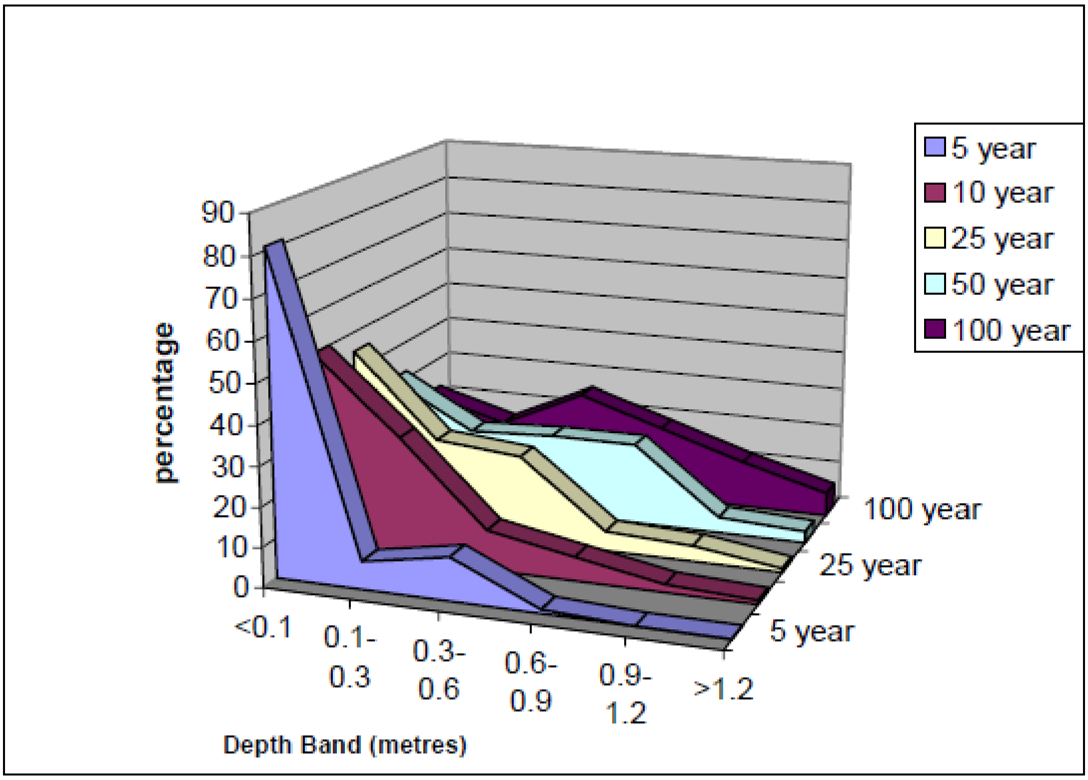


Figure 2.12: Property flood depth distribution by return period (Source: Penning-Rowsell et al., 2005; Messner et al., 2007)

The MCM flood depth data (Figure 2.12) was first developed by FHRC in association with Entec UK, who attempted to derive an algorithm to estimate the weighted average property damage for all property, irrespective of frequency and depth of flooding. This was a vital step, as it removes the need for property levels and flooding threshold levels in the broad scale evaluation of annual average damages. Building on this, John Chatterton Associates improved the sample base of the weighted depth-damage data to some 9,000 properties, from 14 flood plain locations (Penning-Rowsell et al., 2005; Messner et al., 2007). This data, although limited to the English Midlands, broadly represents the average for UK, and can be used to generate WAAD for related studies given some assumptions on flood depths and return periods. For example, a minimum of three return periods is often required in estimating flood damage by this approach and the MCM handbook gives further guidance in using this method (FHRC, 2010). Based on the information shown in Figure 2.12, the MCM has derived WAAD for different standards of protection at the property threshold (FHRC, 2010). For example, the WAAD for a residential property with no protection and no flood warning is £5393 (FHRC, 2010). This figure was derived based on seven flood events which ranged from 2 to 200 year return period, and the damages with respect to two warning lead-time (i.e. less than or greater than 8 hours) are relatively lower.

2.7.2 Economic and financial evaluation

Economic evaluation involves the monetary assessment from the perspective of the national economy. In this case one person's loss can be another person's gain. Unlike the financial evaluation, economists use the opportunity cost in this type of analysis. The depreciated value is taken account of and usually a discount rate of 3.5% (for 0-30 year cycle appraisal) is recommended (HM Treasury, 2003). Another feature of economic damage assessment is the exclusion of VAT and other indirect taxes, given that this involves money transfers within the economy rather than real losses or gains (FHRC, 2010). This also implies that the loss during the incident is not the value of an equivalent new product. In flood damage assessment this value reflects the pre-flood value of the property content, for example.

The financial damage evaluation takes the view of the individual household and uses the actual money transfer involved to evaluate the loss or gain incurred (FHRC, 2010). In this case, VAT is essential in the calculation as well as other indirect taxes as they have impact on the outcome. What this means is that homeowners experience betterment after flooding; it is assumed that property contents are replaced by new products. Another feature of the financial appraisal is the discount rate involved; some studies have stuck with the 3.5% rate as with the economic appraisal, whereas others recommend a higher rate (8%) with the rationale that lower discount rates could overestimate the benefits of PLFP measures (ASC, 2012; Royal Haskoning, 2012). However, the choice of discount rate is flexible and there remains a justification of any choice; but what is important is the implication of a low or high rate on the outcome of the study.

2.7.3 Social impacts evaluation

A number of guidelines have been provided to estimate the social impacts of flood damage appraisal. The use of survey approaches has been highlighted, and employing quantitative and qualitative surveys are all acceptable techniques in appraising social impacts (Gilbert, 2001). However, each method has its advantages and disadvantages, and given the difficulty in directly evaluating the social impacts, the most appropriate technique is used. In practice, the most common techniques widely explored by economists are the revealed preference and the stated preference; these are discussed below.

Revealed approach

The revealed or inferential approach uses an observed behaviour of people and then seeks to infer both the reasons why people adopt that behaviour and the relative importance that they give to different reasons when making the choice to adopt that behaviour (RPA, 2004; Botzen et al., 2009). That is, under this method, people's preference can be observed from their behaviour. A typical example of the revealed preference technique is hedonic property pricing. This type of approach is based on the assumption that property price is influenced by other factors such as environmental characteristics in addition to the structural elements. With this, the technique seeks to infer a price for environmental goods or services by analysing time series data on the property transaction (RPA, 2004).

Despite its wide applicability in various fields, this technique has some limitations as well (Shabman and Stephenson, 1996; Lamond, 2008). These include the fact that not all people may perceive the existence of flood risk problem and moreover, the effect on their property values, which can render the technique ineffective (Lamond, 2008). In addition, the variety of flood risk impacts means that its effect is not just a marginal reduction in property value, but could also mean that a property can lose its selling power; this implies a zero price tag which could be unfeasible in such hedonic pricing.

Stated preference approach

The stated or expressed preference approach uses carefully designed questions to elicit people's preference for non-market intangible impacts. This survey asks people what value they will put on those impacts. For example, households can be asked to state the maximum amount they are willing to pay (WTP) for PLFP, in order to avoid or reduce the impacts of floods such as stress (RPA, 2004). The freedom for respondents to state their maximum WTP means this technique is relevant for this research. With this method, two variants are often involved and they are Contingent valuation (CV) and Choice modelling (CM) (DTLR, 2002; RPA, 2004).

CV is the most common approach for assessing social impacts (Mitchell and Carson, 1989). It addresses the impacts being evaluated as a bundle of attributes and then estimates the WTP for this bundle as a whole (RPA, 2004). For example, in flood studies, the CV technique can be employed to ask how much respondents are prepared to pay to reduce the risk of flooding (Bateman et al 2002; Bateman et al 1992; Mitchell and Carson 1989; Messner, 2007). Sterland (1973) asked how much people would require for compensation to live in a house exposed to various degrees of flood risk (Messner, 2007). Other CV studies have been undertaken both in the UK (Green et al 1992; RPA, 2004), and USA (Daun and Clark 2000; Giese et al 2000) to investigate peoples WTP for non-market items. However, CV has its own limitations. For example, the market used in such valuation is hypothetical hence the WTP can be biased in that respect. It is often the case that the WTP elicited with CV is higher than the real values (Kealy et al., 1990; Neill et al., 1994; Brown et al., 1996), which implies a divergence between the actual and hypothetical values with the latter being the greater. Additionally, there is the tendency for people to understate or overstate their WTP, depending on different factors including their interest in the goods under question and vice versa, which is another limitation of the CV technique.

CM approach concerns individual attributes rather than bundled attributes, and evaluates the WTP for these attributes. It is suitable where a large number of flood scenarios are being considered. An example of a CM study includes that undertaken by Viscusi et al. (1991) in which a total of 389 respondents in North Carolina, USA, were asked to choose, if they had to move home, between different (fictitious) locations with differing risks of chronic bronchitis and death in a road accident. From the expressed preferences between the locations, the researchers were able to infer people’s willingness to trade an increased cost of living for a reduced risk of chronic bronchitis, and other trade-offs such as risk of chronic bronchitis for road fatality risk. Another study by Diener et al. (1997) explored the values attached to a range of outcomes for air pollution in southern Ontario. Again the alternatives presented were based on variations in property rent and the health effects of air pollution (RPA, 2004). Notwithstanding its importance, CM has limitations as well. Most known challenges are that the CM method limits the valuation to predefined options and does not allow people to state a zero value for the goods under consideration. There is also a challenge when respondents are faced with making multiple complex choices or ranking between many attributes (Carson et al., 2001), which may result in fatigue and imprecise response.

Although CV is the most used and preferred technique to elicit WTP of non-use values, CM is a credible option not only for evaluating non-use values but all forms of values (Pearce et al., 2006). Respondents can be presented with descriptions of goods, for example PLFP products with their attributes or function, and asked to rank their preferences or state their choice. WTP can then be recovered from the choices they make; this technique will be explored further in the study. Several forms of CM exist: contingent ranking asks people to rank given scenarios based on their preference whilst choice experiment asks respondents to choose their most preferred scenario (Fajiwara and Campbell, 2011). Given the advantages and disadvantages of each stated preference technique, survey design is critical and should seek to address such potential problems; sometimes it may be desirable to use both CV and CM techniques to maximise results (Pearce et al., 2002).

2.7.4 Cost Benefit Analysis (CBA)

The outcome of any flood scheme evaluation is whether the scheme is viable or should be rejected. A common technique for arriving at such a crucial decision is Cost Benefit Analysis (CBA), which has been widely applied in various fields of study. CBA can provide information on the cost and benefit of PLFP scheme which is essential for decision making for both homeowners and flood risk managers who plan to invest in such a scheme. CBA has evolved over the years from non-formal use to formal applications, and three main aspects or areas of application are common as already indicated. These are classified based on the identity groups in whose interest the CBA is being undertaken namely, economic, financial and social cost benefits analysis (Snell et al., 2011). Notwithstanding the usefulness of CBA, there are some criticisms with this tool particularly the necessity to quantify all costs and benefits in monetary terms, although in reality not all benefits are traded on the market (Joubert at al., 1997; Joseph, 2014). This poses a challenge for economists and in view of this problem, appropriate techniques as discussed earlier would be employed in quantifying some of the intangible impacts of floods. Another element of CBA is the need to discount both cost and benefits of the scheme. Quantifying the benefits and costs of, a particular flood alleviation scheme for example, involves discounting all future costs and benefits to the present value, to allow for a common scale for comparison (Snell et al., 2011). In the UK, the Treasury (Green Book) gives further instructions on discount rates for specific schemes based on their life span, and this will be consulted in the study.

Several techniques of CBA are considered in the decision making process; these are the Net Present Value (NPV) and the Benefit Cost Ratio (BCR). The NPV, which is simply expressed as the difference between discounted present value of benefits and present value costs (Penning-Rowsell et al., 2005), can be used as the final decision making criteria in flood damage appraisal. The higher the NPV the more beneficial the scheme, however NPV and BCR are sensitive to the choice of discount rate, and hence using a uniform rate is essential for comparison. The BCR is often the preferred technique for decision making for flood alleviation scheme (Penning-Rowsell et al., 2005), and has been adopted in this study as well. BCR is defined as the ratio of the present value benefits over the present value costs. When the result is greater than unity, there is a reasonable benefit, and if it is far greater than one the scheme can be said to have substantial gains to the society. Clearly, if the ratio is less than one, the proposed scheme is less cost beneficial.

CBA has been widely applied in the UK industry, with particularly huge applications in the transportation sector (Coburn et al., 1960; Pearce 1998; Snell 1997; Joseph, 2014). Aside the large scale use, the EA has employed the technique in flood alleviation schemes, and other small scale applications are recorded (Snell, 1997; Joseph, 2014). In addition, various previous studies have used the BCR approach for PLFP packages appraisal. The first DEFRA project which assessed the benefits of property protection measures in England employed the BCR technique; BCR was determined for resistance and resilience measures under different flooding scenarios (Bowker, 2007). After this, there has been a recent DEFRA scheme (JBA, 2012a), and other related studies (JBA, 2012b; Royal Haskoning, 2012), which have used similar approach to determine the cost effectiveness of implementing PLFP measures. However, these studies did not assess the cost effectiveness of incentivised PLFP schemes which is further explored in this study.

In their appraisal of PLFP measures, previous studies have acknowledged that the PLFP market is still growing and therefore accurate measurement of the cost of products can be challenging. Royal Haskoning (2012) and JBA (2012b) have estimated the cost of resistance products for different property types based on the number of required products for each property however, they both indicated the difficulty and lack of information for bungalow properties in particular as such no BCR information was found for such property. Moreover, calculating the benefit of PLFP products comes with some assumptions on the product effectiveness and malfunction. For example, one will expect a fully fitted resistant product to prevent floodwater from entering a property; however, this is not always the case and there is a tendency for damage arising due to the product malfunctioning as a result of leakage. In view of this, assumptions are inevitable when estimating the benefits of PLFP products, considering the damage to the property content and the building fabric. Ideally, resistance products are regarded as effective in preventing most internal damages whereas with resilience measures internal damages do occur but are minimised (JBA, 2012b; Royal Haskoning, 2012). Further details on estimating the benefit for PLFP products are outlined in the methodology of the study.

2.8 Chapter Summary

This chapter has presented a detailed literature on flooding, and flood risk management approaches in the UK and elsewhere. Floods were found to be very frequent events compared with other natural disasters, and factors that are increasing the risk of flooding include climate change and urbanisation. These are likely to cause more future threats, with urbanisation of societies expected to increase the risk of greater settlements in floodplains. Climate change will result in more extreme weather events such as droughts and floods, and developing countries are particularly susceptible to these severe impacts. The UK and developed countries will be affected by climate change impacts as well; for instance the risk of coastal flooding and flood related health problems will increase in the UK and make more people vulnerable, implying the need for adequate preparedness to meet future demand.

Different types of flooding have been explained including fluvial, pluvial and sewer flooding. These are becoming increasingly common with fluvial flooding being the most frequent incident in the UK, although pluvial flooding is largely expected to increase with respect to climate change. This chapter has also showed that floodwater characteristics are vital in determining the severity of floods when they occur, such as the velocity of the floodwaters and the depth. For instance, floodwater depth has significant impact on the scale of flood damages in properties, with depth up to 0.5 shown to cause significant damage to building, fittings and personal possessions.

Flood impacts have been thoroughly discussed under two categories; the financial losses are as a result of the direct consequences of floods, normally quantified in monetary terms. Intangible impacts are as a result of indirect consequences of floods including the stress impact and worry about future flood event, and such impacts are often less presented in damage appraisal although they are equally important. Both flood impacts are significant when flooding occurs and there is the growing need to assess and quantify the intangible impacts alongside other damages in flood damage assessments.

The chapter has discussed flood risk management and the roles of various stakeholders including government institutions, non-governmental organisation and homeowners. It has been highlighted that the situation in developed countries is quite different from that of developing countries, as the latter usually have insufficient capacity, poor stakeholder cooperation and also lack the funds to implement flood risk reduction initiatives. This implies that LDCs are less prepared for future floods and more exposed to flood impacts. It has highlighted that the modern approach to flood management requires homeowners or individuals to be aware of flood risk and take actions to reduce the threats at their property level. This is another concern for researchers and will be investigated in this study as it has been reported that the public remain confused about their personal responsibility.

Flood risk management practices have been presented in two groups: structural flood protection measures and non-structural measures. Flood management is changing from the traditional reliance on structural measures to risk reduction, which requires integrated approach to management where both structural and non-structural play vital roles. Managing flood risk at the property level will require raising public awareness of flood risk and preparedness in the form of adopting resistance and resilience measures. This is a key driver for the intended research. Evidence from literature has shown a very low uptake of flood protection at the property level, and this is largely attributed to the lack of knowledge about such measures as well as the costs of installing them. However, no study has investigated the public attitudes towards PLFP measures and the need to incentivise them to encourage wider uptake of such schemes.

Chapter 3: Research Methodology

3.1 Introduction

A research methodology is an essential part of any research. It systematically outlines the different approaches that have been employed to undertake the research study and gives a justification of the methods. It also provides a link between the literature review and the practical data collection.

The research approach used in this work starts with the development of a flood database of significant flood events within Scotland, which serves as database of selecting case study areas for the research. This is detailed in section 3.2.

Section 3.3 discusses the background to the stakeholder consultation activities, including questionnaire survey and focus group discussions, which were used to obtain information from the public. Generally, these methods are useful in terms of the quantity and depth of information that can be assessed. However, the techniques can be expensive in terms of resource requirement, particularly when it involves a large area. This section also discusses further consultation with institutional flood management stakeholders, to understand the strategy for PLFP and the implication of this research.

Section 3.4 explains the financial assessment of the costs and benefits of PLFP measures. The various procedures discussed in this section include flood damage assessment, determination of flood protection benefits and analysis of benefit cost ratios of flood protection measures.

3.2 Selection of Case Study Areas

To aid the selection of appropriate case studies for the research, a number of processes were involved. A flood database of past flood events within Scotland was developed to inform the selection of flood prone areas for the questionnaire surveys. Before the final selection decisions were made on case study areas, SEPA flood maps were interrogated to verify the flood risk vulnerability of all the selected locations from the flood database.

3.2.1 Development of flood database

The flood database was developed to provide real evidence of past flood incidents and affected areas, which formed the fundamental basis of choosing case study areas for the entire research. This was formed from a larger dataset obtained from SEPA (Edinburgh office) and was compiled from a number of sources including LA flood data, SEPA flood records, and other media sources. The database contains major flood events that have occurred within Scottish regions and spans over decades. It is made up of themes such as the location of the event, date of event, source of flood, properties affected and the damage caused (if any). This dataset constitutes a vital part of the project, and together with the SEPA flood maps, it informed the selection of case studies for the project (Appendix A).

3.2.2 SEPA flood maps

The SEPA online Indicative River and Coastal flood maps gives graphical indications of flood risk (SEPA, 2013), and thus provide useful information on flood risk vulnerability within Scotland. Despite the shortfalls of such indicative maps, including the lack of preciseness in the flood risk outlines (SEPA, 2011), they were useful in verifying and authenticating flood risk susceptibility of the case study areas selected from the database. By entering the name or post code of the flood area, the extent of flood risk can be viewed and the potential source of risk such as river or sea flooding can be determined.

3.2.3 Selected case study sites

Based on information from the flood database, twelve case study areas were selected for the stakeholder surveys. To justify the selection of case studies, several factors were critically considered. First of all, areas known to be at continuous threat of floods or to have a history of flooding were of prime relevance. Also, the selected areas were restricted to those with flood experience not more than ten years old including infrequent but significant floods, as this was intended to make the research findings more relevant in terms of current impact. The selected areas were cross-checked against the SEPA flood maps to establish existing risk. In addition, properties were sampled for the survey in most cases, by using street addresses obtained from the database and with the help of the SEPA flood maps. Following this, contacts were made with relevant LAs and Flood Volunteer Groups to establish necessary links and assistance needed for the study. This exercise was extremely important given the useful contacts made and the guidance received for the public engagement process, including target areas for the survey.

Figure 3.1 shows the map of the selected study sites, covering a large scope of the country. It was not possible to cover further areas particularly the noticeable parts in the northern region, due to time and resource constraint. The locations surveyed are a mix of large urban cities including Edinburgh and Glasgow (Cathcart), and small towns such as Hawick. In terms of past flood experience, areas including Stonehaven and Huntly in the north of Scotland have been repeatedly flooded by the river Carron; the most recent flood in 2009 resulted in evacuation of 50 residents in Stonehaven. In the south of the country, Dumfries, Selkirk, Eddleston and Hawick have all experienced severe fluvial floods in the past. Hawick was flooded in October 2005 and November 2009, with the first incident being the most significant; this was estimated to be a 50 year return period event and affected over 100 properties along the river Teviot in the town. It is currently estimated that almost a thousand properties are at risk (1 in 200 year) of flooding in Hawick (SBC, 2011). Dumfries is another flood prone area which has been affected by serious floods, including the 2006 incident which resulted in the river Nith overflowing its banks and flooding properties.

In Edinburgh, residents along the Water Leith were flooded in April 2000 and August 2008, with over 500 properties affected in the Stockbridge colonies and Bonnington area during the 2000 event (CEC, 2003; CEC, 2012). SEPA flood maps estimate that around five thousand residential properties could be at risk of 1 in 200 year flood in this location (SEPA, 2011). In addition, the Cathcart area in the city of Glasgow has been particularly affected by floods, including the 2002 incident which severely affected residents. Dumbarton is another flood risk town in West Dunbartonshire, and was heavily flooded (fluvial flood) in November 2011 with over hundred residents affected.

In Perth, flash flooding is a common problem and has often affected residents and businesses; a recent incident in 2011 caused much disruption and left a number of streets flooded. Another pluvial flood risk area is Dundee, which was especially hit by flash floods in 2010, after a torrential downpour which affected several streets in the city area.

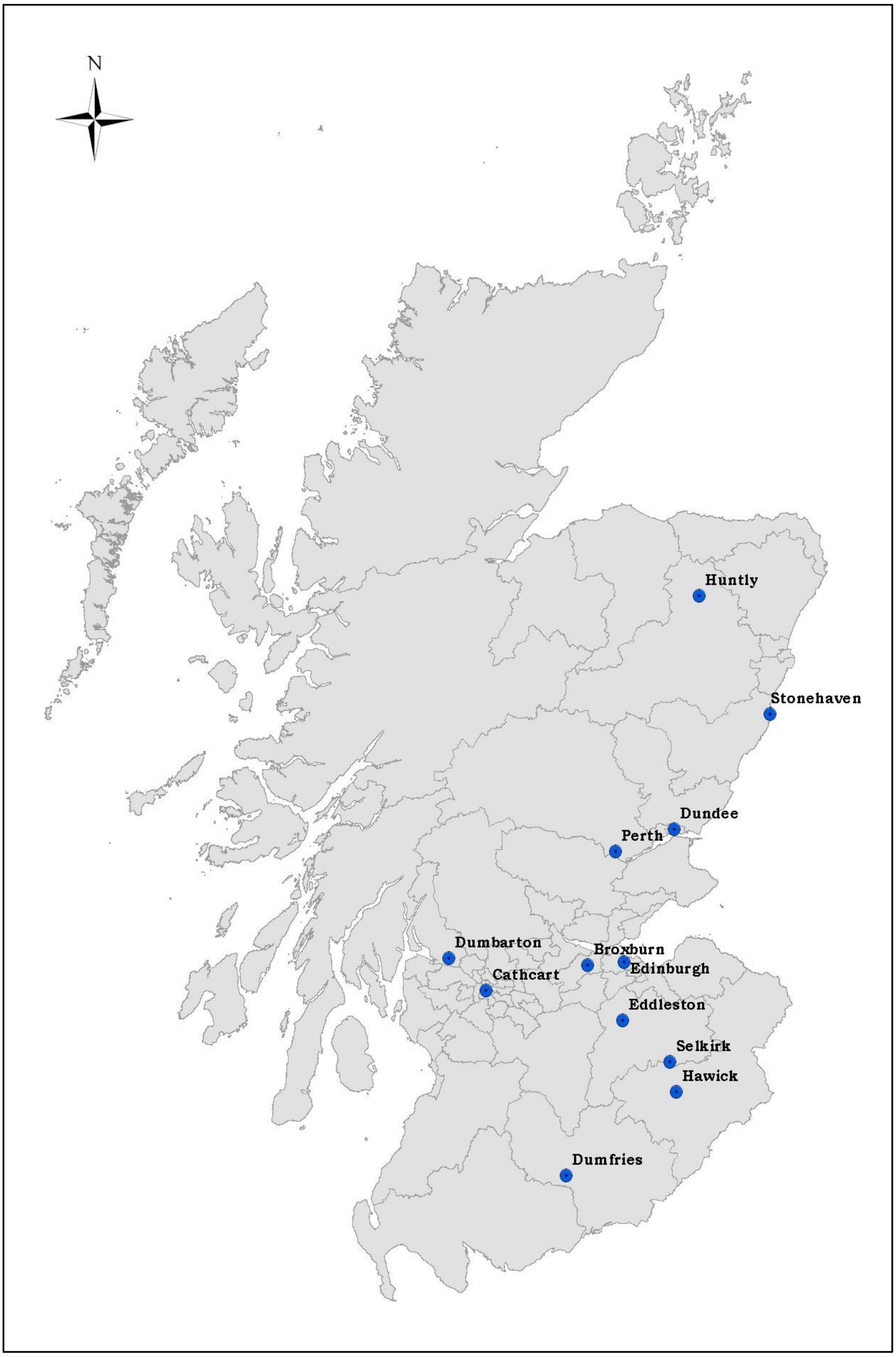


Figure 3.1: Survey and focus group locations

3.3 Stakeholder Consultation

The research employed a number of approaches in order to achieve its objectives. These methods include significant stakeholder consultations involving members of the public in the study areas as well as institutional stakeholders. A stakeholder here is defined as individuals or groups who have an interest in the actions of an organisation and can positively or negatively influence the actions, or be impacted by such actions (Savage et al., 1991). Stakeholder consultation is therefore a method of consulting with people who have an active interest in the matter being investigated; in this case, the subject of research flood risk and PLFP related issues.

The importance of stakeholder consultation in general cannot be underestimated, especially in empirical research it has been marked as an effective tool used to garner primary data or information. In this study, three main forms of stakeholder consultation methods were set out after an extensive literature review and upon consideration of similar studies (Creswell, 2009):

- Questionnaire surveys
- Focus group discussions
- Semi-structured interviews

While literature abounds on various forms of stakeholder consultations, a number of flood-related studies in the UK have been successful through similar stakeholder engagement techniques. For instance, RPA (2004) used questionnaire surveys and interviews to study the intangible health impacts of flooding on residents in England, whilst Werritty et al. (2007) explored the social impacts of flood risk and flooding in Scotland through questionnaire surveys and focus groups. Ball et al. (2012) also engaged the public through questionnaire surveys, focus groups and interviews to study insurance provision and affordability in flood risk in Scotland, and the ABI has reported research findings on property flood protection uptake which was carried out through quantitative and qualitative methods.

3.3.1 Questionnaire surveys

Questionnaires are sets of printed (or online) questions used to elicit views from people on the issue at stake. The function of questionnaires is measurement, and this is dependent on the problem being investigated (Oppenheim, 1992). Two types of questionnaire surveys are commonly used and they include quantitative and qualitative methods. Whilst quantitative method involves asking close questions where respondents are provided alternative answers to choose from, qualitative surveys often use open questions where respondents can provide details by writing their responses. In simple terms, qualitative methods involve describing characteristics of the subject with reference to no measurements or amounts, whilst quantitative methods involve measurement or amounts of the characteristics under study. No one method supersedes the other, however each technique has its own pros and cons and therefore the research goal usually informs the approach to be selected. For the purpose of this phase of the research, a quantitative survey method was employed due to its suitability in quantifying responses from the surveys (Creswell, 2009).

Questionnaire design

The survey questionnaire was designed to be simple and easy to be self-completed by respondents, while capturing the relevant information (see Appendix B). This was essential given that respondents were not going to be assisted in completing the questions as resources limitations did not allow the use of extensive face-to-face surveys. Upon consideration of the feedback from a pilot survey, the final questionnaire was designed to garner information in six key areas.

- Data on household flood experience was collected. This information is particularly important to understand people's knowledge of flood risk, the types of flood experienced, the number of times people have been flooded, and the general characteristic of floodwater such as flood depth, duration and speed (RPA, 2004; Werritty et al., 2007).

- The impacts of flood experiences were assessed. Under this section, the survey questions were designed to collect data on the financial costs of flooding, including those costs covered by insurance claims and those not covered. On the social impacts of flooding, people were asked to rank the severity of five variable impacts resulting from their flood experience, including the stress of flood event and the loss of irreplaceable items. The likert scale used was from 0 (no impact) to 10 (maximum impact). This technique of rating the intangible flood impacts provides a uniform platform of assessing and quantifying such impacts, and has been successfully explored by previous studies.

- To understand people's perception of flood protection responsibility, respondents were asked to indicate who they think is/are responsible for flood protection at their community and property level.

- Data on PLFP uptake was collected by first examining people's awareness of flood protection products, which is anticipated to influence the use of PLFP products. Information on the uptake of such measures was then collected. Here, the question was designed to include pictures of different flood protection products to assist respondents to identify the products they have, even if they are not sure of the appropriate name. Additionally, respondents were asked to indicate their perception of the use of PLFP products, in addition to views on climate change and its impacts on future floods and the need for protection.

- Data on households WTP for PLFP measures was collected using appropriate survey technique. Respondents were first asked to indicate the reason or reasons for which they are willing to pay or contribute towards the cost of flood protection for their property, including the avoidance or reduction of flood impacts. The sated preference method was employed to elicit WTP and respondents were asked to state the maximum amount they will be willing to pay for PLFP, after indicating why they are willing to do so. The mode of questioning followed the pattern of CM design where respondents were given a range of PLFP products differentiated by attributes including mode of operation and cost bands. Although people were not asked to rank or rate their preferences as is usually the case for CM technique, the design was provided as a guideline for people to indicate their maximum contribution. This was particularly important given the difficulty in eliciting WTP information from the public; hence the mode of questioning was to help people make informed decision on their values whilst avoiding hypothetical WTP values and the likely problems of zero bids (protest votes).

- Finally, it was also necessary to collect socio-economic data of the survey respondents. This included data on household characteristics such as age, size, property type and income level. The information from this section will help group respondents in socio-economic classes, which is relevant in the outcome of the survey. Other data collected under this section were information on the length of time householders have lived in their property and the location of survey respondents.

Ethical issues

It is imperative to acknowledge that all research have some ethical implications in one way or another, and therefore investigators need to consider this issue carefully and tactically address them prior to the work. In addressing such potential issues, the ethical guideline of the School of the Built Environment (Herriot-Watt University) was followed to obtain permission to undertake this research after satisfying all the necessary requirements. In addition, a cover letter was attached with the questionnaire survey, describing the research and its implication to all respondents, in order to avoid any sensitive issues arising as a result of the investigation.

Pilot survey

As a good practice, questionnaires have to be tried, tested, and potentially re-designed before they can be relied upon as an effective instrument in achieving the intended purpose (Oppenheim, 1992). Piloting involves undertaking a small scale survey often with the aim of ascertaining whether the questions are well understood, and the survey instrument is suitable without any ambiguity. By piloting the questions, the investigator has the opportunity to revise the survey design, develop the research questions or even undertake a further pilot (Robson 2002; Samwinga, 2009). This is further stressed by Creswell (2009) who indicates that the purpose of piloting questions is to test the survey method, respondents understanding of wordings and questions, and the effectiveness of responses.

After developing the questionnaire, a pilot survey was conducted in Eddleston, a small village (population of 335) in the Scottish borders with known high flood risk, to determine the suitability of the format. A total of thirty questionnaires were sent by post to residents and a return of eight responses, representing a response rate of 27% which was encouraging. A preliminary analysis of the responses showed that the questionnaire design, though suitable and appropriate in terms of coverage, was unduly long and could discourage wider responses. In view of this, the questionnaire was shortened and simplified to motivate wider participation. Also, a few of the questions were revised, given some useful comments by a respondent expressing concern about terminologies.

Main surveys

Following redesign of the initial questionnaire (Appendix B), the main surveys were undertaken in the remaining eleven flood risk communities identified for the study, as shown in Figure 3.1. The questionnaires were delivered by post to properties where street addresses were sampled from the flood database. Some LAs (e.g. Hawick and Dumfries) assisted in distributing the questionnaire to flood affected homes in their area as they could not provide direct contacts. In a few locations including Dumbarton and Huntly, the SFF who were at that time dealing directly with the local residents on flood issues, assisted in delivering the surveys. Their involvement was intended to boost the response rate given that the residents had just been surveyed following a recent flood, and were most likely unwilling to provide another response. In total, 1647 questionnaires were distributed with 256 responses received, representing a response rate of 16%. Compared to other questionnaire based studies, this response rate is considered a reasonable return for a postal and online survey format.

3.3.2 Focus groups

Focus group discussions were undertaken to verify and delve deeper into the findings from the surveys responses. Two focus groups discussions were held to elicit further details from respondents; the first was held in Stockbridge (Edinburgh City) on the 26th February 2013, whilst the second was held in Hawick (Scottish Borders) on the 8th March 2013. Both focus groups sessions lasted approximately one hour each, with participant groups of 10 and 15 people respectively. The social makeup of the participants was similar to that of the survey responses, with the elderly group (over 60 years) accounting for 60% of the Edinburgh group and 86% for the Hawick group. The retired people among the Edinburgh and Hawick participants were 40% and 87% respectively, signifying a high representation of the aged group just as shown by the survey outcome. As a way of rewarding people for participating in such activities, each participant received a modest £15 High Street Voucher.

