Environment Agency

Evidence

Social deprivation and the likelihood of flooding

Report

Version 2

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Professor Doug Wilson
Director, Research, Analysis and Evaluation

Executive summary

Flood risk exposure and social deprivation inequalities

This report provides in-depth evidence on flood risk exposure and social deprivation inequalities using the latest available data. In summary the following were found:

- There is an inequality in terms of social deprivation and flood risk exposure from all sources of flooding. In other words, people from areas classed as more deprived disproportionately face more flood risk than those living in less deprived areas. This is the case when taking into account nearby flood defences.
- Deprived coastal communities still experience significant inequalities for high and medium likelihood of flooding. These inequalities within coastal communities are more pronounced than in inland ones.
- The inequalities found within rural areas is greater than in urban areas. This is presumably because if an urban area is protected, due to its larger size, there is more chance that there is a greater mix of more and less deprived neighbourhoods. Rural areas are also more sparsely populated and therefore their economic welfare benefits tend to be less than those of more densely populated areas.
- The size of the inequality is smaller than found by a comparable 2006 study for the Environment Agency. Two potential reasons for this change are discussed:
    - Patterns of social deprivation have changed since then.
    - The National Assessment of Flood Risk now takes into account the risk-reducing capability of nearby flood defences. Thousands of schemes have been delivered over the decade between the 2 studies.

There is stronger evidence for the latter as other research shows that the patterns of social deprivation have not changed significantly since 2004. In addition, the research highlights there has been significant investment in better protecting households in the 20% most deprived areas in England.

The findings from this report suggest that recent investment has been relatively successful in addressing social deprivation and flood risk exposure inequality for the 20% most deprived areas in England. There are, however, still significant inequalities in rural and coastal areas in England.

Correction

This is the January 2021 (version 2.0), of the report *Social deprivation and the likelihood of flooding*. This version has been published to correct the definition of Outcome Measure OM2c used in the November 2020 version of this report.

Outcome Measure OM2c measures households in the 20% most deprived areas that are moved from the very significant or significant risk bands to the moderate or low risks bands, as a result of a flood capital scheme. (The previous November 2020 version of the report had incorrectly stated that OM2c measured all households in the 20% most deprived areas that moved to any lower risk band.) The correction only relates to text in Sections 1.1 and 4.2. It does not impact upon the analysis and discussion in any other sections of the report.

Contents

1 Introduction

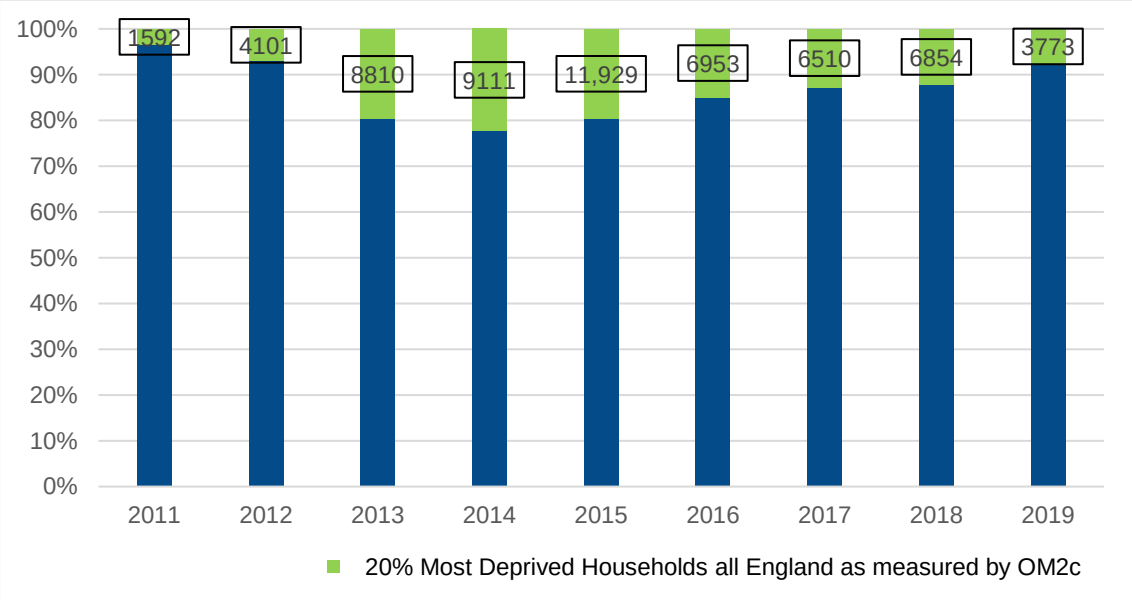
This report addresses the research question: what is the current state of the nation in terms of social deprivation and flood risk inequalities in England? The analysis in the report attempts to answer if flood risk exposure and socioeconomic inequalities still occur by exploring if specific communities, such as the most deprived, are exposed disproportionately to more flood risk.

The Environment Agency published a report in 2006 that looked at this issue in some detail (Environment Agency 2006). This report updates this work to take account of the updating of datasets and the work done to reduce flood risk in many communities over the past 15 years.

