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Flood disadvantage in Scotland: mapping the potential losses in well-being

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FLOOD DISADVANTAGE IN SCOTLAND: MAPPING THE POTENTIAL FOR LOSSES IN WELL-BEING

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The views expressed in this report are those of the researcher and do not necessarily represent those of the Scottish Government or Scottish Ministers.

Table of Contents

EXECUTIVE SUMMARY

1	INTRODUCTION AND AIMS	1
2	DATA AND METHODS	5
3	RESULTS AND DISCUSSION	9
	Disadvantage according to residential flood exposure	9
	Case study examples	18
4	CONCLUSION	27
5	REFERENCES	29
6	APPENDIX 1	30
7	APPENDIX 2	35
8	APPENDIX 3	36

EXECUTIVE SUMMARY

- To understand the differential impacts of hazard events like flooding on people, it is necessary to take a wider perspective than is often assumed. Assessing the exposure of areas is important. However, a wide range of distinct personal, environmental and social factors are involved in the conversion of extreme weather events into losses in well-being. Due to differences in underlying vulnerability, different places can require different policy responses, depending on the specific local personal, environmental and social factors that are most at play.

- The results presented in this report provide a first focused look at flood disadvantage in Scotland. The report aims to help policy makers and practitioners explore the potential of an approach which centres on characterising the underlying vulnerability of people and places to extreme events like flooding through indicators representing the personal, environmental and social factors behind potential losses in well-being ('socio-spatial vulnerability'[1]). The resulting knowledge about neighbourhood socio-spatial vulnerability is then set in the broad context of potential neighbourhood flood exposure to generate a picture of 'flood disadvantage'. This contrasts with many previous approaches where the main emphasis is on understanding detailed patterns of potential flood exposure with a less extensive consideration of how that exposure may translate into losses of well-being in neighbourhoods and their communities.

- A flood disadvantage map associated with coastal and fluvial (river-related) flooding has been produced for Scottish neighbourhoods. It combines existing neighbourhood level estimates of 'socio-spatial vulnerability' with an estimate of flood hazard-exposure. The measure of flood hazard-exposure is based on the percentage of residential addresses within each neighbourhood that are potentially affected by coastal or fluvial (river-related) flooding. Results have been summarised according to local authority (LA).

- It should be noted that consistent with the data available at the time of conducting the analysis and reporting, the current measures of flood hazard-exposure and flood disadvantage do not take into account any existing flood defence schemes. Furthermore, there is no consideration of pluvial flooding, i.e. when extremely heavy downpours of rain saturate the urban drainage system and the excess water cannot be absorbed. This does not affect the underlying merit of the methodology, which highlights the personal, environmental and social factors affecting vulnerability. The research findings are presented as a basis for discussion and potential further development and are intended to be used in conjunction with local knowledge to inform adaptation planning. On this basis, 34% of Scottish neighbourhoods contain residential properties which are potentially exposed to some form of coastal or fluvial (river-related) flooding, covering areas where there is only a very low likelihood of flooding in any particular year (a 0.1% chance) up to those with a higher likelihood (1.0% chance).Within these potentially exposed

[1] 'the geographical expression of the degree to which an external event has the potential to convert into well-being losses' (Lindley et al., 2011: 7).

neighbourhoods, 8.2% are estimated to be 'extremely flood disadvantaged', i.e. they typically have a high potential for losses in well-being and a high proportion of residential properties potentially affected by flood events, relative to the Scottish average[2]. These neighbourhoods represent 2.8% of all Scottish neighbourhoods. It is recommended that the personal, environmental and social factors affecting vulnerability in these neighbourhoods are considered further, in order to establish appropriate responses in each area.

- The local authorities of Moray, Falkirk, Perth and Kinross and Glasgow City have the largest proportions of their total number of neighbourhoods classed as being 'extremely flood disadvantaged' with respect to coastal and fluvial flooding. These local authorities may require additional support to build resilience within the identified neighbourhoods and their associated communities. Responding to flood events and assisting with longer-term recovery processes may also place a particular burden on these authorities.

- This mapping work aims to give policy makers and practitioners the following:

    - Information about where the main concentrations of disadvantage associated with coastal or fluvial (river-related) flooding are to be found.

    - Fine-grained information on the specific sources of disadvantage and socio-spatial flood vulnerability in different locations. Four case study examples are presented to illustrate how the data generated by the approach presented in this report could be used to better target adaptation policy and practice to the specific needs of different localities and populations.

- Mapped neighbourhood characteristics can only provide part of the evidence base required for understanding and responding to individual and community social vulnerability. However, it can provide a useful way of identifying possible areas to target as part of a wider adaptation strategy (see paragraph 2.6, page 7 for a fuller account of limitations).

- The Scottish Government is keen to explore how this work and its underlying model can be used to inform local policy and planning. The mapped results for Scotland are presented here for discussion, with a view to future development and refinement. Further work could combine the socio-spatial flood vulnerability index data with updated flood exposure model outputs, including estimates of pluvial flooding and existing flood defences. It is also recommended that the socio-spatial index work is updated to take account of the findings from the 2011 Census. Other recommendations are made in Chapter 4.

[2] The group of 'extremely flood disadvantaged' neighbourhoods may contain neighbourhoods which have acute socio-spatial vulnerability together with a lower proportion of residential properties potentially exposed to flood. Similarly the group may contain neighbourhoods where there is less extreme socio-spatial vulnerability coupled with a high proportion of residential properties potentially exposed.