Focus group participants were recruited from the questionnaire surveys, the respondents who were interested in the follow up focus groups were asked to provide contact details with the returning questionnaire form. Additional recruitment was undertaken for the Edinburgh study through public notices and also by invitation through community groups including the Stockbridge Colonies Residents Association, Warriston Residents Association, and Dean Village Association. In Hawick, many of the participants were recruited from the surveys, and were mostly members of the Flood Volunteer Group. Although the focus group engagement was limited to two cases, these locations were thoughtfully and carefully selected based on two important criteria:

- To identify any differences between attitudes of people living in a small town and those in an urban city.

- To identify differences in attitudes of people with no large scale defences against those with new defences being built.

The focus groups were deemed to help validate the findings from the surveys. Secondly, the focus groups were intended to probe deeper into some interesting findings from the surveys, such as flood related insurance issues, flood protection awareness and uptake. The discussions were held under six sections with the aim of achieving the following specific objectives:

- To find out more about the flood experience of the participants with respect to the flood event itself and the problems encountered.
- To find out more about flood impacts (financial & intangible) on householders including flood insurance related problems such as premium increases, high excesses and difficulty in obtaining flood cover.
- To investigate deeper into personal flood protection responsibilities and how these are viewed by participants.
- To find out more about what flood protection products are available to householders and what individuals feel should be done to boost the uptake of protection products.
- To further investigate the survey responses on the willingness to pay for property protection.

- To investigate views on climate change and its impacts on future floods, and particularly if this will make individuals more willing to protect their property.

Focus group site: City of Edinburgh

The main flood risk areas in Edinburgh are communities along the Water of Leith, which has repeatedly burst its banks in recent years following intense rainfall. Residents from Bonnington, Stockbridge colonies, Warriston, and Collinton Mains Drive have experienced some severe flooding in the past. Significant past floods include the April 2000 event which affected over 500 properties, and the events in April 2002 and July 2012, where numerous properties were flooded along the water course. Figure 3.2 shows the flood risk outline from the Water of Leith in Edinburgh indicating the affected areas.

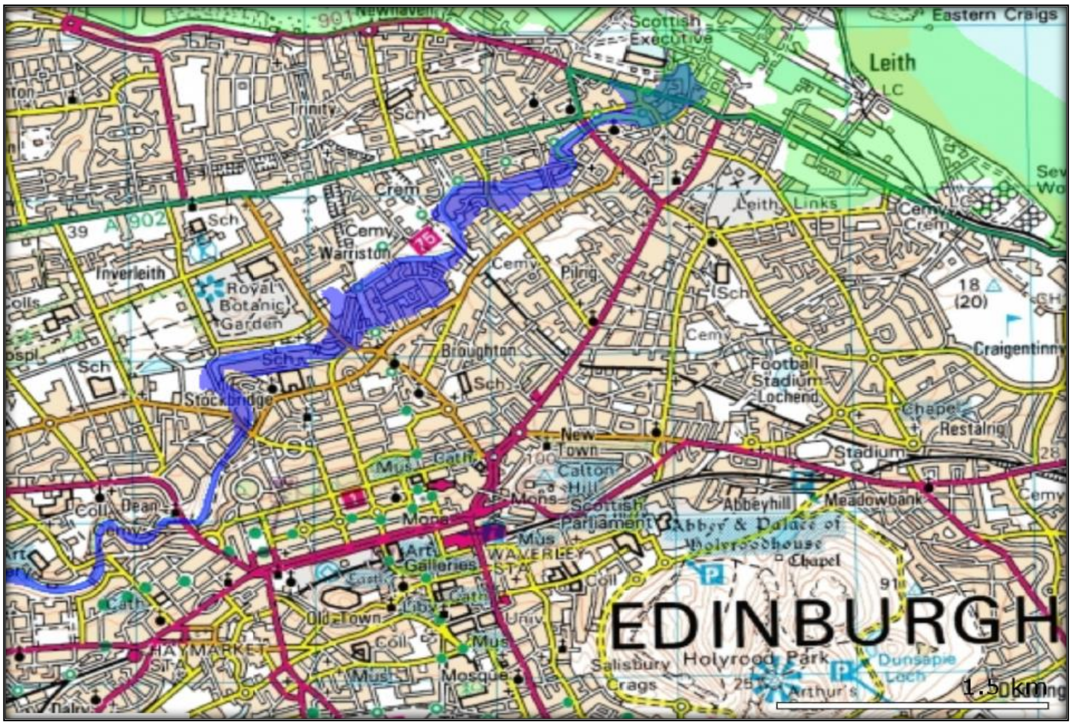


Figure 3.2: Edinburgh indicative flood risk map (© SEPA, 2011)

Focus group site: Town of Hawick

Hawick is a small urban town located in the Scottish Borders Council. Similar to Edinburgh, the main cause of flooding in Hawick is fluvial flooding, and the source of this is from both the River Teviot and Slitrig Water which run through the town. The town has experienced frequent and severe floods in the past including the 1958 floods, the October 2005 floods and the November 2009 floods which were as a result of intense rainfall forcing the River Teviot to overflow its banks.

In each flooding incident, many properties were affected with the 2005 event being the most severe. The risk of flooding is relatively high in this town, with almost 1000 properties known to be at risk from 1 in 200 year flood event. This has necessitated the demand to build a permanent flood prevention scheme for the town as there has been no such flood defences. An outline of flood risk in the town is shown in Figure 3.3.

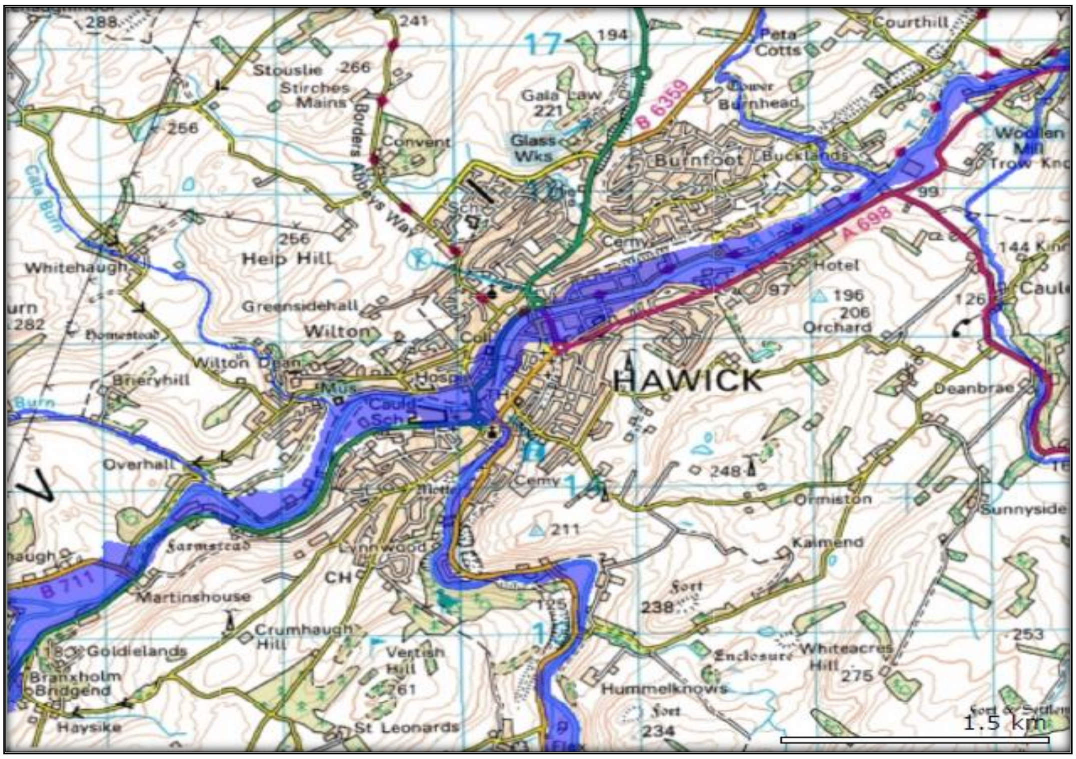


Figure 3.3: Hawick indicative flood risk map (© SEPA, 2011)

3.3.3 Semi-structured interviews

Semi-structured interviews were carried out with key institutional FRM stakeholders, namely SG and SEPA. This method of data collection has been proved effective in obtaining primary information for research, especially where the questions are open and may require extended responses (Gillham, 2000; Samwinga, 2009). Both face-to-face and telephone interviews are approved techniques (Robson, 2002), and were used in this research to solicit responses from the stakeholders.

The institutional stakeholders were first asked to respond to the survey and focus group findings of the study. Secondly, they were interviewed on the national strategy for PLFP to help draw relevant implications for the research. The overall purpose of the research was to contribute to the evidence needed to increase awareness and uptake of PLFP. Hence it was important to contextualise the research outcome in the broader national FRM strategy, and also investigate the immediate impact the findings may have on the strategy of flood risk reduction, especially at the household level. Each stakeholder institution was asked specific questions relevant to their field of operation (see Appendix E); a summary of the questions are shown below:

- The SG was asked about the national policy for promoting flood risk awareness and PLFP, and their views on financial incentivisation of PLFP. They were also asked how they liaise with other institutions, including insurers and PLFP product developers, to encourage wider uptake of flood protection by the public.
- SEPA was asked about its role in flood risk and PLFP awareness raising, and the national and local initiatives to motivate wider uptake such measures at the household level. It was also asked about its working partnership with the SG, SFF, and other bodies.

3.3.4 Survey data analysis

The overall processing and analyses of the survey responses involved two main stages, namely data preparation in Microsoft Excel, followed by data analysis using Social Package for Social Sciences (SPSS 18) software. SPSS was used to provide descriptive analyses of the data, and where appropriate statistical significance was determined for relevant variables, to describe the degree of relationship between those variables.

Statistical analysis

Descriptive analysis is used to present quantitative description of data and helps to summarise large amounts of data. In addition, it enables comparisons across groups. The descriptive techniques used in this data analysis included frequency distribution, cross-tabular distribution, mean and standard deviation. One common way of describing a variable is by frequency distribution which lists each group of the variable and presents the range or percentage of responses for the groups. It shows the number of times a value is observed. The mean is simply the arithmetic average, while standard deviation represents how dispersed the data is around the mean value. The higher the standard deviation value the more scattered the data around the mean value and vice versa. Cross-tabulation is used to show the relationship (or lack of relationship) between two or more categorical variables. The size of the tables will depend on the distinct values in the variable, with each cell representing a unique combination of values. A number of statistical tests are available to determine if the relationship between two cross-tabulated variables is significant. One of the common tests used in this study is the Pearson's Chi-Squared test; one advantage of this test is its appropriateness for almost any kind of data (Pallant, 2007). The significance value gives the degree of relationship; the lower the value, the less likely it is that the two variables are independent. Commonly, for this value to be significant, it needs to be 0.05 or lower. Where significance is determined, it is denoted as $p<0.001$, or $p<0.05$.

Correlation is another inferential analysis technique used to test for statistical significance of data variables. This is used to either test for relationships or predict the degree of association between variables, expressed by a correlation coefficient. Different forms of correlation coefficients exist, including the Pearson coefficient (r) which is suitable for linear relationships (parametric data) between two variables, whilst the Rank correlation coefficients such as Spearman's rank correlation coefficient (ρ) for non-linear relationships (non-parametric data). A correlation coefficient (ρ) range from (+)1.00 to (-)1.00; a value of ±1.00 is a perfect (positive or negative) relationship. A coefficient range of ±0.50 to ±0.70 is regarded as a moderate association whilst a range of ±0.30 to ±0.50 is low, and ±0.10 to ±0.30 is very low. Usually, correlation is used to explore the relationship among a group of variables, rather than just two or few variables.

Regression analysis was one of the statistical tools used to investigate the relationship between survey variables. The parameter to be predicted is the dependent variable and the influencing factor is the independent or predictor variable (Tabachnick and Fidell, 2001). Simple regression involves the test of influence of one predictor on the dependent variables, and can be expressed using linear equation (Equation 1). Multiple regression analysis (MRA) is used when more than one independent variable are involved and this usually requires a larger number of observations (Pallant, 2007). The MRA can be expressed by Equation 2, showing more independent variables. Different statistical techniques are associated with regression analysis including the R, R^2, and adjusted R^2 which are common terminologies. The R^2 is the square of the correlation and it is a measure of how good a prediction of the criterion variable. However, in most cases the R^2 is over estimated, hence an adjusted R^2 gives the best measure of the model success (Pallant, 2007). For example, an adjusted R^2 value of 0.75 indicates the model has accounted for 75% of the variance in the criterion variable.

$$y = a_0+ax+u \qquad (1)$$

Where:
y = dependent variable
a_0 = intercept
a = coefficient of independent variable
x = independent variable
u = random error

$$y = b_0+b_1x_1+b_2x_2+b_3x_3+....b_ix_i+u \qquad (2)$$

Where:
y = dependent variable
b_0 = intercept
b_i = coefficient of independent variables
x_i = independent variables
u = random error

Transcription of data

Transcription involves playing audio recording of meetings and typing down what was said word-for-word. Most often, the recordings have to be played several times in order to produce accurately what was said, especially if the quality is not perfect. This technique was used for the focus group discussions and the interviews with the institutional FRM bodies, before the transcripts were collated and analysed under specific themes of the discussions. As a common practice, verbatim quotations from participants have been extracted from the transcripts to give further illustration.

3.4 Financial Model

The financial assessment is a key part of the research study, with the aim of providing understanding and evidence on the costs and benefits of PLFP schemes. The following sections explain the systematic procedure involved in carrying out the work. It starts with a description of the data used in the assessment and this includes flood model output (showing depth information and flood extent) for Hawick, which was obtained from the SBC for the purpose of this academic research. The principal flood damage data used for the study was the MCM (2010) dataset, developed by the Flood Hazard Research Centre (FHRC), Middlesex University.

3.4.1 Case study data

The case study area selected for the analysis of PLFP scheme was Hawick, because of its high vulnerability to flooding, and also the availability of flood simulated data which was essential for the research (SBC, 2011). The flood frequency depth data used in this study was an output of a 2D model linked with a previously built 1D model to produce a 1D-2D hydraulic model using ISIS 2D software. This output data was produced by Halcrow Limited (now CH2M HILL) for the council, and the process involved analysis of hydrological data from the Hawick gauging station to provide design flows for the hydraulic modelling (see Appendix E). Following this, the model was built by taking into account much greater detail of the out of bank flooding, using high-resolution LiDAR DTM dataset and topographical data of the river and its banks. The linked 1D-2D model was calibrated using data from the past flood event in 2005 which was a 50 year return period, and produced results of a good level of confidence in the output maps. The model output gives information on flood frequency and depth for a range of return periods including 10, 25, 75 and 200 year flood. This data was approved for by the SBC for purpose of this academic research.

3.4.2 Flood damage and PLFP data

Two sources of flood damage information are accessible in the UK: the MCM data and the Dundee Tables (DT) developed by the University of Dundee for the insurance companies. Whilst the MCM method estimates flood damage based on modelled factors (Penning-Rowsell et al., 2003), the DT are based on insurance datasets collected over a protracted period and its damage values are real insurance claims and are often higher damages (almost double) than the MCM (Black et al., 2005). This is mainly because the Dundee data includes VAT, and does not consider flood damages as loss of depreciated values; hence they are not suitable for economic scheme appraisals.

In developing the financial model, the latest MCM flood damage data based on 2010 prices was used (FRHC, 2010). The main reason for using this data was the fact that it was the most recent available dataset, compared with the 2005 version of the DT that was available. The MCM provides flood damages for five property types: Detached, Semi-detached, Terrace, Bungalow and Flat together with data on different property age-bands. It also provides data based on social class categories, but this was not used in the flood damage assessment for the case study due to its unsuitable format of the damage components; these were total damages with no individual components. Under the MCM also, the total financial damage to a property comprises mainly the damage to building fabric and household inventory, and each of these damages consists of eight individual components as described by Table 3.1.

Table 3.1: Components of residential property damage (Source: FHRC, 2010)

Building fabric susceptibility	**Household inventory susceptibility**
• Exterior main building (e.g. damage to drains, brickwork)	• Audio / Video
• Floors (e.g. damage to floorboards, concrete, tiles)	• Domestic appliances (e.g. damage to refrigerator)
• Gardens / Boundary fences / Sheds	• Domestic clean up (all clean-up costs including labour costs)
• Internal decorations (e.g. redecoration)	• Floor coverings / Curtains
• Joinery (e.g. damage to door frames)	• Furniture (e.g. damage to bedroom furniture)
• Paths and paved areas	• Garden / DIY / Leisure
• Plasterwork (e.g. damage to stud partition wall)	• Heating equipment (e.g. radiators, gas fire)
• Plumbing, central heating and electrical installation	• Personnel effects

__Flood protection packages__

This study investigated the available and approved PLFP packages in the UK, and Table 3.2 presents a collection of these products and their suitability from relevant sources. Based on literature sources, industry design and common practices, the PLFP products used in this study were classified under four main themes relating to the component type and function. Table 3.3 shows these categories of PLFP packages which have been used in developing the financial model and they are manual resistance, automatic resistance, resilience measures without flooring, and resilience measures with flooring. The manual resistance was further grouped into two (A & B) based on their cost; the 'A' component is the lower cost range which includes demountable door guards while the 'B' component is the upper cost range combining more components as shown in Table 3.2.

Table 3.2: Resistance and resilience packages (Source: Royal Haskoning, 2012)

Flood protection package	Individual Measures	Source
Manual resistance measures	• Demountable Door Guards • Manual Airbrick and Vent Covers • Sewerage bungs/toilet pan seals • Waterproof external walls • Silicone gel sealant around cables passing through external walls • Sump pump	DEFRA (2007), DEFRA (2008), AECOM (2011)
Automatic resistance measures	• Automatic door guards • Smart airbricks and vents • Non-return valves on main sewer pipe • Waterproof external walls • Silicone gel sealant around cables passing through external walls • Sump pump	DEFRA (2007), DEFRA (2008), AECOM (2011)
Resilience without flooring	• Replace gypsum plaster with water resistant material, such as lime • Replace doors, windows and frames with water-resistant alternatives. • Mount boilers on wall • Move washing machine to first floor • Replace ovens with raised, built-under type • Move electrics well above likely flood level • Move service meters well above likely flood level • Replace chipboard kitchen/bathroom units with plastic units	DEFRA (2007), DEFRA (2008), AECOM (2011)
Resilience with flooring	• All the above, plus • Replace floor with solid concrete plus all measures above	DEFRA (2007), DEFRA (2008), AECOM (2011)

Table 3.3: PLFP packages for the financial model

Classification	Products/measures	Description
Manual resistance (A)	These are lower cost range of the manual resistance products. A typical example considered here is demountable door guard.	They are relatively inexpensive resistance measures and easy to install. Their assumed effective flood depth is up to 0.6m, as with all the PLFP products. Above this depth, maximum damages will occur to property as with no protection.
Manual resistance (B)	These are upper cost of the manual resistance measures, consisting of extensive components.	They are complete manual resistance protection and their assumed effective flood protect depth is up to 0.6m. Above this depth, maximum damages will occur will occur to property as with no protection.
Automatic resistance	These are automatic components of the resistance measures.	This protection option has higher reliability than the manual component and they are more expensive. Their effective flood protect depth is up to 0.6m, above which maximum damages will occur to property as with no protection.
Resilience without flooring	These are resilient packages with no resilient flooring component.	They are relatively expensive than the resistance measures. Their assumed effective flood depth is also up to 0.6m, and maximum damage will occur beyond this depth.
Resilience with flooring	These are resilient packages with additional protection for floors, which the other option does not have.	They are the most expensive packages, with an effective flood depth up to 0.6m; maximum damage to will occur beyond this depth.

Costs of PLFP products

Information on the costs of flood protection products were collected from relevant literature sources including studies by ABI (2003), Bowker et al. (2007) and Royal Haskoning (2012). In addition to this, further investigation of the common products available on the UK PLFP market was used to provide the best fit costs of the range of products used in this research (Floodgate Limited, 2012; Aquobex Limited, 2012; Caro Systems, 2012). Based on the required number of products needed to protect each property type (see Table 3.4), which have been determined using different property size and floor plans, the costs of PLFP products were calculated accordingly for the analysis. These costs were updated to 2013 prices using the CPI value, and with VAT allowance of 20%. For the final analysis, the whole life costs of the flood protection measures were discounted at a rate of 3.5%, in line with the 2003 HM Treasury Green Book recommendation, using a product life of 20 years as per the manufacturer's recommendation. The total costs of each PLFP package constituted the cost of product purchase, as well as annual maintenance cost which were estimated as 5% of the cost for automatic measures and 2% of the costs of manual units as the industry standard, and also used by previous related studies (Royal Haskoning, 2012).

Table 3.4: Resistance measures required by different property types (Source: Royal Haskoning, 2012)

Resistance Measures	**Detached**	**Semi-detached**	**Terraced**	**Flat**
Demountable Door Guards	3	3	2	2
Airbrick Cover	23	14	12	14
Sewerage Bung	3	2	2	2
Toilet Pan Seal	1	1	1	1
Sump Pump	1	1	1	1
Silicone gel around openings for cables etc.	1	1	1	1
Waterproof external walls	1	1	1	1
Automatic Door Guards	3	3	2	2
Self-closing airbrick	23	14	12	14
Non-return valves 110mm soil waste pipe	1	1	1	1
Non-return valves 40mm utility waste pipe	3	3	3	3
Non-return valves 12mm overflow pipe	1	1	1	1
Garage/Driveway Barrier	1	0	0	0
Average property size (m^2)	76	46	41	45

Table 3.5: Unit costs (£) of flood protection packages (Source: Royal Haskoning, 2012; JBA, 2012b)

Protection	Individual measures	Unit cost (£)	Detached	Semi-detached	Terraced	Flat
Resistance manual	Demountable door guards	716	2149	2149	1433	1433
	Airbrick cover	31	706	430	368	430
	Sewerage bung	41	123	82	82	82
	Toilet pan seal	72	72	72	72	72
	Sump pump	512	512	512	512	512
	Silicone gel around openings	102	102	102	102	102
	Total (incl. VAT)		3663	3346	2568	2630
Resistance automatic	Waterproof external walls	307	307	307	307	307
	Automatic door guards	1535	1535	4605	3070	3070
	Self-closing airbrick	72	1648	1003	860	1003
	Non-return valves 110mm soil waste pipe	614	614	614	614	614
	NRV 40mm utility waste pipe	102	307	307	307	307
	NRV 12mm overflow pipe	92	92	92	92	92
	Total (incl. VAT)		7572	6928	5250	5393
Resilience measure	Replace timber floor with solid concrete		7521	6477	5444	5945
	Replace gypsum plaster with water resistant material		2354	2047	1914	2016
	Replace doors, windows, with water-resistant alternatives		6580	5454	4339	5925
	Mount boilers on wall		174	174	174	174
	Move washing machine to first floor		235	235	235	0
	Replace ovens with raised, built-under type		235	235	235	208
	Move electrics well above likely flood level		440	348	297	297
	Move service meters well above likely flood level		583	583	583	583
	Replace chipboard kitchen/bathroom units with plastic units		3878	1535	2476	2814

3.4.3 Flood damage assessment

The Weighted Annual Average Damage (WAAD) method has been used as the preferred technique in flood damage evaluation. Over the years, this approach has become the UK industry standard and is well documented in the Flood and Coastal Management Appraisal Guidance (Environment Agency, 2010), as well as in the MCM (FHRC, 2010). Unlike other methods where flood damage assessments are done with reference to just a single flood event, the WAAD procedure annualises flood damage by using all available flood events to estimate the long-term annual average damage. As a result this method is very useful for damage appraisal as it solves the challenge of understanding the total exposure of all potential flood risks to property, rather than only the hazard from individual flood events. In view of its relevance, key researchers on flood PLFP schemes in the UK, including JBA (2012b) and Royal Haskoning (2012) have largely employed the WAAD procedure.

In this study, the WAAD has been used to calculate flood damages with respect to different PLFP package for all property types, as well as for unprotected properties. In all cases, the WAAD has been computed using information on seven different return periods for the case study area. The computation commenced with an analysis of the flood data for all affected residential properties in the study area to obtain a frequency-depth distribution, which describes the proportion of properties flooded at specific depths for each return period.

WAAD computations

Using the frequency depth distribution information for the case study area, the direct damage is obtained from the MCM data from which the total weighted damage for the flood event is calculated (see Appendix G). The total weighted damage for each flood event then forms a complete set of inputs for calculating the Annual Average Damage (AAD). The AAD is the potential annual damage in relation to a particular flood event and it is expressed as the product of the mean damage and the probability of flood interval between successive return periods. The AAD is calculated for all mean damages and their related probability interval, and the summation of these values gives the WAAD for all the flood events considered. Table 3.6 explains the computational arrangement for arriving at the WAAD values.

Table 3.6: WAAD computation approach

Return period (year)	Exceedance probability	Total weighted Damage (£)	Probability of flood interval	Mean damage	Annual interval damage (£)
2	0.5	a			
			0.4	(a+b)/2	0.4 (a+b)/2 = i
10	0.1	b			
			0.06	(b+c)/2	0.06 (b+c)/2 = j
25	0.04	c			
			0.02	(c+d)/2	0.02 (c+d)/2 = k
50	0.02	d			
			0.01	(d+e)/2	0.01 (d+e)/2 = l
100	0.01	e			
			0.005	(e+f)/2	0.005 (e+f)/2 = m
200	0.005	f			
WAAD					∑(i+j+k+l+m)

3.4.4 Benefit assessment of PLFP products

The benefits of adopting PLFP measures is defined in this study as the flood damage prevented as a result of the flood protection product installed in relation to the damage sustained by unprotected property. The assessment of the benefits of PLFP products in the financial model therefore involves two main activities:

- Calculating the WAAD of a property with respect to no PLFP measure at all.
- Calculating the WAAD of a property with respect to the PLFP measure employed.

In assessing the benefits of the different packages of protection products used in the study, key assumptions were made with respect to product malfunction and failure (see Table 3.7). This involves judging the potential benefits of each protection package based on their capabilities and effectiveness. Seepage or leakage with the PLFP measures has been estimated by applying a 20% reduction in damages for where there is protection, for example. The factors applied were in line with similar steps taken by previous studies based on further consultation, particularly for long duration floods (Royal Haskonning, 2012; JBA, 2012b). In addition, the effective design depth for resistance products was taken to be 0.6m above the threshold of a property, as the industry standard (Atkinson and Price, 2005). This figure has been recommended, based on physical testing of the ability of properties to withstand hydrostatic loading of floodwater. Beyond this threshold depth, flood damage is assumed to occur as with no protection at all.

The benefits explained in Table 3.7, are those involving the direct consequences of floods that are avoided by using PLFP products. These damages are primarily the household inventory and building fabric damages, as well as the clean-up costs which are evaluated separately in the MCM using the National Flood School data (FHRC, 2010). This data gives more comprehensive estimates for various clean-up costs components, including moving contents for storage and dehumidification, and the average value is £6423 for a property with no flood protection measure (JBA, 2012b).

Indirect benefit of PLFP products

Indirect costs of flood were evaluated separately in the financial model. They include the costs of temporary accommodation, absence from work and intangible impacts of floods with regards to the health or stress problems. In the past, an estimated value of £225 has been assumed as the benefit of avoiding the health or stress impacts based on survey outcome (DEFRA, 2008). However, more information has now become available on the costs of the health impacts of floods; as such, the previous figure (£225) has been updated to £2513 per household per event, based on future climate change metrics and considering an average household size of 2.36 for the UK (JBA, 2012b). The largest portion of the overall figure was estimated by the "UK climate change Risk Assessment: Health Report" in 2012 (HR Wallingford, 2012), and they constitute the mean costs of general practitioner care, cognitive behaviour therapy and non-directive counselling, and equates to £970. Using the total value (£1065) for the avoidance of stress and an average household of 2.13 persons for the Scottish borders, the resulting figure is £2268 and this has been used in the assessment.

In addition, a mean time of 26 days has been used as the average time people are absent from work after floods, and this was derived from findings reported by Werritty et al. (2007). The total loss due to absence from work is estimated at £2235, and is based on the mean weekly wage for Hawick which is estimated at £429 by the National Office of Statistics: Annual Survey of Hours and Earnings (ONS, 2012). Also, the mean cost of temporary accommodation was approximated as £6695 based on evidence of costs arising from the 2007 summer floods in England (Environment Agency, 2010). This average is derived from Weathernet insurance data which estimated the cost of temporary accommodation from the 2007 floods using a subset of 5,800 households. These indirect costs of floods have been included in the financial model to reflect the additional benefits of using PLFP products. The full costs have been used where there is no measure, but reduced accordingly for where there is flood protection product installed.

Table 3.7: Assessment of flood damages with respect to PLFP measures

Building fabric component

PLFP product	**Short duration flooding (< 12 hours)**	**Long duration flooding (> 12 hours)**
Manual resistance (A & B)	• Full damage to external building • No damage to floors up to 0.6m • Full damage to gardens/fences/sheds • No damage to internal decorations up to 0.6m • No damage to joinery up to 0.6m • Full damage to paths and pavement • No damage to plasterwork up to 0.6m • No damage to plumbing and electric up to 0.6m	• Full damage to external building • No damage to floors up to 0.6m • Full damage to gardens/fences/sheds • Damage to internal decorations is 20% of 0.05m flood up to 0.6m • Damage to joinery is 20% of 0.05m flood up to 0.6m • Full damage to paths and pavement • No damage to plasterwork up to 0.6m • No damage to plumbing and electric up to 0.6m
Automatic resistance	• Full damage to external building • No damage to floors up to 0.6m • Full damage to gardens/fences/sheds • No damage to internal decorations up to 0.6m • No damage to joinery up to 0.6m • Full damage to paths and pavement • No damage to plasterwork up to 0.6m • No damage to plumbing and electric up to 0.6m	• Full damage to external building • No damage to floors up to 0.6 m • Full damage to gardens/fences/sheds • Damage to internal decorations is 20% of 0.05m flood up to 0.6m • Damage to joinery is 20% of 0.05m flood up to 0.6m • Full damage to paths and pavement • No damage to plasterwork up to 0.6m • No damage to plumbing and electric up to 0.6m
Resilience with no flooring	• Full damage to external building • Full damage to floors • Full damage to gardens/fences/sheds	• Full damage to external building • Full damage to floors • Full damage to gardens/fences/sheds

	• Full damage to internal decorations • No damage to joinery up to 0.6m • Full damage to paths and pavement • No damage to plasterwork up to 0.6m • No damage to plumbing and electric up to 0.6m	• Full damage to internal decorations • Damage to joinery is 25% of costs up to 0.6m • Full damage to paths and pavement • No damage to plasterwork up to 0.6m • No damage to plumbing and electric up to 0.6m
Resilience with flooring	• Full damage to external building • No damage to floors up to 0.6m • Full damage to gardens/fences/sheds • Full damage to internal decorations • No damage to joinery up to 0.6m • Full damage to paths and pavement • No damage to plasterwork up to 0.6m • No damage to plumbing and electric up to 0.6m	• Full damage to external building • No damage to floors up to 0.6m • Full damage to gardens/fences/sheds • Full damage to internal decorations • Damage to joinery is 25% of costs up to 0.6m • Full damage to paths and pavement • No damage to plasterwork up to 0.6m • No damage to plumbing and electric up to 0.6m

Table 3.7: Contd.

Household inventory component

PLFP product	Short duration flooding (< 12hours)	Long duration flooding (>12 hours)
Manual resistance (A & B)	• No damage to audio/video up to 0.6m • No damage to domestic appliances up to 0.6m • Domestic clean-up cost is 20% of <0.1m flood • No damage to floor covering/curtains up to 0.6m • No damage to furniture up to 0.6m • Full damage to garden/DIY/leisure • No damage to heating equipment up to 0.6m • No damage to personnel effects up to 0.6m	• Damage to audio/video is 20% of 0.05m flood • Damage to domestic appliances is 20% of 0.05m flood • Domestic clean-up is 20% of < 0.1m flood • Damage to floor covering/curtains is 20% of 0.05m flood up to 0.6m • Damage to furniture is 20% of 0.05m flood up to 0.6m • Full damage to garden/DIY/leisure • Damage to heating equipment is 20% of 0.05m flood up to 0.6m • Damage to personnel effects is 20% of 0.05m flood up to 0.6m
Automatic resistance	• No damage to audio/video up to 0.6m • No damage to domestic appliances up to 0.6m • Domestic clean-up cost is 20% of < 0.1m flood up to 0.6m • No damage to floor covering/curtains up to 0.6m • No damage to furniture up to 0.6m • Full damage to garden/DIY/leisure • No damage to heating equipment up to 0.6m • No damage to personnel effects up to 0.6m	• Damage to audio/video is 20% of 0.05m flood up to 0.6m • Damage to domestic appliances is 20% of 0.05m flood up to 0.6m • Domestic clean-up is 20% of <0.1m flood up to 0.6m • Damage to floor covering/curtains is 20% of 0.05m flood up to 0.6m • Damage to furniture is 20% of 0.05m flood up to 0.6m • Full damage to garden/DIY/leisure • Damage to heating equipment is 20% of 0.05m flood up to 0.6m • Damage to personnel effects is 20% of 0.05m flood up to 0.6m
Resilience with no flooring	• Full damage to audio/video • Damage to domestic appliances is reduced by 40% up to 0.6m • Domestic clean-up is reduced by 50% of domestic clean up to 0.6m	• Full damage to audio/video • Damage to domestic appliances is reduced by 40% up to 0.6m • Domestic clean-up is reduced by 50% of domestic clean up to 0.6m

	• Full damage to floor covering/curtains • Full damage to furniture • Full damage to garden/DIY/leisure • No damage to heating equipment up to 0.6m • Full damage to personnel effects	• Full damage to floor covering/curtains • Full damage to furniture • Full damage to garden/DIY/leisure • No damage to heating equipment up to 0.6m • Full damage to personnel effects
Resilience with flooring	• Full damage to audio/video • Damage to domestic appliances is reduced by 40% up to 0.6m • Domestic clean-up is reduced by 50% of domestic clean up to 0.6m • No damage to floor covering/curtains up to 0.6m • Full damage to furniture • Full damage to garden/DIY/leisure • No damage to heating equipment up to 0.6m • Full damage to personnel effects	• Full damage to audio/video • Damage to domestic appliances is reduced by 40% up to 0.6m • Domestic clean-up is reduced by 50% of domestic clean up to 0.6m • No damage to floor covering/curtains up to 0.6m • Full damage to furniture • Full damage to garden/DIY/leisure • No damage to heating equipment up to 0.6m • Full damage to personnel effects

3.4.5 Financial analysis of PLFP products

The costs and benefits of using different packages of PLFP products have been analysed using the WAAD method and the flood frequency-depth data for the case study area. In all, seven flood protection packages were analysed using the 2010 MCM data to determine flood damages for both short (< 12 hours) and long (> 12 hours) flood durations. The average damages from both flood durations have been used in calculating the overall flood damage reduction with respect to each flood protection option. Also, the benefit of PLFP products was determined for four different property types (detached, semi-detached, terraced and flats) using the appropriate damage data with no consideration to particular age-band to help maintain consistency in the outcome, although age-band is not expected to affect the BCRs of PLFP assessments.