1.1 Recent investment in deprived communities

Flood management schemes in the capital programme are typically the most significant intervention for reducing the likelihood of flooding. Since 2011, the Environment Agency has measured the number of households moved into a lower likelihood band and reported these as Outcome Measures. Outcome Measure OM2 measures the total number of houses moved into a lower risk band. Outcome Measure OM2c measures households in the 20% most deprived areas (as measured by the Index of Multiple Deprivation, see Section 2.1.2) that are moved from the very significant or significant risk bands to the moderate or low risks bands. The number of households better protected in more deprived areas, as measured by OM2c, gradually increased from 2011 to 2015 but then declined again (Figure 1).

Figure 1: Percentage of households within the 20% most deprived areas of England better protected between 2011 and 2019 as measured by OM2c.



Source and notes: Progress Report on Spending Review 2010 and FCERM capital programme data. The numbers shown on the bars are the number of households moved from the very significant or significant risk bands to the moderate or low risks bands in the 20% most deprived areas (OM2c).

2 Analysis of flood risk inequalities

This chapter describes the methodology used to examine social deprivation and flood risk exposure inequality. The analysis seeks to understand whether flood risk exposure is concentrated among more socially deprived communities than others or not, using a defended flood map to update the 2006 study for the Environment Agency. A 'defended' flood map is one that takes into account the risk reduction from the existence of nearby flood defence assets. The 2006 study investigated flood risk exposure and social deprivation solely using data from 'undefended' flood models.

2.1 Data and methodology

The analysis presented in this report uses 2 data sources to investigate social deprivation and flood risk exposure inequality:

- The National Flood Risk Assessment (NaFRA)
- National Receptor Database
- Index of Multiple Deprivation (IMD) data (DCLG 2015) at the Lower Layer Super Output Area (LSOA) level

2.1.1 The National Flood Risk Assessment and the National Receptor Database

NaFRA directly counts the number of residential properties within risk bands of flood risk exposure (Environment Agency 2018) using the National Receptor database (2014) which provides data on property location. NaFRA uses the following flood risk exposure categories:

- High: each year, there is a chance of flooding of greater than 1 in 30 (3.3%)
- Medium: each year, there is a chance of flooding of between 1 in 30 (3.3%) and 1 in 100 (1%)
- Low: each year, there is a chance of flooding of between 1 in 100 (1%) and 1 in 1,000 (0.1%)
- Very Low: each year, there is a chance of flooding of less than 1 in 1,000 (0.1%)

Previous methods relied on overlaying LSOA boundaries with postcode geodata for all residential properties in the UK taken from the Ordnance Survey. Flood zone maps were then used to determine which residential properties within each LSOA were at risk of flooding. The previous work used the different categories of risk shown in Table 1.

Table 1: Categories of flood risk used in the 2006 study

Zone	Level of risk	Annual probability of flooding
1	Little	<0.1% (1 in 1,000 year floods) from rivers and the sea
2	Low to medium	>0.1% (1 in 1,000 year floods) from rivers >0.1% (1 in 1,000 year floods) from the sea
3	High	≥1.0% from rivers ≥0.5% from the sea

Source: Environment Agency (2006)

These differences are, however, reconcilable as Zone 1 is the same as the NaFRA risk category 'Very Low'. In addition, Zone 2 is equivalent to the NaFRA risk category 'Low' and Zone 3 is equal to the sum of the number of households within the 'High' and 'Medium' risk categories in NaFRA[1].

The 2006 report also relies on undefended flood models, that is, the flood models do not take into account whether or not an area at risk is better protected by a flood defence.

This report relies instead on a defended model which incorporates information on flood defences for example, their location, standard of protection and condition (from National Flood and Coastal Defence Database or local sources) that are linked with the 50m x 50m impact zones to identify which defences affect which impact zones. Information about the height of the natural banks affecting each impact zone is also added. Predicted flood water levels (in-channel water levels from fluvial models and overtopping rates from coastal models) produced by local modelling are compared to the height of the natural banks and the defences to calculate the likelihood of flooding from defences and natural banks overtopping for each impact zone. The same predicted flood water levels are then compared to the condition of defences to calculate the likelihood of the defences failing and the effect that this would have on each impact zone. This estimates the likelihood of defences failing for 40 different return periods. The volume of water entering the floodplain is calculated and the Rapid Flood Spreading method is used to route water over the land. The overall likelihood of flooding for each impact zone is calculated by combining the calculated results

One similarity with the previous study is the method used to estimate the population exposed to flood risk. To derive this estimate in the older study, the population estimates for each LSOA were divided by the number of residential properties within the LSOA to derive the number of people per household at the LSOA level. This ratio was then applied to the number of households falling within any of the flood zones and LSOAs to arrive at an estimate of the number of people exposed to flood risk in Zones 2 and 3.

2.1.2 Index of Multiple Deprivation

The 2015 version of the IMD (DCLG 2015) uses the same approach, structure and methodology as used to create previous versions of the index (2004, 2007 and 2010).

The IMD is a relative measure of social deprivation and describes each LSOA by combining information from all 7 domains of deprivation:

[1] The number of households (and therefore people) within Flood Zone 3 with the new data can be calculated as the number of households in the Medium and High risk categories of NaFRA added together.