1 INTRODUCTION AND AIMS

1.1 Formulating a just response to the problem of flooding requires consideration of both the potential for flood exposure and an assessment of the potential impacts of flooding on people's well-being. Much analysis to date has centred on understanding the characteristics of exposure. There has been less emphasis on the personal, environmental and social factors which help to explain why people and communities exposed to the same flood events can experience very different outcomes in their longer term well-being.

1.2 The Joseph Rowntree Foundation recently published the report *Climate change, justice and vulnerability* (Lindley et al., 2011). The associated project involved an inter-disciplinary team seeking to explore how climate change may differentially impact people's health and well-being across the UK. The work had conceptual and empirical elements. It developed core ideas and then implemented them to create mapped results. The project used the context of heat- and flood-related events as its basis. Three key concepts developed within the study were vulnerability, socio-spatial vulnerability and climate disadvantage. These are explained below.

- **Vulnerability** – The vulnerability of individuals is characterised by the degree to which an event such as a flood or a heat wave converts into losses in their well-being. A variety of personal, environmental and social conversion factors affect how far an individual is able to respond to stresses placed on well-being. Personal factors include features associated with individuals such as disability, age and health. Environmental factors include features of the physical environment such as the extent of built up areas, quality of housing stock and building elevation. Social factors include features associated with the wider social and institutional context such as levels of inequality and income, the strength of social networks and neighbourhood cohesion.

- **Socio-spatial vulnerability** – Socio-spatial vulnerability is understood as 'the geographical expression of the degree to which an external event has the potential to convert into well-being losses' (Lindley et al., 2011:7). In other words, considering how the characteristics of people and places can affect the chance of the people within any particular neighbourhood to be negatively affected by an event, irrespective of whether they come into contact with one. Socio-spatial vulnerability has five dimensions, each of which has a number of domains populated by a number of indicators (Appendix 1, Table A1.1). In the context of flooding, the five dimensions can be explained as follows:

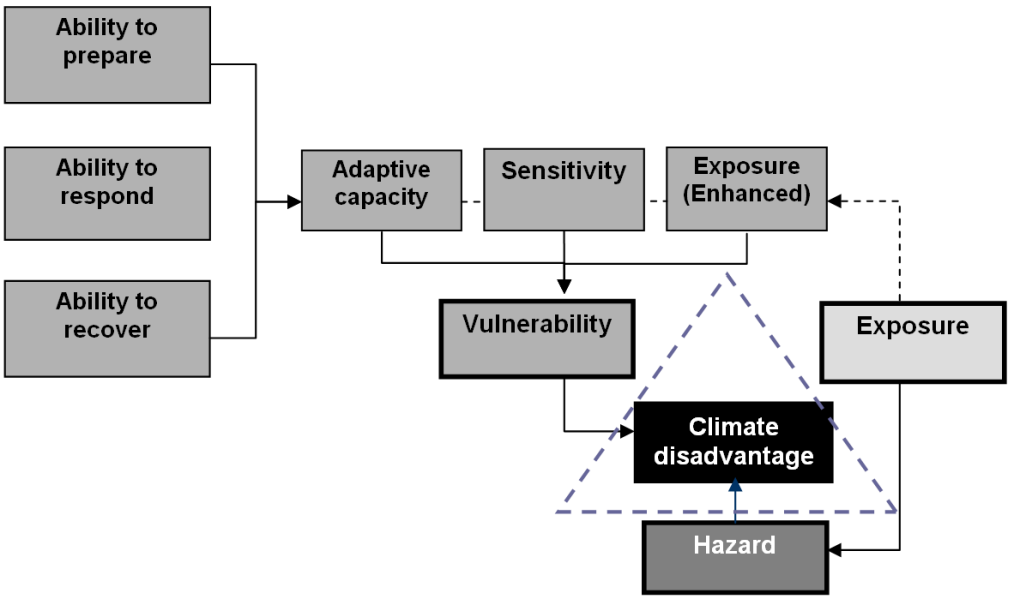
    - **Sensitivity** – factors which describe personal biophysical characteristics such as age and health. These affect people's underlying susceptibility to health-related outcomes of flood events.
    - **Enhanced exposure** – factors which describe aspects of the physical environment, such as the extent of built-up zones or housing characteristics, which tend to accentuate or mitigate the severity of flood events.

- **Ability to prepare** – factors that describe the extent to which people within a neighbourhood are able to prepare for floods, such as income, insurance and local knowledge.
- **Ability to respond** – factors that enable people within a neighbourhood to immediately respond to floods such as income, community networks and personal mobility.
- **Ability to recover** – factors that enable people within a neighbourhood to recover from floods (and thereby overcome direct and indirect impacts) such as income, insurance, housing mobility and social networks.

- **Climate disadvantage** – A combination of '(a) the likelihood and degree of exposure to a hazard and (b) individual or group vulnerability with regards to such hazards' (Lindley et al., 2011: 7). In the original report, assessing climate disadvantage involved mapping neighbourhood scale socio-spatial vulnerability against measures of hazard-exposure, such as temperature patterns and flood likelihood (chance of occurring). The method used in this report is broadly the same, but with a few technical differences and with a specific focus on flood disadvantage[3]

Figure 1 below shows how these key concepts fit within a research framework. This model includes exposure, both in terms of potential flood likelihood (hazard) and features of the environment that may accentuate the impact of flooding (enhanced exposure). This model illustrates how socio-spatial vulnerability and hazard exposure maps - both useful data in their own right - are particularly powerful when combined to map climate disadvantage.