The overall analysis has been presented using BCR analysis to indicate how each flood protection package performed over its whole life. The BCR technique was used in this research to provide a uniform platform for comparing the cost and benefit of each PLFP product. It is useful in providing information which informs the selection of the most cost beneficial PLFP products for any scheme. To arrive at this decision, the PV (i.e. discounted whole life benefit and cost) of each PLFP product has to be determined (Equation 3). Again, the whole life of flood protection products used was 20 years, and a discount rate of 3.5%. The BCR is then estimated as the ratio between the PV benefit of the PLFP product over the PV cost of the PLFP product (Equation 4). Where the ratio is greater than unity (BCR>1), the PLFP product is said to be cost beneficial; this implies some savings in the PLFP investment. Alternatively, the NPV can aid decision making and is determined as the difference between the PV benefit and cost (Equation 5), a positive value signify substantial gain by the scheme.

$$PV = Cn / (1 + r)^{n} \qquad (3)$$

Where:

PV = Present Value (£)

Cn = Damage cost (£)

r = Discount Rate (fraction)

n = Number of years (years)

$$BCR = (PV_B / PV_C) \quad (4)$$

Where:

PV_B = Present Value Benefit (£)
PV_C = Present Value Cost (£)

$$NPV = (PV_B – PV_C) \quad (5)$$

3.5 Chapter Summary

This chapter has thoroughly described the different methods that have been used in this research. The entire process in the data collection has been discussed, from the development of a flood database which formed the basis of selecting case study areas for the research. The use of extensive stakeholder consultations in the form of questionnaire survey, focus groups and interviews have been explained and justified. These are approved techniques as shown in the literature review and are particularly useful for data collection in empirical studies. The use of questionnaire survey was relevant in assessing and quantifying attitudes of the public towards flooding and PLFP, and SPSS was used to analyse the responses. The focus groups were undertaken in two locations to probe further into the findings from the surveys, whilst interviews were conducted with institutional stakeholders to assess the national plan for PLFP uptake.

The financial analysis of PLFP products has been explained. This analysis involved the use of flood frequency depth data obtained from the SBC, and employed the WAAD method as the appropriate technique based on the literature evidence, to undertake the CBA of PLFP and different models of incentivised schemes. The BCR analysis was useful in comparing the benefits of various measures, to inform decisions that will promote and fund the uptake of such measures.

The proceeding chapters sum up the analyses and findings from the expansive data collected through the research methods outlined here. The analysis of the stakeholder consultations has been presented in the next chapter. Chapter 5 details the findings from the financial analysis of PLFP products and Chapter 6 discusses the institutional stakeholder interview.

Chapter 4: Stakeholder Survey Analysis

4.1 Introduction

This chapter presents the analysis of the data gathered from the stakeholder consultation involving questionnaire surveys and focus group discussions. The findings from the surveys are presented in the first part of the chapter, and are based on a total of 256 responses collected from twelve surveyed locations. Statistical analyses of the survey variables involved descriptive analysis, cross-tabulation and test of statistical significance of relevant variables.

Section 4.2 of the chapter gives the breakdown and distribution of the survey responses, followed by a summary of the background information of survey respondents. Section 4.3 presents findings on flood experience and flood risk perception, while section 4.4 details the impacts of flooding at the household level, in terms of both financial and social consequences.

Analysis of flood protection responsibilities, awareness of flood protection products as well as uptake of flood protection measures is presented in section 4.5. Section 4.6 reports the findings on people's willingness to pay for PLFP products and the reasons for reluctance to make any contributions towards flood protection costs.

The second part of the chapter details the findings from the focus group discussions which have been presented under relevant themes to give further explanation on the earlier findings from the questionnaire surveys. It also discusses other relevant issues that were not captured in surveys including flood insurance problems.

4.2 Survey Responses and Background Data

The survey responses from twelve sampled areas representing flood risk locations are reported in Table 4.1. In all, a total of 1,647 questionnaires were disseminated and 256 responses returned. This represents a response rate of 16% which is a satisfactory return for quantitative surveys given the typical low response rates for such kinds of studies. Previous studies have reported lower response rate, with Soetanto et al. (2001)

analysing a response rate in the region of 15% and Samwinga (2009) an even lower rate of 11%.The distribution of the survey responses indicate that large urban cities with large-scale flood defence schemes (e.g. Edinburgh and Glasgow) recorded relatively lower responses than small towns and rural areas where there are usually no flood defences (e.g. Dumfries and Hawick), which suggests that the latter group appeared more concerned and interested in the topic being investigated. This revelation is also consistent with previous similar study in Scotland which found that majority of survey responses were from small urban locations (Werritty et al., 2007).

Table 4.1: Survey locations and responses

Survey locations	Council	Questionnaire administered	Returned responses	Response rate (%)	Percentage of total responses (%)
Broxburn	West Lothian	20	7	35	2.7
Dumbarton	West Dunbartonshire	100	6	6	2.3
Dumfries	Dumfries & Galloway	80	33	41	12.9
Dundee	Dundee City	80	2	3	0.8
Eddleston	Scottish Borders	30	8	27	3.1
Edinburgh	Edinburgh City	500	65	13	25.4
Glasgow	Glasgow City	200	18	9	7.0
Hawick	Scottish Borders	200	50	25	19.5
Huntly	Abedeenshire	67	14	21	5.5
Perth	Perth & Kinross	120	21	18	8.2
Selkirk	Scottish Borders	200	21	11	8.2
Stonehaven	Abedeenshire	50	11	22	4.3
Total		1,647	256	16	100.0

4.2.1 Household age-groups and members

Figure 4.1 shows that nearly 40% of the respondents were from the elderly age-group of which 27% were between 60-74 years and 12% were 75 years or more. This finding has been compared to the Scottish national demographic data from the Office for National Statistics (ONS, 2012), and it shows a bias towards the older group given that just under a quarter (23%) of Scots were aged at least 60 years. However, the large proportion of elderly respondents shown by this result seems very common with most questionnaire surveys as this group remains the most regular and well represented participants; a finding that is perhaps due to the availability of older people as a result of being on retirement. This observation is reportedly a common experience with questionnaire surveys (Harris, 2001).

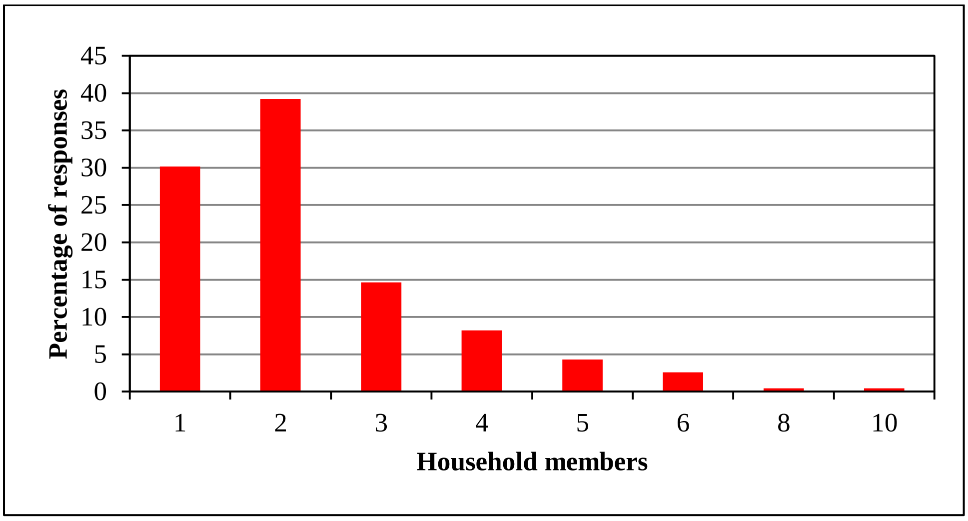


Figure 4.1: Household members distribution

With the distribution of household members a total of 232 responses were collected, out of which the majority (39%) were households of two members and 30% were single occupants only. This was followed by 15% for a three-member household whilst households with ten and eight formed 0.4% each of the remaining responses. Again, these findings appeared broadly similar to the 2011 census data where single occupant households accounted for 35% of all households and the average household size was approximately two.

4.2.2 Household income and employment

Almost 39% of respondents declined to provide information on their household income, but of those who did, the result signifies that the majority (over 60%) were below the approximate average income level of £32k, for all responses. Those who had income between £10000-19999 were about 30%, whereas 21% belonged to the income group of £20000-29999 (see Figure 4.2). The overall distribution of income among both flooded and non-flooded households were quite similar, and were also consistent with findings from several UK flood studies. For example, RPA (2004) reported that the mean income level for surveyed English residents was £22k and showed a very similar distribution for both flooded and at risk respondents, whilst Werritty et al. (2007) also suggested a similar distribution for flooded and non-flooded households using an average income level of £20k.

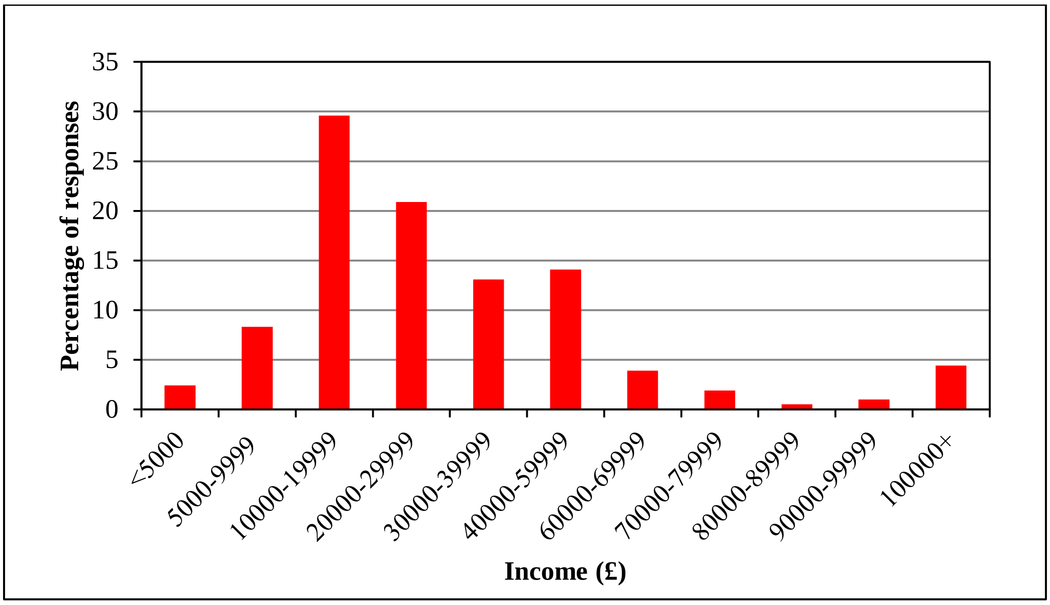


Figure 4.2: Households income distribution

In terms of the employment status of household members, 33% of the survey respondents were retired people and this figure far exceeded the national average (6%) for those who have permanently retired. This outcome could imply that significant households are low income earners; a situation that is particularly common among the elderly and the disabled and suggests that these groups are more vulnerable to the impacts of flooding as they may be unable to invest in flood protection (McCarthy et al., 2007; Thurston et al., 2008). On the contrary, it can be argued that the aged groups often tend to have paid off their mortgages and have no dependants at home, implying less financial responsibility. In addition, those working full-time accounted for 32% of the responses and were also less than the average national working force which is 45%. However, the proportion of part-time workers was more similar to the national trend (ONS, 2012), and formed 13% of the responses. The unemployed (4%) were lower than the national average (7%), and does not seem to represent a large non-working people in the sampled locations. Other household members including students and pupils accounted for 12% of the responses, and close to the national average of 10%.

4.2.3 Property type and situation

Of the total 232 responses collected, about 4% have lived in their property for less than a year and over 60% have resided for more than ten years for both flooded and non-flooded respondents. From these figures, it was clear that the majority of respondents had spent substantial years in their properties, and could imply that most of them may own their property and probably be more abreast of flood risk problems in their communities; this is particularly relevant for the overall impact of the research findings. This inference is also supported by findings from the recent Scottish Household Survey (SHS) which suggested that 47% of people are more likely to live in their properties for more than ten years, particularly those in owner-occupied households (SHS, 2011).

The distribution of various property types among respondents is shown in Figure 4.3, and indicates that the most common property type was terraced houses which represented 39% of the total responses. In addition, ground floor flats, bungalows and basement flats which are regarded as the most vulnerable properties at risk from flooding, accounted for almost 33% of the responses. Out of this figure ground floor flat alone was 22% and is the most significant. Overall, the distribution is fairly different from the national housing statistics provided by the National Records of Scotland (2013), which indicate that flats form 38% of all properties followed by terraced and detached at 21% each, while semi-detached houses are 20%.

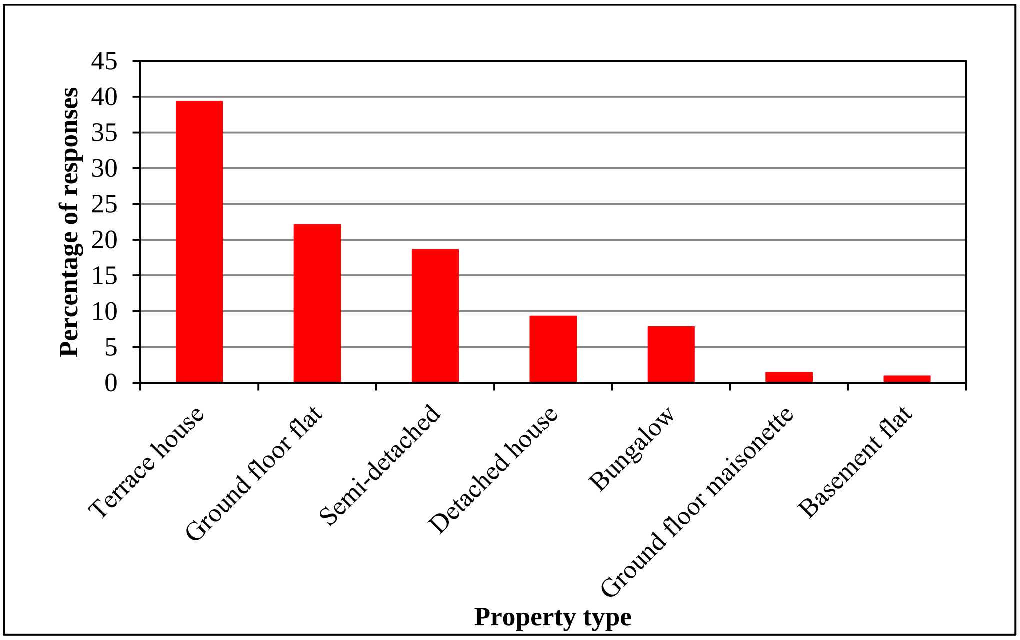


Figure 4.3: Property types of the survey respondents

It was found that the majority of respondents (84%) were in owner-occupied properties; 51% owned their property outright and 33% owned their property with mortgage. The remaining 16% of properties were rented from various sources including those from private landlords which was 7%. This distribution is similar to an earlier study in the sense that those who owned their property either with mortgage or outright were reported to be 79%, while private rented houses formed 10% (Ball et al., 2012). However, these findings are slightly biased compared with the national pattern where the majority (65%) of householders were found to reside in owner-occupied houses, and 33% in rented houses including 10% of private rented houses (SHS, 2011).

4.3 Flood Experience and Perception

4.3.1 Knowledge of flood risk

Of all the survey data collected, just over half (58%) of the respondents had not been flooded in their current properties. Interestingly, an earlier Scottish study covering a wider case study areas suggests very close split between flooded (52%) and non-flooded (48%) properties (Werritty et al., 2007), which reveals the narrow margin of being at risk of flooding and being flooded at some point or similar targeted areas. Knowledge of flood risk was further investigated considering those who had not been flooded in their properties, and on the premise that all surveyed locations were areas of known flood risk. From this analysis it was found that 68% (n = 99) of the non-flooded households were aware of flood risk at their property, whilst 27% (n = 40) were unaware and the remaining 5% (n = 7) were unsure about their flood risk. The findings show a high awareness of flood risk among non-flooded households, which is significant given that knowledge of flood risk in general has been shown to be a source of motivation to individuals to undertake precautionary measures for flood events (Kreibich et al., 2011; Koerth et al., 2013).

4.3.2 Flood types

The most significant floods experienced by households was fluvial floods (62%), followed by sewer floods (15%) and surface water floods which was almost 10%. There was surprisingly high reported incidence of groundwater flooding (8%), which is uncommon in Scotland, and perhaps due to respondents mistaking water entering via airbricks for groundwater flooding. Considering the survey locations visited, it is unsurprising to see coastal flooding forming just 4% of the reported incidents. The rareness of coastal flooding is consistent with the reported incidents in the SEPA flood database used for selecting the case study areas (Section 3.2.1); they were by far less compared with other flooding types including fluvial and sewer floods.

4.3.3 Flood experience

Two forms of flood experiences were analysed; those flooded above floor level and those flooded below floor level. Figure 4.4 shows the results of the number of times people were flooded under each case. The majority of respondents have been flooded just once, with 81% of those flooded above floor level and 66% of those below floor level. Those flooded on multiple times are relatively low for both cases of flooding, and this outcome could imply that people either move homes or invest in flood protection measures in order to avoid repeated flooding.

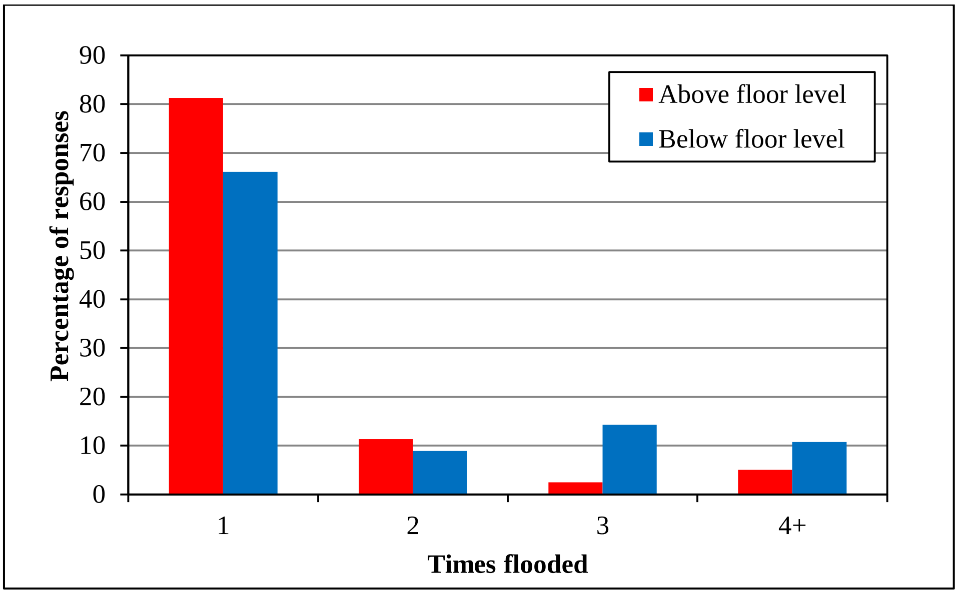


Figure 4.4: Number of times flooded in property

Table 4.2 shows the years people have lived in their property and the years since they were last flooded. The results show that the majority (78%) of floods occurred in the last ten years; the most significant experience was 6-10 years ago with 39%, followed by 1-5 years with 32%. Overall, the results generally show that people were flooded more with increasing years lived in properties, and could imply substantial number of people living in properties flooded before.

Table 4.2: Years lived in property and years since last flooded

Years in property	Years since last flooded					Total (%)
	<1	1-5	6-10	11-19	20 +	
<1	0.0	1.0	1.0	0.0	0.0	2.0
1-5	2.0	6.1	4.0	2.0	0.0	14.1
6-10	1.0	3.0	6.1	3.0	1.0	14.1
11-19	1.0	8.1	10.1	5.1	0.0	24.2
20 +	2.0	14.1	18.2	10.1	1.0	45.5
Total	6.1	32.3	39.4	20.2	2.0	100.0

4.3.4 Floodwater characteristics

To understand flood experience at the household level, respondents were asked to gauge various floodwater characteristics (e.g. depth, speed and duration) against a clearly defined scale, based on their most recent flood experience.

Floodwater depth

Flooded households were first asked to indicate the maximum floodwater depth in their rooms downstairs. Figure 4.5 presents the outcome based on 93 responses, and shows that 58% (n = 54) of respondents have experienced flood depths over 25cm whereas 42% (n = 39) pointed out to lower flood depth between 0-25cm. This finding could imply that most floods generate significant depth above ground level which can result in both damages to property and social impacts to affected people.

Flood depths above 75cm accounted for almost 20% (n = 19) of the responses with 11% (n = 10) indicating more extreme flood depth of at least 100cm ,which denotes maximum flood impacts to properties as in such situations flood resistance and resilience protection measures can be overwhelmed by floods. Generally, extreme flood depths were not as common as shallow depth, an observation which is supported by RPA (2004) who reported only 16% response for flood depths of 1m or more and a mean depth of 55cm for main room flooding, based on an average of three rooms. The significant lower flood depths reported in this research suggests a high potential for PLFP products which are particularly feasible for flood depths up to 60cm.

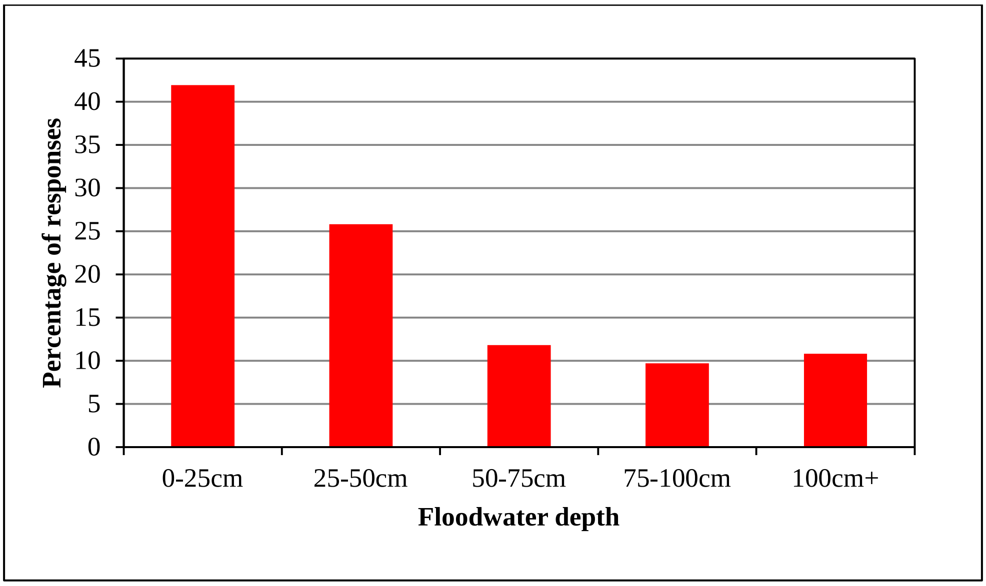


Figure 4.5: Floodwater depth in flooded properties

Floodwater velocity

The rise time of floodwater was measured by how long it takes the floodwater to reach its maximum depth in a flooded property. The majority (76%) of residents were flooded to their highest depth within 3 hours of flood onset. This figure consists of 34% (n = 32) of those flooded under 1 hour, which is key for taking some action of protection against quick rising water. In addition, 42% (n = 40) were those flooded between 1-3 hours, and was similar to earlier findings which suggested that 66% of flooding occurred within 3 hours after flood warning with the most flooding occurred between 1-3 hours. A similar finding is reported by another study which highlighted a direct connection between floodwater speed and receipt of advanced flood warning. These findings are quite useful information as floodwater velocity has a huge influence on how well people can prepare for floods after receiving warning, including moving their belongings to safety.

Flood water duration

Figure 4.6 shows the floodwater duration which was assessed by how long floodwater was present in a property after flooding had occurred. There were 98 responses, out of which 40% (n = 38) had water present in their homes up to 5 hours and just 7% (n = 7) were under 1 hour. Floodwater exceeding 5 hours was significant (n = 60) with 21% reported to have lasted for 24 hours and more. Overall, these findings indicate that the net majority had floodwater present in their rooms for over 1 hour, with significantly longer durations suggesting greater impacts as well as longer recovery times. Although there was no statistical relationship between flood duration and the financial damages sustained by households, and most of the flood damages reported were associated with flood durations between 1-5 hours, the highest damage occurred with a longer duration between 10-24 hours.

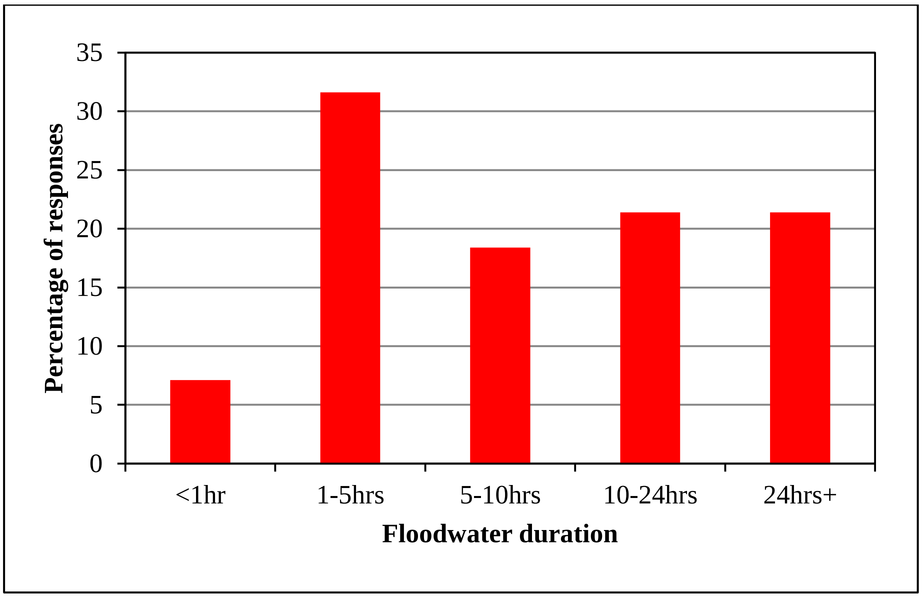


Figure 4.6: Floodwater duration in flooded properties

Floodwater pathway

The essence of the floodwater pathway analysis was to help investigate floodwater entry into a property, which will in turn assist in planning appropriate mitigation techniques. Figure 4.7 shows that 29% (n = 68) of households were flooded through their airbricks, and 29% (n = 67) through their doors. These findings are significant as they account for the majority (60%) of internal flooding reported, and have key implication for PLFP depending on floodwater depths. It suggests that simple resistant products (e.g. door cover, airbrick and vent covers) could have proved beneficial in preventing the majority of the flooding incidents. In addition, this finding identifies substantial floodwater through floors, cellars or basement which accounted for 21% (n = 48) of responses, whilst floodwater through drains (n = 26), windows (n = 3) and walls (n = 19) formed the remaining 20% of the responses. These figures are an indication of the diverse route of floodwater entry path, and therefore highlight the very real need for total protection.

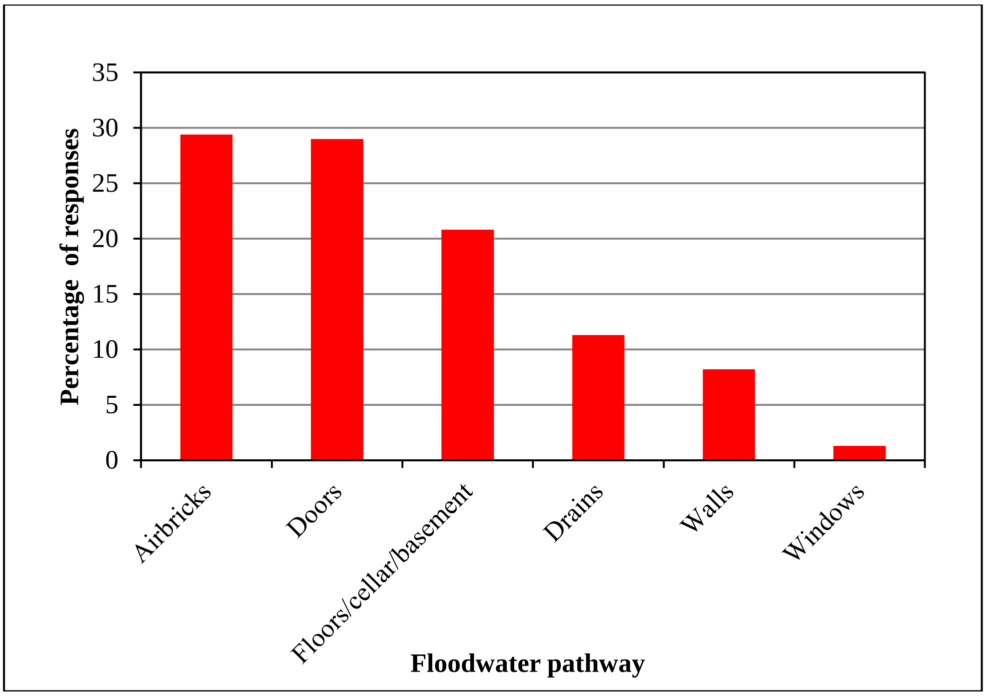


Figure 4.7: Floodwater pathway into flooded properties

To explore further, Table 4.3 shows the distribution of floodwater depths against floodwater pathways in affected homes. The results confirm that a significant proportion of shallow floodwaters were found in flooded homes, particularly via doors, airbrick and floors/basement. In terms of PLFP feasibility, the majority (68%) of flooding through all entry points were floodwater depths less than 0.6m, consisting of 20% of those through doors and 22% for airbricks.

Table 4.3: Floodwater depth and pathway in properties

Floodwater pathway	**Depth of floodwater in affected homes (%)**					**Total (%)**
	0-25cm	25-50cm	50-75cm	75-100cm	100cm+	
Through doors	9.39	8.92	4.225	3.29	3.76	29.58
Through windows	-	-	0.47	-	0.47	0.94
Through airbricks	11.74	8.45	2.82	2.82	3.29	29.11
Through drains	4.22	1.41	1.41	1.41	2.82	11.27
Through walls	2.82	2.35	0.47	1.41	0.94	7.98
Through floors/cellar or basement	7.51	5.16	3.29	2.35	2.82	21.13
Total	35.68	26.29	12.68	11.28	14.10	100.00

4.4 Flood Impacts on Flooded Homes

4.4.1 Financial impacts

The financial costs of flooding were assessed by taking into consideration both the insured and uninsured costs that were incurred as well as other personal costs that were not covered. Approximately 90% of flooded households suffered some damage to their property and possessions, and almost 92% of the flood affected households had buildings and contents insurance. For those that provided information on costs, the mean insured building and contents costs were £30,123 (n = 29) and £10,493 (n = 27) respectively (Table 4.4). The costs that were not covered by insurance including personal costs was relatively high at £13,274 (n = 13). Overall, these figures are within the limits of those previously reported. For example, Werritty et al. (2007) surveyed flood victims in Scotland and determined that buildings and contents losses were £31,980 and £13,552 respectively, whilst Bowker (2007) used measured flood depths to estimate total losses of £10-50k. RPA (2004) reported that the mean total losses (insured buildings and contents, and uninsured) for a flooded property in England was approximately £30k, whilst insurance claims following the 2007 floods in England were reported to be £23-30k (Environment Agency, 2010).

Table 4.4: Financial impacts of floods

Insured Costs	Responses (N)	Min (£)	Max (£)	Mean (£)
Building	29	55	198,000	30,123
Contents	27	200	50,000	10,493
Cost Not covered	13	100	94,000	13,275

4.4.2 Social impacts

To determine the social impacts of flooding, respondents were asked to rate five separate variables based on their last flood experience, using a scale of 0-10 (0 = no impact, 10 = maximum impact). As shown in Table 4.5, all of the variables had a significant impact on flooded households, with the most noteworthy being “the stress of the flood event itself” (6.97) and “worry about future flooding” (6.86). These results have been compared with related studies, and are found to show a similar pattern to an earlier Scottish study (Werritty et al., 2007), as well as broadly similar findings to an

English based study (RPA, 2004). However, it is interesting to note that both Scottish based studies placed a far higher emphasis on “worry about future flooding” and far less emphasis on “having to stay in temporary accommodation”; a finding that perhaps reflects the availability of emergency accommodation in England or the lack of confidence in flood defence strategies in Scotland.