- Income Deprivation
- Employment Deprivation
- Health Deprivation and Disability
- Education Skills and Training Deprivation
- Barriers to Housing and Services
- Living Environment Deprivation
- Crime

A description of which indicators are associated with these domains is given in Table 2.

Table 2: IMD domains (2015)

Domain	Description
Income	Number of: – Adults and children in Income Support families – Adults and children in income-based Jobseeker's Allowance families – Adults and children in income-based Employment and Support Allowance families – Adults and children in Pension Credit (Guarantee) families – Adults and children in Child Tax Credit and Working Tax Credit families not already counted – Asylum seekers in England in receipt of subsistence support, accommodation support, or both
Employment	Number of: – Claimants of Jobseeker's Allowance – Claimants of Employment and Support Allowance – Claimants of Incapacity Benefit – Claimants of Severe Disablement Allowance – Claimant of Carer's Allowance
Health	Number of: – Years of potential life lost – Comparative illness and disability ratio – Acute morbidity – Mood and anxiety disorders
Education, Skills and Training	Children and young people: – Key Stage 2 attainment: average points score – Key Stage 4 attainment: average points score – Secondary school absence – Staying on in education post 16 – Entry to higher education Adult skills: – adults with no or low qualifications – English language proficiency

Crime	Recorded crime rates for: – Violence – Burglary – Theft – Criminal damage
Barriers to Housing	Geographical barriers: – Road distance to post office: primary school; general store or supermarket; GP surgery Wider barriers – Household overcrowding – Homelessness – Housing affordability
Living Environment	Indoors living environment: – Housing in poor condition – Houses with central heating Outdoors living environment: – Air quality – Road traffic accidents

There are 2 issues to note when making comparisons between different versions of the IMD due to minor changes in the underlying indicators of deprivation over time.

First, the underlying populations have changed because the 2004 IMD used population estimates from the 2001 Census while the 2015 IMD used estimates from the 2011 Census. Population estimate changes can result in changes in deprivation levels.

Second, LSOA boundaries have changed since these 2 different versions of the IMD. However, only 2.5% of English LSOAs merged, split or underwent a more complicated change.

In spite of these changes, research has shown that deprivation patterns have persisted between 2004 and 2015 at this low geographical level (Kontopantelis et al. 2018).

2.1.3 The Concentration Index

The Concentration Index is used to examine whether there is a socioeconomic-related flood risk exposure inequality. It is similar to the Gini Coefficient, but extends it by ranking the extent to which people are at risk by a socioeconomic descriptor. The Gini Coefficient, however, looks only at the population of people exposed to flood risk within the total population. It is therefore of no use for examining social deprivation and flood risk exposure inequalities, and therefore the Concentration Index is more appropriate.

Unlike the Lorenz curve (the curve used to estimate the Gini Coefficient), the Concentration Index curve can lie above the 45□ perfect equality line indicating more concentration of flood risk exposure for people at the more deprived end of social deprivation. The Concentration Index is twice the area between the concentration curve and the 45° line indicates no relationship between the 2 variables. It is defined as:

$$C = \frac{1}{n}\sum_{i=1}^{n}\left[\frac{h_i}{\bar{h}}(2R_i - 1)\right]$$

where hi is the number of people at a particular level of flood risk exposure and source, $\bar{h}$ is the average number of people at risk across all ranks of social deprivation, and Ri is the fractional (deprivation) rank (areas are ranked in terms of deprivation deciles from 1, most deprived to 10, least deprived).

C ranges from (1 − n)/n (maximal pro-deprived inequality, that is, all flood risk exposure is concentrated within the population that is relatively the most deprived area in the country) to (n−1)/n (maximal pro-least deprived inequality). In this case, the maximal pro-deprived inequality is a score of approximately –0.9 while maximal pro-least deprived inequality is near 0.9.

The Concentration Index is a commonly used statistical measure in the health sector. For example, it was used in a study in northern Sweden which explored and quantified income-related inequalities in mental health in a population consisting of over 25,000 participants in a 2014 health survey. The study found the overall Concentration Index of mental health in northern Sweden was −0.15, which was described as a 'substantial' inequality (Amroussia et al. 2017).

3 Results of the analysis of flood risk inequalities in England

3.1 Flood risk exposure and social deprivation

In terms of the total population at risk from river, sea and surface water flooding, 5.3 million people in England are estimated to live in Low risk areas (Flood Zone 2) while 2.5 million live in either High or Medium risk areas (Flood Zone 3) (Table 3). This number is not directly comparable with the 2006 report as that did not look at surface water risk.

The negative Concentration Indices shown in Panel A of Table 3 indicate that there are inequalities between people at different levels of social deprivation and flood risk exposure in England. More specifically, individuals who are more socially deprived disproportionately bear more flood risk than less deprived people. Figure 2 shows the risk by deprivation decile.