Figure 1: Conceptual framework used in the study (from Lindley et al., 2011)



[3] It should be noted that the data used to represent potential flood exposure do not account for climate change. Further assessment of flood disadvantage will be required as and when data on the further impacts of climate change on future flood exposure become available.

1.3 The original report produced neighbourhood-scale maps of socio-spatial heat vulnerability and heat disadvantage for the whole of the UK. Socio-spatial flood vulnerability maps were similarly produced for the whole of the UK. Appendix 1 (Table A1.2) lists the set of indicators used to map Scottish socio-spatial flood vulnerability. It was only possible to map flood disadvantage for neighbourhoods in England and Wales due to a lack of available flood hazard-exposure data for Scotland and Northern Ireland. Flood hazard-exposure measures for England and Wales were derived from the Environment Agency's Nafra Spatial Grid 09/10 dataset, which was purchased for use in the project. Equivalent data were not available for Scotland within the time frame of the initial project.

1.4 The overall aim of this follow-on study is to produce flood disadvantage maps for Scotland that take into account estimated flood exposure as well as underlying socio-spatial vulnerability. This brings the Scottish data in line with maps already produced for England and Wales, though results are not directly comparable for reasons outlined in Chapter 2 (paragraph 2.4). This work uses available data for potential flood hazard-exposure supplied by the Scottish Environment Protection Agency (SEPA), through the Scottish Government. Directly equivalent data to that used for England and Wales were not available.

1.5 A map of flood disadvantage for Scottish neighbourhoods[4] has been produced (Chapter 3), by combining socio-spatial flood vulnerability with an estimate of hazard-exposure, represented by the percentage of residential addresses which are potentially affected by coastal or fluvial flooding within each neighbourhood. This is an improved flood exposure metric to that produced for England and Wales, because it gives a better representation of the proportion of people potentially affected. The flood exposure metric used to produce flood disadvantage maps for England and Wales combined socio-spatial flood vulnerability with an estimate of hazard-exposure, represented by the proportion of the land surface of the neighbourhood potentially affected by coastal or fluvial flooding. A neighbourhood may have a large land area potentially affected by flooding but this land area may not be associated with housing.

1.6 Additional work compared the historical flood event data used within the socio-spatial flood vulnerability assessment, against SEPA's current historical flood event database. In the original study, the database was used to construct a proxy indicator of potential insurance access problems (see Appendix 1, Table A1.2). The supplied data were noted as being under review, so close examination of the most recent version of the data was carried out to explore opportunities to improve the existing indicator (see paragraph 2.7 for findings).

[4] Neighbourhoods refer to Scottish Data Zones from the 2001 Census, see Chapter 2.

1.7 The results are related to four case study examples taken from the south west, the north and the central lowlands. The case studies discuss the specific sources of flood disadvantage and socio-spatial vulnerability in each selected location.

1.8 The Scottish Government is keen to explore how this work and its underlying model can be used to inform policy and planning. The mapped results for Scotland are presented here for discussion, with a view to future development. Although this work used the best available flood hazard exposure data at the time of writing, the absence of data on pluvial flooding and flood defences means conclusions should be treated with some caution and used in conjunction with local knowledge. SEPA is due to publish improved flood hazard exposure maps by the end of 2013 which, along with forthcoming neighbourhood level data from the 2011 Census, could enable the current work to be updated. Those interested in using the data to inform flood and adaptation planning can request the data via envstats@scotland.gsi.gov.uk. Feedback on the report and data can also be made to the same address.

1.9 A short summary of the data and key points of the method, as applied to Scotland, are provided in Chapter 2.

2 DATA AND METHODS

2.1 The research presented in this report is based on a quantitative geospatial assessment underpinned by the conceptual framework and literature review work reported in Lindley et al. (2011). The assessment develops and combines a series of map layers which together can be used to understand the geographical characteristics of flood disadvantage.

2.2 Table 1 summarises the data used for the work and their sources. The analysis has been carried out using the best available data at the time. Other data acknowledgements are given in Appendix 1.

Table 1 Data and data sources

Theme	Source	Date provided (version date)
Indicative River & Coastal Flood Map (Scotland) 1:100 undefended[5] fluvial flood areas[6]	SEPA	Dec 2012 (Jun 2006)
Indicative River & Coastal Flood Map (Scotland) 1:200 undefended fluvial flood areas	SEPA	Dec 2012 (Aug 2009)
Indicative River & Coastal Flood Map (Scotland) 1:1000 undefended fluvial flood areas	SEPA	Dec 2012 (Jun 2006)
Indicative River & Coastal Flood Map (Scotland) 1:100 undefended coastal flood areas	SEPA	Dec 2012 (Jan 2006)
Indicative River & Coastal Flood Map (Scotland) 1:200 undefended coastal flood areas	SEPA	Dec 2012 (Mar 2008)
Indicative River & Coastal Flood Map (Scotland) 1:1000 undefended coastal flood areas	SEPA	Dec 2012 (Jan 2006)
Ordnance Survey Address Point[7]	Scottish Government	May 2012 (Apr 2012)
Data Zones 2001 Census Boundary Derived Datasets (Scotland)[8]	EDINA UKBORDERS	Dec 2010 (Census 2001)
Historical Flood Zones	SEPA	Dec 2012 (Dec 2011)
Unitary Authority Boundaries[9]	EDINA UKBORDERS	Dec 2010 (2010_05)