Table 4.5: Social impacts of floods

Intangible flood impact	**Responses (N)**	**Mean score**	**Mean score (Werritty et al., 2007)**	**Mean score(RPA, 2004)**
Stress of flood event itself	98	6.97	6.77	7.1
Worry about future flooding	81	6.86	7.13	6.6
Getting house back to normal	99	6.62	7.37	7.8
Having to stay in temporary accommodation	94	5.31	5.40	7.0
Loss of irreplaceable items (e.g. photos)	88	5.22	5.10	5.6

Score: 0 = no impact, 10 = maximum impact

The problem of getting ones house back to normal after flooding was further investigated and has been reported in Figure 4.8. These results show that over 70% (n = 68) of flooded households took at least 3 months to get their property back to normal, with almost 39% (n = 37) taking longer than 6 months to return to their properties. Again, this finding is consistent with what appears to be the typically long recovery time in UK, and is estimated by the National Flood Forum as 9 months (Pitt, 2008).

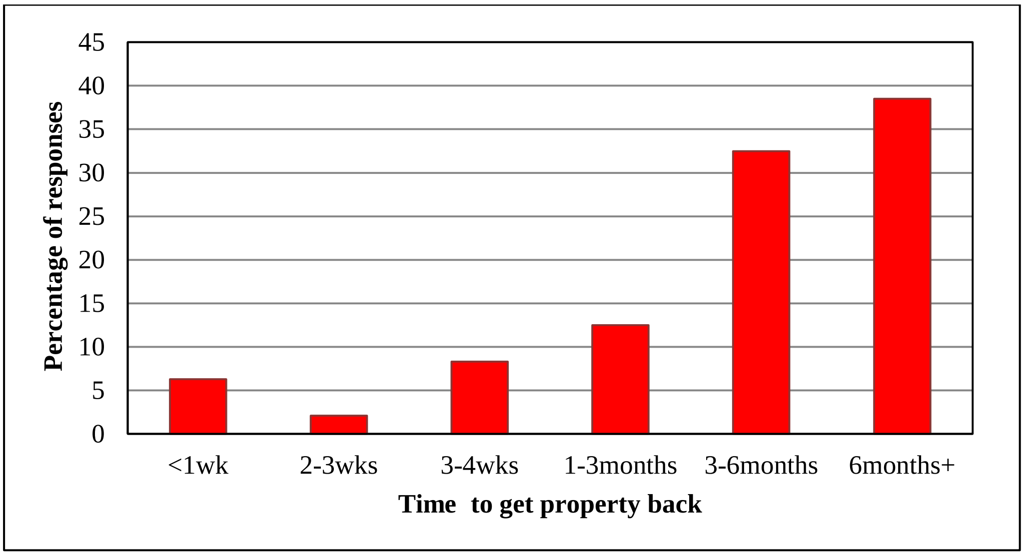


Figure 4.8: Getting property back to normal after flooding

4.5 Property Level Flood Protection (PLFP)

4.5.1 Flood protection responsibility

Figure 4.9 depicts how the survey respondents viewed the burden of flood protection responsibility for both community level (i.e. large scale, centrally funded) and property level flood protection. This question allowed respondents to select multiple answers, and hence the total responses were 770 and 775 for community and property protection respectively. It was surprising that only 22% (n = 172) of the public felt they were responsible for their own protection, whilst over 70% (n = 603) of the public felt some other public body was responsible. However, most respondents attributed property protection responsibility to other agencies; local authorities recorded the highest at 28% (n = 214), followed by Scottish Government at 18% (n = 143) and SEPA had 14% (n = 112). These findings were confirmed by the focus group findings (reported in later sections), and are consistent with earlier similar studies (Werritty et al., 2007; Terpstra and Gutteling, 2008), and indicate that the majority of the public remain very uncertain about their responsibility towards their own flood protection.

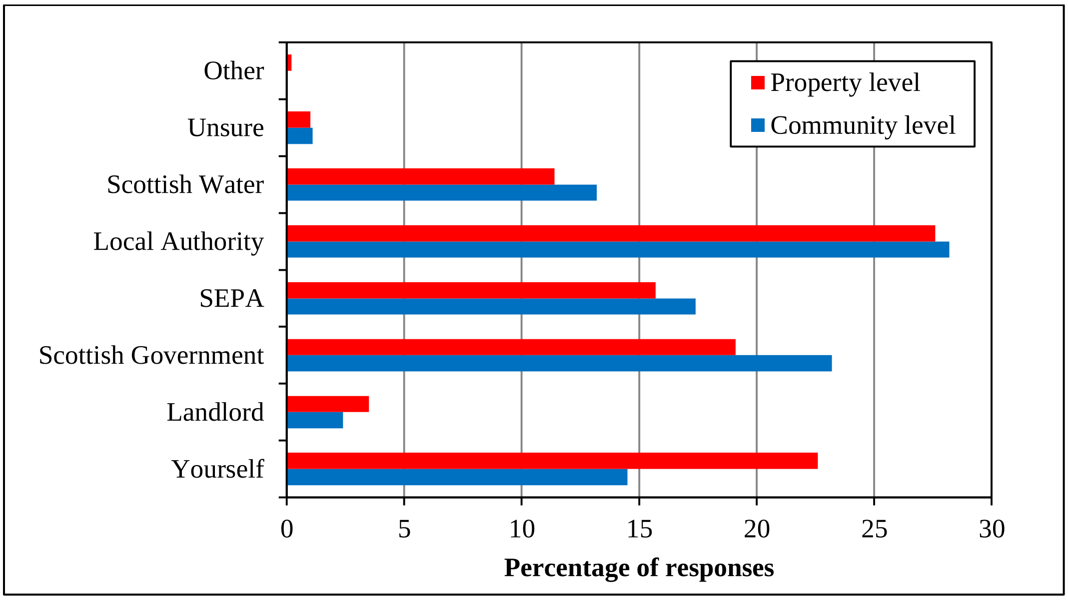


Figure 4.9: Flood protection responsibility at the community and property level

Interestingly, 14% (n = 108) of respondents felt they were responsible for community level flood protection schemes. As in most other countries, such responsibilities within Scotland actually lay with a range of relevant institutional bodies (Scottish Government, 2011). Presumably, those individuals who felt responsible for community level protection were referring to a more general, “societal responsibility” expressed through payment of the taxes that fund such schemes.

4.5.2 Flood protection awareness

Despite the low number of respondents being aware of their own responsibility to protect their property, awareness of PLFP measures was high for both flooded and non-flooded households. Table 4.6 shows that 77% of flooded households and 53% of non-flooded households stated that they were aware of PFLP measures, yielding an overall mean of 63% (n = 161). It also shows a statistical significance (p < 0.001) between the subgroups (flooded/non-flooded) and awareness of PLFP. These findings differ from earlier studies which suggested a very low awareness of PLFP products (DEFRA, 2008), and this may seem to indicate that recent flood education campaigns have been successful in getting key messages across to the public. The need for flood awareness education is echoed by Bubeck et al. (2013) who suggested that that such activities can lead to increased flood precautionary behaviour among flood prone residents (Bubeck et al., 2013).

Table 4.6: Awareness of property level protection products by households

Awareness	**Flooded (%)** **N=107**	**Non-flooded (%)** **N=148**	**Total (%)** **N=255**
Yes	77.6	52.7	63.1
No	22.4	47.3	36.9
Total	42.0	58.0	100.0

Chi-squared = 16.500; df = 1; p < 0.001

4.5.3 Flood protection uptake

From the overall responses of those aware of PLFP products, the majority (n = 100) had taken up some form of measures. Table 4.7 indicates a statistical relationship (p < 0.001) between PLFP uptake by flooded and non-flooded sub-groups of the respondents and uptake of PLFP; hence the null hypothesis of no association is rejected. It shows that 77% of flooded households and 44% of non-flooded households had taken up flood protection, with an overall mean of 61%. For those who indicated the total cost of their protection (n = 66), the range was from £10-11,000 with a mean total of £576. With those who had flood protection, just over a third received some financial assistance in purchasing their products which ranged from £25-500 per property, with the average contribution being £223, representing 39% of the total costs of their products.

Table 4.7: Uptake of property level flood protection products by households

PLFP uptake	**Flooded (%)** **N=84**	**Non-flooded (%)** **N=79**	**Total (%)** **N=163**
Yes	77.4	44.3	61.3
No	22.6	55.7	38.7
Total	51.5	48.5	100.0

Chi-squared =18.785; df = 1; p < 0.001

Figure 4.10 shows the PLFP products installed by households. It illustrates that the most significant uptakes were sandbags at 31% (n = 66), followed by door guards and airbricks or vent covers both at 25% (n = 53), which could be due to their relatively low cost. Overall, these findings differ from those of earlier studies (Werritty et al., 2007; Thurston et al., 2008), who reported far lower uptakes of PFLP. However, the findings also suggest the reactive nature of people's behaviour towards flood protection as the majority purchased their products after flood event; just one third of respondents purchased flood protection products before flooding.

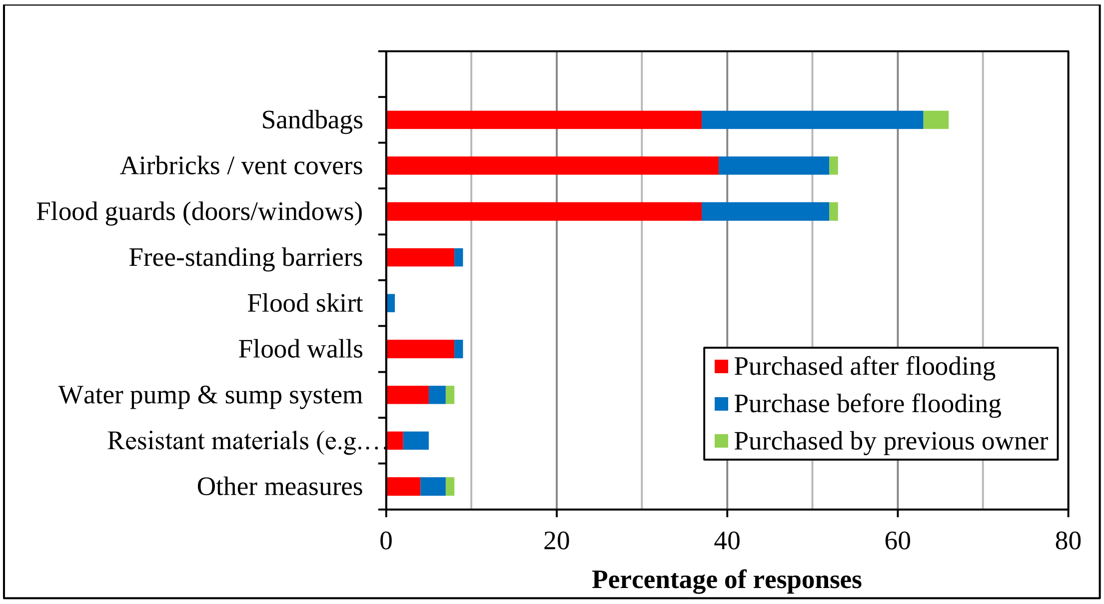


Figure 4.10: Property flood protection uptake by households

Perception of PLFP measures

Common perceptions of the use of PLFP products were examined. Those aware of the products were asked to rank views on flood protection uptake using a scale of 0-10 (where 0 = disagree strongly and 10 = agree strongly), and the results are shown in Table 4.8. The findings suggest that most people recognise PLFP products are effective and useful, with the most supported views being their ability to "reduce flood damage and save money (7.08)" and "effective and simple to use (6.42)". In contrast to previous studies, householders rejected what seems to be the negative perception about PLFP products which has often been a barrier to promoting greater uptake of such products. These findings imply significant acceptance and confidence in the use flood protection products, and this may be linked to the impact of flood education and perhaps the acceptance of risk.

Table 4.8: Perceptions on the use of PLFP products

Perception	Responses (N)	Min	Max	Mean
They are effective and simple to use	136	0	10	6.42
They can reduce flood damage and save me money	138	1	10	7.08
They can increase the value of my property	125	0	10	3.73
They would make me feel safe	135	0	10	5.63
I feel they are too expensive to buy and maintain	119	0	10	4.87
They would make my house look odd and unattractive	121	0	10	4.84
They would reduce the value of my house	119	0	10	4.71
I do not feel able to choose the right products for my property	121	0	10	4.12

Score: 0 = disagree strongly, 5 = neutral, 10 = agree strongly

Perception of climate change and PLFP

Additionally, further investigation of public perception of climate change and flood mitigation showed that the majority appeared to share the common views on climate change and its implication on flood risk. Whilst most people indicated a high score (7.50) for the opinion that climate change will result in more frequent and severe flooding of properties, the most significant score (7.62) was for the view that climate change will result in the need for more flood protection for properties. These findings suggest that people are aware of climate change and concerned about the impacts, particularly on flood risk and the demand for adequate flood protection.

Table 4.9 shows the results of subgroups, households with children and those with no children and their responses on climate change and PLFP. Clearly, households with no children recorded higher responses and scores than those with children for both statements. More people ranked the need for flood protection against climate change impacts higher than the need for individuals to take greater responsibility for flood protection, with relatively more people being neutral in the latter response. Those who agreed with both statements were 16% and 14% for household with children, and 66% and 55% for those with no children for the respective opinions.

Table 4.9: Perception of climate change and PLFP

Perception	**Responses (%)**											**Total**
	0	1	2	3	4	5	6	7	8	9	10	**(%)**
I think that climate change will result in the need for more flood protection for residential property.												
Household with children	0.43	-	-	-	-	1.29	0.86	1.72	4.72	0.86	7.73	17.60
Household with no children	3.00	0.43	0.86	2.58	1.29	7.73	6.44	11.59	15.88	4.72	27.90	82.40
Total	3.43	0.43	0.86	2.58	1.29	9.01	7.30	13.30	20.60	5.58	35.62	100
I think that climate change will mean individuals have to take more responsibility for flood protection.												
Household with children	0.43	-	-	0.43	-	2.60	0.43	3.46	3.90	0.43	6.06	17.75
Household with no children	5.63	0.43	2.16	3.46	2.60	12.55	4.33	10.82	14.72	4.76	20.78	82.25
Total	6.06	0.43	2.16	3.90	2.60	15.15	4.76	14.29	18.61	5.19	26.84	100

Score: 0 = disagree strongly, 5 = neutral, 10 = agree strongly

4.6 Willingness to Pay (WTP) for PLFP

4.6.1 Descriptive analysis

The survey participants were asked whether they were willing to pay for PLFP, and if so, they were asked to provide their reasons as well as the maximum contribution they were willing to make towards protecting their property. In total, 57% (n = 145) of the respondents stated that they were willing to pay for PLFP. When asked to explain their willingness to pay for PLFP, at least three quarters of the respondents agreed with each of the proffered reasons such as to avoid the impacts associated with current flooding, to avoid the impacts associated with future flooding, and to avoid increases in insurance premiums and excesses. Table 4.10 displays the various reasons behind the WTP for flood protection.

Table 4.10: Reasons behind WTP pay for flood protection

Reasons	Responses (N)	Percentage (%)
To avoid flood impacts associated with flooding	143	29.5
To avoid impacts as a result of climate change	118	24.3
To avoid increase in flood insurance premiums	127	26.2
Not willing to pay	94	19.4
Other reasons	3	0.6
Total	485	100.0

Respondents were asked to state their maximum WTP for PLFP, having been given a range of PLFP products and series of prices; the results are shown in Figure 4.11. The total amount households were willing to pay for PFLP ranged from £50-10000, with almost 80% of respondents selecting a figure of either £100 (36%) or £1000 (43%). This clustering of responses around the two prices of PLFP is an observation that could reflect the sensitivity of the stated preference method used and the mode of questioning. Interestingly, whilst the overall mean that households were willing to pay was £795, the figure for those who had previously been flooded (£734) was less than those who had never been flooded (£834). This may indicate that people without previous flood experience tend to overestimate the cost of protecting their property, or could just mean that people are aware of the cost, but are just less willing to pay based on their own flood experience.

As with PLFP awareness and uptake, these findings are again at odds with earlier research, where just over half of survey respondents were unwilling to pay additional council tax to fund flood protection at the community level, and even amongst those willing to pay, only 8.5% were prepared to pay £100 or more (Werritty et al., 2007). Interestingly however, a similar Dutch study found that nearly two thirds of homeowners would be willing to invest in flood mitigation measures (e.g. water barriers) in exchange for discounted flood insurance, with the mean willing to pay value being €120 per year (Botzen et al., 2009).

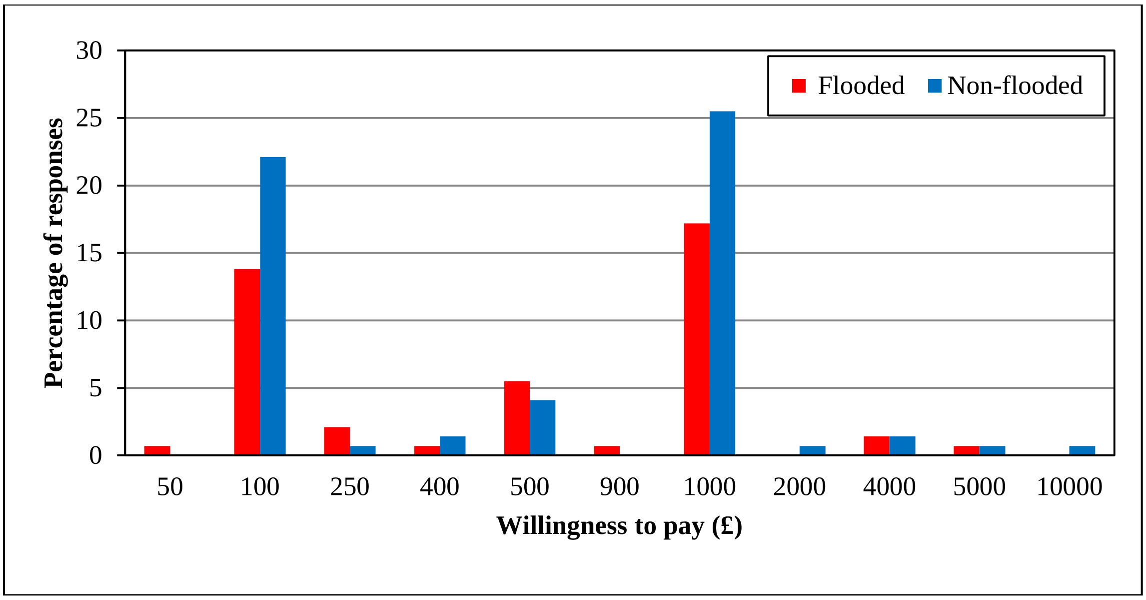


Figure 4.11: Willingness to pay for PLFP products

For those who were not willing to pay, just over half of respondents felt that they could not afford PLFP measures, and a similar proportion stated that the government or council should pay for such protection. Approximately a third of respondents indicated that they already had PLFP measures, and a further third felt that they were not at risk from flooding. A small number of people (13%) felt that such measures were simply not effective.

4.6.2 Correlation analysis

Further statistical analysis involving the WTP variable and factors that affect people's WTP was carried out; comprehensive results are presented in Appendix C. In this analysis the Spearman's correlation was employed rather than the Pearson correlation coefficient which appears to be more sensitive to skewed data and outliers (Field, 2009).

The surveys responses showed a skew towards the aged groups especially the retired, as well as the responses for the WTP values were biased towards less expensive costs of PLFP products. The factors tested here include those that are socio-economic and those related to flood experience. Previous studies in this area have suggested that WTP value can be influenced by flood experience of the survey respondents such as stress (RPA, 2004), and Grothmann and Reusswig (2006) also reported the effect of other factors including income level and home ownership on people's preparedness to adapt flood mitigation measures. From these, it can then be concluded that several factors can potentially influence the WTP for PLFP measures, including household income.

Household income

Table 4.11 shows the correlation matrix for the household characteristics that were found to have significant relationship with the WTP variable. Unsurprisingly, there was a statistically significant relationship between households WTP for flood protection and income level ($r = 0.273$, $p < 0.001$, $n = 126$). This result is consistent with the findings by RPA (2004) who indicated that these variables were correlated.

Household age and employment

The age of household members was found to have an influence on the WTP. Households members with age groups of 40-59 years especially, was significantly correlated ($r = 0.370$, $p < 0.001$, $n = 59$) with WTP value, and the distribution of WTP shows that this age group indicated an amount between £100-10000, with the average value of £910. Also, employment status, particularly households with part-time workers were found to be significantly correlated ($r = -0.401$, $p < 0.05$, $n = 28$) with the WTP. The average WTP value for this group was £843 and ranged from £100-4000. However, this was a negative association and therefore implies that as one variable increases the other decreases, and vice versa. In addition, households with retired members were strongly linked ($r = 0.389$, $p < 0.001$, $n = 57$) with WTP and their average total contribution was £680, and ranged between £50-5000.

Table 4.11: Correlation between WTP and socio economic factors

Variables	1	2	3	4	5	6
1. WTP	1.000					
2. Age group 40-59yrs	.370**	1.000				
3. Part-time workers	-.401*	.157	1.000			
4. Retired	.389**	.115	.816	1.000		
5. Property type	-.258**	-.073	.135	-.033	1.000	
6. Income level	.273**	.418**	-.127	.248*	-.166*	1.000

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed)

Property type and ownership

Other factors that were expected to influence people's WTP for PLFP include the type of property people lived in and their ownership status. Property types were coded based on their sizes, with bungalow and detached houses being the largest and terraced houses and flats were the smallest. Analysis of the WTP responses under property dwelling types showed a negative correlation (r = -0.258, p < 0.001, n = 122), with the mean WTP value as £840 and ranged from £50-10000. The most willing to pay respondents were from terraced houses (40%) and ground floor flats (24%). Although, this relationship is significant, it also implies a negative relationship between the two variables; as one variable increases the other decreases, and vice versa.

There was no significant statistical association between WTP for flood protection products and property ownership (r = -0.161, n = 133). However, Figure 4.12 shows the distribution of WTP under property ownership and highlights some interesting results. First, people with some ownership of their property were keener to pay for protection. This group represented 86% of the total WTP responses, of which 48% were those who owned their property outright whilst those with properties on mortgage formed 38%. On the contrary, people with no ownership of property were less interested in paying for flood protection as would be expected; they formed the remaining 14% of the responses and were from rented houses. Again the distribution here shows clustering of large responses for WTP of £100 and £1000, similar to the earlier observation and as a result of the mode of questioning used in the valuation.

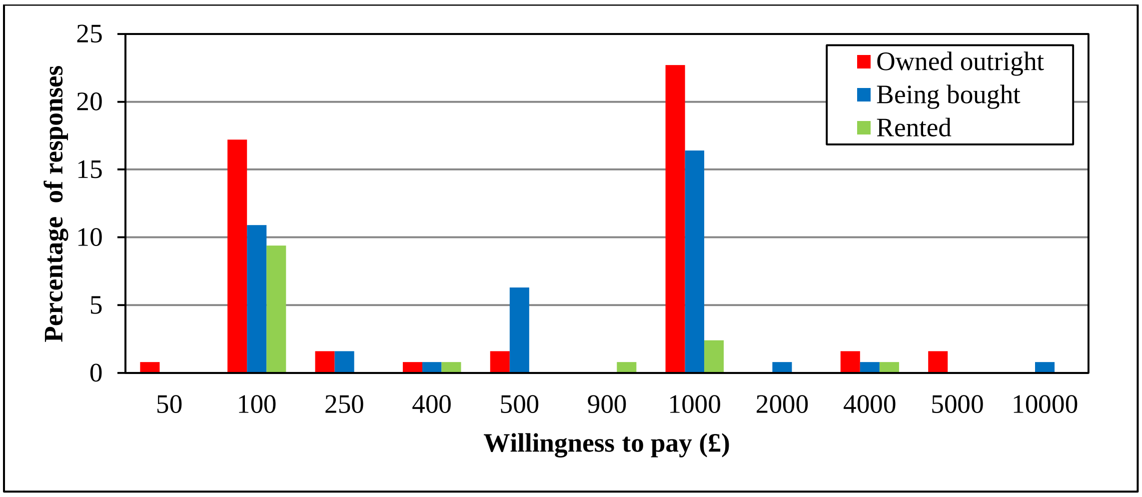


Figure 4.12: Willingness to pay by property ownership of householders

Additionally, Table 4.12 shows the WTP response for different property types of the respondents. The results show that the most significant property type was terraced house with 40% of the responses followed by ground floor flat with 24%, which make the majority of the overall responses. Semi-detached house was 19% while detached property formed 9%. Again, these findings are consistent with earlier pattern with 43% for WTP value of £1000 and 36% for £100. The average WTP value for this analysis was £840.

Table 4.12: Willingness to pay by property type

WTP (£)	**Property type responses (%)**						**Total (%)**
	Detached	Semi detached	Terraced	Bungalow	Ground floor flat/ maisonette	Basement flat	
50	-	-	0.82	-	-	-	0.82
100	0.82	5.74	12.30	0.82	13.93	1.64	36.07
250	-	0.82	0.82	0.82	0.82	-	3.28
400	-	1.64	0.82	-	-	-	2.46
500	-	2.46	2.46	0.82	0.82	-	6.56
900	-	-	0.82	-	-	-	0.82
1000	6.56	6.56	21.31	2.46	6.56	-	43.44
2000	0.82	-	-	-	-	-	0.82
4000	0.82	1.64	-	-	0.82	-	3.28
5000	-	-	-	0.82	0.82	-	1.64
10000	-	-	0.82	-	-	-	0.82
Total	9.02	18.85	40.16	5.74	24.59	1.64	100

Survey location

Table 4.13 shows the analysis of the WTP for PLFP products based on the surveyed locations. This outcome does not seem to show any statistical inference of location on people's WTP for protection products, though previous study by RPA (2004) showed a positive effect of survey location on WTP. Despite this outcome, the distribution of the mean WTP values seems to indicate higher figures for big cities and towns, such as Glasgow (£1133) and Edinburgh (£852), which is perhaps due to the higher economic status.

Table 4.13: WTP values by surveyed locations

Location	Responses (N)	Min (£)	Mean (£)	Max (£)
Broxburn	3	100	533	1000
Dumbarton	6	100	766	1000
Dumfries	24	100	1139	4000
Dundee	2	100	550	1000
Eddleston	6	100	683	1000
Edinburgh	36	100	852	10000
Glasgow	9	100	1133	4000
Hawick	25	100	666	5000
Huntly	7	50	492	1000
Perth	11	100	700	4000
Selkirk	10	100	540	1000
Stonehaven	6	100	683	1000
Total	145	50	795	10000

Financial and social impacts

Table 4.14 shows the correlation matrix for the WTP variable and flood impacts which are likely to have significant influence on the WTP value. These factors include all variables of the financial and social impacts reported by flooded households. Analysis of the financial impacts, both insured building ($r = 0.469$, $p < 0.05$, $n = 21$) and content losses ($r = 0.449$, $p < 0.05$, $n = 21$), shows a strong relationship with the WTP variable ($r = 0.224$, $n = 5$). The average WTP values for those significant associations were £893 and £967 respectively; this is significantly higher than the overall mean WTP. Moreover, the results also suggests a link between households WTP and the total cost incurred ($r = 0.438$, $p < 0.01$, $n = 47$) for PLFP products. This is a positive relationship and can imply that these groups of respondents are more likely to pay for protection due to their previous experience with such measures; the average WTP figures based on this variable was £878 and clearly higher than the overall mean.

The results for the social impacts analysis show that, the problem of staying in temporary accommodation ($r = 0.288$, $p < 0.05$, $n = 48$) and getting house back to order after flooding ($r = 0.286$, $p < 0.05$, $n = 54$), were the most significant factors that seem to influence the WTP. The average WTP values under these impacts were £780 and £791 respectively. Again, it is surprising to see the stress impact ($r = 0.015$, $n = 56$) and worry about future floods ($r = 0.223$, $n = 56$) being weakly linked with WTP value, though these impacts were the most rated by respondents. The stress impact has been previously proved to be significantly related to WTP (RPA, 2004).

Table 4.14: Correlation between WTP and flood experience

Variables	1	2	3	4	5	6	7	8	9	10	11
1. WTP	1.000										
2. Financial impact (building)	.469*	1.000									
3. Financial impact (content)	.449*	.640**	1.000								
4. Financial impact (uninsured)	.224	-.319	.058	1.000							
5. Stress of flood	.015	-.104	.144	.125	1.000						
6. Temporary accommodation	.288*	.288	.442*	-.177	.587**	1.000					
7. Worry about future flood	.223	.079	-.095	.060	.657**	.511**	1.000				
8. Getting house back to normal	.286*	.178	.161	-.337	.695**	.670**	.602**	1.000			
9. Loss of irreplaceable item	-.025	-.126	.173	-.085	.550**	.426**	.541**	.551**	1.000		
10. Financial help received for protection	.450	-.263	.527	.400	.089	.237	-.066	.345	.145	1.000	
11. Total cost of protection	.438**	.340	.612*	.441**	.039	.347*	.230	.107	.333*	.354*	1.000

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

4.6.3 Regression analysis

Regression analysis was carried out on those factors that were found to be correlated with the WTP value. The variables considered in particular are household income level and flood impacts on buildings (Table 4.15). For household income level, the standard regression analysis showed that this variable could account for 11% of the WTP value and the relationship was significant (R^2 = 0.12, R^2_{adj} = 0.11, p = 0.000). Although this figure shows some influence on the predicted variable (WTP), it suggests that other factors account for a larger proportion of the variance. In view of this, the flood impacts on building was examined, and found to have significant relationship with the WTP variable and accounted for 32% of that (R^2 = 0.35, R^2 ad j = 0.32, p = 0.004).

Table 4.15: Model summary for WTP value by income level

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.341[a]	.116	.109	1163.8179	.116	16.275	1	124	.000	1.783

a. Predictors: (Constant), Income level

Regarding the use of multiple regression analysis, different authors tend to give different views on the sample size needed, although larger sample sizes are usually recommended. One author suggests a greater sample size denoted by this formula: N> 50 +8m, where m is the number of independent variables (Tabachnick and Fidell, 2007; Pallant 2007). However other studies suggest lower samples; Stevens (1996) recommends about 15 subjects for a reliable equation, and RPA (2004) suggests that the number of observations (n) should be at least four times greater (4k) than the number of variables (k). The overall response for this study was 256, and 145 for the WTP variable which was deemed sufficient for the analysis. A stepwise multiple analysis of the influencing factors was done to understand their combined effect in predicting the WTP outcome. Table 4.16 shows a summary of the result which indicates that all the variables tested are significant ($p < 0.05$), which is useful and shows confidence in the model. In addition, the overall influence of the variables is significant given the high R^2 value (R^2 = 0.69, R^2_{adj} = 0.64, $p < 0.05$); this suggests that 64% of the variance in the WTP value is explained by the predicting variables whereas the remaining 36% could be explained by other factors which were not included. With this test, the resulting mean WTP is £793.