Table 3: Population at risk from river, sea and surface water flooding by deprivation decile and risk level

Panel A

Deprivation decile	High or Medium Risk (Zone 3)	Percentage	Low Risk (Zone 2)	Percentage
1	221,938	9%	634,352	12%
2	256,492	10%	620,183	12%
3	295,672	12%	640,959	12%
4	284,188	11%	570,417	11%
5	285,050	11%	520,605	10%
6	272,802	11%	505,810	9%
7	263,178	10%	489,900	9%
8	242,102	9%	465,507	9%
9	222,893	9%	449,956	8%
10	208,447	8%	429,986	8%
Total	2,552,762		5,327,675	
Concentration Index	–0.03		–0.08	

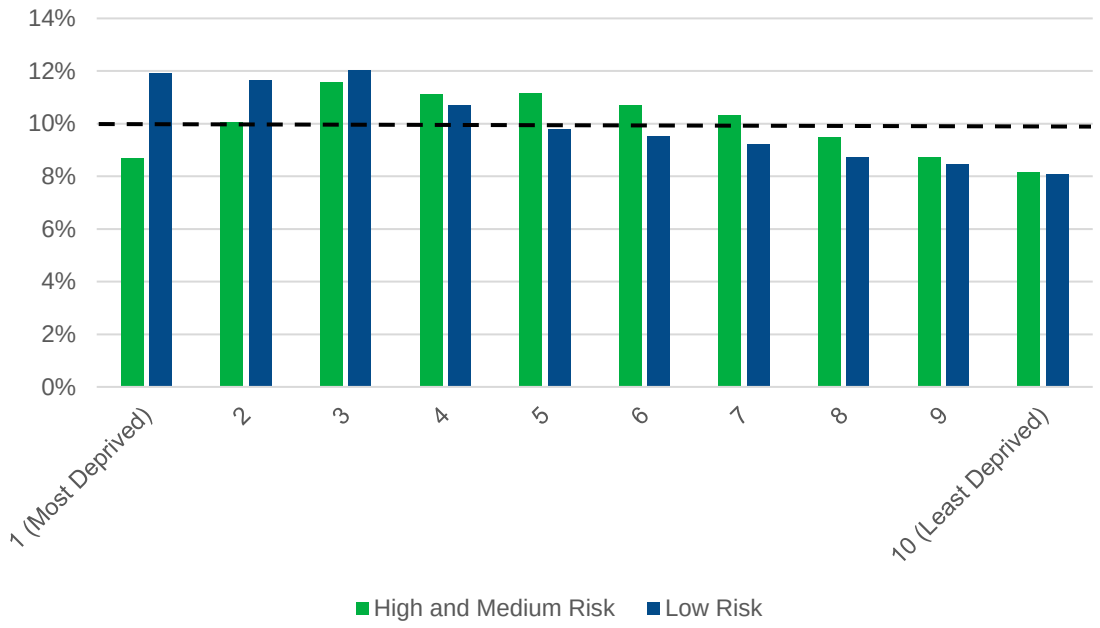
Panel B

Concentration Index subsamples			
Urban	–0.02		–0.07
Rural	–0.08		–0.06

Coastal	–0.15	–0.18
Inland	–0.02	0.07

Panel B of Table 3 shows the values for the Concentration Indices for different subsamples of the population living in urban/rural and coastal/inland areas. The indices indicate that the inequalities are greater within rural and coastal areas where more deprived households are exposed to High or Medium flood risk than comparatively less disadvantaged areas.

Figure 2: Percentage of total population at different levels of risk from river, sea and surface water flooding by deprivation decile



3.2 Population at risk from river and sea flooding

An estimated total of 1.3 million people in England live in areas of high risk of exposure to flooding from the rivers and sea (that is, a risk of greater than 1% annual probability) (Table 4). Around 1.8 million live in areas that have a lower risk of flooding (between 0.1% and 1% annual probability from the rivers or sea). Figure 3 shows the risk by deprivation decile.

This shows an improvement from 2006 when, taking into account capital investments showing that risk has been reduced by 800,000, it was calculated that 4.1 million people were at risk from river and sea flooding at a Low flood risk exposure and nearly 3.3 million were exposed to a higher risk of flooding.

The analysis also shows that social deprivation and flood risk exposure equalities have decreased as measured by the Concentration Indices shown in Table 4. The Concentration Index for higher risk of flooding is –0.03, a fall from –0.15 in 2006. Put differently, the 2 most deprived deciles used to account for 26% of at risk people, now they form 17% of the households at this level of risk.

The inequalities existing at Low risk areas have also shown an improvement in social deprivation equality in terms of flood risk exposure, although it is smaller in terms of

magnitude (the Concentration Index in 2006 was –0.19). This presumably reflects the prioritisation of capital investments in areas of greater flood risk exposure in England, as it is rare for a project to move households from Low to Very low risk. Instead, schemes tend to move households from High or Medium risk to Low risk.

