

# **Present and future flood vulnerability, risk and disadvantage**

A UK assessment

## **EXECUTIVE SUMMARY**

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## Overview

Developing a better understanding of the relationship between social vulnerability and exposure to flood risk across different communities is a prerequisite to delivering a socially just (*i.e.* fair) approach to prioritising flood risk management efforts within national policy and funding structures. The Future Flood Explorer (UK-FFE, Sayers *et al.*, 2015) has been used here to assess present day social vulnerability to flooding and resulting flood disadvantage across the UK and how this may change in the future in response to exogenous influences (*e.g.* climate change and population) and endogenous influences (*e.g.* flood management policy and its broader impacts on issues such as insurance). In doing so, a *Neighbourhood Flood Vulnerability Index* (NFVI) is introduced and used to compare risks between more and less flood vulnerable neighbourhoods (where vulnerability is characterised in terms of communities experiencing a loss in wellbeing when floods occur) and a *Social Flood Risk Index* (SFRI) is used to identify where vulnerability and exposure coincide to create flood disadvantage.

The results highlight significant variation in flood disadvantage across the UK. For example, ten local authorities account for fifty percent of the most vulnerable people that live in flood prone areas (those living in the 5% most vulnerable neighbourhoods according to the NFVI). Coastal areas, declining urban cities and dispersed rural communities are also highlighted as representing the greatest concentrations of disadvantage (as measured by the *Social Flood Risk Index*, SFRI<sup>1</sup>). When income and insurance penetration are considered, the *Relative Economic Pain*<sup>2</sup> (a metric defined here as the ratio between uninsured loss and income) is significantly in vulnerable communities than elsewhere.

Re-analysis of the Environment Agency's Long-Term Investment Scenarios (LTIS) (for England), which are used to support the case for investment in flood risk management, suggest there is a robust economic case for improving protection afforded to the most vulnerable communities. The reason for this is unclear but nonetheless suggests that there is both a utilitarian imperative (that seeks to maximise return on investment) as well as a Rawlsian rationale (that preferentially targets the most vulnerable) to reduce flood risk in the most vulnerable communities.

Low income and poor health are important drivers of flood vulnerability and are more influenced by broader planning and welfare policy than flood risk management policy. Delivering flood risk management (FRM) more effectively therefore requires greater effort to bring together, and be supportive of, multiple government and private sector investment streams to achieve overall policy goals. This includes preferentially selecting interventions to both reduce flood risk and have wider

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<sup>1</sup> Defined here as the product of the NFVI, the number of people exposed, the flood probability.

<sup>2</sup> In recognition of the varying coping capacity between more affluent and lower income households, this metric captures the relationship between uninsured economic damages and household income – Discussed further in Section 3 of the report.

health and wellbeing benefits (for example, green infrastructure approaches) and support other policy agendas.

## Study focus

Social vulnerability in the context of floods relates to how flooding impacts on and creates losses in people's wellbeing. Delivering socially just FRM thus requires two central issues to be addressed. The first relates to addressing **geographic flood disadvantage** (places where many socially vulnerable people are exposed to flooding) and requires an understanding of where the most socially vulnerable communities are located and their exposure to flooding. The second relates to addressing **systemic flood disadvantage** (the degree to which the most vulnerable communities are disproportionately affected by flooding) and requires an understanding of the degree to which FRM policy (and its implementation in practice) successfully delivers socially just outcomes (as expressed by the comparative risks faced by more and less vulnerable communities).

To better understand the geographic and systemic nature of flood disadvantage the analysis here seeks to:

- (i) Identify those neighbourhoods at greatest flood disadvantage now and in the future (through to the 2020s, 2050s and 2080s) across the UK;
- (ii) Assess the degree to which FRM can be considered socially just; and
- (iii) Identify policy gaps and recommend policy changes to improve flood resilience and reduce disadvantage.

## Key findings: Flood disadvantage now and in the future

The Future Flood Explorer (FFE) has been used to quantify present and future flood risk for the whole of the UK through to the 2080s, based on two climate futures (+2°C and +4°C), two population growth scenarios (high and low) and assuming current levels of adaptation (CLA) continue. The key findings from this analysis are presented below.