Table 4.16: Model summary for WTP values using stepwise analysis

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.596[a]	.355	.321	956.086	.355	10.446	1	19	.004	
2	.740[b]	.547	.497	822.898	.192	7.648	1	18	.013	
3	.832[c]	.692	.638	689.0.39	.145	8.015	1	17	.012	2.209

a. Predictors: (Constant), Flood impact on building

b. Predictors: (Constant), Flood impact on building, Flood impact on building content

c. Predictors: (Constant), Flood impact on building, Flood impact on building content, Household income

The equations for the regression models are presented below. Equations 6 and 7 are the linear regression for WTP using the income level and building impact variables respectively as presented earlier. The remaining equations are the results of the (stepwise) multiple regression analysis presented in Table 4.16. Equation 8 is made up of both the building impact and content impact variables, whereas Equation 9 consists of both flood impacts variables together with the income level variable, to predict the WTP for PLFP. The fitted model for the single-variable models (Equations 6 and 7) are shown in Figure 4.13 (a) and (b) respectively.

$$WTP = 199.51+0.0172I \quad (6)$$

$$WTP = 80.305+0.0483BI \quad (7)$$

$$WTP = 576.397+0.029BI-0.061CI \quad (8)$$

$$WTP = -10.151+0.03BI-0.066CI+0.019I \quad (9)$$

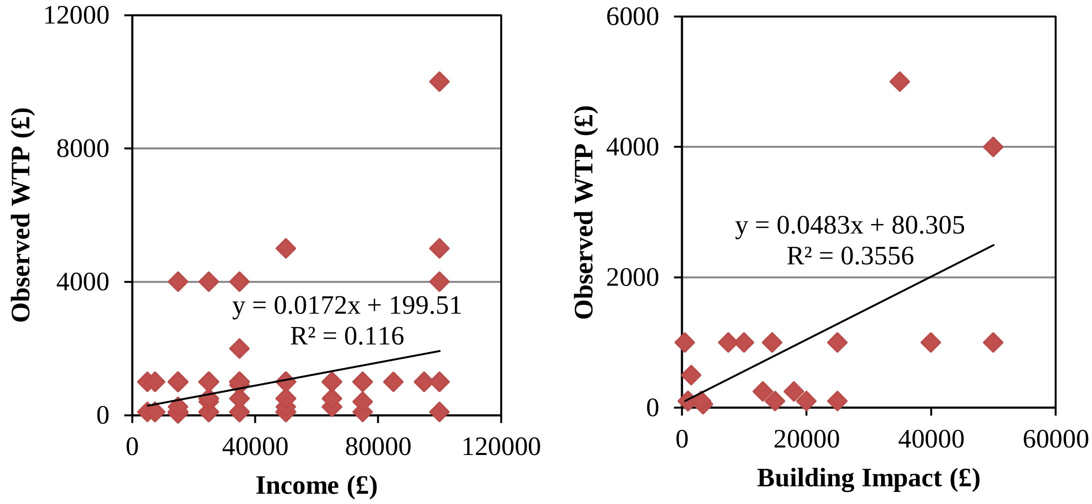
Where:

WTP = Willingness to pay (£)

I = Income level (£)

BI = Building impact (£)

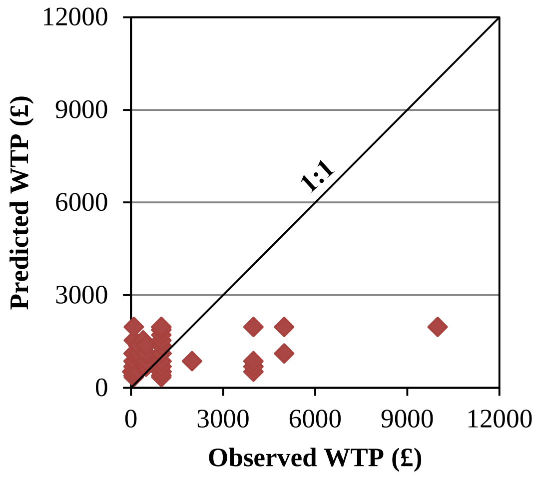
CI = Content impact (£)



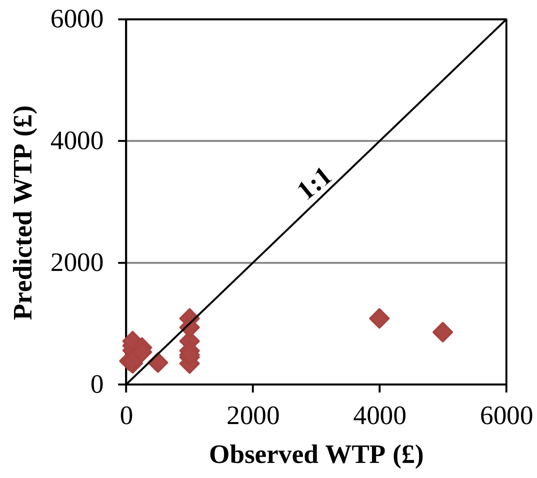
(a) Equation 6 (b) Equation 7

Figure 4.13: Fitted regression models for WTP

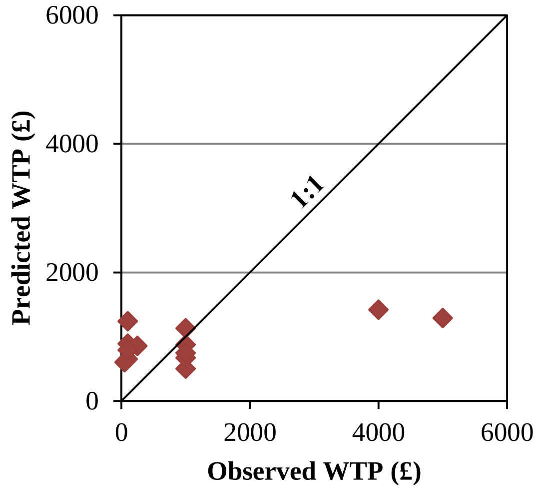
Figure 4.14 shows the scatter plots of the observed WTP (X axis) and the predicted WTP (Y axis) for the derived equations of the models. These scatter plots are often useful in checking how well the models have performed in predicting the dependent variable. The points should be symmetrically distributed or uniformly spread around the 1:1 line (diagonal line), for a well-performing model. Any asymmetry in the distribution of the points is a sign of under-prediction (downward bias) or over-prediction (upward bias) by the model. As Figures 4.14 (a-d) show, the scatter plots deviate from the diagonal lines particularly for Equations 6 and 9 where most of the plots are located away from the diagonal line, signifying a poor correlation between the predicted and observed values. The spread of the plots from the remaining Equations (7 and 8) are not much improved; however, they show a better correlation between the predicted and observed values with more clustering of points around the diagonal line than the previous case. Overall, the distribution of the scatter plots suggest that the regression models may not be adequate for predicting peoples WTP for PLFP, and this could be improved through transformation of some variables but this was not investigated in the current study.



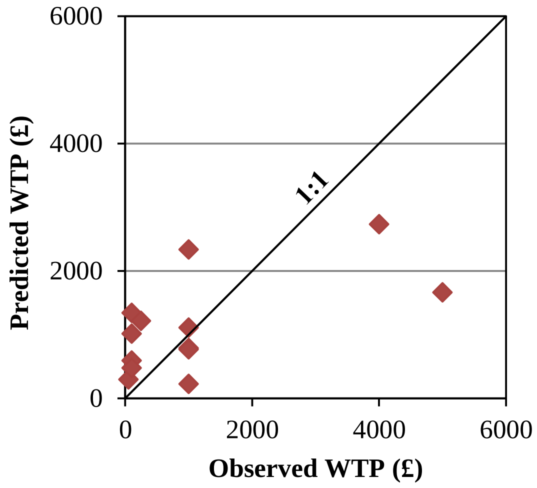
(a) Equation 6



(b) Equation 7



(c) Equation 8



(d) Equation 9

Figure 4.14: Scatter plot of observed and predicted WTP

4.7 Focus Groups Findings

This section reports the findings from two focus group discussions held in Hawick and Edinburgh to complement the questionnaire surveys. The findings presented herein are based on the views of the focus groups participants, which have been transcribed, checked and analysed collectively for each issue discussed. The answers have been presented under two broad headings, "flooding and related problems" and "property flood protection issues", and verbatim quotations have been used to highlight interesting views from participants.

4.7.1 Flooding and related problems

Flood experience

Most of the focus group participants from Hawick had been flooded in their property or witnessed such events in their area. Almost 87% of participants had been flooded in their properties, and the reported past flood experience include the 2005 and 2009 incidents with some participants having been flooded more than once in their life.

"I was flooded twice in 2005, which left me completely traumatised I didn't know where I was. It took three months to get back; I lost everything because I was in a bungalow". [Hawick]

"If you look at the floods we've had so far, it's never been when we've had rains all week, but wild wet stormy nights and that's it". [Hawick]

By contrast, far less participants (30%) from the Edinburgh group had been flooded in their properties, whilst the majority had witnessed floods in their area but were not directly affected by them. The most common floods in this area were the 2000 floods and the recent event in July 2012. Although it is known that the Water of Leith overflowed its banks and resulted in major past floods, most participants did not seem to accept this view, but rather expressed dissatisfaction with the way the watercourse has been managed by the local authority.

Flood impacts

The Hawick focus group participants appeared to have experienced severe flood damages in their community, with the 2005 flood alone said to have affected 157 properties and resulting in £2 million worth of damages to houses. The participants also recounted how damaging the floods were to their properties and entire life.

"I have been flooded twice, it cost £63,000 to repair the January one, I got back to the house after 6 months, and the 2005 October flood hit again. I was wiped out again, this time it cost a £100,000. So the two floods have cost me £163,000…which obviously nobody has enough house insurance because nobody ever expects to lose everything they have in their house". [Hawick]

"The insurance company informed me afterwards, with my accommodation, replacement of furniture, and repair that had to be done cost nearly £200,000…and the flat is worth only £25,000". [Hawick]

"I was then flooded in October again, I had a huge insurance bill and I had to pay my insurers but I thought they were fantastic; everything was done by the insurance company. But there is a psychological effect and also effect on your building because nobody is going to buy your property. If I put my property on the market and someone comes to buy it, one of the things I have to show them are my flood defences. Nobody in their right mind will want to buy a property that has been flooded. Nobody is going to buy your property, so really you're at that disadvantage". [Hawick]

Similarly, the Edinburgh focus group participants expressed grave concern about the damaging impacts floods have had on their properties and neighbourhood. Some participants were worried about the direct destruction to their properties and the length of time they endured to recover, whilst others were critical about the problems of dealing with builders and contractors during the recovery process.

"I also got flooded in 2000, we had 2/3 ft of water at the bottom of our home…we moved out, we were out for 7 months. And we got flooded last year as well…though we didn't move out this time". [Edinburgh]

"…but I think the problem is when something of such nature (floods) happens, the builders and other companies in …They all come out and spend a lot of time to rebuild…They say we will do it in three months, and six months later the line they have still not finished. If people need help or advice that is where they need it, how to deal with the builders because contractors come, and say they will do the work, get your signature and then disappear". [Edinburgh]

Intangible flood impacts

Generally, both participant groups shared the view that flood impacts extended far beyond the financial damages and loss of physical belongings. Also, the psychological impacts associated with floods were of significant worry to the participants. It was reported that such impacts have had lasting effects on people and it would be harsh to overlook such impacts.

"…but obviously there are some things you can do to help yourself, buy flood defences, protect your property…but at the end of the day the psychological effect never goes away". [Hawick]

"You can go over with the insurance thing, the financial impact…but the problem is the long term psychological effect, the effect is major…it doesn't matter how people help". [Hawick]

"Furniture is not a problem because there are pieces of furniture. But it (flood) totally leaves you devastated; you lose all that you have collected in your lifetime, so in a matter of about 5 or 10 minutes your life is wiped out. We were absolutely terrified… Between the two floods it left me that, every time we had a wild stormy night, and the river rose I was that panic". [Hawick]

Insurance problems

The focus group participants expressed mixed opinions on flood insurance cover, with the majority of those who have been flooded in their properties acknowledging the vital role of flood insurance in flood recovery as well as commending the work of the insurance companies particularly during and after floods. However, some participants were rather critical about the rising flood insurance premiums and excesses due to their repeated flood experience, in addition to the reported difficulty in getting new flood insurance policy after being flooded.

"My insurance told me there was no problem if you want to reinsure…they were duty bound to reinsure you but if someone did buy your property then they may have problem getting insurance. So you are caught in this problem, because you own a property but you are not able to sell them". [Hawick]

"With insurance it all went up…I know I can't move on if I don't stay with the insurance company I've got, then I won't get covered for floods. My house insurance has really gone up over the years. I now pay £900 per year; it used to be about £400 a year". [Hawick]

"My insurance has been going up since 2000 quite a bit…few years ago it was £1000 per anum, then up to £3000 I think last year, then up to £6000. I got a broker, and the broker didn't manage to find anything so my neighbour put me on the listed property owners club…and I have had insurance of £1000 per year as opposed to £6000". [Edinburgh]

"We were flooded in July (2012), and the insurance came in November they were tripled, we pay £1500 for a year now…this was ridiculous. We asked our broker if he could find us new deal but no we had to stick with this one". [Edinburgh]

Such increases in insurance premiums and excesses were not only reported by those who have been flooded, but this was said to be common, affecting most properties in flood risk zones irrespective of a property being actually flooded or not. The majority of participants accepted the fact that rises in premiums were inevitable if you live in flood risk area, however some participants were worried about the rapid increases and the criteria used in assessing their flood risk.

"Yes, I am on the 2nd floor and my insurance has gone way up, £12 per month rise...so is not a matter of being flooded or not.., it's the postcode". [Edinburgh]

"With my insurance, as I said, I wasn't flooded, I managed to keep the flood out…but when insurers come and you give then your post code. They say 'oh you are in a flooding area'. But I managed to get it, but my insurance was going to go way sky high but I managed to get... This is very unfair to a certain extent, because I haven't been flooded, I haven't claimed off you". [Hawick]

Concerning the cessation of the Statement of Principles regarding the provision of flood insurance, the participants appeared to be aware of the problems associated with the expiration of SoP, but they did not seem to be too concerned. Rather they gave the indication that the situation was out of their control and there was not much they could do to ensure similar provision in future, but could only hope for the right arrangement.

"It's something we know of but there is no point of thinking about it to be honest. We have done all we can, put up the flood walls, pumps, etc but that doesn't really make a difference to the insurance. They don't spend their time looking at those; all they do is the postcode. So all the measures I have taken do not actually make a difference in the insurance… I have a neighbour on the same street who has not been flooded, but pays the same amount of insurance…all they look at is the postcode". [Edinburgh]

4.7.2 Property level flood protection (PLFP) issues

Flood protection products

In accordance with the findings from the surveys, there was high awareness of PLFP products among the focus group participants, particularly within the Hawick group. This was largely attributed to the ongoing flood education campaigns to promote PLFP in the Scottish borders and the flood protection subsidy scheme running in the region. With this scheme, there are discounts up to 67% on flood products, and there was the general affirmation that many households have signed up for the products; the most common products were door guards, airbrick covers and flood sacks. In addition to taking up the discounted products, a few participants had other home-made products from blacksmith which they claim were equally effective. In contrast to the findings from Hawick, only one participant from the Edinburgh group had taken up PLFP products, though a few more people had knowledge of the products via other media. Overall, there was a low awareness of PLFP among the participants from Edinburgh, and sandbags seemed to be the most available option to the group.

For the participants who had taken up PLFP in Hawick, there was a general sense of confidence in using those products, which affirms the earlier findings from the surveys regarding the general perceptions on PLFP. In terms of installing PLFP, the cost varied; one participant reported to have invested £2000 on the products, whilst most of participants had door guards purchased from the council at an average cost of £150.
Some of the participants reported how they acquired their products:
"Another thing is that I had to buy my own flood defences…most people will buy their own flood defences. It cost me £2000 to do my flood defences". [Hawick]
"My husband made a few of them, my products, we didn't get it through the council because we were a bit desperate to get them early… my floodgates cost £50 each (£150 in all)". [Hawick]
"We had a blacksmith made us one in 2000, and it fits right against the door frame like that, it did work in July, there was no water going through that. We were on holiday in July when it flooded, but we put it up as a precaution before we went away as we knew the water table was rising". [Edinburgh]

Flood protection promotion

Regardless of the low uptake of PLFP products, particularly among the Edinburgh group, the participants recognised the need for flood education and greater awareness to promote flood protection uptake. There was also a consensus that community engagement was vital in order to increase the uptake of flood protection among households, and to achieve this, there was a greater need for strong community spirit.
"It will be a waste of time to protect your houses, unless we get every single person to agree…'We should get everybody to agree, we should make sure everybody has something to block everything". [Edinburgh]

"I think the key is to get everyone (say everybody in a street) to agree on this. Which I think will be difficult…if we can get all to agree whether you have been flooded or not". [Edinburgh]

"I think it should be a community thing rather than individual thing because someone may say I am on the second floor… it has to be obligation thing to make such people pay. If it's a community thing it might make it affordable…whether or not you are affected, you have to pay towards the block or towards the street. Make it statutory …but I think it is very difficult to get people to agree". [Edinburgh]

Unsurprisingly, the cost involved in purchasing PLFP product was a source of worry and the main cause for low uptake of protection, particularly for low income households. In Hawick for instance, though the participants commended the LA discount scheme, there was a clear concern about some households being unable to afford the reduced costs. The problem was not only due to the total cost involved; but also, having to pay the entire amount at one time was difficult for low income households and pensioners. It was suggested that more flexible forms of payment (e.g. instalments) could be worthwhile in such situations, whilst those who needed further assistance in purchasing flood products should be helped. Generally, the participants seemed willing to invest in flood protection if they are effective and cost beneficial.

"The council gives discount on all their products… For those that signed up, for the flood group I think the uptake was great". [Hawick]

"Yes, but that was a problem as well because not everybody could afford them…. it was a big amount at one time… for low income or pensioners because the amount was far too much at a goal even with the subsidies…". [Hawick]

Flood protection responsibility

The focus group participants appeared to strengthen the finding that people are reluctant to accept individual flood protection responsibility. Although some participants were ready to accept their personal responsibility, the majority were indecisive and blamed flood risk management authorities including LAs. For example, most participants from Hawick who accepted such responsibility also strongly demanded LAs to fulfil their delegated duty towards flood risk reduction particularly in managing the watercourse within the town.

"We all agree that we have responsibility to protect our home…Yes. But there has to be a joint operation". [Hawick]

"Up to a point in your house you should be responsible to do something...I think you definitely have to spend money yourself…if people don't have the money I think they should be helped there with flood defences. I think the council and SEPA have to carry some of the responsibility. I know some of the things are rubbish…you can't touch the river, there are salmons in…but I think life comes first". [Hawick]

In contrast, the Edinburgh participants were more disinclined to accept flood protection responsibility. Although some participants felt flooded households should accept such responsibility, the majority blamed past floods on mismanagement by LAs. In addition, some reiterated that they have paid tax for the construction of flood protection scheme, and hence expect adequate protection from the scheme in future.

"I think if you ask who has been flooded they will say yes because they don't want to do it again…having been flooded before do you think I like floodwalls in my garden…I just want to be safe in my flat, I don't want to panic. 'I know my property is in a floodplain area and I bought the property, so why not…". [Edinburgh]

"I will say there is a personal responsibility, but those floods were caused by bad management…so it's the council's responsibility, so the situation is different". [Edinburgh]

Moreover, most of the participants emphasised the need for government and other authorities to play a bigger role in flood protection. It was reported that even though householders may perceive some responsibility towards their own flood protection, there was a limitation as to how far people can go in protecting their homes particularly in extreme flood events. In view of this, the participants raised some pressing issues including the poor management of rivers, climate change and the problem of deforestation as factors that have increased flood risk.

"The government needs to play a bigger role in recognising that this…the issue of climate change and every time you see floods, it's no more seasonal now… The government needs to recognise that this is not a problem that is going to go away, it's nationwide…and people who have been affected before are likely to be affected again". [Hawick]

WTP for PLFP

As reported by the surveys, both focus groups participants seemed to agree that the average willingness to pay amount (£795) was a fair outcome, and thus reflect their individual contributions. However, the participants were quick to voice their concern for poor and vulnerable households who cannot afford to pay for flood protection, insisting that such people will need greater help. The idea of government providing assistance in the form of financial incentives or subsidies appeared very appealing to majority of the participants who felt such initiatives could prove useful to motivate greater uptake of PLFP product.

"I think people on low income/ pensioners, there should be something…even though the council gives a big discount which is fantastic, I think there should be something they can do, a £1 per week, whatever, and however long it takes to pay up…but I think the council should be burdened to help". [Hawick]

"They (government/authorities) need to listen to the general public and not all these engineers that know about facts and figures…it's the people who care every day, its true…You watch it and you will see what has happened, a perfect example is they have put a level up under the bridge…I don't need that…there is a bush when it reaches that bush I know my house is going to flood". [Hawick]

"Subsidised products, yes I think this will change our perception, that is if the products work…government subsidy for those who met eligibility criteria". [Edinburgh]

Climate change and flood protection

The findings on climate change and its impacts on future flooding were in harmony with earlier findings from the surveys. There was a general agreement by both focus groups that climate change was happening and may result in more severe floods in future, which could imply the need for greater protection. Despite this, there was no consensus that climate change impacts would make participants more willing and responsible for flood protection at their homes. Hawick participants were of the view that people's preparedness to pay for flood protection can be influenced by climate change concerns, whilst the Edinburgh group felt that willingness to pay would first of all depend on individuals acknowledging their personal protection responsibility.

"I think climate change can make people pay more…if we have to go above £800, if you can afford that…but I think people will be willing to pay what they can afford". [Hawick]

4.8 Chapter Summary

The chapter has employed statistical techniques to analyse the stakeholder survey responses and the findings have been thoroughly discussed. The findings show that there is a high awareness of flood risk among respondents, and just over half of the people have not experienced flooding of their properties. With those who have been flooded, there was evidence of substantial flood impacts at the household level for both insured building and content losses, and the social impacts of floods were rated high by affected households. The most ranked intangible impact was the stress of flood event, followed by worry about future floods.

Analysis of floodwater characteristics in flooded homes showed that most people were flooded through their doors and airbricks, and the floodwaters in flooded rooms were enough to generate significant damages to building and contents. However, most of the internal floodwaters could have been prevented by installing resistant door guards and airbrick covers given the depths of the floodwaters and their route into properties.

The chapter also examined the perception of personal flood protection responsibility at the property, which apparently revealed high uncertainty among the public. Few people accepted their personal responsibility whilst the majority selected other flood management stakeholders as responsible for their property. The findings also suggest high awareness of PLFP measures and uptake of such measures among both flooded and non-flooded homes, which was at odds with what was reported in the literature study.

This chapter also discussed the WTP of the public to contribute towards the cost of PLFP for their property, and the reasons for which people are prepared to make such payment include the avoidance or reduction rising insurance premiums and excesses. The mean WTP was relatively high, and could be linked with factors such as income level and flood impacts sustained by households. Although the majority of respondents were willing to contribute, the reasons for those who declined to pay include concerns about the cost of PLFP; however such groups were more likely to pay given subsidies or incentives. This implies that such packages were likely to motivate people and encourage wider uptake of PLFP measures to reduce their flood risk exposure.

The chapter has reported findings from the two focus groups discussions, which generally support the findings from the survey. Highlights of interesting views and personal experiences of the participants have been provided, using verbatim quotations to amplify and emphasise some of the findings. Further details of the findings from the stakeholder consultation are as follows:

- Significant financial damage has been reported at the property level; the average insured costs to building and contents were £30,123 and £10,493 respectively, whilst costs not covered was £13,275.
- Significant social impacts were reported amongst households with flood experience with the most common impact being the stress of the flood event. In addition, the focus groups findings confirmed the psychological impacts and trauma associated with flood events.
- Almost 60% of the reported internal flooding incidents were through airbricks and doors, which could have been prevented by simple resistant products.
- Only 22% of the public felt they were responsible for their property level protection whilst over 70% think other public bodies were responsible, which suggests that people are reluctant to accept personal flood protection responsibility, or just was unaware of any legal responsibility.
- There was high awareness of PLFP measures among the public, with 77% of flooded households and 53% of non-flooded properties being aware of different options.
- The majority (61%) of households aware of PLFP had adopted such measures, however about 66% of those installed products were after flood event, which suggests the reactive nature of people’s behaviour to flood risk management.
- The majority (57%) of the public appear willing than before to pay for PLFP in terms of the number of households willing to contribute and the scale of these contributions; the mean total WTP was £795.

- There appears to be a statistical significance between people's WTP and factors including the level of building damage previously sustained and household income.
- Just over half of respondents felt they could not afford PLFP measures, however, these groups were found to be more likely to contribute towards the cost if subsidies or incentive packages were available.

Chapter 5: Financial Analysis of PLFP

5.1 Introduction

This chapter focuses on the outcomes of the financial analysis of PLFP products, using Hawick as the case study. The chapter starts by giving a concise account of the financial model setup before presenting the results of the cost benefit analysis of flood protection products, which have been assessed through the Weighted Annual Average Damage (WAAD) approach. The different flood protection products examined include manual resistance products and resilience measures. The benefits of using these products have been presented with respect to the direct and indirect damages that are avoided by installing the PLFP products, compared with a no protection option. Benefit and cost ratios (BCRs) have been used to express the cost effectiveness of the PLFP products in terms of the whole life savings of the products.

5.2 Financial Model set up

5.2.1 Model description

The financial model has been built using the 2010 flood damage data from the MCM. For residential properties, the MCM provides standard data on: five house types (detached, semi-detached, bungalow, terrace, and flat), seven building ages (e.g. pre 1919, 1919-1944) and four social classes of the building occupants. In addition, it provides WAAD estimates for different standards of protection at the threshold, and for an average house with no flood warning and no protection the estimated WAAD is £5393. This figure is recommended for initial appraisal of the potential direct damages when the appraiser is not privileged to flood data required to determine the actual damages (FHRC, 2010).

In developing the financial model, four property types were used for the damage assessment and all the damage data were updated to 2013 prices using the Consumer Price Index (CPI). All the property types have been used in the cost and benefit analysis, with bungalows exempted due to the limited information on the costs of protecting this type of property. In total, four main PLFP packages were analysed and the costs of the packages were obtained precisely from past studies and the UK flood products market, which provided a useful guide on current costs.

Whilst the developed model can be useful for assessing the cost and benefit of flood protection for single flood events, the primary goal of this study was to examine the collective effect of all flood risk scenarios in the study area. To achieve this, the WAAD method was used to assess the financial benefits of the PLFP products, considering the impact of the flood events in the area. The WAAD technique is particularly relevant where improved understanding of the overall consequence of potential flood hazard and the impact of mitigation measures are needed for decision making (Penning-Rowsell et al., 2003; Penning-Rowsell et al., 2006). For this work, the flood depth distribution of all affected properties in the study area, under each flood risk scenario (i.e. 25, 50, 75, 100 and 200 year return period) was used in the model (SBC, 2011). This data was considered the best available for the study area. Otherwise, where such information cannot be obtained for the area under investigation, it is recommended to use existing data, such as developed by John Chatterton from a number of case studies (9000) in the UK (Penning-Rowsell et al., 2006; Messner et al., 2007).

The results of the analysis of PLFP products have been presented in terms of the complete benefits over the whole life of products, as well as adjusted benefits that account for the products' reliability. This reliability adjustment is essential in the sense that it is impossible for PLFP measure to work perfectly; hence the adjustment factor caters for any potential faults and operational failure. Based on practical considerations and consultations with industry, reliability factors of 77% and 90% have been recommended for manual and automatic resistance products respectively (JBA, 2012b; Royal Haskoning, 2012). The relatively low factor for manual units is due to several reasons, including the tendency for the equipment to be misplaced or installed incorrectly.

5.2.2 Flood depth distributions

Figure 5.1 displays the flood frequency depth distribution for the case study area, based on the SBC data. This comprises six return periods coupled with flood depth information which range from very low depths (< 0.1 m) to levels exceeding 3 m for some locations. The overall distribution which shows the proportion of properties inundated under each flood frequency and depth bands was obtained from the SBC, based on their flood assessment model output (see Appendix F). This data was used because it is site-specific which is more reliable, as opposed to the other datasets such as developed by John Chatterton which are generalised and have been used by previous studies (Penning-Rowsell et al., 2006; Messner et al., 2007).

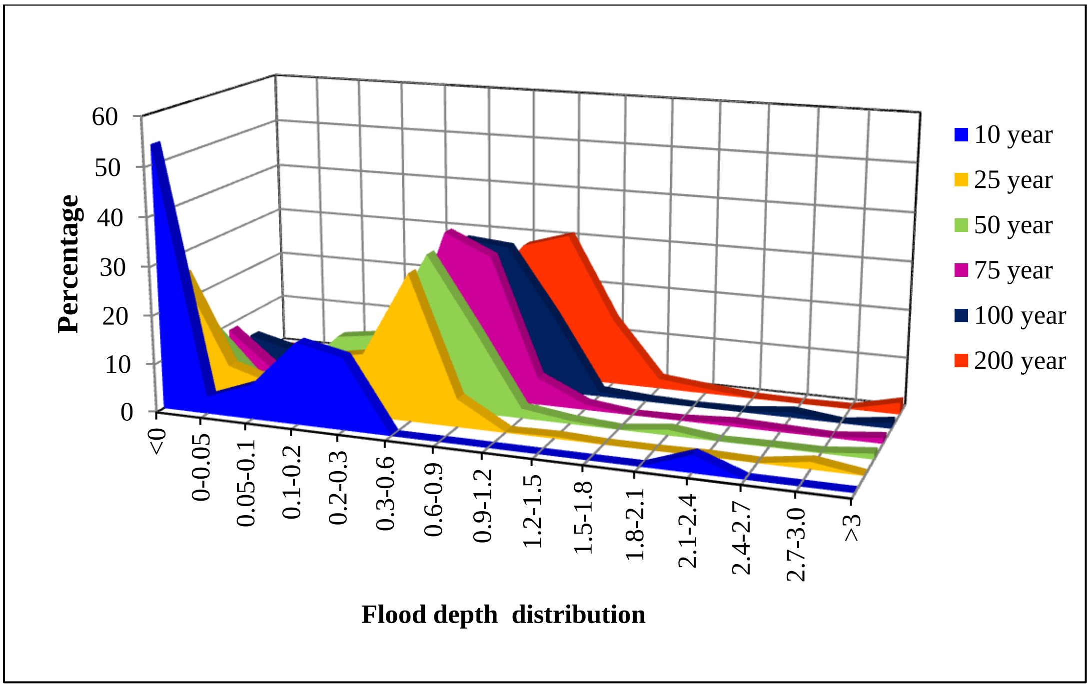


Figure 5.1: Flood depth distribution by return periods (Source: data from SBC, 2011)

The SBC flood frequency depth distribution (Figure 5.1) has some similarities with the MCM data shown previously in Figure 2.12. For instance, the 1 in 10 year flood event from the SBC data indicates that approximately 54% of properties were flooded at depths below floor level (< 0 m), which underscores the very low depths of such flood scenarios. This observation is consistent with the findings from the MCM data which also suggested high proportion (50%) of such low depths for the same event (Penning-Rowsell et al., 2006). The major distinction between these two datasets is that, the distribution for low flood depths (0-0.1 m) is generally higher for the MCM data; this was 45% for 1 in 25 year flood compared with 37% for the same event for the SBC data. On the contrary, the SBC data shows relatively high distribution across all flood frequencies for greater depth bands (0.3-0.6m), and this could imply the use of a single case study data compared with the more comprehensive assessment by the MCM data.

5.3 Damage and Benefit Assessment

5.3.1 Calculating flood damage

Using the distribution data described in Figure 5.1, flood damage was assessed for the different property types. Table 5.1 illustrates the step by step calculation of WAAD for a detached property with no protection measure. The first step involved the calculation of weighted damages for individual depth intervals, which is derived as a product of the proportion of properties affected at each depth band and their corresponding damage from the MCM (see Appendix G). The sum of the weighted damages for each depth interval gives the total weighted damage for the flood event, which is then used to determine the mean damage for successive flood frequencies. The mean damage and the corresponding interval between successive flood probabilities were used to estimate the Annual Average Damage (AAD). The AAD is a factor of the probability of the future flood event and the vulnerability in terms of the damage; the aggregation of the AAD therefore gives the WAAD for all the flood risk assessed.

Table 5.1: WAAD for detached property with no protection measure

Return period (year)	Exceedance probability	Total weighted Damage (£)	Probability of flood interval	Mean damage	Annual interval damage (£)
2	0.5	0			
			0.4	9059	3624
10	0.1	18118			
			0.06	23257	1395
25	0.04	28395			
			0.02	31965	639
50	0.02	35535			
			0.007	37817	265
75	0.013	40100			
			0.003	41447	124
100	0.01	42794			
			0.005	46308	232
200	0.005	49822			
WAAD					6279

The results show that, seven flood risk probabilities were considered in calculating the WAADs for the study which was far in excess of the minimum requirement of three frequencies recommended for financial appraisal (FHRC, 2010). It starts with the most likely flood event for the area which was a 2 year return period, but at this threshold no flood damages actually occurred as no property was affected according to the simulated flood data; hence the total damage here is equivalent to zero. The next flood probability was a 10 year return period and at this point, flood damage starts to accrue and build up for subsequent flood events. The maximum likelihood of flood risk used for the study was a 200 year return period, given that as the most extreme flood event assessed for the case study area.

5.3.2 Calculating benefit of PLFP measures

The benefits identified with PLFP products have been calculated using key assumptions on product operation and seepage as outlined in the study methodology. The expected benefit for each package of flood protection has been determined for different residential properties, and they are equal to the damage that would be avoided by using those products. This uses a similar approach as that described earlier for the WAAD with no protection, but this time with reference to the benefits of each flood protection. This means the initial damages used in the calculation will be reduced considering the benefit of each protection option, which is regarded to be effective up to 0.6m depth; beyond this depth maximum damage is as with no protection (Atkinson and Price, 2005). The resulting damages were used to compute total weighted damage for each flood return period and subsequently the WAAD. Table 5.2 shows a reduced WAAD of £1,843 relating to a manual resistance protection, compared with the initial damage of £6,279 for an unprotected detached house (see Table 5.1). The difference in the two figures yields the benefit linked with that flood protection measure, which is almost £4,400 and signifies a substantial gain for any household.

Table 5.2: WAAD for detached property with manual resistance protection

Return period (year)	Exceedance probability	Total weighted Damage (£)	Probability of flood interval	Mean damage	Annual interval damage (£)
2	0.5	0			
			0.4	2264	905
10	0.1	4527			
			0.06	5805	348
25	0.04	7084			
			0.02	10646	213
50	0.02	14208			
			0.007	18173	127
75	0.013	22138			
			0.003	24781	74
100	0.01	27423			
			0.005	34893	174
200	0.005	42362			
WAAD					1843

5.3.3 WAAD of PLFP measures

All of the computed WAAD for the various PLFP products under different properties, as well as WAAD for unprotected properties, have been collated in Table 5.3. They have been grouped into two parts to highlight the different benefits of flood protection. The direct benefit comprises just the tangible or direct damages obtained from the MCM data, and these include figures for household inventory, building fabric and clean-up cost. From the results, the mean direct damage for all property types with no protection was £5,388, compared to £5,393 which was the average damage estimated by the MCM (2010) based on the John Chatterton data and recommended for where there is no threshold data for detailed appraisal (FHRC, 2010). Whilst these findings seemed to be very similar, the MCM value appeared slightly higher (£5,975) when compared at the same price level (2013 prices); a finding which points out the discrepancies in the underlying frequency depth data of the two cases. The data of the MCM shows more frequent floods with shallow flood depths (Chatterton 1998; Penning-Rowsell, et al., 2005), compared with this case study which has just one event (i.e. 10 year return period) with a similar distribution.

Additionally, the direct and indirect benefit is more comprehensive and represents a better evaluation of having flood protection. They consist of all the direct benefits explained earlier, in addition to the indirect benefits on stress, temporary accommodation, absence from work and insurance cost. Figures used in assessing these indirect damages were obtained from previous studies in the UK, as well as from earlier findings of this work which investigated household contributions towards the cost of protection for the avoidance of rising insurance premiums. Overall, the total indirect costs of floods amounted to £13,398 (updated by 2013 CPI) and include additional stress-related health costs; they represent the total damages for where there is no protection measure for a property. These damages have been reduced accordingly with reference to each flood protection and also in line with similar assumptions about product malfunction and seepage.