Note on flood data: Fluvial flooding is flooding associated with rivers; coastal flooding is flooding associated with the sea. 1:100 refers to an event which has a 1% chance of occurring in any one year. 1:100 year events are the most likely to occur of the events considered in this study. 1:200 refers to an event with a 0.5% chance of occurring within any one year. 1:1000 refers to an event which has a 0.1% chance of occurring in any one year. A 1:1000 event therefore has the least likelihood to occur of all the events considered in this study.

[5] 'Undefended' is a SEPA term and the name of the dataset, but it should be noted that the data simply show the areas that may be affected if no fluvial or coastal flood defences were present, in other words assuming that all areas are undefended. In practice some areas identified as flood prone do have defences in place and thus have a lower chance of flooding than the data suggest.

[6] The data are technically referred to as flood extent data. The Flood Map for Scotland is an indicative map showing areas of Scotland which could experience flooding from rivers or the sea, or both.

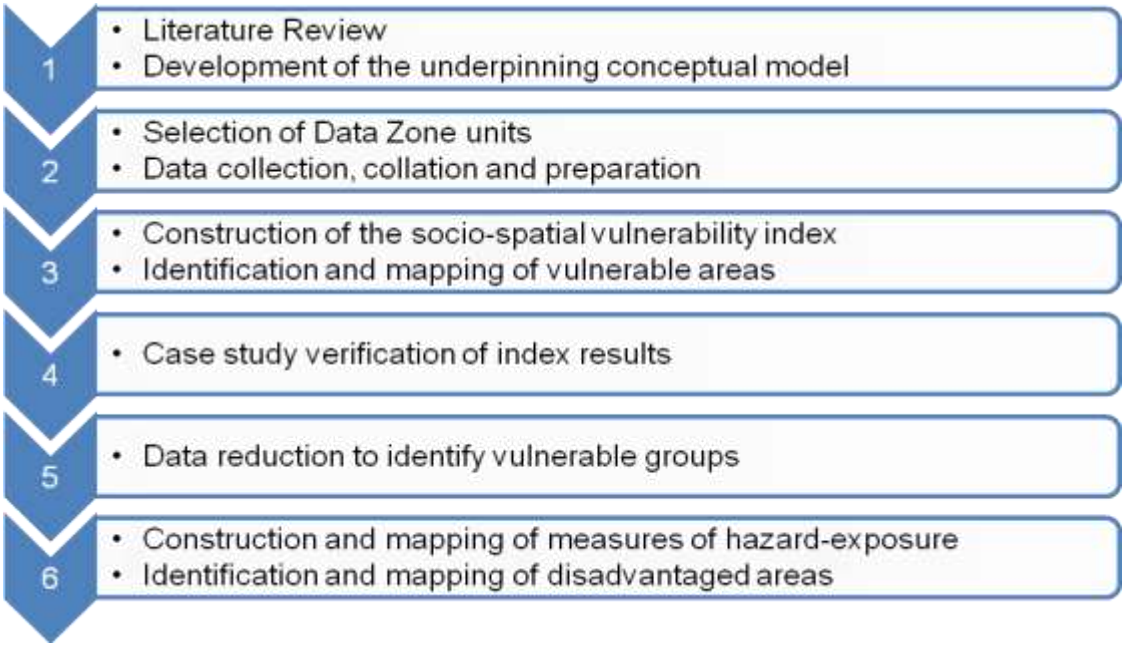
[7] Ordnance Survey, Crown Copyright.

[8] This work is based on data provided through EDINA UKBORDERS with the support of the ESRC and JISC and uses boundary material which is copyright of the Crown and the Post Office.

[9] This data is provided with the support of the ESRC and JISC and uses boundary material which is copyright of the Crown, the Post Office and the ED-LINE consortium.

2.3 The methodological basis for the production of the flood disadvantage maps, is the same as reported in Lindley et al. (2011), following the conceptual framework outlined in Chapter 1. A summary of the research stages is given in Figure 2 below. Standardised scores for neighbourhoods (Data Zone units) are combined to produce a standardised scoring scheme for the final output maps. High positive values indicate neighbourhoods with relatively high levels of socio-spatial flood vulnerability or flood disadvantage, while high negative values indicate neighbourhoods with relatively low socio-spatial flood vulnerability or flood disadvantage. Values of zero correspond to the Scottish mean. All scores have been given appropriate labels using the classification schemes outlined in Appendix 2 (Tables A2.1 and A2.2).

Figure 2 Stages in the research methodology associated with the original study (adapted from Lindley et al., 2011)



2.4 While the methods used are broadly equivalent, mapped flood disadvantage results are not directly comparable across the UK due to differences in the indicators and size of the Census units used. The Data Zone units in Scotland allow a better spatial representation of socio-spatial flood disadvantage than was used elsewhere. These units of around 750 people (500-1000) are subsequently referred to as Scottish neighbourhoods.