### Floodplain population, vulnerability and exposure to frequent flooding

- The most vulnerable neighbourhoods are over-represented in areas prone to flooding (all sources), but most significantly in areas prone to coastal (and tidal) flooding.
- The proportion of people living in the most vulnerable neighbourhoods is much greater in Northern Ireland than elsewhere in the UK.
- Over 50% of those exposed to flooding and living in the most vulnerable neighbourhoods are in just ten local authorities.
- By the 2080s more and less vulnerable neighbourhoods will both experience more frequent floods.

Today approximately 6.4 million people live in flood prone areas, with around 1.5 million (or 23.4% of these people), living in the 20% most vulnerable neighbourhoods. Within all neighbourhoods, 31% (2 million people) are exposed to frequent flooding from either fluvial (river), coastal or surface water sources (with a return period of 1:75 years or more frequent). Of those, 6.1% live within the 5% most flood vulnerable neighbourhoods (ranked in the top 5% by Neighbourhood Vulnerability Index (NFVI), a measure of the propensity of those that live in a neighbourhood to experience a loss of well-being should a flood occur). This is a factor of 1.2 (20%) higher than would be expected (assuming exposure to flooding to be equally distributed between more and less vulnerable

neighbourhoods). Of the 1.8 million people living in the coastal floodplain, 33% are within the 20% most vulnerable neighbourhoods and 10% in the 5% most vulnerable neighbourhoods (top 5% by NFVI). This is a significant over-representation. In Northern Ireland 55% of the population exposed to flooding live in the top 20% of neighbourhoods by NFVI (almost double the UK average) and 25% of the total population exposed to frequent flooding are in the 5% most vulnerable neighbourhoods (almost five times the UK average); with the most significant disadvantage seen in Belfast (a finding that also reflects the higher levels of poverty that exist in Northern Ireland compared to other parts of the UK).

Seventy-five local authorities (approximately one fifth of the UK total) account for 50% of those living in flood prone areas. The concentration becomes more marked when the most vulnerable neighbourhoods (top 5% by NFVI) are considered, with over 50% of people exposed to flooding in the most vulnerable neighbourhoods located in just ten local authorities (Hull, Boston, Belfast, Birmingham, East Lindsey, Glasgow, Leicester, North East Lincolnshire, Swale District, and Tower Hamlets).

The number of people living in flood prone areas is set to increase by 45% to 10.8 million people by the 2080s, assuming high population growth. Combined with a +4°C climate future, and assuming current approaches to adaptation continue, 6.4 million people will be exposed to frequent flooding, up from 2 million today (an increase of over 200%). In the most vulnerable neighbourhoods the increase is equally dramatic, again more than trebling, from 451,000 today to 1.4 million by the 2080s (an increase of over 200%). The greatest increases are experienced in England and in areas prone to surface water and fluvial flooding.

#### **Expected annual damage (EAD) and the influence of income and insurance**

- At a UK scale EAD is dominated by England, but from the perspective of the most vulnerable neighbourhoods the contribution from other nations is greater.
- In England and Northern Ireland, the average EAD per person is highest in the most vulnerable neighbourhoods.
- Today, vulnerable neighbourhoods contribute two-thirds of the EAD in Northern Ireland, but their future contribution rises fastest in Scotland.
- At the coast, the most vulnerable neighbourhoods experience disproportionately high levels of EAD, today and in the future.
- Lower income and lower levels of insurance penetration heighten the 'relative economic pain' of flooding in vulnerable neighbourhoods (across all sources of flooding).
- EAD is set to rise, from £351 million today, residential direct damages only, to £1.1 billion by the 2080s<sup>3</sup>.

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<sup>3</sup> Assuming a +4°C climate future, high population growth and a continuation of current adaptation approaches.