Table 5.3: WAAD for property types with and without PLFP measures

Property type	No measure	Manual resistance	Automatic resistance	Resilience without flooring	Resilience with flooring
Direct cost (£)					
Detached	6279	1843	1843	4307	3311
Semi-detached	4996	1479	1479	3269	2730
Terraced	4710	1352	1352	3031	2565
Bungalow	6147	1865	1865	4333	3379
Flat	4808	1325	1325	3083	2562
Mean	5388	1573	1573	3605	2909
Direct and indirect cost (£)					
Detached	10231	2395	2395	5471	4091
Semi-detached	8949	2032	2032	4433	3510
Terraced	8663	1904	1904	4195	3345
Bungalow	10099	2418	2418	5497	4159
Flat	8761	1878	1878	4248	3341
Mean	9341	2125	2125	4769	3689

5.4 Whole Life Benefit and Cost of PLFP

5.4.1 Scale of PLFP benefits

The scale of the benefits linked with each PLFP measure over their whole life is shown in Figure 5.2, using detached and terraced properties as an example. Generally, the largest benefit of protection was linked with detached houses as they are the most impacted, whilst terraced property recorded the least benefit. The magnitude of flood protection benefits varies depending on the option; the highest benefit was associated with manual and automatic resistance products and was £47,736 for a detached house. Resilience measures recorded the lowest benefit among all the PFLP packages, particularly the option without resilient flooring. This product has an average benefit of £27,850 for all properties, and £27,216 for a terraced property.

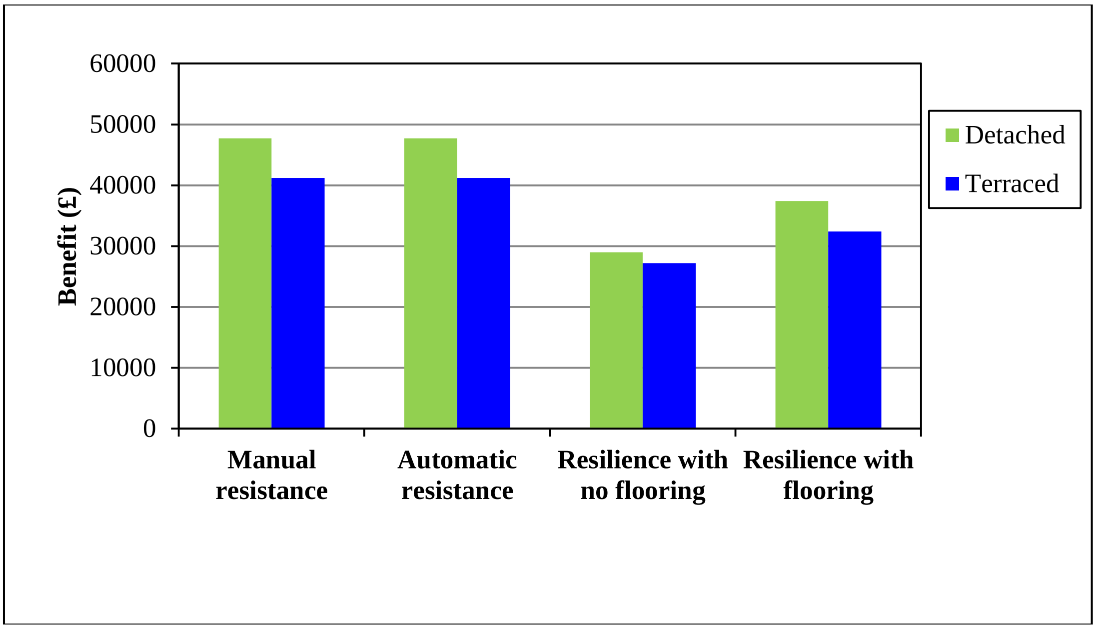


Figure 5.2: Scale of present value benefits of PLFP

5.4.2 Direct and indirect benefits

Figure 5.3 shows a further analysis of the different benefits of flood protection measures (for detached properties), to help highlight the effect of including the indirect flood damages in the assessment PLFP measures. The outcome markedly shows the significant consequence that the indirect flood impacts have on the overall benefits of having flood protection products. The magnitude of flood damages avoided was huge, with the resistance products gaining a significant benefit of £20,711. Resilience measures with no flooring registered the lowest benefit of £16,986, and the overall cost saved across all protection packages was averagely £19,690 for detached house. These findings show the relevance of flood protection in reducing the indirect flood impacts, and highlight their effect on PLFP appraisal.

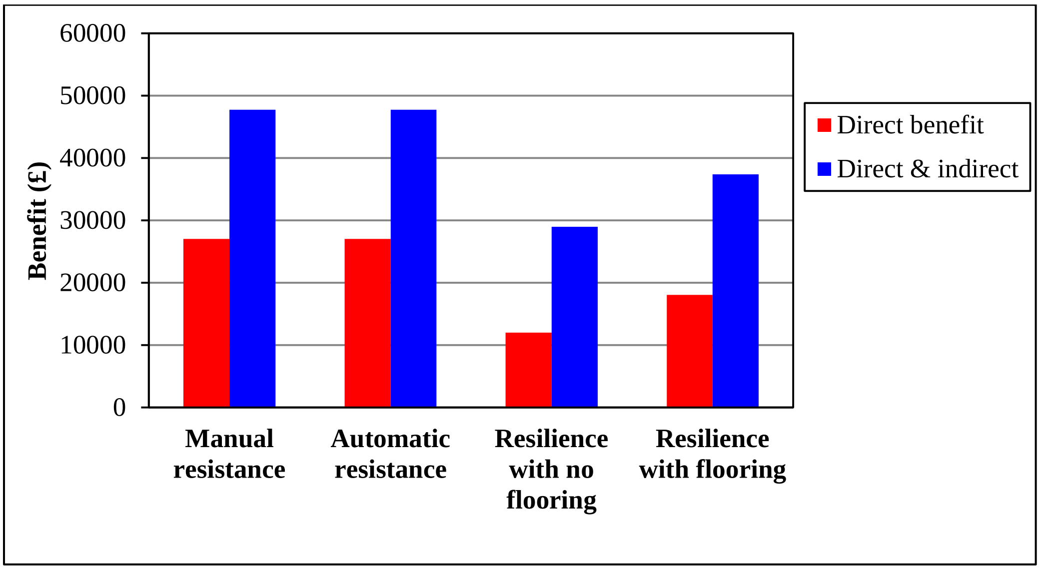


Figure 5.3: Present value benefits of PLFP for detached property

5.4.3 Whole life benefits of PLFP measures

The total benefits of the PLFP products determined from the analysis have been compiled in Table 5.4. These overall benefits include both the direct benefit, including reduction of clean-up cost, as well as the indirect benefit, such as avoidance of health or stress impact and insurance cost. These benefits have not been adjusted for further reliability purposes at this point hence there is no difference between manual and automatic resistant products. Overall, the figures here are regarded to be best estimations for the protection measures with respect to the assumptions on which they were assessed.

Table 5.4: Whole life benefits of PLFP measures

PLFP products	Detached	Semi-detached	Terraced	Flat	Mean
Manual resistance	47736	42137	41169	41929	43953
Automatic resistance	47736	42137	41169	41929	43953
Resilience without flooring	29000	27510	27216	27492	27850
Resilience with flooring	37406	33135	32394	33012	34426

5.4.4 Whole life costs of PLFP measures

Whole life costs of PLFP products were calculated using the industry standard of 20 year product life, a discount rate of 3.5% and VAT rate of 20%. The total cost of each PLFP package constitutes the cost of products and annual maintenance costs, which was assessed as 5% of product cost for automatic resistance and 2% of product cost for manual resistance and resilience measures respectively (Royal Haskoning, 2012; JBA, 2012a). Table 5.5 shows the discounted whole life costs for the range of PLFP measures under different properties. The manual resistance products were grouped into two, A and B to help highlight lower and upper cost range of the product which was £2,868 and £5,106 respectively. From the results, the cost of automatic resistance products in particular was relatively high. This is also highlighted by past studies (ABI, 2003; Royal Haskoning, 2012) who pointed to several reasons, including the limited information on PLFP costs and the fact that the PLFP market is still maturing. The costs of protection products are expected to be lower and more uniform as the market matures.

Table 5.5: Whole life costs of PLFP measures

PLFP products	Detached	Semi-detached	Terrace	Flat	Mean
Manual resistance (A)	3437	3437	2298	2298	2868
Manual resistance (B)	5922	5497	4474	4531	5106
Automatic resistance	20579	14678	11654	11819	14683
Resilience without flooring	19978	14800	14321	16716	16454
Resilience with flooring	30038	23454	21599	24676	24942

5.5 Benefit Cost Ratio (BCR) Analysis

5.5.1 BCRs of direct and indirect benefit (no reliability)

The results of the benefit cost ratio (BCR) analysis of PLFP products are detailed in Table 5.6. Interestingly, all the PLFP packages obtained BCRs in excess of one, including both resilience measures which usually fail to reach this threshold due to their relatively high costs. The manual resistance products have the best savings with average BCRs of 15:1 and 8:1 for lower and upper cost respectively, followed by automatic resistance products with a BCR of 3:1 for all properties. These results were slightly higher, but generally consistent, with earlier findings which seemed to suggest that resistance packages are the most beneficial (JBA, 2012b). Manual resistance were found to have a BCR in excess of 5:1 whilst automatic resistance protection had benefits of at least 2:1 (DEFRA, 2007; JBA, 2012b; Royal Haskoning, 2012).

In addition, previous studies showed that resilience measures generally do not generate high BCRs because of their high investment costs. However, this seems to be at odds with the findings of this study as both resilience protection measures were found to be cost beneficial. The average BCR for resilience package without flooring was 2:1 and resilience with flooring was 1:1, though the latter does not show high savings which is needed to invest.

Table 5.6: BCRs of direct and indirect benefit (no reliability)

PLFP products	Detached	Semi-detached	Terrace	Flat	Mean
Manual resistance (A)	13.89	12.26	17.92	18.25	15.58
Manual resistance (B)	8.06	7.67	9.2	9.25	8.55
Automatic resistance	2.32	2.87	3.53	3.55	3.07
Resilience without flooring	1.45	1.86	1.9	1.64	1.71
Resilience with flooring	1.25	1.41	1.5	1.34	1.37

5.5.2 BCRs of direct and indirect benefit (with reliability)

The results presented in Table 5.7 show the BCR where the benefits of the resistance components of the products have been adjusted for further reliability. This was done by applying a reliability factor of 77% and 90% for manual and automatic components respectively. These figures account for several elements needed for the success of such measures, including correct installation of products and flood warning for effective deployment of PLFP. The findings here are much different, as would be expected; the reliability adjustment has lowered the magnitudes of the BCR across the protection packages. For example, the average BCR for manual resistance (A) has been reduced from 15:1 to 11:1, whilst the manual resistance (B) product decreased from 8:1 to 6:1. Despite this, the general trend of the earlier results remains the same, with none of the protection products fell short of the BCR threshold. Automatic resistance products which recorded relatively lower BCR average of 3:1 in the initial analysis, remained cost beneficial with a similar BCR following the reliability adjustment.

Table 5.7: BCRs of direct and indirect benefit (with reliability)

PLFP products	Detached	Semi-detached	Terrace	Flat	Mean
Manual resistance (A)	10.69	9.44	13.79	14. 05	11.99
Manual resistance (B)	6.21	5.90	7.09	7.13	6.58
Total resistance (automatic)	2.09	2.58	3.18	3.19	2.76
Resilience without flooring	1.45	1.86	1.90	1.64	1.71
Resilience with flooring	1.25	1.41	1.50	1.34	1.37

5.5.3 BCRs of direct benefit (no reliability)

The analysis of just the direct benefits of PLFP packages is set out in Table 5.8. This explains the effect of excluding the benefits of avoiding the health impacts, absence from work, temporary accommodation and insurance costs from the original findings shown in Table 5.6. Clearly, the values shown here are lower due to the relatively lower benefits of the flood protection products. For instance, the average BCRs of manual resistance products which were 15:1 and 8:1, dropped to 8:1 and 4:1 when only direct benefits are assessed. Also, the ratios of the resilience measures in particular were highly affected, such that they appeared less beneficial and extremely unprofitable. The vast difference in the BCR when compared with the earlier findings, suggests that ignoring the indirect benefits of PLFP products can have significant influence on the appraisal of PLFP schemes. In this analysis, the overall effect has seen the BCR reduced by almost twice, across all the protection packages. This is a significant figure and can render PLFP schemes unprofitable, especially the resilience measures which had the greatest down turn.

Table 5.8: BCRs of direct benefit (no reliability)

PLFP products	Detached	Semi-detached	Terrace	Flat	Mean
Manual resistance (A)	7.86	6.23	8.90	9.23	8.06
Manual resistance (B)	4.56	3.90	4.57	4.68	4.43
Automatic resistance	1.31	1.46	1.76	1.80	1.58
Resilience without flooring	0.60	0.71	0.71	0.63	0.66
Resilience with flooring	0.60	0.59	0.60	0.55	0.59

5.5.4 Impact of individual flood frequencies

Analysis of the impact of individual flood events on the BCR of PLFP products was undertaken, and the results are presented in Table 5.9. The previous assessment (Table 5.6) involving the collective flood frequency was subjected to additional tests, by excluding subsequent flood events in the computation to understand the changes. Clearly, the results demonstrate that the most frequent events (i.e. 10 and 25 year return periods) have a marked effect on the BCRs, particularly the 10 year return period. This single event has impacted the BCRs such that manual resistance (A) has now reduced from 15:1 to 3:1, while the average BCR for manual resistance (B) has declined from 8:1 to 2:1. Similarly, the automatic resistance has dropped from 3:1 to 0.7:1 and is now less cost beneficial alongside the resilience measures. At those rare flood events, PLFP measures are likely to be overwhelmed by floodwaters and therefore may not be suitable investment option. Table 5.9 has been tinted (red) to mark the relevant points at which the BCRs obtained may not be useful. Table 5.10 shows further details of the impact of the 10 year return period on the BCR of PLFP products.

Table 5.9: Impact of individual flood frequencies on BCRs

PLFP products						Return Period (year)	
	Mean	10	25	50	75	100	200
Manual resistance (A)	15.58	3.71	13.09	14.80	15.34	15.42	15.53
Manual resistance (B)	8.55	2.04	7.18	8.12	8.42	8.46	8.52
Automatic resistance	3.07	0.73	2.58	2.91	3.02	3.04	3.06
Resilience without flooring	1.71	0.39	1.45	1.63	1.69	1.70	1.71
Resilience with flooring	1.37	0.32	1.16	1.31	1.35	1.36	1.37

Table 5.10: Impact of the 10 year return period on BCR

PLFP products	Detached	Semi-detached	Terrace	Flat	Mean
Manual resistance (A)	3.48	2.89	4.17	4.30	3.71
Manual resistance (B)	2.02	1.81	2.14	2.18	2.04
Automatic resistance	0.58	0.68	0.82	0.84	0.73
Resilience without flooring	0.34	0.42	0.42	0.37	0.39
Resilience with flooring	0.31	0.33	0.34	0.31	0.32

5.6 Uncertainty analysis of BCRs (no reliability)

5.6.1 Sensitivity of discount rate (direct and indirect benefit)

The sensitivity of the BCR of PLFP products to changes in the discount rate has been examined. Sensitivity analysis helps to understand the model performance as a result of changes in some of the parameters, which in this case is the discount rate. The model was built with a discount rate of 3.5%, which is the standard recommended by the HM Treasury (2003) for economic analysis of schemes which normally have 0-30 year cycle. Previous studies in similar assessment have use this rate, and have recommended it as using higher rates can negate the benefits of some of the PLFP products (DEFRA, 2007; JBA, 2012b).

However, in this test, the discount rate has been increased to 8%, to see the effect on the overall BCR obtained in the study. This rate was used in line with previous studies in the financial appraisal of PLFP measures (ASC, 2012; Royal Haskoning, 2012). The results of the test have been presented in Table 5.11, using both the direct and indirect benefits of PLFP products. The results have been highlighted where there appears to be a significant change. Generally, increasing the discount rate has reduced the BCR of the protection packages, making them less cost beneficial. Significant changes are observed for resilience measures in particular which now appear very much less beneficial, and for a detached property both resilience packages record BCR of less than one. Overall, the discount rate variability means that the BCR have been reduced by almost 34%, and this will affect the PLFP measures and make them less beneficial.

Table 5.11: Sensitivity of discount rate (direct and indirect benefit)

PLFP products	Detached		Semi-detached		Terrace		Flat		Mean
	3.50%	8%	3.50%	8%	3.50%	8%	3.50%	8%	8%
Manual resistance (A)	13.89	9.12	12.26	8.05	17.92	11.77	18.25	11.98	10.23
Manual resistance (B)	8.06	5.29	7.67	5.03	9.20	6.04	9.25	6.08	5.61
Automatic resistance	2.32	1.63	2.87	2.02	3.53	2.48	3.55	2.49	2.16
Resilience without flooring	1.45	0.95	1.86	1.22	1.90	1.25	1.64	1.08	1.12
Resilience with flooring	1.25	0.82	1.41	0.93	1.50	0.98	1.34	0.88	0.90

5.6.2 Costs variability analysis (direct and indirect benefit)

The costs of PLFP products can have impact on the overall BCR; higher costs will reduce the magnitude of the ratios and vice versa. To analyse such case, the costs used for the model have been varied, using upper and lower costs; a figure of (±) 10% was applied as the level for the data variability. Table 5.12 shows the results of the analysis. As would be expected, the low costs have positive effect on the BCR with a change of almost 11%, while the high costs have reduced the BCR by a difference of 9%. Overall, very slight increases are observed in the mean figures compared with the original BCR, and will therefore not affect the results.

Table 5.12: Cost variability analysis (direct and indirect benefit)

PLFP products	Detached		Semi-detached		Terrace		Flat		Mean
	High	Low	High	Low	High	Low	High	Low	
Manual resistance (A)	12.65	15.40	11.16	13.60	16.27	19.92	16.57	20.28	15.73
Manual resistance (B)	7.31	8.94	6.96	8.52	8.35	10.25	8.44	10.30	8.63
Automatic resistance	2.11	2.58	2.61	3.19	3.21	3.92	3.22	3.94	3.10
Resilience without flooring	1.32	1.61	1.69	2.06	1.73	2.11	1.49	1.83	1.73
Resilience with flooring	1.13	1.38	1.28	1.57	1.36	1.67	1.22	1.49	1.39

5.6.3 Uncertainty in flood data (direct and indirect benefit)

To investigate potential errors with the modelled flood depths, the data was subjected to further tests by applying a factor of (±) 10%, which was assumed as the probability limits of errors adjustment. This factor was applied to individual depths which produced a new set of frequency-depth distribution for the analysis. Table 5.13 shows the results of the BCR generated from the analysis. Generally, the mean BCR here are similar to the initial findings of the study, with a very minimal change which range between 0.3-1% across the protection measures. This is not a notable difference, and hence will not affect the overall results.

Table 5.13: Uncertainty in flood data (direct and indirect benefit)

PLFP product	Detached		Semi-detached		Terrace		Flat		Mean
	+10%	-10%	+10%	-10%	+10%	-10%	+10%	-10%	
Manual resistance (A)	13.87	13.65	12.22	12.13	17.86	17.73	18.19	18.05	15.46
Manual resistance (B)	8.05	7.92	7.64	7.58	9.17	9.11	9.23	9.15	8.48
Automatic resistance	2.32	2.28	2.86	2.84	3.52	3.50	3.54	3.51	3.05
Resilience without flooring	1.45	1.44	1.85	1.85	1.89	1.89	1.64	1.63	1.70
Resilience with flooring	1.24	1.23	1.41	1.40	1.49	1.49	1.33	1.33	1.37

5.7 Incentivised PLFP scheme

Past studies have shown the benefits of PLFP incentive initiatives, including the improvement to property flood resilience leading to reduction of flood losses (Hendrichs, 2011; Sandink, 2013). In addition, Bichard and Kazmierczak (2009) have investigated attitudinal change in people, and they suggest that householders would response positively to incentive schemes. Based on these findings and related studies, it can be deduced that implementing some subsidy scheme on PLFP products could help increase uptake in such measures by removing some of the cost barrier to wider participation (DEFRA, 2008; White et al., 2012).

In view of the above, a range of PLFP subsidy schemes have been analysed to understand their net impact. The proposed scheme considers an average subsidy of 70% for the products, and this is based on the present local level discount scheme in the SBC (Gill, 2011), with similar schemes in Canada offering a maximum subsidy of 80% (Sandink, 2013). Additionally, a 90% uptake of the scheme has been used in the analysis, which is justified in reference to the 93% uptake in the DEFRA scheme (JBA, 2012a); no other studies have reported uptake levels. This information has been considered with reference to the number of properties at risk of flooding, to determine the benefit of PLFP scheme on a small scale and national level.

5.7.1 Small scale PLFP subsidy scheme

An assessment of a small scale benefit of PLFP subsidy scheme was undertaken using Hawick as a case study area. It is estimated that almost a 1,000 properties are at risk of a 200 year flood event, including almost 780 residential properties (SBC, 2011). An analysis of a range of PLFP subsidy schemes for the vulnerable households has been done using the proposed average subsidy and uptake.

Table 5.14 shows the results, indicating the BCRs, the net benefits, and the costs of the project analysed. Overall, the figures demonstrate that there are substantial net benefits of the scheme, particularly with the resistance products. The manual resistance products have the best savings of £18.4 million and a cost of £2.5 million for protection against those vulnerable properties, while the resilience measures with flooring have the lowest net benefit of £8 million and cost of £12 million. In terms of the BCRs of the measures, the manual resistance products range from 8:1 to 15:1, and are gains greater than £5 which imply sufficient returns required to fund such measures where they are feasible. The automatic resistance products have relatively lower BCR as would be expected, and this was 3:1.

Table 5.14: Small scale PLFP subsidy scheme

PLFP schemes	Detached	Semi-detached	Terrace	Flat	Mean
BCRs with reliability					
Manual resistance (A)	15.28	11.35	17.36	16.89	15.22
Manual resistance (B)	8.87	7.10	8.92	8.57	8.36
Automatic resistance	2.98	3.11	4.00	3.84	3.48
Resilience without flooring	2.07	2.25	2.46	1.99	2.19
Resilience with flooring	1.45	1.70	1.91	1.61	1.67
Net benefits with reliability (£ million)					
Manual resistance (A)	22.72	16.27	16.43	16.74	18.04
Manual resistance (B)	22.89	16.47	17.41	16.85	18.40
Automatic resistance	20.05	15.19	17.19	16.49	17.23
Resilience without flooring	10.54	9.09	10.27	8.14	9.51
Resilience with flooring	6.70	8.09	9.69	7.42	7.98
Cost (£ million)					
Manual resistance (A)	1.69	1.69	1.13	1.13	1.41
Manual resistance (B)	2.91	2.70	2.20	2.23	2.51
Automatic resistance	10.11	7.21	5.73	5.81	7.21
Resilience without flooring	9.82	7.27	7.04	8.21	8.09
Resilience with flooring	14.76	11.53	10.61	12.13	12.26

5.7.2 *National scale PLFP subsidy scheme*

The benefit of a national scale PLFP subsidy schemes was assessed using information on the number of flood risk properties which could invest in PLFP measures. SEPA has indicated that 1 in 22 homes in Scotland is at risk from flooding, which was equivalent to over 120,000 (SEPA, 2012). A more recent study by Ball et al. (2012) has estimated that approximately 158,000 residential addresses are located within flood zones and they include homeowners or primary tenants, who would have some responsibilities for home insurance. In the same way, it can be inferred that these people would have personal flood protection responsibilities; hence this figure was used in analysing the benefit of PLFP schemes on a national scale and the results are presented in Table 5.15.

The findings highlight the significant impact of the proposed scheme, with a net benefit from £2.6 billion to £4.5 billion for the protection measures. Manual resistance products have an average net benefit of £4.4 billion which is the highest, while the automatic resistance component has a net benefit of £4.3 billion. In terms of the investment costs, manual resistance products have relatively lower costs from £237 million to £423 million, while the cost for automatic resistance components was £1.2 billion. The average net benefit of a national scheme was £4.4 billion for those with resistance measures and £2.7 billion for the resilience measures. Compared with the local scale scheme, there is significant difference in the yields; the national scheme benefit outweighs the small scale benefit by over 200 times.

In addition, the BCRs from this analysis are higher compared with the small scale scheme. The manual resistance products have BCR from 20:1 to 11:1 compared with 15:1 to 8:1 for the small scale, and automatic resistance have increased benefits from 3:1 to 4:1, while the resilience measures have additional gains as well. Clearly, the findings for both case studies have shown material benefits of PLFP subsidy schemes, and thus present a compelling case for a large scale subsidy scheme in particular given their greater impact.

Table 5.15: National scale PLFP subsidy scheme

PLFP products	Detached	Semi-detached	Terrace	Flat	Mean
BCRs with reliability					
Manual resistance (A)	18.33	16.18	23.65	24.08	20.56
Manual resistance (B)	10.64	10.12	12.15	12.21	11.28
Automatic resistance	3.58	4.43	5.45	5.47	4.73
Resilience without flooring	2.49	3.19	3.26	2.82	2.94
Resilience with flooring	2.13	2.42	2.57	2.29	2.36
Net benefits with reliability (£ billion)					
Manual resistance (A)	4.93	4.32	4.31	4.39	4.49
Manual resistance (B)	4.73	4.15	4.13	4.21	4.31
Automatic resistance	4.40	4.17	4.30	4.38	4.31
Resilience without flooring	2.46	2.68	2.68	2.52	2.59
Resilience with flooring	2.82	2.76	2.81	2.64	2.76
Costs of scheme (£ billion)					
Manual resistance (A)	0.28	0.28	0.19	0.19	0.24
Manual resistance (B)	0.49	0.46	0.37	0.38	0.42
Automatic resistance	1.70	1.22	0.97	0.98	1.22
Resilience without flooring	1.65	1.23	1.19	1.38	1.36
Resilience with flooring	2.49	1.94	1.79	2.04	2.07

5.8 Decision support tools

5.8.1 Spreadsheet models

The results of the financial analysis of PLFP products have been used in developing an informative spreadsheet tool to assist both the general public and LAs in making informed decisions on PLFP options. The models which have been designed to be simple to use, require users to enter few inputs. For instance, the public tool (see Figure 5.4) requires input such as property type and inundation depth to be able to display the outcome, including the expected flood cost for where there are no measures installed and the benefits associated with a range of PLFP measures. Further, the LAs model (Figure 5.5) requires real data on the flood events and the distribution of properties at different depth intervals. A minimum of three flood events are required for the appraisal, and the outcome gives the net benefit and BCR for different options of PLFP. In addition to the development of these models, the outcome of the financial model has been used in developing a physical interactive tool (Wheel of Flooding Fortune) for the public, which is detailed in the following section.

Data Input

	Enter details
Property Type (code)	5
Number of Properties	5
Flood Depth (m)	0.50
Property Age	3
Social class (code)	1
Flood duration (hours)	1.00

Data Output

PLFP measure	COST (£)	BENEFIT (£)
Do nothing	100,504	
Airbrick Covers	1,041	99,463
Door Guard	1,441	99,063
Total Resistance (manual)	5,471	95,034
Total Resistance (automatic)	10,471	90,034
Resilience (no flooring)	18,561	81,943
Resilience with flooring	23,561	76,943

Figure 5.4: PLFP spreadsheet tool for the public

Input Data

Depth	Flood frequency depth distribution (%)						
	5 YR	10 YR	25 YR	50 YR	75 YR	100 YR	200 YR
<0	50	0	0	0	0	0	0
0-0.05	22	0	0	0	0	3	0
0.05-0.1	7	0	0	0	0	2	1
0.1-0.2	17	0	0	0	0	4	2
0.2-0.3	15	0	0	0	0	6	3
0.3-0.6	0	0	0	0	0	31	16
0.6-0.9	0	0	0	0	0	30	28
0.9-1.2	0	0	0	0	0	16	31
1.2-1.5	0	0	0	0	0	1	14
1.5-1.8	0	0	0	0	0	0	2
1.8-2.1	0	0	0	0	0	0	1
2.1-2.4	4	0	0	0	0	0	0
2.4-2.7	0	0	0	0	0	1	0
2.7-3.0	0	0	0	0	0	0	0
>3	0	0	0	0	0	1	3

Output Data

PLFP measures	Damage	Net benefit	BCR
Do nothing	40,865		
Basic (airbrick covers)	11,726	29,139	37.60
Intermediate (door guards	10,341	27,656	10.64
Total resistance (manual)	8,239	27,520	6.39
Total resistance (automatic)	8,239	17,943	2.22
Resilience (no flooring)	19,417	4,994	1.30
Resilience with flooring	15,061	863	1.03

Figure 5.5: PLFP spreadsheet tool for LAs

5.8.2 Wheel of Flooding Fortune

The development of the "Wheel of Flooding Fortune" was carried out through the FATE (Flood Awareness Through Engagement) project, which was co-funded by the SG and the Natural Environment Research Council (NERC) as part of the Probability, Uncertainty & Risk in the Environment (PURE) research initiative. The project was initiated based on the recognition that the impacts of climate change and urban creep will increase future flood risk, and that everyone can play a role in helping to reduce their own flood risk. While the SG is currently working to ensure that flood resilience is an integral part of the Curriculum for Excellence for school children, it is accepted that it is extremely difficult to engage the wider public on such issues unless they have recently experienced a flood event themselves. Hence, there is a very real need to develop innovative ways to engage the wider public. This project was designed to develop an interactive model that will be engaging and at the same time communicate key flood risk information to the general public and wider audience who visit the Glasgow Science Centre (GSC). It spanned between November 2013 to April 2014, with the aim to improve public awareness of flood risk and uncertainty and to help encourage people to take up proactive measures to protect themselves.

Figure 5.6 shows the interactive model, which incorporates a “wheel of fortune” linked to a database of flood event impacts. The wheel is split into segments to represent different weather scenarios (1 in 25/50/75/100 year return period events), with the number of segments for each event being dependent on the probability of the event occurring. Participants manually spin the wheel to determine the prevailing weather conditions, and this introduces an element of uncertainty. The weather “selected” by the wheel is used in conjunction with historical and simulated data to determine whether a flood will occur, and the resulting flood depths within peoples houses. Industry standard methodologies are then applied to determine the associated financial damages. Each wheel spin represents a 25 year period, and participants can spin the wheel 3 times, so each “game” lasts 75 years, which is around a person’s lifetime. To emphasise the benefits associated with proactive actions, such as the installation of PLFP products, the impacts of specific events are dependent on “investment” choices (including doing nothing) made by the participant prior to each wheel spin. Participants can play in two player mode with the overall “winner” being the player who spends the least amount of money (flood damages and protection costs) over the 75 year game period.

Figure 5.6: Wheel of Flooding Fortune

The exhibit has now been installed at GSC and will remain there for the foreseeable future, where its impact will continue to be evaluated. Initial reports suggest the model success, especially for families with children who seem to find it very interesting and informative. In the future, the exhibit will be moved to alternative venues and be targeted at other audiences, such as local authority planners. In addition, the SG is keen to reproduce an online version on its website which will be accessible to the wider public and could have greater impact.

5.9 Chapter Summary

This chapter used the WAAD technique to investigate the cost and benefit of PLFP measures and the impact of different models of incentivised PLFP scheme on the economy, using a case study data from the SBC. The findings indicate that the flood frequency depth data used in the assessments has much similarity with the comprehensive datasets employed by the MCM, giving a good confidence in the overall outcome. The results of the analysis have been presented using BCRs and net benefits.

The BCRs of the PLFP assessed by considering the direct and indirect impacts of flooding were found to be generally greater than one for all the protection packages, signifying sufficient returns for such measures. The indirect benefits of adopting PLFP including stress impacts were found to have marked effect on the BCRs of PLFP measures, and this underscores the importance of including them in flood damage appraisal. The reliability of the PLFP products was taken into consideration in the assessments and the effect on the BCR results was noticeable, making them less beneficial. Further test was undertaken to examine the effect of individual flood events, and this highlights that, more frequent floods have greater influence on the BCR findings, with the 10 year return period being the most impactful. It was noted that for rare flood events, from 50 year return period and more, PLFP measures were likely to be overwhelmed by floodwaters; hence they may not be suitable investment options.

An attempt was made to account for uncertainties in the data used for the assessments, the flood frequency depth data, the cost of PLFP products and the discount rate. The findings have shown very minimal effect on the overall BCRs determined, with the exception of the discount rate of 8% used which showed noticeable impact on the results.

The chapter has demonstrated the impact of different PLFP subsidy schemes on the economy, by assessing a small scale and nationwide schemes. It has established that the BCRs and net benefits of such projects are high, and has highlighted that PLFP schemes with manual total resistance products appear the most optimal investment choice based on several factors.

Finally, the chapter has reported the development of spreadsheet tools to help the public and LAs assess the cost and benefit of PLFP products to guide their decisions. It has discussed the FATE project which was undertaken to develop an interactive tool for public engagement activities, to help improve public flood awareness and the uptake of proactive measures to reduce flood risk.

Chapter 6: Institutional stakeholder consultation

6.1 Introduction

This chapter documents consultations with two of the key stakeholder institutions responsible for FRM in Scotland; they are the SG and SEPA. Those interviewed are policy advisers in FRM with an interest in PLFP. They were asked to respond to the earlier findings from this research to help contextualise them in line with the national FRM strategy. They were also asked to comment on key matters and implications of the research outcome on the national PLFP plan. The purpose of this discussion was to contribute to the evidence on PLFP, which is needed to improve public awareness and uptake of such measures in order to reduce flood risk, and help come up with possible models of PLFP scheme.