2.5 Two improvements to the original methodology Lindley et al. (2011) have been developed:

- Use of the percentage of residential properties as a measure of flood hazard-exposure (see paragraph 1.5), as opposed to the land surface area exposed to flooding. Residential properties are assumed to be any property without an

organization name in the Ordnance Survey Address Point data. This assumption is considered reasonable[10].

- Use of an estimate of flood disadvantage restricted only to neighbourhoods with some coastal or fluvial flood-hazard exposure. This avoids neighbourhoods which are not exposed to fluvial or coastal flooding being shown as flood disadvantaged, as a result of averaging a very high socio-spatial flood vulnerability score with a low flood exposure score. This issue was not a particular problem for assessments based on larger geographical units. However, it was considered important to address for Scotland because of: the small size of the Scottish neighbourhood units; the relatively geographically confined characteristics of some of the flood types; and the very high values of socio-spatial flood vulnerability in some neighbourhoods. An important caveat should be noted, that the study does not include pluvial flooding – surface water flooding from rainwater. Inclusion of pluvial flooding will increase the number of neighbourhoods with high flood disadvantage scores.

2.6 A number of caveats apply to the assessment and its results. These are discussed at length in Lindley et al. (2011). The quantitative methodology was informed by an extensive literature review, but mapped neighbourhood characteristics can only provide part of the evidence base required for understanding and responding to individual and community social vulnerability. The construction of Scottish Data Zones takes some account of physical and social characteristics; that is, by delineating boundaries which follow "prominent features in the physical environment" and which represent zones which are broadly socially homogenous (GI-SAT; 2011: 3; HM Government, 2013). However, even where populations are small and unit boundaries carefully chosen, the broad characteristics of neighbourhoods can never be inferred for every individual within them. The main additional caveats associated with this work are the following:

- The flood area data do not account for flood defences and therefore over-estimate hazard exposure in some areas.

- The assessment does not take account of pluvial flood likelihood and therefore under-estimates hazard exposure in some areas. Inclusion of pluvial flooding will increase the number of neighbourhoods with high flood disadvantage.

- Version dates of the provided data are inconsistent (Table 1, page 5) and in some cases are considerably different to the indicators used in the socio-spatial vulnerability analysis (Table A1.2, Appendix 1). The latter are primarily based on data from the 2001 Census. Ideally, all data would refer to the same base year, but this is often not possible in studies of this type.

[10] The resultant residential property count is within around 0.5% of the 2006 count of dwellings in Scotland reported from Ordnance Survey Address Point 2 (Scottish Government Geographic Information Science and Analysis Team (GI-SAT) 2007).

- There is no detailed consideration of residential addresses associated with flats and apartments.

2.7 The socio-spatial flood vulnerability index contains an indicator which estimates the potential ease of access to flood insurance across Scotland (Appendix 1, Table A1.2). It is constructed from area-based data within SEPA's Historical Flood Zone dataset. The area-based data are known to have incomplete coverage across Scotland. This study investigated whether point-based event data might provide a more suitable basis for the indicator. At the present time, the point-based historical flood events dataset is not considered to be a suitable basis for an alternative indicator of flood insurance access. The current dataset contains a lack of information for many events, incomplete geographical coverage and inconsistent reporting. These caveats in the dataset are well known to SEPA and reported on supply of data to potential users. Despite the limitations of its use within this particular study, the Historical Flood Zone dataset is considered a valuable resource which merits ongoing maintenance and further development.

3 RESULTS AND DISCUSSION

3.1 The primary means of reporting the flood disadvantage results is in map form. Associated summaries are provided which identify the relative number and proportions of neighbourhoods classified as 'extremely flood disadvantaged'[11] within Scottish local authorities (LA).

Disadvantage according to residential flood exposure

3.2 34% of Scottish neighbourhoods contain residential properties which are potentially exposed to some form of coastal or fluvial flooding (Table 2). Of the potentially exposed neighbourhoods, 184 (8.2%) are estimated to be 'extremely flood disadvantaged', i.e. they typically have a high potential for losses in well-being and a high proportion of residential properties potentially affected by flood events, relative to the Scottish average[11]. These neighbourhoods represent 2.8% of all Scottish neighbourhoods.

3.3 Case Studies A and B (page 18) are both within this group of 184 'extremely flood disadvantaged' neighbourhoods. The geographical distribution of flood disadvantage as a result of residential property exposure to coastal and fluvial flooding is shown in Figure 3 (page 10).

Table 2 Neighbourhood flood exposure and disadvantage associated with residential addresses by different coastal and fluvial flood types.

Flood type (code used in Figures 5 and 6)	% of neighbourhoods exposed	extremely disadvantaged as a % of exposed neighbourhoods	extremely disadvantaged as a % of all neighbourhoods
1:100 undefended fluvial (F100)	25.1	7.7	1.9
1:200 undefended fluvial (F200)	27.9	7.3	2.0
1:1000 undefended fluvial (F1000)	26.5	7.8	2.1
1:100 undefended coastal (C100)	7.8	9.2	0.7
1:200 undefended coastal (C200)	8.4	8.6	0.7
1:1000 undefended coastal (C1000)	8.7	9.2	0.8
Any flood type[12]	34.4	8.2	2.8

[11] 'Extremely flood disadvantaged' is a term used to describe neighbourhoods that have flood disadvantage scores of >=1.5 (See Table A2.1 Appendix 2 for classification scheme). The group of 'extremely flood disadvantaged' neighbourhoods may contain neighbourhoods which have acute socio-spatial vulnerability together with a lower proportion of residential properties potentially exposed to flood. Similarly the group may contain neighbourhoods where there is less extreme socio-spatial vulnerability coupled with a high proportion of residential properties potentially exposed.