Table 4: Population at risk from river and sea flooding by deprivation decile and risk level

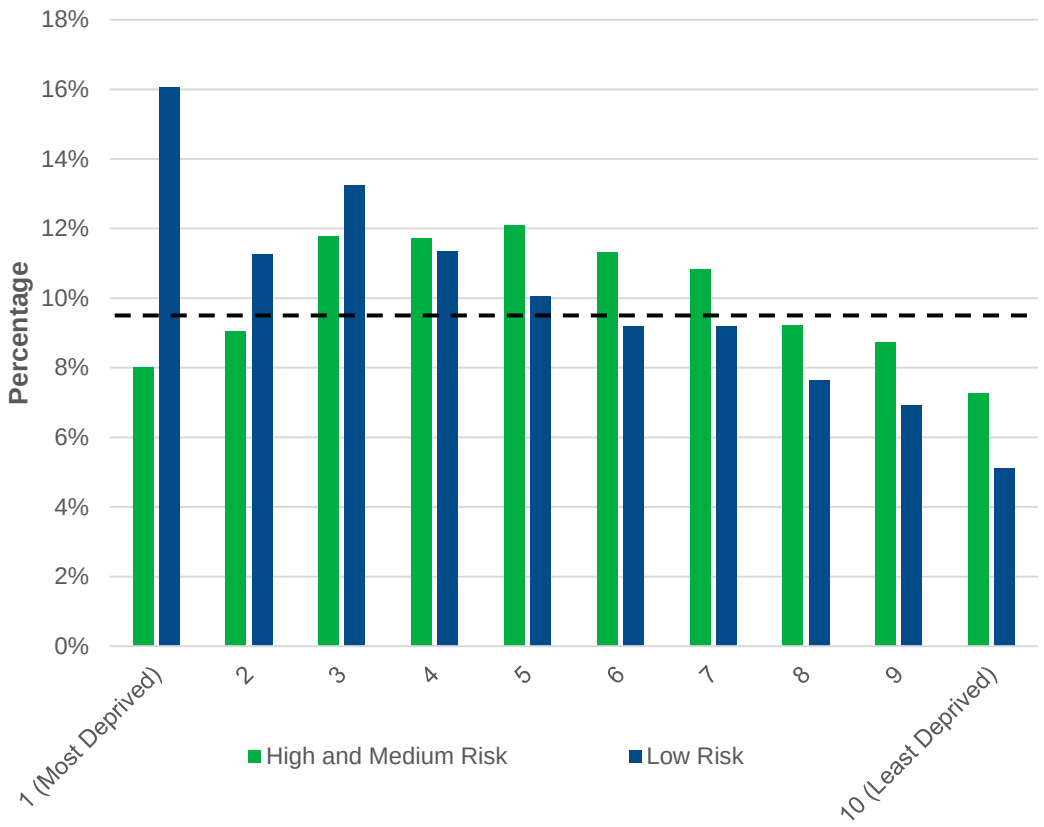
Panel A

Deprivation decile	High or Medium Risk (Zone 3)	Percentage	Low Risk (Zone 2)	Percentage
1	107,713	8%	292,549	16%
2	121,556	9%	205,019	11%
3	158,060	12%	241,439	13%
4	157,606	12%	206,534	11%
5	162,577	12%	183,171	10%
6	151,837	11%	167,568	9%
7	145,559	11%	167,556	9%
8	123,689	9%	139,059	8%
9	117,228	9%	125,955	7%
10	97,696	7%	93,063	5%
Total	1,343,521		1,821,913	
Concentration Index	**–0.03**		**–0.16**	

Panel B

Concentration Index for subsamples			
Urban	–0.03		–0.15
Rural	–0.13		–0.25
Coastal	–0.17		–0.23
Inland	–0.01		–0.15

Figure 3: Percentage of total population at different levels of risk from river and sea flooding by deprivation decile



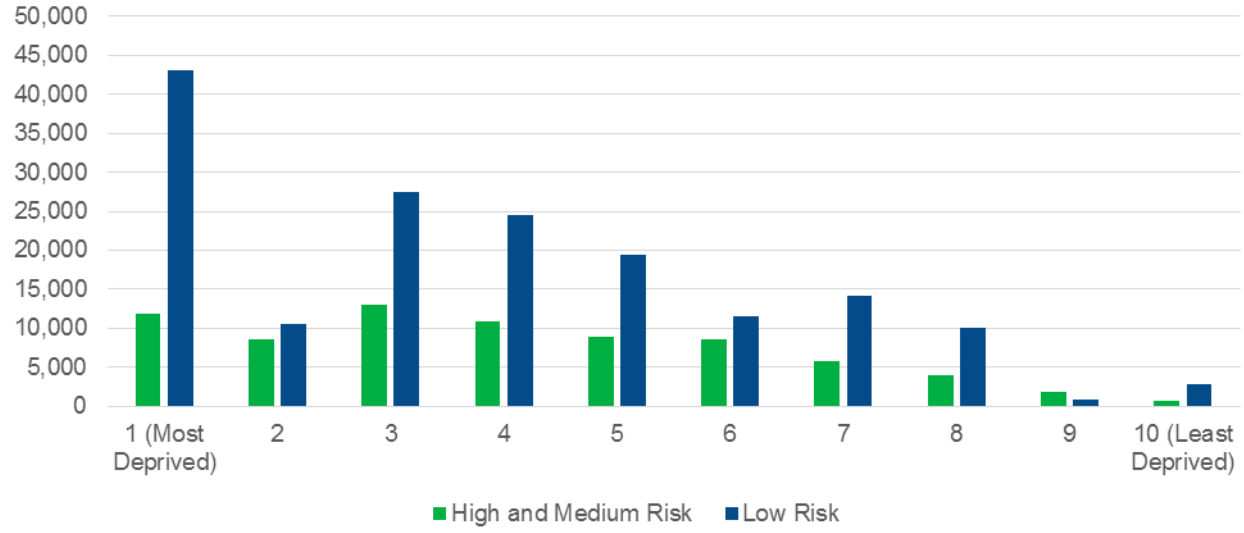
3.3 Subsample analysis: urban v rural, coastal v inland

Panel B of Table 4 shows the values of the Concentration Indices within urban, rural, coastal and inland areas of England. Any difference between urban and rural or between coastal and inland area is statistically significant as the whole population of England is under study.