6.2 Property Level Flood Protection (PLFP) strategy

6.2.1 National uptake plan

The literature review revealed a low uptake of PLFP measures in the UK. Reasons for this included low public awareness of PLFP products and the perceived high cost of purchasing those products (DEFRA, 2008). In view of these findings consultation was set out to discuss the SG's plan for PLFP uptake in terms of the wider FRM strategy. This question is also justifiable given that, as an emerging technology, PLFP schemes appear to be struggling to fit into existing FRM plans and practices (White et al., 2012).

Discussion with the SG department tasked with managing flood risk showed that PLFP remains an integral part of the wider FRM strategy. This unit pledged its commitment towards ensuring sustainable, FRM and at the community level this will be ensured through an improved flood awareness and PLFP uptake. To achieve this goal, both organisations recognised the vital role of PLFP products, and will therefore continue to encourage individuals, business and communities to adopt proactive measures to increase their resilience to flooding. For example, there have been significant efforts towards raising public awareness of PLFP in communities and schools, and the SG is currently working with Education Scotland to introduce flood resilience as part of the Curriculum for Excellence in schools.

6.2.2 Promote awareness and uptake of PLFP

SEPA has shown how PLFP is being widely promoted as part of its agenda toward flood risk reduction. It has been supportive of the work being undertaken by the SFF which is directly involved at the local level of operation. The SFF, which is funded by the SG, is working to increase flood risk awareness and community resilience by adapting PLFP products; it engages LAs to support local FRM plans. There has been much success through the activities of SFF and from all accounts it appears that PLFP has gained increasing publicity among communities, especially in flood affected areas. This is positive progress, which supports the survey results that suggested a higher awareness and uptake of PLFP products among residents.

Despite the growing flood awareness campaigns, the key stakeholders admit the need for greater awareness of PLFP, particularly due to the demand of our changing climate. This realisation is also necessary to promoting PLFP uptake, as the survey findings point to a link between flood risk awareness and flood protection uptake. The lack of education regarding PLFP products and their benefits is a barrier to greater uptake of such measures, as well as the lack of knowledge of flood risk as people who do not understand their risk could refuse personal responsibility of protecting their homes.

High flood risk areas have special needs as these areas are particularly affected by floods and face problems with insurance cover. Further discussions held on these issues showed that FRM stakeholders are concerned about the greater need for PLFP awareness in high flood risk areas, although the SG acknowledged the difficulty in identifying the most vulnerable areas and targeting those properties most suited to PLFP. In view of this challenge, the SG has been working with the Joseph Rowntree Foundation and Manchester University to identify the neighbourhoods which are the most flood-disadvantaged in Scotland; that is communities most socially and spatially vulnerable to flooding. The outcome of this work will provide a valuable tool for helping target PLFP and awareness raising activities in general, and especially in the schools in those areas.

6.3 Financial incentives for PLFP scheme

There has been a limited funding for PLFP schemes and a general lack of financial incentives for such schemes (White et al., 2012). Moreover, the cost of PLFP products has been problematic for majority of people (DEFRA, 2008), and this further adds to the call for financial incentives as a solution to motivate people to participate in flood protection programs. For example, the recent DEFRA incentivised PLFP scheme was successful with a 93% uptake in the flood protection products (JBA, 2012a).

In Canada, a number of cities have implemented flood protection subsidy scheme, to help reduce the risk of basement flooding (Sandink, 2011; Sandink, 2013). The uptake in such schemes has been high, with the city of Saskatoon recording rates over 50% each time it was made available to the public. Overall, the program has been beneficial where adopted. For instance, sewer backup occurrences have reduced by 85% in homes that adopted retrofitted measures, and 96% of households have experienced reduce damages associated with sewer backup (Hendrichs, 2011; Sandink, 2013).

In view of the above outcomes, and in light of the focus group findings of this research, which indicated a general acceptance of financial incentives for PLFP schemes, the FRM institutions were asked to provide views on such schemes. From the discussions, it was clear that the idea of providing wider incentives for PLFP schemes was appealing to the stakeholder organisations and was in line with recent developments, highlighting a greater need for community resilience. The SG showed an acceptance of new initiatives that are both viable and will enable residents and business owners to take responsibility for their flood risk, including incentivising PLFP products.

6.3.1 Existing local level PLFP subsidy schemes

LAs are directly responsible for implementing local level FRM plans in their respective jurisdictions. These local level strategies include PLFP, and in promoting the uptake of such measures, some LAs have implemented subsidy schemes in their communities to encourage greater participation. For example, SEPA stressed the importance of the PLFP discount scheme operating in the Scottish Border Council, which has proved successful with evidence that the products are helping to reduce damages in affected properties. The SG welcomed the news that some LAs are willing to offer PLFP products to residents and businesses, and was also impressed by such developments which aim to contribute to the national plan of improving community resilience. In view of their relevance, both institutional stakeholders would recommend wider coverage of the discounted schemes.

In terms of the support for existing PLFP schemes, there was a unanimous view of the need to encourage a greater uptake of PLFP measures among individuals and communities. The SG in its position as a policy maker emphasised its continuous support for LAs to enhance the uptakes of flood protection products. Recently, it has commissioned JBA to investigate the benefits of PLFP which will help provide LAs with guidance on setting up successful schemes. The JBA work may have resulted following this crucial step to understand public attitudes towards flooding and the cost and benefit assessment of PLFP products. In addition, SEPA also affirmed its support through the assistance that its flood advisers extend to LAs by providing guidance and material on the PLFP products that are available on the market, especially those approved by the British Standard Institution (BSI).

6.3.2 Insurance incentive of PLFP uptake

Further discussion was held on the provision of improved incentivisation for PLFP uptake. This question was as a result of the problems that people in the high flood risk areas face in obtaining insurance cover for their properties. In view of this, the SG stressed the benefit of having PLFP as far as insurance cover is concerned, and suggested that the SFF has been working directly with flood risk residents to provide PLFP products through which householders have then been able to get insurance cover. Also the SG cited that its current project will seek to engage directly with the members of the ABI (Association of British Insurers) to get their views on PLFP and on the actions that can be taken to ensure that PLFP surveys meet the standards of the insurance industry to facilitate insurance for people. In previous SG study, insurers seem to acknowledge the merits of deploying resistance and resilience measures by households; however they stressed the difficulty in pricing the adoption of PLFP measures in insurance premiums and excesses. The process is currently complex and challenging and there is the need to explore easier ways of incorporating such measures into the underwriting process (Ball et al., 2012).

There was another consultation on the possibility of negotiating other insurance benefits for PLFP uptake, such as a reduction in insurance premiums for households with PLFP. Whilst there were no assurances on this proposal given the lack of such incentive in the UK, the SG showed that there have been some discussions in the past in relation to insurance cover and the future of PLFP scheme. It also revealed that the Scottish Minister for Environment and Climate Change regularly meets with officials of the ABI where such matters can be discussed, but it will be premature to speculate any possibilities whilst there is ongoing work to understand the benefits of PLFP.

6.4 Partnership and collaboration

Flood risk management, including the uptake of PLFP scheme requires collaborative partnership between relevant stakeholders to ensure the success of such scheme (Scottish Government, 2009). This is particularly important as it has been identified that institutional fragmentation is also a barrier to coordinating PLFP integration (White et al., 2012). As a result of this, both the SG and SEPA were asked about current arrangements and future collaboration that could ensure wider uptake of PLFP.

The SG recognised its role in promoting the national strategy for PLFP and therefore will continue to liaise with other stakeholders to achieve their goals. Presently, the SG is networked with a number of different stakeholders on its project steering group (e.g. Scottish Water, SEPA, LA, SFF and Building Standards Agency) to ensure success of the work. At the local level, the SG works with LAs to encourage them to include PLFP products in local management plans. There is also a national level partnership between the SG and SEPA, and besides this, both institutions pledged their willingness to continue to work with the SFF to ensure that residents are aware of flood protection products, know how to use them effectively and have access to free surveys.

With insurers, the SG underscored the importance of an effective working partnership, to ensure that people have flood insurance or other benefits for taking up PLFP. The SG understands that the insurance industry has a very important part to play and has highlighted this as the reason for regularly meeting the ABI to deliberate on flood issues. Additionally, the SG plans to work with the ABI to show the benefits of PLFP. Their engagement will aim to demonstrate that when installed and maintained appropriately, PLFP products can lower the damage caused by more frequent floods and therefore reduce insurance claims.

Another level of partnership and collaboration examined was regarding the role of flood protection product manufacturers, where effective collaboration is expected to generate more appropriate products and matured market needed to encourage a wider uptake of such measures. This kind of partnership is essential as it will help manufacturers to see greater uptake of their products and at the same time, homeowners will be confident with the standard of protection they receive from these products. Both the SG and SEPA acknowledged that engaging with product manufacturers will help to deliver approved and certified products.

6.5 Chapter summary

This chapter has reported discussions with institutional stakeholders to improve the understanding of the national strategy for PLFP uptake. It was found that PLFP is an integral part of the flood risk management strategies, and the key stakeholders recognised the need to promote flood awareness and PLFP uptake to help meet the demand for adequate protection in future. Another issue discussed is the need for financial incentives to motivate people to participate in PLFP scheme, as it was found that such initiatives were few in Scotland and they are usually LAs led actions. Generally, the SG was willing to fund and support schemes that have economic benefits to help people reduce their flood impacts, and evidence on benefits of PLFP was key for policies and guidance to promote wider uptake of PLFP schemes. The institutional stakeholders also emphasised the need for effective working partnership and collaboration among relevant organisations in achieving sustainable flood management in Scotland, including the uptake of PLFP.

Chapter 7: Conclusion and Recommendation

7.1 Introduction

The aim of this research was to understand public attitudes towards flooding and especially property level flood protection (PLFP) products. The goal of the research was to contribute to the evidence needed to promote uptake of PLFP products among the public to help reduce their flood risk.

To achieve the research aim, the work commenced with a comprehensive literature review to set the context of the study, and this has been presented in Chapter 2. The areas of focus include assessing flood impacts to understand the dangers of floods, particularly at the community and household level. Flood management approaches were examined, with particular concentration on large scale community defences, PLFP and non-structural measures including flood forecasting and the role of flood insurance. The review also covered the various techniques in flood damage appraisal including economic, financial and social evaluation methods, and together these fulfil the first objective of the research.

To meet the aim of the research, the methods used in the study have been presented in Chapter 3. These include the development of flood database which served as the basis for sampling survey locations. Stakeholder consultation comprising questionnaire surveys, focus groups and interviews were used to collect primary data for the research. Statistical analysis of the survey data, involving descriptive and inferential analysis was done using SPSS and the results have been presented in Chapter 4, in addition to the transcribed analysis of the focus group discussions.

Further, a financial model was developed to assess the cost benefit of PLFP packages using a case study area. The findings of this analysis and the economic implication of different models of incentivised PLFP schemes have been discussed in Chapter 5. Finally, Chapter 6 has reported additional consultation with key institutional stakeholders including SG and SEPA, regarding the future of PLFP and the need for a wider uptake of such measures to improve communities' flood resilience.

7.2 Main Findings

The study has revealed key findings with respect to flood risk perception and flood protection at the household level. It has provided further insights into the severity of reported flood impacts, and also the cost and benefit of using PLFP products and the impact of incentivised schemes on the economy. The main findings and deductions from the research are presented in this section under specific objectives of the study. These include findings from the literature review, stakeholder consultations and financial analysis of PLFP products. This section will be followed by key implications emerging from the study.

7.2.1 Literature review

The literature review of the study (Chapter 2), has established that floods are the most frequent hazards across the globe and can have damaging impacts. The impacts of floods are worse in the developing parts of the world including Asia and Africa, and those least developed countries are hugely affected in terms of the scale of economic losses and fatalities (CRED, 2012; UNFCC, 2012). These countries usually have weak institutions and inadequate capacity to handle floods and other disasters when they occur, and are often plagued by the lack of funds and resources to implement sustainable flood mitigation measures unlike the developed nations. In the UK also, floods are very common, often resulting in major destruction with the widespread 2007 summer floods being one of the most extreme floods resulting in almost £3.2 billion worth of damages (Pitt, 2008). Additionally, the impact of flooding at the community level is significant, with both financial losses to property and intangible social impacts being a major source of concern (RPA, 2004; Werritty et al., 2007). Although the social impacts are of increasing concern to flooded people, including the stress of flood and worry about future floods, they are often underestimated or less represented in flood damage appraisal, and this another area for research.

Moreover, flood risk is increasing particularly due to climate change impacts and the problem of urbanisation. This means that more properties and people could become vulnerable to flooding, with climate change expected to increase the severity and frequency of flooding (IPCC, 2007). Again, severe impacts are expected in the developing countries as a result of climate change, with potential extreme weather events including droughts and floods. This could pose further threats to developments in those poor countries and particularly the achievement of the Millennium Development Goals (UNFCC, 2012). At the same time it is not always feasible to implement large scale defences for all situations of flood risk, these often require much resources and time (Pitt, 2008). Alternatively, PLFP measures provide another option for homeowners to reduce their risk. These are in the form of resistance and resilience measures which either prevent water from entering a property or reduce the damage caused to property respectively. Although PLFP measures can be cost effective solution (Bowker, 2007; Thurston et al., 2008), their uptake is generally very low even among flooded households, with common barriers including the low awareness of flood risk and PLFP options, and the cost of such measures (DEFRA, 2008).

In view of this, there is the need to raise public awareness of flood risk and promote the uptake of PLFP measures to help people improve flood resilience. One practical way to improve greater uptake of PLFP measures is by providing some incentives for such scheme (JBA, 2012a; White et al., 2012), to help remove some of the cost barrier to wider uptake of PLFP. Financial incentives have proved an effective tool to motivate people and cause the needed transformational change to increase participation in such initiative.

7.2.2 Stakeholder surveys

The findings from both the questionnaire survey and focus group involving members of the public are reported in Chapter 4. It was found that there is a high awareness of flooding at the household level, even among those that have not been flooded (Section 4.3.1). Probably, this can be linked to the recently increased flood awareness campaigns across Scotland and the UK. In spite of the high awareness of flood risk among respondents, the findings showed that the public are very confused about personal responsibility towards flood protection or may not be aware of such legal responsibility (Section 4.5.1). Just about one-fifth of the respondents felt they were responsible for their property protection whereas the majority felt institutional stakeholders (e.g. SG and SEPA) were responsible for their own property.

Reported impacts of floods on affected households was found to be significant, with the average financial damage for insured building and contents reported as £30,123 and

£10,493 respectively, and uninsured costs to households was estimated at £13,000 (Section 4.4.1). In addition to the financial losses, there were also significant social impacts of flooding, including the stress of flooding which was the most ranked impact by respondents (see Section 4.4.2). These key findings highlight how impactful recent floods have been on households and emphasize the need for improved resilience to minimise flood impacts.

Analysis of floodwater characteristics in flooded properties has revealed that the majority (60%) of the reported internal flood incidents were through airbricks and doors (Section 4.3.4). In addition to this, the inundation depths in flooded homes were found to be mostly shallow depths (< 0.60 m), and it can therefore be deduced that the greater number of internal flooding cases could be prevented by installing simple resistance products including door guards and airbrick covers.

Although previous studies have found low awareness and uptake of PLFP, this research has shown relatively high uptake of PLFP products among both the flooded and non-flooded households (Section 4.5.3). However, it was noted that most of the products were installed after flooding had occurred, which seem to confirm the generally reactive nature of people’s behaviour to flood risk management rather than taking proactive measures before flooding.

Most households were willing to pay for PLFP products for their properties for a number of reasons including the avoidance or reduction of flood impacts and the rising costs of insurance premiums and excesses (Section 4.6). The total mean WTP was significant and was £795; this appears to be strongly linked with factors such as scale of flood damage and household income level. For those who were not willing to pay, just over half felt they could not afford flood protection products. However, these groups were found to be more likely to contribute towards the cost if subsidies or incentive packages were available. It can therefore be concluded that most people, in general, will be prepared to contribute towards the cost of purchasing PLFP products to protect themselves.

Nonetheless it is noted that the mean WTP found could be biased due to the survey technique used. Firstly, respondents were asked to state their maximum WTP using the stated preference method, which has limitations including the tendency for people to overstate or understate their values. Different reasons account for this; for instance, if contributing towards the cost of PLFP will become a liability for people they are more likely to understate their values, whilst those with more interest in such measures particularly where there are no existing flood defences could overstate their true value (Pearce et al., 2006). Secondly, stated preference technique is sensitive to the mode of questioning used to determine WTP values. People were presented with a series of prices for different PLFP options to help them express their maximum WTP, and this may have influenced their stated values given the trend of responses. The results showed clustering for WTP values of £100 (36%) and £1000 (43%) which were prices linked with airbrick covers and door guards respectively, representing the majority of responses. These two PLFP options were the least expensive measures and also commonly known among respondents, aside the use of sandbags. In view of this, respondents especially those from areas where such measures were being subsidised and largely patronised (e.g. Hawick and Dumfries) were more likely to show preferences for those options based on their experience. This could imply that their true WTP values may not have been expressed, and that could present further bias in the overall outcome.

7.2.3 Financial analysis of PLFP products

The findings here have produced key revelations regarding the cost effectiveness of PLFP measures. Generally, all the PLFP packages investigated have shown sufficient returns (BCR>1) which is needed for investment, most especially for the combined direct and indirect benefits of PLFP where the savings were extremely high (see Sections 5.5.1 & 5.5.2). It has been demonstrated that the indirect benefits of using PLFP measures, including the avoidance of stress and temporary accommodation have major impact on the BCR findings, and underscore the very need for such impacts to be considered in damage assessments (Werritty et al., 2007; Messner et al., 2007). The manual resistance products were found with a higher BCR that ranges from 6:1 to 12:1, which makes it the best option in terms of the returns and the moderate cost of £3,000 to £5,000 per household. The automatic component was less beneficial with an average BCR of 2:1. Similarly, the initial investment for the resilience measures was relatively high; hence such measures are the least preferred option especially the package with resilient flooring.

While PLFP measures can be beneficial in several ways including the improvement to property flood resilience, such measures are marginally participated and they also lack financial incentives (DEFRA, 2008; White et al., 2012). This has been a major challenge which is partly due to the way PLFP has been viewed in the past; they were less recognised for governments funding unlike other structural defences. However, the approach to flood management is changing to risk reduction and in the UK, PLFP measures are now being considered under the new arrangement of funding (DEFRA, 2011; Environment Agency, 2012a). The new partnership approach to funding projects means that such schemes are more likely to be funded now than in the past, and there could be better incentives for individuals and communities to invest in PLFP given that they are cost effective (DEFRA, 2011; Environment Agency, 2012a). Generally, cost effective schemes can receive financial assistance depending on the number of households being protected and other benefits; a typical BCR is at least 5:1 for flood defences (DEFRA, 2011; JBA, 2012a). In line with this, there is a clear opportunity for PLFP measures which are likely feasible (e.g. DEFRA scheme), particularly the manual resistance products which has high benefit and moderate cost. In view of this, other parts of the world where PLFP measures are not being seriously considered in flood management planning process could be encouraged to do so, following the examples in the UK and elsewhere to work towards achieving sustainable flood management.

Different PLFP subsidy schemes were analysed, and the findings have shown that incentivised schemes can have a major impact on the economy (Section 5.7). The net benefit for a small scale scheme ranged from £8 million to £18 million for all the PLFP products, while a national scale scheme had a net benefit from £2.6 billion to £4.5 billion. Again, the manual resistance product schemes appeared the most significant with an average net benefit of £4.4 billion and cost of £330 million for a national scheme, while a small scale program has a benefit of £18 million and cost of £2.5 million. In addition, the BCRs of a national scheme were higher than those of the small scale; for example, manual resistance have BCR of 20:1 compared with 15:1.

Although these findings have demonstrated that incentivise PLFP scheme could have significant impact, it should be noted that there are potential barriers that can constrain their success. Generally, a low awareness of flood risk means that people may not understand the seriousness of the problem, and hence may still show less interest even for incentivised programs. In view of this challenge, it is suggested that such projects should be coupled with improved flood education programs that raise awareness of flood risk and mitigation measures, while providing financial incentives to encourage residents to take up personal protection (Kreibich et al., 2005; Kreibich et al., 2011). In the UK, the relevance of flood awareness campaigns has been highlighted; for instance, in Scotland, the SG continues to invest in flood education by working with Schools and communities to help improve flood resilience (Frame, 2014). Forth to this, the recent SG led FATE project (Section 5.8.2), adds another dimension to the ongoing flood awareness campaign in Scotland. The importance of flood awareness education is highlighted in other flood risk countries in the world, with the typical example of the "River Game" activity in the Zambezia Province in Mozambique, which is being used to raise flood awareness and prepare residents for flood events (Dale et al., 2009; Jha et al., 2012).

Additionally, there is the belief that existing community level flood defences to some extent can discourage homeowners from taking up PLFP measures, although it is clear that no single flood management solution provides complete protection (Jha et al., 2012). As such, there has been the need for sustainable flood management options including PLFP, to complement existing structural measures due to the growing risk of flooding and pressures on such defences (Pitt, 2008). In view of the importance of incentivised PLFP schemes, implementing them alongside other flood management strategies, including flood warning and land use regulations could help provide a remedy to the increasing threats of floods to properties and reduce flood losses.

7.2.4 Institutional stakeholders consultation

The consultation with key institutional stakeholders has revealed that PLFP remains an integral part of the national flood management strategy for Scotland (Section 6.2.1), to help improve communities resilience to flood risk, as a result of climate change and the problems of urban creep. It has also stressed the need to increase the awareness of flood risk and PLFP products, particularly as PLFP is a fairly new scheme in Scotland. In doing so, a number of activities are being carried out by the institutional FRM stakeholders, including the initiative by the SG to raise flood awareness and encourage the use of PLFP measures to improve people's resilience to flooding.

This research found that there is a lack of evidence on the benefits of PLFP products to propel national policies towards funding and promoting such measures on a larger scale. For developing countries, national policies on disaster risk management were more on response and relief, although people are becoming aware of the need for risk reduction through appropriate actions. Whilst some vulnerable communities are being prepared for floods through awareness raising and early flood warning, the uptake of PLFP by individuals or through governments initiatives was rare in the LDCs perhaps due to the lack of awareness and benefits of such measures. Elsewhere the SG has recently taken crucial steps to investigate PLFP which is particularly important, as strong evidence on the benefits of PLFP is needed in drawing policies and guidance for such schemes. In view of this, the research findings reported earlier have shown realistic benefits of PLFP scheme. They are supported by similar studies in England (Bowker, 2007; Royal Haskoning, 2012; JBA, 2012b), where significant benefits associated with PLFP schemes have been found. These insights will add to the SG project when completed, and will help provide the evidence needed to support decision making in the funding and promoting of PLFP schemes. Overall, this has implications for the most vulnerable communities in the world who are exposed to flooding and may not benefit from large scale flood defences. Flood management stakeholders could consider investing in flood resistance and resilience measures as alternatively cost effective solutions to protect people and properties from flooding.

Moreover, there were limited cases of incentivised PLFP schemes in the UK and the world at large, and in Scotland such initiatives are usually LAs led schemes. In addition, there are currently no policies by institutional stakeholders to incentivise or regulate the uptake of PLFP schemes as part of the wider flood management options. This is perhaps, also due to the lack of evidence and understanding of the benefits of PLFP schemes which is fundamental for decision making. In view of the usefulness of financial incentives to transform attitudes and motivate greater participation in PLFP uptake as shown by some UK studies (Bichard and Kazmierczak, 2009; JBA, 2012a), it will be worthwhile considering such a tool when drawing strategies that will promote PLFP schemes.

Further, institutional stakeholders should be prepared to assist programs that are feasible and have economic benefits, as was shown by the SG (Section 6.3). In particular, stakeholders in developing countries could incentivise PLFP schemes in delivering the holistic approach to flood management, as such schemes require relatively less funds and resources to manage compared with the structural engineered solutions which are very expensive. Such willingness to fund new initiatives given their cost effectiveness and benefits, would imply a clear opportunity for investing in PLFP scheme and promoting wider uptake of such measures to help reduce flood impacts worldwide. Nonetheless, this study found other key determinants are necessary to the success of a larger scale PLFP schemes. They include the need for an effective partnership and collaboration among LAs, institutional stakeholders and PLFP product manufacturers who should design products to the required specifications. Finally homeowners and communities should be willing to participate in PLFP programs for successful outcome, especially when they are incentivised. Effective cooperation is important for flood management and particularly vital for the developing parts of the world, where there is usually weak institutions and poor cooperation between stakeholders involved in disaster risk management and reduction.

7.3 Research Implication

The outcome of this research has major implications in flood risk management and will be beneficial to governments, key institutional stakeholders and the public, particularly as PLFP is an emerging practice and an essential part of flood mitigation strategies.

First of all, the findings on the public perception of flood risk and household flood impacts will provide relevant authorities further insights on the continuing problem of flood risk, and the significance of flood impacts. This will help inform policy decisions on how to assist households and vulnerable communities to increase their resilience to flooding, including taking up PLFP measures and signing up for early flood warnings.

The willingness of households to contribute towards the cost of PLFP products has a major implication for drawing short and long term PLFP strategies, which will seek to promote awareness and uptake of such products among the public and flood risk communities. This finding in particular will help inform the funding of PLFP scheme, with greater implication for a large scale national PLFP subsidy schemes which generally have high participations and better benefits. Moreover, the reasons for which people were not willing to pay for PLFP are equally relevant, and suggest the need for financial incentives to motivate the general public particularly the fact that people cannot afford such measures.

The findings on the cost benefit assessments of PLFP particularly the resistance products have significance in many areas. This will contribute to existing evidence and will help promote PLFP at the local and national level in Scotland, and other vulnerable parts of world. The findings will contribute to advancing PLFP scheme, given the real benefits incentivised schemes can have on the national economy. For LAs, the spreadsheet tool developed to aid decision-making will provide enlightenment on the BCR of PLFP products, and inform their decisions on investment options with such schemes needed to improve their communities flood resilience.

Insurers will reduce their financial losses through floods, as their clients will learn through the interactive model (FATE project) to adopt resistance and resilience measures to their homes. Additionally, homeowners will gain an improved knowledge on the cost and benefit of using PLFP products, and they will be better informed about their options and related benefits, which will encourage them to install protection products for their properties. For those in high flood risk areas where insurance cover is extremely difficult, homeowners can reduce their flood damage and improve their chance of getting flood insurance cover by adopting PLFP products. Finally, PLFP product manufacturers will see a profit in their business as their products are being heavily patronised by the public, and this will in turn encourage them to produce new and innovate products to suit all cases of flood protection.

7.4 Research Contribution

7.4.1 Contribution to knowledge

The research has made key contributions to knowledge in several fields. It has highlighted the attitudes of the public towards flooding and PLFP, adding to the insight on household level flood experience, and the preparedness of people to make some payments towards protecting their property. The findings have outlined the importance of flood awareness raising to help people prepare better for floods, which is a key component of the non-structural approach to flood risk reduction.

This research has contributed to the evidence on the benefits of adopting PLFP measures, which is needed to implement wider-scale PLFP schemes to ease the growing pressure on flood defences due to increasing climate change and urbanisation. This finding is particularly key, given the integrated approach to flood management and the emerging practice of adopting resistance and resilience measures to reduce peoples flood risk exposure. PLFP is also being viewed as an alternative flood protection option where there is no permanent structural flood defence, and can be used alongside existing measures as well. The research outcome has provided material evidence on the cost and benefits of PLFP products using Scotland as a case study, and this could serve as an example for other flood management stakeholders in the world who need such information to draw strategies in funding and promoting PLFP schemes. For the developing countries where there are inadequate institutional capacity, and the lack of resources hinder the implementation of major flood management plans, there is a clear opportunity to invest in PLFP schemes which are usually cost effective.

There is also a practical contribution in the area of public engagement in Scotland, which is an important means of getting key messages to the wider community. Through the FATE project, an interactive flood model has been produced to help communicate flood risk awareness and uncertainty to the public, and this will enhance the knowledge of flood risk and encourage adoption of measures to mitigate flood impacts. This is particularly essential in preparing people for floods and meeting the demand of increased risk due to climate change and urbanisation, and useful lessons can be drawn from such engagement and applied elsewhere. An improved public understanding of flood risk will benefit the world, as people will be more resilient to flooding and the economic losses due to floods will be minimised.

7.4.2 Dissemination

Findings from this research have been presented in conferences, and discussed in other relevant forums. A summary of the stakeholder survey findings has been shared with relevant institutions and the final outcome, including the decision support tools for assessing PLFP options will be made available to relevant bodies. The FATE project is also going to be on the SG website where it will be accessible to the wider public. Further publications of the work are in preparation and in review.

7.5 Recommendation for Further Research

This research was mainly focused on the UK and particularly Scotland, to understand public attitudes towards flooding and the uptake of PLFP measures in mitigating flood impacts. It is therefore recommended that similar studies be undertaken in other parts of the world particularly in the most vulnerable and flood affected areas, to assess the benefits of adopting PLFP and integrate such measures into the wider flood management strategies. Such studies could provide other useful lessons not shown here given the uniqueness of countries and differences in institutional arrangements to flood management.

The research was primarily focussed on attitudes of residential householders towards flooding and flood protection uptake. While the findings are important and suit the overall purpose of the work, the scope of the study is limited by excluding commercial property owners. It is recommended that further work should extend the scope to cover attitudes of commercial property owners. This could provide further revelations which are not captured in this study.

Although the stakeholder surveys involved sizeable locations with the aim of collecting a wide range of responses, the overall return rate of 16%, though satisfactory for this type of work does not represent a large response rate, and therefore can influence the findings. In addition, the focus groups were restricted to just two locations due to resources and time constraints, which means that the responses do not cover a wider participant groups. It is suggested that further work should undertake a more comprehensive focus groups and interviews, to account for a wider participants. Moreover, further study can be tailored to compare different catchment area responses and attitudes towards flooding, to help provide further insights not revealed by this study.

It is recommended that future works employ detailed flood risk data in the financial assessment of PLFP, as this study only involved one case study data for a national level assessment. Further works should also better account for uncertainties related with the PLFP assessment including the flood depth data. This could be done by modelling the flood data, where parameters can be adjusted to address potential uncertainties. The impact of climate change variability on the flood data can be modelled, and then quantified in the CBA of PLFP. These could provide new insights on the impact of PLFP schemes and will to help draw relevant conclusions for their wider application in future.

7.6 Chapter Summary

This research has examined public attitudes towards flooding and PLFP. It has improved the understanding on public perception of flood risk and flood experience, and highlighted the financial losses and intangible impacts of floods at the household level. It has established that people are generally willing to contribute towards the cost of protecting their property, and are more likely to do so if there are subsidies or incentive packages available to motivate them. This chapter has also reported the cost and benefit findings of PLFP products which were shown to be generally cost beneficial, especially the manual resistance products which have very high returns. It has demonstrated the impact of a national and a local level PLFP subsidy schemes which were both significant, and could imply an opportunity to invest in such measures to mitigate flood impacts. The chapter has also reported the consultation with key stakeholders which stressed the willingness of government to support and fund cost effective projects including PLFP. The findings of this research indicate that PLFP has a role to play in flood management, and the evidence provided by the assessment of PLFP products will inform governments and relevant authorities decisions to fund and promote their uptake to help vulnerable communities reduce their risk exposure.

References

ABI (2004) Flood Resilient Homes. Association of British Insurers, London. [Online] Available at: http://www.abi.org.uk/Display/File/Child/553/Flood_Resilient_Homes.pdf (Accessed: 12 February 2012).

ABI (2006) Flood resilience and resistance factsheet for insurers and loss adjusters. Association of British Insurers, London. [Online] Available at: http://www.abi.org.uk/Publications/Flood_Resilience_and_Resistance_Factsheet_for_Insurers_and_Loss_Adjusters1.aspx (Accessed: 25 October 2011).

ABI (2008) Revised Statement of Principles on the Provision of Flood Insurance. Association of British Insurers, London.

ABI (2010a) Fighting Flood risk together. Association of British Insurers, London.

ABI (2010b) Massive rise in Britain's flood damage bill highlights the need for more help for flood vulnerable communities says the ABI. News release [Online] Available at: http://www.abi.org.uk/Media/Releases/2010/11/Massive_rise_in_Britains_flood_damage_bill_highlights_the_need_for_more_help_for_flood_vulnerable_communities_says_the_ABI.aspx (Accessed: 18 November 2012).

ABI (2011a) Flooding and Insurance. Association of British Insurers, London. [Online] Available at: http://www.abi.org.uk/_Policy_Issues/Flooding_and_Insurance.aspx (Accessed: 12 May 2012).

ABI (2011b) Under-pricing of the flood element of home insurance for domestic customers at significant flood risk. Association of British Insurers, London.

ABI (2011c) ABI responds to Government update on the future of flood insurance, Association of British Insurers, London.

ABI (2011d) Flood resilient repairs and resistance measures: Qualitative and quantitative research to examine the views of consumers. ABI Research Paper, No 28.

ABI (2012) No time to lose in securing a long- term, sustainable flood insurance market. [Online] Available at: http://www.abi.org.uk/Media/Releases/2012/03/No_time_to_lose_in_securing_a_long_term_sustainable_flood_insurance_market_says_the_ABI.aspx (Accessed: 11 September 2012).

ABI (2013) Written evidence to the Environment, Food and Rural Affairs Select Committee inquiry into flood funding. [Online] Available at: http://www.publications.parliament.uk/pa/cm201213/cmselect/cmenvfru/writev/flood/m07.htm (Accessed: 09 September 2013).