[12] These figures refer to the percentage of neighbourhoods which are exposed to *any* flood type, whether that is fluvial or coastal, or is for 1:100, 1:200 or 1:1000 flood events. See the **Note on flood data** box at the end of Table 1, page 5 for the meanings of these flood recurrence terms.

Figure 3 Flood disadvantage associated with residential property exposure to <u>any coastal or fluvial flood</u> recurrence type

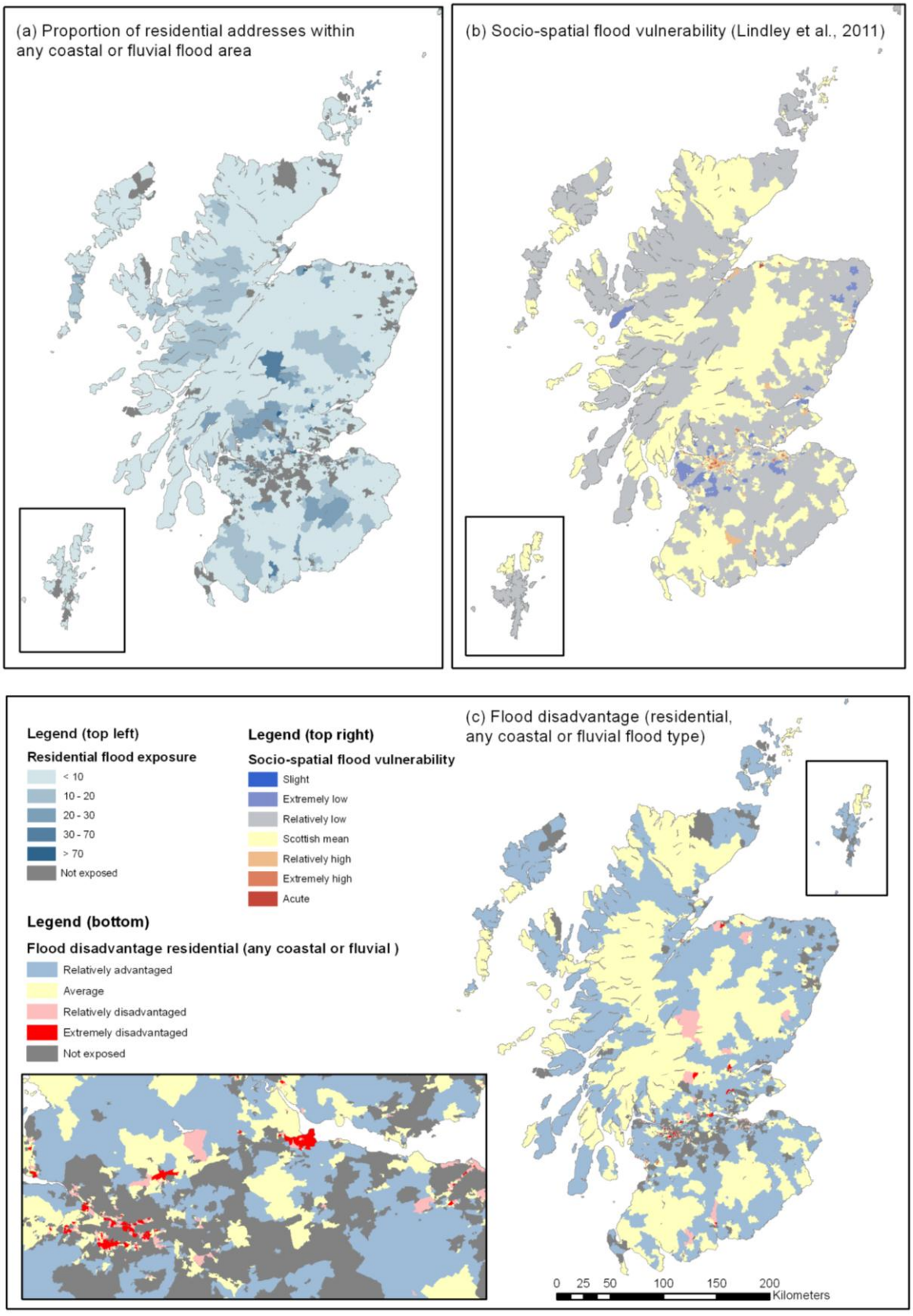
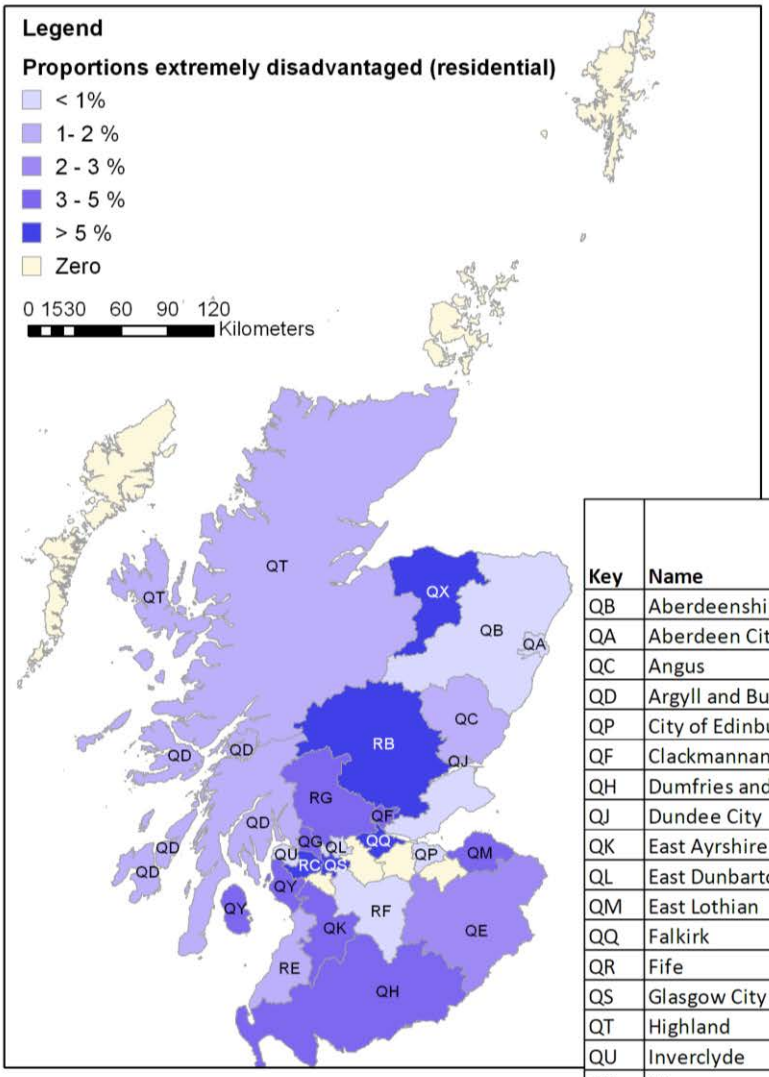
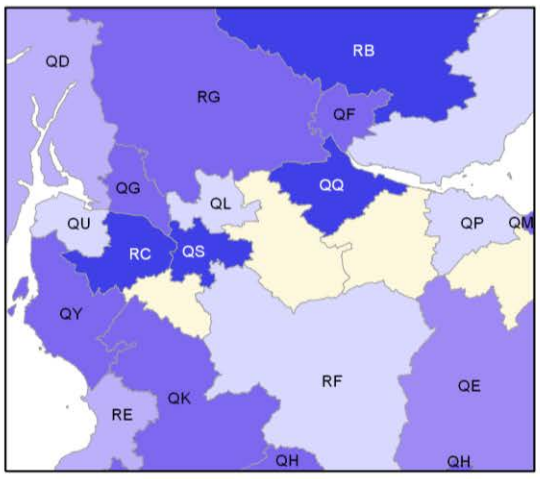