Social deprivation and flood risk exposure inequality is worse in rural and coastal areas for High or Medium risk. This is because the Concentration Index values are more negative for rural and coastal areas (–0.13 and –0.17 respectively). Comparing the coastal sea flooding Concentration Index from this analysis with those from Environment Agency (2006) shows a large reduction in inequality to exposure as the previous study reported values of –0.33 for High or Medium risk (Flood Zone 2 and 3).

Figure 4 shows the absolute estimated number of households at risk from flooding in the respective national social deprivation deciles in coastal areas. It shows there are around 12,000 households in the 10% most deprived areas in the country at High or Medium risk from flooding by river and sea flooding on the coast. This is more than the combined total of the 4 least deprived deciles.

Figure 4: Total households at different levels of risk from river and sea flooding by deprivation decile within coastal areas



3.4 Population at risk from surface water flooding

An estimated 1.4 million are at risk from medium to higher risk of flooding from surface water. Just over 4.2 million people are at Low risk from surface water flooding (Table 5).

The negative Concentration Indices in Table 5 imply that risk of exposure to surface water flooding is more concentrated for people in areas that are relatively more socially deprived. The subsample comparisons demonstrate that surface water risk is more evenly distributed in rural areas while, in urban areas, the risk is more concentrated in areas that are more deprived. There are no significant differences between coastal and inland inequalities – both show a concentration of the flood risk exposure in more deprived areas (Table 5, Panel B). Figure 5 shows the risk by deprivation decile.

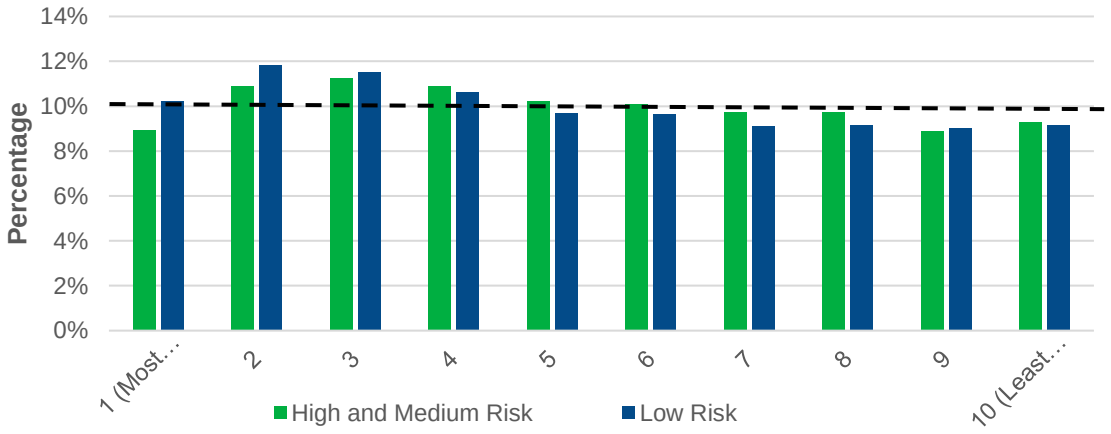
Table 5: Population at risk from surface water flooding by deprivation and risk level

Panel A

Deprivation decile	High or Medium risk (Zone 3)	Percentage	Low risk (Zone 2)	Percentage
1	121,248	9%	425,897	10%
2	148,232	11%	493,075	12%
3	153,147	11%	480,026	12%
4	147,996	11%	442,550	11%
5	138,657	10%	404,557	10%
6	137,127	10%	401,703	10%
7	132,574	10%	380,300	9%
8	132,367	10%	381,441	9%
9	120,901	9%	376,446	9%

10	126,529	9%	382,126	9%
England total	1,358,776		4,168,121	
Concentration Index	**–0.02**		**–0.05**	
Panel B				
Concentration Index subsamples				
Urban	–0.01		–0.04	
Rural	0.03		0.04	
Coastal	–0.07		–0.06	
Inland	–0.02		–0.05	

Figure 5: Percentage of total population at different levels of risk from surface water flooding by deprivation decile



4 Discussion of findings

This chapter discusses the findings of the analysis presented in Chapters 2 and 3. The results are summarised and then compared with widely cited studies from the past 15 years. The aim of these comparisons is to identify the extent to which the social distributional issues associated with flood risk management have persisted or changed over the past 15 years.

This study found that the social deprivation and flood risk exposure inequalities appear to be lower than those from the 2006 study (Environment Agency 2006). Inspection of the findings suggests this may be due to 3hree different reasons.