Aboagye, D. (2012) Living with the familiar hazards: Flood experiences and human vulnerability in Accra, Ghana. Articulo-Journal of Urban Research.

Alexander, M., Faulkner, H., Viavattene, C. And Priest, S. (2011) A GIS-based Flood Risk Assessment Tool; Supporting Flood Incident Management at the local scale. Proof of the concept report to the FRMRC2. July 2011.

Allsop, W., Kortenhaus, A., and Morris, M. (2007) Failure Mechanisms for Flood Defence Structures. FLOODsite project report. [Online] Available at: http://www.floodsite.net/html/publications2.asp (Accessed: 02 June 2012).

ASC (2012) Climate change – is the UK preparing for flooding and water scarcity. Adaptation Sub-Committee Progress report. Committee on climate change, London.

Ashley, R. M., Blanksby, J. R., Cashman, A., Jack L., Wright, G., Packman, J., Fewtrell, L., Poole, A. (2007) Adaptable Urban Drainage - Addressing Change In Intensity, Occurrence And Uncertainty Of Stormwater (AUDACIOUS). J. Built Environment. 33 (1), 70-84.

Atkinson, T. and Price, N. (2005) Improving the flood resilience of buildings through improved materials, methods and details.WP3-Health and Safety. [Online] Available at: http://www.ciria.org.uk/flooding/pdf/WP3%20Health%20&%20Safety%20Impacts.pdf (Accessed: 10 December 2011).

Ball, T., Geddes A., Werritty, A., Black, A. and Easton, A. (2012) Flood insurance provision and affordability beyond the statement of principles: implication for Scotland. CREW, University of Dundee.

Ball, T., Werritty, A., Duck, R.W., Edwards, A., Booth, L. and Black, A. (2008) Coastal Flooding in Scotland: A Scoping Study. Report to SNIFFER, Edinburgh.

Bell, A. (2011) Morpeth Flood Action Group Insurance Survey Results and Analysis. January 2011, Morpeth Flood Action Group. [Online] Available at: www.voicesoftheflood.org/attachments/download/45/Morpeth%2520Flood%2520Action%2520Group%2520Insurance%2520Survey.pdf (Accessed: 19 February 2013)

Bichard, E. and Kazmierczak, A. (2009) Resilient Homes: Reward-based methods to motivate householders to address dangerous climate change. University of Salford, For the Environment Agency.

Bichard, E. and Thurairajah, N. (2011) Resilient Homes (Phase 2): The Timperley Green Homes trial on methods to motivate home-owners to address property-level effects of climate change. A report for Trafford Borough Council and the Environment Agency.

Botzen, W.J.W., Aerts, J.C.J.H. and Van den Bergh, J.C.J.M. (2009) Willingness of homeowners to mitigate climate risk through insurance. Ecological Economics, 68, 2265-2277.

Bowker, P. (2007) Flood resistance and resilience solutions: an R&D scoping study. DEFRA Report, London.

Bowker, P., Escarameia, M. and Tagg, A. (2007) Improving the Flood Performance of New Buildings: Flood Resilient Construction. Guidance produced by a consortium of CIRIA, HR Wallingford Ltd, Leeds Metropolitan University, WRc and Waterman Group, RIBA Publishing, London.

Brinke, W.B.M., Kolen, B., Dollee, A.,Waveren,, H.V., and Wouters, K. (2010) Contingency Planning for Large-Scale Floods in the Netherlands. Journal of Contingencies and Crisis Management, 18 (1), 55-69.

Bubeck, P., Botzen, W.J.W., Kreibich, H., and Aerts J.C.J.H. (2012) Long-term development and effectiveness of private flood mitigation measures: an analysis for the German part of the river Rhine. Natural Hazards Earth System Sci., 12, 3507-3518

Bubeck, P., Botzen, W.J.W., Kreibick, H. and Aerts, J. C. J. H. (2013) Detailed insights into the influence of flood-coping appraisals on mitigation behaviour. Global Environmental Change, (in press).

Buizza, R., Hollingsworth, A., Lalaurette, F. and Ghelli, A. (1999) Probabilistic predicions of precipitation using the ECMWF ensemble prediction system. Wearher and forecasting, 14, 168-189.

Carpenter, T., Sperfslage, J., Georgakakos, K., Sweeney, T., and Fread, D. (1999) National threshold runoff estimation utilizing GIS in support of operational flash flood warning systems. Journal of Hydrology, 224, 21–44.

CLG (2006) Planning Policy Statement PPS25: Development and Flood Risk Practice Guide. Department for Communities and Local Government, London.

Cloke, H.L. and Pappenberger, F. (2009) Ensemble flood forecasting: A review. Journal of Hydrology, 375(2009), 613–626.

Consumer Council (2013) Research paper on flood protection and insurance. Belfast, Northern Ireland.

CRED (2010) Disaster data: a balance perspective. No.22. Brussels, Belgium. [Online] Available at: http://cred.be/sites/default/files/CredCrunch22.pdf (Accessed: 20 June 2012)

CRED (2012) Disaster data: A balanced perspective. No. 27. Brussels, Belgium [Online] Available at: http://www.cred.be/sites/default/files/CredCrunch27.pdf (Accessed: 12 December 2012).

Creswell, J.W. (2009) Research design: qualitative, quantitative, and mixed methods approaches. 3rd ed. London: Sage

Ghimire, S., Holmes, B., Hasting, E., Dawson, S., Werritty, A., Duck, R., Powell, V., Ball, T., Dawson, A. And Muir, D. (2012) Coastal flooding in Scotland: A guidance document for coastal flood practioners. The James Hutton Institute/The Scottish Government

Crichton, D. (1999) 'The risk triangle', in J. Ingleton (ed) Natural Disaster Management, London: Tudor Rose.

Crichton, D. (2002) UK and global insurance responses to flood hazard. Water International 27 (1), 119-131.

Crichton, D. (2005) Flood risk and insurance in England and Wales: Are there lessons to be learned from Scotland? Technical report. Benfield Hazard Research Centre, University College London, UK.

Crichton, D. (2007) 'What can cities do to increase resilience?' Philosophical Transactions of the Royal Society 10(1098) 1–11.

Crichton, D. (2008a) Role of Insurance in Reducing Flood Risk. The International Association for the Study of Insurance Economics. The Geneva Papers, 2008, (33), 117–132.

Crichton, D. (2008b) Towards a Comparison of Public and Private Insurance Responses to Flooding Risks. Water Resources Development, 24 (4), 583–592.

CRUE (2007) National Research Programmes on Flood Risk Management across Europe. ERA-NET CRUE WP2, CRUE Report.

CRUE (2008) Systematisation, evaluation and context conditions of structural and non-structural measures for flood risk reduction. FLOOD-ERA Joint Report, CRUE Research Report No I-1.

Dale, M., Wicks, J., Mylne, K., Pappenberger, F., Laeger, S. and Taylor, S. (2014) Probabilidtic flood forecasting and decision-making: an innovative risk-based approach. Natural Hazards (2014), 70, 159-179.

Dawson, R.J., Ball, T., Werritty, J., Werritty, A., Hall, J.W. and Roche, N. (2011) Assessing the effectiveness of non-structural flood management measures in the Thames Estuary under conditions of socio-economic and environmental change. Global Environment Change, 21(2011), 628-646.

DEFRA (2001) National appraisal of assets at risk from flooding and coastal erosion, including the potential impact of climate change. DEFRA Technical Report, London.

DEFRA (2005) Making space for water: Taking forward a new Government strategy For flood and coastal erosion risk management in England. DEFRA, London.

DEFRA (2006) Flood Risks to People - Phase 2 project record - F2321/PR: London Environment Agency and Department for Environment, Food and Rural Affairs.

DEFRA (2008) Consultation on policy options for promoting property-level flood protection and resilience. DEFRA Report, London.

DEFRA (2010) Availability and uses of property level flood risk data and information. DEFRA, London.

DEFRA (2011) Flooding and insurance: a roadmap to 2013 and beyond: An interim report of the flood insurance working groups. DEFRA, London.

DEFRA (2012a) Flood and Water Management Act 2010. DEFRA, London.

DEFRA (2012b) Obtaining flood insurance in high risk areas. DEFRA, London.

DEFRA (2012c) UK Climate Change Risk Assessment 2012 Evidence report. DEFRA, London.

DEFRA (2013) Securing the future availability and affordability of home insurance in areas of flood risk. DEFRA, London.

DeSalvo, K.B., Hyre, A.D., Ompad, D.C., Menke, A., Tynes, L.L. and Muntner, P. (2007) Symptoms of posttraumatic stress disorder in a New Orleans workforce following Hurricane Katrina. Journal of Urban Health, 84(2), 142-52.

De Roo, A., Gouweleeuw, B., Thielen, J., Bartholmes, J., Bongioannini-Cerlini, P., Todini, E., Bates, P., Horritt, M., Hunter, N., Beven, K., Pappenberger, F., Heise, E., Rivin, G., Hills, M., Hollingsworth, A., Holst, B., Kwadijk, J., Reggiani, P., Van Dijk M., Sattler, K., and Sprokkereef, E. (2003) Development of a European flood forecasting system. Intl. Journal for River Basin Management, 1, 49–59.

Djordjevic,´ S., Butler, D., Gourbesville, P., Mark, O. and Pasche, E. (2011) New policies to deal with climate change and other drivers impacting on resilience to flooding in urban areas: the CORFU approach. Environmental science & policy, 1 4, 864-873.

DTLR (2001) Planning Policy Guidance Note 25 - Development and Flood Risk. TSO, London.

DTLR (2002) Preparing for Floods - Interim Guidance for Improving the Flood Resistance of Domestic and Small Business Properties. TSO, London.

Douglas, I., Garvin, S., Lawson, N., Richards, J., Tippet, J. and White, I. (2010) Urban fluvial flooding: a qualitative case study of the cause, effect and non-structural mitigation. Journal of flood risk management, 3 (2), 112-125.

EEA (2003) Mapping the impacts of recent natural disasters and technological accidents in Europe. Environmental issue report, No 35.

EEA (2010) Mapping the impacts of natural hazards and technological accidents in Europe. An overview of the last decade. Technical Report No.13/2010.

Environment Agency (2005) The impact of flooding on urban and rural communities. Joint Defra/Environment Agency flood and coastal erosion risk management programme, Bristol.

Environment Agency (2009a) Flooding in England: A National Assessment of Flood Risk. Environment Agency, Bristol.

Environment Agency (2009b) Thames catchment flood management plan. Environment Agency, Bristol.

Environment Agency (2010a) Working with Natural Processes to Manage Flood and Coastal Erosion Risk. Environment Agency, Bristol.

Environment Agency (2010b) The cost of the summer 2007 floods in England. Bristol

Environment Agency (2012a) Types of flood defences. [Online] Available at: http://www.environment-agency.gov.uk/homeandleisure/floods/31738.aspx (Accessed: 22 January 2012).

Environment Agency (2012b) Principles for implementing flood and coastal resilience funding partnerships. Environment Agency, Bristol.

Evans, E., Ashley, R., Hall, J., Penning-Rowsell, E., Saul, A., Sayers, P., Thorne, C. and Watkinson, A. (2004) Foresight Future Flooding. Scientific Summary: Volume I Future risks and their drivers. Office of Science and Technology, London.

Field, A. (2009) Discovering statistics using SPAA. 3rd ed. London: Sage Publications.

FitzGerald, G., Du W., Jamal, A., Clark, M., Hou, X. (2010) Flood fatalities in contemporary Australia (1997–2008). 22 (2), 180-186.

FHRC (2010) The Benefits of Flood and Coastal Risk Management: A Handbook of Assessment Techniques – 2010. Flood Hazard Research Centre, Middlesex University.

Garvin, S., Reid, J., and Scott, M. (2005) Standards for the repair of buildings following flooding: London. CIRIA C623. [Online] Available at: http://www.nirca.org.uk/Docs/CIRIA%20-%20Standards%20for%20the%20repair%20of%20buildings%20following%20flooding.pdf (Accessed: 12 June 2012).

GFDRR (2014) Country update [Online] Available at: https://www.gfdrr.org/sites/gfdrr/files/region/GH.pdf (Accessed 28 October 2014)

GHK (2009) Economic incentive schemes for retrofitting London's existing homes for climate change impacts. Greater London Authority, London.

Golding, B. (2009) Review – long lead time flood warnings: reality or fantasy? Meteorological Applications, 16 (1), 3-12.

Green, C.H. and Penning-Rowsell, E.C. (2002) Flood risk and insurance; strategic options for the insurance industry and government, Enfield: Middlesex University, Flood Hazard Research Centre.

Green, C., and Penning-Rowsell, E.C. (2004) Flood insurance and government: 'parasitic' and 'symbiotic' relations. The Geneva Papers on Risk and Insurance 29, 518–39.

Hancock, R. and Rea, M. (2013) Australian storms and floods: White paper. Zurich Australian Insurance limited, Australia and New Zealand.

Handmer, J. (2001) Improving flood warnings in Europe: a research and policy agenda. Environmental Hazards 3, 19-28.

Haggett, C. (1998) An integrated approach to flood forecasting and warning in England and Wales. J. Chart. Inst. Water Environ. Manage. 12, 425–432.

Harries, T. (2009) Review of the Pilot Flood Protection Grant Scheme in Recently Flooded Area. Joint DEFRA/EA Flood and Coastal Erosion Risk management R&D Programme. Defra, London.

Harries, T. (2010) Summary of findings – National Flood Forum 2010 survey of flooded individuals'. [Online] Available at: http://floodforum.org.uk/files/Summary%20of%20findings.pdf (Accessed: 21 December 2011).

Hellmuth, M. E., Moorhead, A., Thomson, M. C. and Williams, J. (2007) Climate risk assessment in Africa: Learning from practice. International Research Institute for climate and society, Columbia University, New York, USA.

House of Commons (2007) Environment Agency: Building and maintaining river and coastal flood defences in England. Fourth Report of session 2007-08. House of Commons, London.

House of Commons (2010) Future flood and water management legislation. Environment, Food and Rural Affairs Committee. House of Commons, London.

House of Commons (2011). Flood Defence Allocations. [Online] Available at: http://www.publications.parliament.uk/pa/cm201011/cmhansrd/cm110209/debtext/110209-0001.htm#11020962000006 (Accessed: 5 July 2012).

House of Commons (2012) Flood risk management in England: sixty-fourth report of session 2010-12. House of Commons, London.

House of Commons (2013) Managing flood risk. Third report of Session 2013-14, volume 1. House of Commons, London.

Houston, D., Werritty, A., Bassett, D., Geddes, A., Hoolachan, A. and McMillan, M. (2011) Pluvial (rain-related) flooding in urban areas: the invisible hazard. Joseph Rowntree Foundation.

HR Wallingford (2008) Evacuation and traffic management. Floodsite consortium.

HR Wallingford (2012) Climate Change Risk Assessment for the Health Sector. [Online] Available at: http://randd.defra.gov.uk/Default.aspx?Module=More&Location=None&ProjectID=15747 (Accessed: 12 March 2013)

Hulme, M., Jenkins, G. J., Lu, X., Turnpenny, J. R., Mitchell, T. D., Jones, R. G., Lowe, J., Murphy, J. M., Hassell, D., Boorman, P., McDonald, R .and Hill, S. (2002) Climate Change Scenarios for the United Kingdom: The UKCIP02 Scientific Report. Tyndall Centre for Climate Change Research, University of East Anglia, Norwich.

ICE (2002) Better flood management: the insurance perspective. 4, 283-286.

ICE (2006) A Partnership approach to managing flood risk. Civil Engineering, 159 (14733), 41-45.

IPPC (2007) Climate change 2007: The physical science basis. Contribution of working group I to the fourth assessment report of the Intergovernmental panel on climate change. Cambridge University press, Cambridge.

Jacobs (2004) Strategy for flood and coastal erosion risk management: groundwater flooding scoping study (LDS 23), Final Report.

JBA (2005) Scoping Study into the cost of flooding using the August 2004 event as a case study. Scottish Executive, Edinburgh.

JBA (2012a) Evaluation of the Defra property-level flood protection scheme. Environment Agency project.

JBA (2012b) Establishing the cost effectiveness of property flood protection. Defra project.

Jha, A.K, Bloch, R., and Lamond, J. (2012) Cities and flooding: A guide to integrated urban flood risk management for the 21st century. The World Bank, Washington DC.

Johnson, C.L, and Priest, S. L (2008) Flood risk management in England: A changing landscape of risk responsibility? International Journal of Water Resources Development, 24(4), 513-525.

Johnson, R. (2008) The role of catchment land use planning in flood risk management. Paper presented at a Workshop on Flood Management in Local Planning, Austria/Slovenia, 8-10th April 2008.

Jonkman, S. N. and Kelman, I. (2005) An analysis of the causes and circumstances of flood disaster deaths. Disasters, 29, 75-97.

Jongejan, R. and Barrieu, P. (2008) Insuring Large-Scale Floods in the Netherlands. The International Association for the Study of Insurance Economics. The Geneva Papers, 2008, 33, 250–268.

Joseph, R., Proverbs, D., Lamond, J. and Wassell, P. (2011) An analysis of the costs of resilient reinstatement of flood affected properties: A case study of the 2009 flood event in Cockermouth. Structural Survey, 29 (4), 279-293.

Joseph, R. D. (2014) Development of a comprehensive systematic quantification of the costs and benefits of property level flood risk adaptation measures in England. PhD thesis, University of the West of England.

Kazmierczak, A. and Bichard, E. (2010) Investigating homeowners' interest in property-level flood protection. International Journal of Disaster Resilience in the Built Environment, 1(2), 157 – 172.

Koerth, J., Vafeidis, A., Hinkel, J. and Sterr, H. (2013) What motivates coastal households to adapt pro-actively to sea-level rise and increasing flood risk? Regional Environmental Change, 1-13.

Kreibich, H., Seifert, I., Thieken, A. H., Lindquist, E., Wagner, K. and Merz, B. (2011) Recent changes in flood preparedness of private households and businesses in Germany. Regional Environmental Change, 11, 59-71.

Krzysztofowicz, R., Kelly, K., and Long, D. (1992) Reliability of Flood Warning Systems. Journal of Water Resource Planning Management, 120, 906–926.

Lamond, J E, Proverbs, D.G. and Hammond, F.N. (2009) Accessibility of flood risk insurance in the UK: confusion, competition and complacency. Journal of Risk Research, 12(6), 825–841.

Lamond, J. E., Booth, C., Hammond, F.N. and Proverbs, D.G. (2012a) Flood Hazards: Impacts responses for the Built Environment. CRC Press, USA.

Lamond, J. Bhattacharya, N. and Bloch, R. (2012b) The role of solid waste management as a response to urban flood risk in developing countries, acase study analysis. In: Proverbs, D., Mambretti, S., Brebbia, C. and De Wrachien, D., eds (2012) Flood recovery innovation and response. Sothampton: WIT Press, pp 193-205.

Langdon, D. (2011) Research to identify potential low-regrets adaptation options to late change in the residential buildings sector. AECOM.

Lancaster, J.W., Preene, M. and Marshall, C.T. (2004) Development and flood risk: guidance for the contruction industry. London: CIRIA, (C624).

Lawlor, G., Currier, B.A., Doshi, H., and Wieditz, I. (2006) Green roofs: A resource manual for municipal policy makers. Canada Mortgage and Housing Corporation, Canada.

Leitch, J.A. and Shultz, S. (2007) Floods and Flooding. In Encyclopedia of Water Science. Taylor and Francis, New York, Published online, 300-305.

Lumbroso, D., Gaume, E., Logtmeijer, C., Mens, M., van der Vat, M. (2008) Evacuation and traffic management. Floodsite.

Macdonald, D.M.J, Bloomfield, J.P., Hughes, A.G., MacDonald, A.M., Adams, B. and McKenzie, A.A. (2008) Improving the understanding of the risk from groundwater flooding in the UK. Proceedings of FLOOD Risk 2008, European Conference on Flood Risk Management, Oxford, UK, 30 September to 2 October 2008. CRC Press, the Netherlands.

Messer, F. and Meyer, V. (2005) Flood damage, vulnerability and risk perception – challenges for flood damage research.UFZ, Discussion papers.

Messner, F., Penning-Rowsell, E., Green, C., Meyer, V., Tunstall, S. and Van der Veen, A. (2007) Evaluating flood damages: guidance and recommendations on principles and methods. Helmholtz Centre for Environmental Research – UFZ. FLOODsite Project report.

Meyer, V. and Messner, F. (2005) National Flood Damage Evaluation Methods – A Review of Applied Methods in England, the Netherlands, the Czech Republic and Germany. FlOODsite project report**.**

Meyer,V., Kuhlicke, C., Schwarze, R., Scholz, M., Haase, D., and Luther, J. (2013) 100 % flood protection is not possible – we need four pillars of sustainable flood mitigation and adaptation measures [Online] Available at: https://www.ufz.de/(Accessed: 15 September 2013)

MGSDP (2012) Metropolitan Glasgow Strategic Drainage Partnership. Briefing note 9.

Mitchell, R.C. and Carson, R.T. (1989) Using surveys to value public goods: the contingent valuation method. Baltimore: Johns Hopkins University Press.

MR-G (1997) Flooding and insurance. Munchener Ruckversicherungs-Gesellschaft.

Munich Re (2005) Land Under Water - Flood loss trends. [Online] Available at: http://www.munichre.com/ (Accessed: 22 December 2010).

Murphy J., Sexton D., Jenkins G., Boorman P., Booth B., Brown K., Clark R., Collins M., Harris G. and Kendon E. (2009). Climate Change Projections, Version 2, UK Climate Projections.

Nisbet, T., Silgram, M., Shah, N., Morrow, K. and Broadmeadow, S. (2011) Woodland for Water: woodland measures for meeting Water Framework Directives. Forest Research Monograph: 4

O'Neill, M. and O'Neill, J. (2012) Social Justice and the Future of Flood Insurance. Joseph Rowntree Foundation.

Paklina, N. (2003) Flood insurance. OECD.

Pallant, J. (2007) SPSS survival manual: A step by step guide to data analysis using SPSS. 3rd ed. Buckingham: Open University Press.

Parker, D. and Fordham, M. (1996) Evaluation of flood forecasting, warning and response systems in the European Union. Water Resource Management 10, 279–302.

Paranjothy, S., Gallacher, J., Amlôt, R., Rubin, G.J., Page, L., Baxter, T., Wight, J., Kirrage, D., McNaught, R., Palmer, S.R. (2011) Psychological impact of the summer 2007 floods in England. BMC Public Health 2011, 11:145.

Patrick, S. (2002) The future of flood forecasting. Bulletin of the American Meteorological Society, 183.

Pender, G., and Faulkner, H. (2010) Flood Risk Science and Management. Wiley-Blackwell, Oxford, UK.

Penning-Rowsell, E., Tunstall, S., Tapsell, S., and Parker, D. (2000) The benefits of flood warnings: Real but elusive, and politically significant. Journal of the Chart. Inst. Water Environ. Management, 14, 7–14.

Penning-Rowsell, E. C., Johnson, C., Tunstall, S., Tapsell, S., Morris, J., Chatterton, J., Coker, A. and Green, C. (2003) The Benefits of flood and coastal defence: techniques and data for 2003. Flood Hazard Research Centre, Middlesex University.

Penning-Rowsell, E. C., Johnson, C, Tunstall, S., Tapsell, S, Morris, J., Chatterton, J., Green, C (2005) The benefits of flood and coastal risk management: a manual of assessment techniques. Middlesex University Press, London.

Penning-Rowsell E., Tapsell, S., Johnson, C., Wilson, T. (2006) Development of economic appraisal methods for flood management and coastal erosion protection. EA/Defra joint project.

Persoons, E., Vanclooster, M. and Desmed, A. (2002) Flood Hazard Causes and Flood Protection Recommendations for Belgian River Basins. Water International, 27(2), 202-207.

Pitt, M. (2008) The Pitt Review: Lessons learned from the 2007 floods. Cabinet Office, London.

POST (2007a) Urban flooding. Postnote Number 289, Parliamentary Office of Science and Technology, London.

POST (2007b) Climate Change Science. Postnote, Number 295, Parliamentary Office of Science and Technology, London.

POST (2011) Natural Flood Management. 396. Parliamentary Office of Science and Technology, London.

Rackhecha, P. R. and Singh, V.P. (2009) Applied Hydrometeorology: floods. Springer Netherlands, 343-376.

Ramsbottom, D., Floyd, P. and Penning-Rowsell, E. (2003) Flood and Coastal Defence R&D Programme: Flood Risks to People Phase 1. Defra/Environment Agency.

Ramsbottom, D., Sayers, P. and Panzeri, M. (2012) Climate Change Risk Assessment for the Floods and Coastal Erosion Sector. Climate Change Risk Assessment. Defra Project Code GA0204, DEFRA. London.

RIBA (2009) Designing for flood risk. The Royal Institute of British Architects. [Online] Available at: http://www.architecture.com/Files/RIBAHoldings/PolicyAndInternationalRelations/Policy/Environment/2Designing_for_floodrisk.pdf (Accessed: 10 June 2012).

RIBA (2011) Sustainability and Climate Change. The Royal Institute of British Architects. [Online] Available at: http://www.architecture.com/Home.aspx (Accessed: 10 June 2012).

Robson, C. (2002) Real World Research: A Resource for Social Scientists and Practioner-Researchers. 2nd ed. Oxford: Blackwell Publishers.

Roode, N., Van Heuvel, T., and Misdorp, R. (2011) The Netherlands: flood, erosion and management. CCC Part I - Chapter 2: The Netherlands. Coastal planning and implementation. [Online] Available at: www.coastalcooperation.net (Accessed: 22 December, 2012).

Royal Haskoning (2012) Assessing the economic case for property level measures in England. Bretton, UK.

RPA (2004) The appraisal of human related intangible impacts of flooding. Report FD2005/TR Joint DEFRA/EA Flood and Coastal Erosion Risk Management R&D Programme.

Safecoast (2008) Coastal flood risk and trends for the future in the North Sea region, synthesis report. Safecoast project team. The Hague, 136.

Sandink, D. (2013) Urban flooding in Canada:Lot-side risk reduction through voluntary retrofit programs, code interpretation and by-laws. ICLR research paper series, number 52, Canada.

Scottish Borders Council (2011) Hawick Town Centre Direct Flood Defences – Options Assessment. Non-technical report by Halcrow.

Scottish Executive (1999) Climate change: Scottish Implications Scoping study. Edinburgh.

Scottish Executive (2004) Scottish Planning Policy (SPP7): Planning and Flooding. [Online] Available at: http://www.scotland.gov.uk/Resource/Doc/47210/0026394.pdf (Accessed: 01 September 2011)

Scottish Excecutive (2007) Impact of Flooding in Scotland: In-house GIS analysis using the SEPA Indicative Flood Map 2007Summary results. [Online] Available at: http://www.scotland.gov.uk/Resource/Doc/198321/0053031.pdf (Accessed: 15 December 2011).

Scottish Government (2010) Flood Risk Management Act: Annual report to parliament 2009. Scottish Government, Edinburgh.

Scottish Government (2010) Flood prevention progress. [Online] Available at: http://www.scotland.gov.uk/News/Releases/2010/05/13155431 (Accessed: 15 December 2011).

SEPA (2010) 2,000 homes and businesses to benefit from new SEPA flood warning scheme. [Online] Available at: http://www.sepa.org.uk/about_us/news/2010/new_flood_warning_scheme.aspx (Accessed: 10 December 2012).

Scottish Government (2011) The Flood Risk Act: Delivering Sustainable flood risk management – a consultation. Scottish Government, Edinburgh.

Scottish Government (2008) Consultation on ‘The Future of Flood Risk Management in Scotland’. Edinburgh.

Scottish Government (2011) The Flood Risk Act: Delivering Sustainable flood risk management – a consultation. The Scottish Government, Edinburgh.

SEPA (2006) Indicative River & Coastal Flood Map (Scotland) Summary of Technical Methodology. SEPA, Stirling.

SEPA (2011) National Flood Risk Assessment. SEPA, Stirling.

SFF (2012) Forming a Scottish Community Flood Resilience Group. [Online] Available at: http://www.scottishfloodforum.org/flood-groups/ (Accessed: 15 June 2011).

Stanke, C., Murray, V., Amlôt, R., Nurse, J. and Williams, R. (2012) The effect of flooding on mental health: Outcomes and recommendations from a review of literature. PLOS Current Disasters. Ed 1.

Simonovic, S.P. (2002) Two New Non-structural Measures for Sustainable Management of Floods. Water International, 27(1), 38-46.

Smith, K. and Fewtrell, L. (2006)Examination of the possible health risk due to urban flooding: toxicological agents in fluvial systems. Urban flood management report for FRMRC, University of Wales, Aberystwyth University.

Smith, K. and Ward, R. (1998) Floods – Physical Processes and Human Impacts. Chichester.

Soetanto, R. and Proverbs, D.G. (2004) Impact of flood characteristics on damage caused to UK domestic properties: the perceptions of building surveyors. Structural Survey, 22(2), 95-104.

Spalding, J.V. (1954) A general survey of the damage done and action taken. Conference on the North Sea Floods of 31 January – 1 February 1953. The Institute of Civil Engineers, London, 3-15.

Swiss Re (2012) Flood – an underestimated risk inspect, inform, insure. Zurich, Switzerland.

Terpstra, T. and Gutteling, J. M. (2008) Households' perceived responsibilities in flood risk management in the Netherlands. International Journal of water resources development. 24(10), 555-565.

Thieken, A. H., Petrow, T., Kreibich, H., and Merz, B. (2006) Insurability and Mitigation of Flood losses in private households in Germany. Risk analysis. 26(2), 383-395.

Thurston, N., Finlinson, B., Breakspear, R., Williams, N., Shaw, J. and Chatterton, J. (2008) Developing the Evidence Base for Flood Resistance and Resilience. DEFRA/EA, Technical Report FD2607/TR1, London.

Trombetta, M. J. (2008) Environmental security and climate change: analysing the discourse, Cambridge Review of International Affairs, 21(4), 585-602.

Tunstall, S., Tapsell, S., Green, C., Floyd, P. and George, C. (2006) The health effects of flooding: Social research results from England and Wales. Journal of Water and Health, 4(3), 365-380.

UKCIP (2009) UK Climate Projections. UK Climate Impacts Programme, Defra. [Online] Available at: http://www.defra.gov.uk/publications/files/pb13274-uk-climate-projections-090617.pdf (Accessed: 14 December 2012).

UK Floodgates (2012) Unique protection against floodwater [Online] Available at: http://www.floodgate.ltd.uk/products.html (Accessed: 09 November 2012).

UN (1992) United Nations Framework Convention on Climate Change: Definitions. Article1. [Online] Available at: http://unfccc.int/essential_background/convention/background/items/2536.php (Accessed: 14 December 2012).

UNICEF (2012) An urban world. [Online] Available at: http://www.unicef.org/sowc2012/urbanmap/# (Accessed: 08 October, 2012).

UN-HABITAT (2010) Hidden Cities: unmasking and overcoming health inequities in urban setting. WHO. Printed in Switzerland, 1-10.

Van Griensven, F., Chakkraband, M.L., Thienkrua, W., Pengjuntr, W., Lopes Cardozo, B., Tantipiwatanaskul P., et al. (2006) Mental health problems among adults in tsunami-affected areas in southern Thailand. JAMA, 296(5), 537-48.

Van Ree, C.C.D.F., Van, M.A, Heilemann, K., Morris, M.W, Royet, P. and Zevenbergen, C. (20011). FloodProBE: technologies for improved safety of the built environment in relation to flood events. Environmental science & policy, 14 (7), 873-883

Van Stokkom, H.T.C., Smith, A.J.M. and Leuven, R.S.E.W (2005) Flood defense in the Netherlands. Water International, 30(1), 76-87.

Ward, R. (1978) Floods, A Geographical Perspective. The MacMillan Press, London.

Werner, M. (2005) FEWS NL Version 1.0 – Report Q3933, Delft Hydraulics, Delft.

Werner, M., Rreggiani, P., De roo, A., Bates, P., and Sprokkereef, E. (2005) Flood Forecasting and Warning at the River Basin and at the European Scale. Natural Hazards, 36, 25-42.

Werner, M., Cranston, M., Harrison, T., Whitfield, D. and Schellekens, J. (2009) Review: Recent developments in operational flood forecasting in England, Wales and Scotland. Meteorological Applications,16, 13-22.

Warren, R., Tindle, A., and Whalley, R. (2011) Flood resilient repairs and resistant measures: Qualitative and quantitative research to examine the views of consumers. ABI research Paper No 28.

Werritty, A., Black, A and Duck, R. (2002) Climate change: flooding occurrences review. Scottish Executive, Edinburgh.

Werritty, A. and Chatterton, J. (2004) Foresight Future flooding: Scotland. Office of Science and Technology, Department of Trade and Industry.

Werritty, A., Houston, D., Ball, T., Tavendale, A. and Black, A. (2007) Exploring the social impacts of flood risk and flooding in Scotland. Report to the Scottish Executive.

White, I., O'Hara, P., Lawson, N., Garvin, S. and Connelly, A. (2012) Barriers to flood resilience: Findings from the SMARTest project. The University of Manchester and BRe, Manchester.

Wingfield, J., Bell, M. and Bowker, P. (2005) Improving the flood resilience of buildings through improved materials, methods and details: report number WP2c – review of existing information and experience (final report). Leeds Metropolitan University, Leeds.

Wheater, H. and Evans, E. (2009) Land use, water management and future flood risk. Land Use Policy, 26, 251-264.

WHO (2002) Floods: climate change and adaption strategies for human health.UK, London. Report on a WHO meeting 30 June – 2July 2002.

Zsamboby, M., Fernández-Bilbao, A., Smith, D., Knight, J., Allan, J. (2011) Impact of Climate change on disadvantaged UK coastal communities. Joseph Rowtree Foundation.