Figure 4 Proportions of neighbourhoods in each local authority classed as having extreme flood disadvantage with respect to residential exposure to any coastal of fluvial flood recurrence type





Key	Name	Extreme flood disadv.	Total count of Ns	% extreme
QB	Aberdeenshire	2	301	0.7
QA	Aberdeen City	1	267	0.4
QC	Angus	2	142	1.4
QD	Argyll and Bute	2	122	1.6
QP	City of Edinburgh	5	549	0.9
QF	Clackmannanshire	3	64	4.7
QH	Dumfries and Galloway	6	193	3.1
QJ	Dundee City	2	179	1.1
QK	East Ayrshire	6	154	3.9
QL	East Dunbartonshire	1	127	0.8
QM	East Lothian	6	120	5.0
QQ	Falkirk	20	197	10.2
QR	Fife	1	453	0.2
QS	Glasgow City	57	694	8.2
QT	Highland	5	292	1.7
QU	Inverclyde	1	110	0.9
QX	Moray	13	116	11.2
QY	North Ayrshire	6	179	3.4
RB	Perth and Kinross	17	175	9.7
RC	Renfrewshire	11	214	5.1
QE	Scottish Borders	3	130	2.3
RE	South Ayrshire	2	147	1.4
RF	South Lanarkshire	2	398	0.5
RG	Stirling	5	110	4.5
QG	West Dunbartonshire	5	118	4.2
QZ	North Lanarkshire	0	418	0.0
RH	West Lothian	0	211	0.0
QN	East Renfrewshire	0	120	0.0
QW	Midlothian	0	112	0.0
RJ	Na H-Eileanan an Iar	0	36	0.0
RA	Orkney Islands	0	27	0.0
RD	Shetland Islands	0	30	0.0

Figure notes: Only LAs with one or more 'extremely flood disadvantaged' neighbourhood are labelled on the map. Key: Extreme flood disadv: count of neighbourhoods (Ns) in the LA estimated to be 'extremely flood disadvantaged'.

3.4 The largest proportions of ‘extremely flood disadvantaged’ neighbourhoods for residential exposure to coastal or fluvial floods are found in the local authorities of Moray and Falkirk. Within each, more than 10% of neighbourhoods are classed as ‘extremely flood disadvantaged’ (Figure 4, page 11). Other local authorities with high proportions of ‘extremely flood disadvantaged' neighbourhoods are Perth and Kinross (9.7%) and Glasgow City (8.2%).