Residential EAD from flooding across the UK is £351 million (residential property only). These headline figures also mask the disproportional risks faced by vulnerable communities in all four nations. In Northern Ireland, the 20% most vulnerable neighbourhoods account for 67% of the EAD (in Scotland the equivalent figure is 22%, in England 22% and Wales 26%). This reflects a significant contribution from Belfast.

At the coast, the 5% most vulnerable neighbourhoods account for 10% of the EAD; the 10% most vulnerable contribute 19% and the 20% most vulnerable 32%. This implies that the risk experienced by the most vulnerable communities is much higher than the average; a disproportionality that persists into the future.

Those living in flood prone areas in Scotland experience the highest EAD per person (on average, £113 per person); this is over double that of England (on average, £50 per person). By the 2080s (assuming a +4°C climate future and high population growth) the EAD per person in Scotland increases to £183 per person (compared to £95 per person in England) with the risk in the most vulnerable neighbourhoods (top 20% by NFVI) increasing twice as quickly as elsewhere (increasing from £93 to £206 per person). This is not the case in England, Wales and Northern Ireland where more and less vulnerable neighbourhoods experience a similar rate of increase in EAD per person.

Low incomes and low levels of insurance penetration means the REP associated with flooding is much greater in vulnerable neighbourhoods than elsewhere. In areas prone to coastal/tidal flooding, for example, the most vulnerable neighbourhoods (top 5% by NFVI) experience over twice the REP of less vulnerable neighbourhoods; in fluvial floodplains, it is three times higher. By the 2080s (under all scenarios) the increase in EAD translates to significant increases in the REP across the UK and all sources of flooding, particularly for the most vulnerable neighbourhoods.

#### **Urban and rural influences on flood disadvantage**

- Many socially vulnerable people live in urban areas prone to flooding, however vulnerable people living in rural settings are often exposed to more frequent flooding (and hence, on average, higher levels of EAD per person).
- By the 2080s, all neighbourhoods experience significant increases in EAD, with the most vulnerable neighbourhoods in more dispersed settings (both urban and rural) experiencing slightly greater increases than elsewhere.

At a UK scale, people living in more vulnerable neighbourhoods in the fluvial and coastal floodplains are mostly in urban settings (840,000, over 90% of the total 900,000 of the people exposed to flooding in more vulnerable neighbourhoods) whereas the remaining 60,000 in rural settings are exposed to more frequent flooding (reflected in an EAD per person, on average, of £76 compared to £42 in urban settings).

By the 2080s, assuming a continuation of CLA, there is a significant increase in risk across all settlement types. In many settings, more and less vulnerable neighbourhoods experience similar increases. In dispersed urban and rural settings however, the most vulnerable neighbourhoods experience slightly higher percentage increases in risk when compared to less vulnerable neighbourhoods.

### Local authorities and flood disadvantage

- Clusters of high social flood risk exist in local authorities across the UK.
- In some cases, flood disadvantage is highly localised, in others it is widespread.
- In most cases, local authorities that experience the highest level of flood disadvantage today continue to do so in the future. There are however several exceptions where the increase is much faster than elsewhere.

The SFRI provides the most direct measure of flood disadvantage (where exposure to flood risk and social vulnerability coincide) and highlights Hull, Boston, Belfast, East Lindsey, Glasgow, Swale, Newham, Leicester, Shepway, North East Lincolnshire, and Birmingham as the ten most flood disadvantaged local authorities in UK.

Flood disadvantage typically reflects areas where a large number of vulnerable people are exposed to flooding (such as in Hull). In such situations, conventional flood defences are more likely to be feasible (technically and economically). Elsewhere, however, flood disadvantage may be highly localised and reflect the exposure of a small number of vulnerable people to frequent flooding. When considered from this perspective, other areas emerge as experiencing high levels of disadvantage, such as West Somerset, for example, where highly localised (individual and community based) approaches may be needed to manage flood risks.

Across the Highlands of Scotland, Cardiff, Enfield, North Somerset, Tower Hamlets and Haringey the rate of increase in SFRI is significantly higher than elsewhere. In these authorities, the SFRI in the future is much greater than today.