First, as mentioned, the flood extents take into account defences reducing risk for benefitting areas. Second, new defences have been built over the past 12 years in more deprived areas. Third, the spatial distribution of deprivation has changed since 2006, although research has shown that the patterns of deprivation have remained relatively unchanged since the 2004 IMD (Kontopantelis et al. 2018).

4.1 Summary of the analytical findings for inequalities

The analysis in Chapter 2 explores how the population exposed to the likelihood of flooding is distributed in places ordered by their deprivation (categorised into 10 deciles). The likelihood of flooding (termed 'flood hazard') was measured using Environment Agency (Environment Agency 2018).

Two flood hazard categories were use: a 'high and medium' likelihood combined category and a 'low' category. Flooding from rivers, sea and surface water were analysed, all combined and also for rivers and sea combined and surface water separately. Deprivation was measured using the standard government IMD data from 2015.

Inequality was measured using the Concentration Index, which is commonly used in the public health sector as a measure of health inequalities. This statistical measure of a distribution allows a single value to be calculated for the whole dataset. It ranges from –0.9 to 0.9, with 0 representing equality and a negative number indicating inequality with more deprived disproportionately bearing more of the flood risk. The values of the Concentration Index calculated for England are summarised in Table 6, which shows that inequalities exist for all forms of flood hazard.

Table 6: Inequality as measured by the Concentration Index for likelihood of flooding ranked by deprivation for the population of England

Flood hazard	High or Medium	Low
All (river, sea and surface water flooding)	–0.03	–0.08
River and sea flooding	–0.03	–0.16
Surface water flooding	–0.02	–0.05

Previous work has identified that coastal communities in deprived areas are associated with flood risk. The analysis therefore also measured the inequality for coastal and inland populations, where coastal communities are defined as places with a coastline.

The results are given in Table 7, which shows that deprived coastal communities still experience inequalities for a high and medium likelihood of flooding.

Table 7: Inequality as measured by the Concentration Index for likelihood of flooding ranked by deprivation for coastal and inland populations in England

Flood hazard	High or Medium	Low
Inland		
All (river, sea and surface water flooding)	–0.02	0.07
River and sea flooding	–0.01	–0.15
Surface water flooding	–0.02	–0.05
Coastal		
All (river, sea and surface water flooding)	–0.15	–0.18
River and sea flooding	–0.17	–0.23
Surface water flooding	–0.07	–0.06

The analysis also measured the inequality for urban and rural populations using the Office for National Statistics definition of rural areas. This is given in Table 8, which shows that deprived rural communities experience inequalities for river and sea flood hazard.

Table 8: Inequality as measured by the Concentration Index for likelihood of flooding ranked by deprivation for urban and rural populations in England

Flood hazard	High or Medium	Low
Urban		
All (river, sea and surface water flooding)	–0.02	–0.07
River and sea flooding	–0.03	–0.15
Surface water flooding	–0.01	–0.04
Rural		
All (river, sea and surface water flooding)	–0.08	–0.06
River and sea flooding	–0.13	–0.25
Surface water flooding	+0.03	+0.04

4.2 Summary of the findings for capital schemes

Flood management schemes in the capital programme are typically the most significant intervention for reducing the likelihood of flooding. Since 2011, the Environment Agency has measured the number of households moved into a lower likelihood band and reported these as Outcome Measures (see Section 1.1). Outcome Measure OM2 measures the total number of houses moved into a lower risk band. Outcome Measure OM2c measures households in the 20% most deprived areas that are moved from the very significant or significant risk bands to the moderate or low risks bands.

The 5 years of data from 2011 to 2015 showed an increase in the proportion of the 20% most deprived areas OM2c households in the overall total (OM2). It started at a

low level of 4% in 2011 but increased to 29% in 2014. The average for the 5 years was 17%. In terms of households, around 35,500 were recorded as OM2c.

Many of these flood management schemes were coastal schemes with just 6 accounting for over half (18,200 households) of the OM2c total. These were the Humber, Lincshore, Thames Tidal, Grimsby Docks, Anchorsholme and Rossall schemes (Environment Agency 2015).

Between 2016 and 2019, the annual proportion of OM2c category households has declined from 24% to 8%. The average for these 4 years was 13% and the total is 24,090 households in the OM2c category.

4.3 Comparing these analytical findings to previous studies

4.3.1 Comparison of the current study with the 2006 Environment Agency study

One of the primary aims of this work was to update the analysis published in 2006 with current data. In addition, the flood hazard likelihood data used in 2006 were from an early version of NaFRA. This did not model the benefits of existing defences (that is, it overestimated the likelihood of flooding), a known weakness of the analysis at the time.

Table 9 compares the 2006 study with the current analysis. Note that:

- different definitions of flood hazard and coastal areas were used in the 2 studies
- surface water flooding is excluded from the results presented in the table

Table 9: Inequality as measured by the Concentration Index for likelihood of flooding ranked by deprivation – comparison of the 2006 report and the current analysis

Flood hazard	High or Medium	Low
2006 report		
River and sea flooding	–0.15	–0.19
Coastal sea flooding	–0.32	–0.33
Current analysis		
River and sea flooding	–0.03	–0.15
Coastal areas	–0.17	–0.23

The current analysis still finds inequalities in the exposure to the hazard of flooding (as measured by likelihood and ranked by deprivation). However, the size of the inequality is smaller than found in the 2006 study. The difference is explained by changes in the 2 main datasets.