### Cities in decline and their influence on flood disadvantage

- City regions in relative economic decline tend to experience levels of flood disadvantage above the UK average; suggesting flood risk could undermine economic growth in areas that need it most.
- Belfast, Grimsby, Glasgow and Hull are all examples of struggling cities where the flood disadvantage is much higher than the UK average.

Sixteen of the 24 cities classed as in relative decline by Pike *et al.* (2016) experience levels of flood disadvantage above the UK average. This reflects a combination of influences but is driven by higher than average levels of vulnerability (as shown by the NFVI) and a greater than average number of people exposed to frequent flooding (in Glasgow, for example, those living in the floodplain are almost twice as likely to experience frequent flooding than the UK average). When income and insurance penetration are considered, the '*relative economic pain*' associated with flooding is significantly higher in these sixteen cities, reflecting the lower levels of income (on average) and lower levels of insurance.

### Suitability of 'deprivation' as a guide for FRM investment

- The Index of Multiple Deprivation (IMD) fails to identify all areas of greatest flood vulnerability; with flood risk in the most vulnerable areas (defined by the NFVI) consistently greater than that in deprived areas (defined by the IMD).

The UK government collects data on deprivation across a range of domains (including income, health, housing quality, availability of services) associated with geographic areas. These are then combined into a measure of multiple deprivation (the Index of Multiple Deprivation, IMD) and used

across government to understand the distribution of social inequalities associated with a neighbourhood and to inform resource allocation. The IMD is not however a measure of 'flood vulnerability' per se and flood risk in the most vulnerable areas (as defined here using the Neighbourhood Flood Vulnerability Index) is consistently greater than in deprived areas (as defined by the IMD). This suggests that the IMD fails to identify all those areas that are at greatest flood disadvantage. Given the role of the IMD in FRM policy across the UK (including supporting the identification of investment priorities in England through the FDGiA) these differences may be significant and raise questions over whether the IMD is the most appropriate measure for promoting Rawlsian principles within FRM investment decisions.

#### **Recent developments in vulnerable neighbourhoods (England)**

- Recent developments (2008-14) in areas prone to frequent coastal and surface water flooding (1-in-75 years or more frequent) have disproportionately taken place in the most vulnerable neighbourhoods.
- By the 2080s all developments built between 2008-14 will experience a significant increase in exposure to flooding. Across all sources of flooding the increase is greatest in those developments built in the most vulnerable neighbourhoods (but this is particularly the case in coastal floodplains).

Analysis by the Adaptation Sub-Committee (ASC) of new developments built between 2008-14 found that floodplain development continues (ASC, 2015). Further review of this analysis highlights that of the 1,199,000 new residential developments built in the period 2008-14 (ASC, 2015), 225,000 (or 20%) were built in flood prone areas (across all sources) with one in four of those properties being built in the 20% most vulnerable neighbourhoods. Vulnerable neighbourhoods in coastal and surface water floodplains have experienced greatest disproportionality in development. For coastal floodplains and surface water prone areas, new properties are ~20% more likely to be in areas prone to more frequent flooding (1:75 or greater) for the 20% most vulnerable neighbourhoods than for all neighbourhoods.

By the 2080s all developments built between 2008-14 will experience a significant increase in their exposure to flooding. Across all sources of flooding the increase is greatest in those developments built in the most vulnerable neighbourhoods; a discrepancy that is most significant at the coast.

#### **Long-term investment in England: Evidence for greater investment in vulnerable neighbourhoods**

- There is strong evidence to support improving the protection provided to the most vulnerable neighbourhoods.

Reanalysis of the optimised investment scenario in England within the LTIS (used to support the case for investment in flood risk management, Environment Agency, 2014) highlights a long-term economic case for improving the protection afforded to vulnerable communities, suggesting there is both an economic and a social justice argument for improving protection. It is also clear that income (and consequently health) are important drivers of flood vulnerability and are directly influenced by broader welfare, social and economic policy. The opportunity to enhance FRM outcomes, broader policy areas will be required to address localised flood disadvantage. This will include recognising the linkage between green infrastructure responses, such as Sustainable Urban Drainage Systems (SUDS), and the wider health and wellbeing benefits they provide. It will also be increasingly important to recognise the role of planning/welfare or other social policy interventions play in either

increasing or offsetting flood disadvantage (by putting more people into areas exposed to risk in the case of planning or increasing vulnerability through cuts to welfare benefits affecting incomes).

## Policy gaps and recommendations

Two important policy findings emerge from the analysis: (i) the distribution of flood risk today suggests that, in general, vulnerable neighbourhoods have fared no differently compared to less vulnerable neighbourhoods and, in some instances, are at greater risk today, and (ii) the distribution of flood risk in the future suggests the largest increases in flood risk will, in many instances, be experienced by those areas which are currently most vulnerable. This does not imply that the current policy framework is wholly inadequate; there are many good examples of the progressive policy statements across the UK that acknowledge the need to reduce flood risk for vulnerable communities and often refer to prioritising vulnerable groups. Despite these high level aims a new approach is needed that requires FRM policy to more effectively support broader socio-economic goals (including inclusive and sustainable growth). Doing so will require a stronger Rawlsian approach to positive discrimination (in support of the most vulnerable) to be adopted alongside utilitarian and egalitarian goals.

Seven policy recommendations are made to aid this transition, namely:

**#1 Introduce new metrics that better reflect the nature of flood vulnerability and the risks faced by vulnerable neighbourhoods.**

The research presented here reinforces the inability of existing metrics to capture the differential nature of the flood risks faced by socially vulnerable communities. To overcome the deficiencies in existing approaches, the three (new) metrics are introduced here which should be considered in FRM decision-making: **Neighbourhood Flood Vulnerability Index (NFVI)** – to better identify the most vulnerable communities; **Social Flood Risk Index (SFRI)** – to better understand the combination of probability, exposure and vulnerability; and **Relative Economic Pain (REP)** – to better understand how issues of lower income and less effective insurance impact the significance of flood risk.

**#2 Reconfigure outcome measures to monitor flood disadvantage based upon a better understanding of flood vulnerability.**

To some degree FRM policies across the UK promote the notion of targeting effort towards managing the risk for the most vulnerable populations; yet there is no routine assessment of the extent to which policies achieve this (notwithstanding that in England outcomes for households in deprived areas are monitored). To do so, alternative approaches could include assessing levels of systemic flood disadvantage (by routinely recording a comparison of the risk faced by the more and less vulnerable) as well as geographic flood disadvantage (focusing, for example, on the number of homes protected in the most vulnerable neighbourhoods defined by NFVI and ranking local authorities by SFRI with clear targets to reduce risk in the worst affected neighbourhoods).

**#3 Embed positive discrimination in FRM investment decisions to target support to the most vulnerable communities.**

Many FRM policy documents across England, Wales, Scotland and Northern Ireland refer to reducing vulnerability. The only formal mechanism for targeting investment towards the most vulnerable neighbourhoods however is in England (through the preferential weighting given to protecting



households protected in deprived areas, as defined by the IMD). This process appears to have had some success, with the systemic flood disadvantage lowest in England (when viewed at a national scale for each UK nation and based on the number of people exposed to frequent flooding). Across the UK however these headline findings mask areas where disadvantage remains significant, including at the coast, in urban areas in relative economic decline, and many dispersed rural communities.

Further work is needed to formalise approaches that help vulnerable people to reduce their flood risk. This may involve formalising the preferential targeting of investment towards helping the vulnerable people in a way that recognises the context of the communities in which they live (for example, this may require a reframing the partnership funding formula in England to better reflect the differential ability to pay between businesses located in more and less vulnerable neighbourhoods). In doing so, it should also be recognised that flooding has a significant impact on the public purse, including significant and long-term physical and mental health impacts (Waite *et al.*, 2017), which also support the investment case for reducing flood risk for the most vulnerable.