- The IMD has been updated twice since the 2006 study. The current study uses the 2015 deprivation data.
- NaFRA has been updated several times too. It now models the benefits of flood management schemes and many schemes have been delivered over the decade between the 2 studies.

Looking at the changes, the most significant one is the inclusion of flood management schemes – both pre-existing and new ones built in the past decade – in the NaFRA flood hazard exposure modelling. The IMD has not changed significantly in general terms (Kontopantelis et al. 2018).

4.3.2 Comparison between the current study and other previous studies

A number of other studies have looked at social distributional issues associated with flooding in England.

The 2011 study published by the Joseph Rowntree Foundation (JRF) looked not only at exposure to hazards but also the vulnerability of society to hazards (Lindley et al. 2011). The study used 'disadvantage' as the term for their index that measures the combination of hazard exposure and vulnerability. In the case of flooding, it used both the exposure to flood hazard and social vulnerabilities to flooding when constructing its measure of disadvantage.

In 2016, the JRF published another report which looked at flood disadvantage again and also how flood investment is targeted (England and Knox 2016). The report explored which neighbourhoods received investment and whether flood disadvantaged ones benefitted or not from flood investments.

In 2017, the JRF funded a piece of work by Sayers and Partners which also looked at flood disadvantage (Sayers et al. 2017).

Also in 2017, the Adaptation Sub-Committee of the Committee on Climate Change Climate published an evidence report on climate change risk assessment which reviewed the distributional impacts, including risks and vulnerabilities to flooding. Chapter 8 of this report on cross-cutting issues is particularly relevant.

Table 10 summarises the findings from these 4 studies and compares them to the findings from the analysis in this report. In general, the current analysis is consistent with these widely cited studies.

Table 10: Comparison of studies

Study	Findings	Comparison to findings in this report
Climate change, justice and vulnerability (Lindley et al. 2011)	Most socially vulnerable neighbourhoods are in large urban centres and costal component is notable.	Not directly comparable as it included social vulnerability to flooding in calculation of flood disadvantage.
	Some 7.5% of English neighbourhoods were found to be extremely flood disadvantaged, with Yorkshire and Humberside having the highest concentration.	Deprivation found to be a significant factor but several other social characteristics were also found to be important.
Targeting flood investment and policy to minimise flood disadvantage (England and Knox 2016)	Flood disadvantage found to be a better 'indication of likely community preparedness and impacts' than the IMD alone.	Inequality measure based on the IMD does not take into account impacts, only exposure to the hazard.
	The analysis 'suggests there is not a strong link between those local authorities that contain the most flood disadvantaged	There was significant investment in flood management schemes

Study	Findings	Comparison to findings in this report
	neighbourhoods, and levels of planned expenditure'.	between 2011 and 2016, especially in coastal areas.
UK Climate Change Risk Assessment 2017: Evidence Report Chapter 8 (Street el al. 2017)	The chapter reviews distributional impacts in Section 8.3.2 and draws upon the same authors as studies discussed here.	The Climate Change Risk Assessment re-states the correlation between the likelihood of coastal areas flooding and deprivation.
Present and future flood vulnerability, risk and disadvantage (Sayers et al. 2017)	The most vulnerable neighbourhoods are over-represented in areas prone to flooding and significantly over-represented in areas prone to coastal flooding. The study identified higher flood risk rural areas as being more vulnerable.	Same pattern for flood inequality and flood vulnerability measures, including it being a more significant issue for coastal communities. Inclusion of surface water flooding in both studies does not change overall situation. Both studies identified the greater inequality (or vulnerability) of rural areas exposed to higher likelihood of flooding.
	The vulnerability index focuses more on loss of well-being than the IMD index that measures deprivation in general terms.	The inequality measure in this report looks at exposure to the likelihood of flooding only, not vulnerability.

4.4 Summary of the evidence base on social distributional issues associated with flooding in England

This section summaries the findings of the current and previous studies.

- All find social inequalities (or disadvantage) for flood risk.
- The 2006 study used flood hazard exposure data that did not account for flood defences. The current study used NaFRA flood hazard data that account for flood defence schemes in the likelihood of flooding calculated. Thus the current study provides a more accurate measurement of the social inequality for flood hazard.
- All identify an increased social inequality (or vulnerability or disadvantage) issue for coastal communities.
- The 2 most recent studies (this one and Sayers et al. 2017) identify social inequalities (or vulnerability) for rural communities at a higher likelihood of flooding.
- The number of households in the 20% most deprived areas protected by new flood schemes grew significantly between 2010 and 2015, especially in coastal areas. But more recent years have seen a decline. Thus the pattern of new

capital schemes in deprived communities remains a complicated situation to analyse.

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List of abbreviations

IMD	Index of Multiple Deprivation
JRF	Joseph Rowntree Foundation
LSOA	Lower Layer Super Output Area
NaFRA	National Flood Risk Assessment
OM	Outcome Measure