**#4 Ensure FRM actively supports inclusive growth, the delivery of multi-functional and resilient developments whilst continuing to deliver flood risk reduction benefits.**

Low income and poor health are important drivers of vulnerability to flooding. These are most directly influenced by agendas outside of FRM policy (including economic and welfare policies as well as sustainable development initiatives such as those promoted by Local Enterprise Partnerships). Ensuring FRM policy plays a proactive role in supporting broader agendas, and promote interventions that not only deliver risk reduction but also co-benefits for health, wellbeing and amenity (for example, by using green infrastructure responses where possible).

**#5 Improve take-up of appropriate property level measures and wider community level approaches in vulnerable neighbourhoods.**

Government support has previously been made available to local authorities in the aftermath of a flood to provide support to householders to fund measures which improve a property's resilience or resistance to damage from flooding, over and above repairs that would normally be covered by insurance. Evidence from local case studies for this study however suggests the take-up of such grants is significantly lower in vulnerable communities than in the population as whole and highlights six issues that will be needed to improve the take-up of appropriate property level measures, including: (i) The need for an on-going grant scheme targeted towards supporting flood disadvantaged areas (not only in reaction to flood events); (ii) Streamlining access to grants for the most vulnerable; (iii) Removing/reducing the need for the most vulnerable to provide supplementary funding; (iv) Raising awareness of both the flood risks faced, the availability of grants and reputable contractors and products; (v) Supporting the role of intermediaries in enabling individual and whole communities to access financial aid, appropriately install and maintain measures (*e.g.* drawing upon the National Flood Forum, local resilience fora, flood action groups and other local routes); and (vi) Continuing to develop a complementary approach with insurance providers to incentivise/require appropriate property level measures to be in place.

**#6** Improve access to appropriate insurance for the most vulnerable by developing an insurance mechanism that bridges the gap in take-up between the more and less vulnerable.

When income and insurance penetration (a function of tenure and income) are considered, the REP associated with flooding is significantly higher in flood vulnerable neighbourhoods than elsewhere. Addressing the complex issues that exist in providing effective insurance in vulnerable neighbourhoods (including those associated with affordability, excesses, capability, awareness, and tenure) imply the solution does not lie with flood policy alone and a greater coherence between wider housing and welfare policy together with flood insurance approaches will be required. In the short term this should include evolving insurance solutions for low income households (within the period of Flood Re) to better support affordable, and appropriate, insurance for vulnerable people.

**#7** Better reflect the differential nature of the long-term flood risks faced in vulnerable neighbourhoods within national planning policy and local guidance.

To avoid exacerbating flood disadvantage through inappropriate new development, national planning policies and local planning approaches should be revisited to: (i) Take a long-term view that includes consideration of more extreme, but plausible, climate change; (ii) Ensure opportunities for blue-green responses are taken (*e.g.* sustainable urban drainage systems that promote green spaces and deliver additional health and well-being benefits that act to reduce flood vulnerability in addition to flood hazards); (iii) Ensure new developments are flood resilient; and (iv) Give greater consideration to the flood vulnerability of likely inhabitants of any new development. The opportunity provided through the Housing White Paper (*'Fixing our broken housing market'*, DCLG, 2017) should be used to promote these goals and ensure greater account is taken of flood risk in light of climate change in the future development of vulnerable neighbourhoods.

**#8** Ensure flood events do not divert significant funds inappropriately from managing risk in more vulnerable areas and do not foreclose more sustainable longer-term options.

It is well known that funding, in part at least, responds to public 'outrage'. This can lead to those with the loudest voice being prioritised over those with the greatest need. Investment made in response to a flood event should be additional investment, and not undermine established investment processes or divert funds that have been committed elsewhere. Where they are made, they must avoid foreclosing future choices (*e.g.* decisions made in haste may be counter to providing a longer-term solution including, for example, relocating communities when protection through conventional FRM approaches is no longer feasible). Understanding how to respond to emergencies whilst transitioning towards a more sustainable approach (that may require a transformative approach in the face of climate change) is a significant challenge. To do so in a socially just way will require a combination of community involvement and a policy imperative to establish objectives with communities and agree how these can be achieved to support a sustainable future (providing the procedural justice to ensure that those involved have their voice heard).

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