3.5 Seven local authorities have no ‘extremely flood disadvantaged’ neighbourhoods. They may however still contain relatively flood disadvantaged neighbourhoods or have extreme socio-spatial flood vulnerability in one or more dimensions of socio-spatial flood vulnerability.

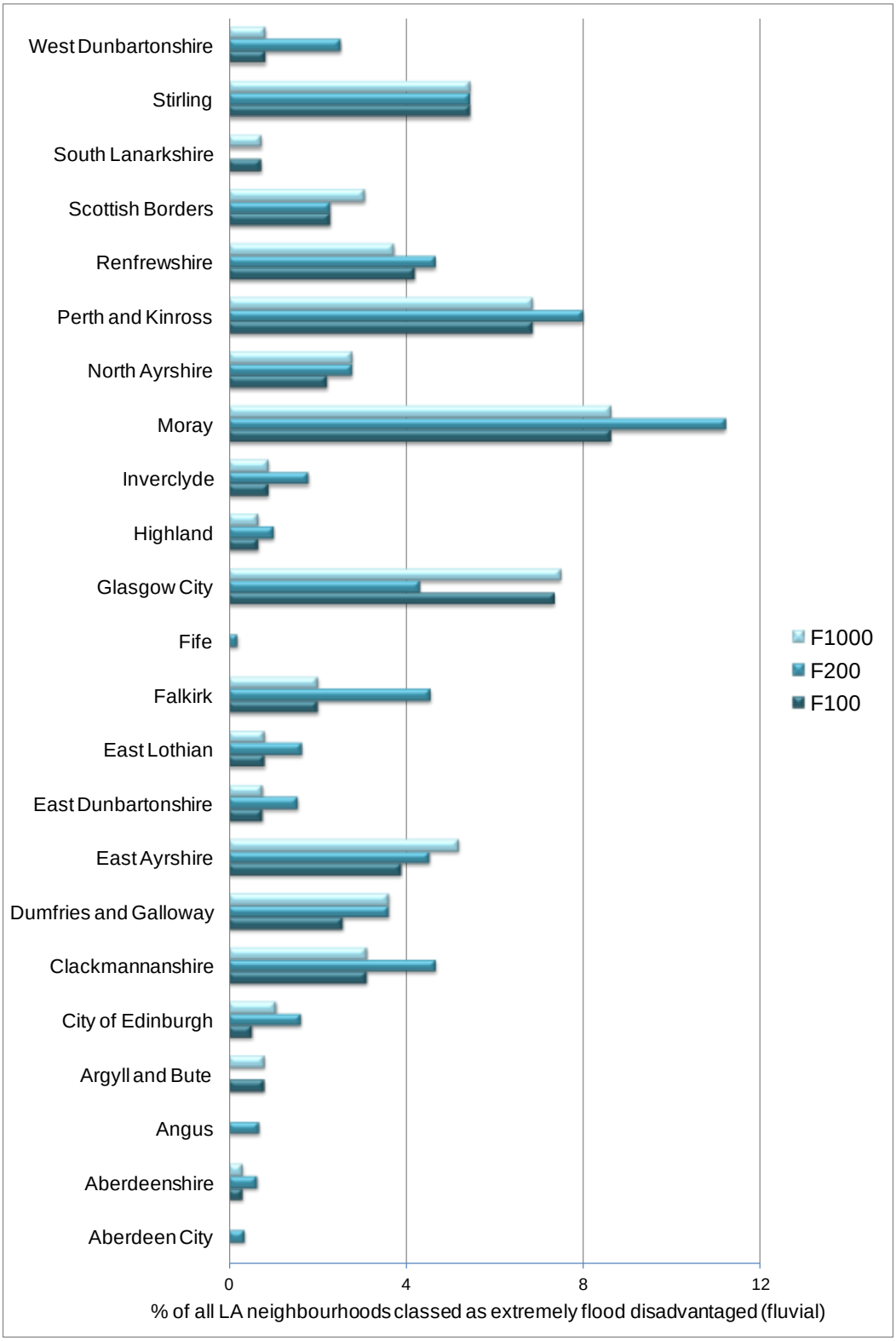
3.6 Figures 5-8 (pages 13-16) show how ‘extremely flood disadvantaged’ neighbourhoods, with respect to residential properties, are distributed by flood type and local authority[13]. Full breakdowns are provided in Appendix 3 (Table A3.1). Figures 5 and 6 relate to fluvial flooding and Figures 7 and 8 relate to coastal flooding.

3.7 Moray, Perth and Kinross and Glasgow City have the largest proportions of ‘extremely flood disadvantaged’ neighbourhoods (as a share of their total number of neighbourhoods) in relation to fluvial flooding (Figure 5 page 13). Glasgow City has the largest overall share of Scotland’s ‘extremely flood disadvantaged’ neighbourhoods associated with fluvial flooding. It contains between 20-40% of the Scottish total depending on fluvial flood likelihood type (Figure 6 page 14).

3.8 The local authority of Falkirk has the largest proportion of ‘extremely flood disadvantaged’ neighbourhoods in relation to coastal flooding (Figure 7 page 15). Falkirk also has the largest overall share of the Scottish total of ‘extremely flood disadvantaged’ neighbourhoods in relation to coastal flooding. Falkirk contains between a fifth and a quarter of the Scottish total, depending on the coastal flood likelihood type (Figure 8 page 16).

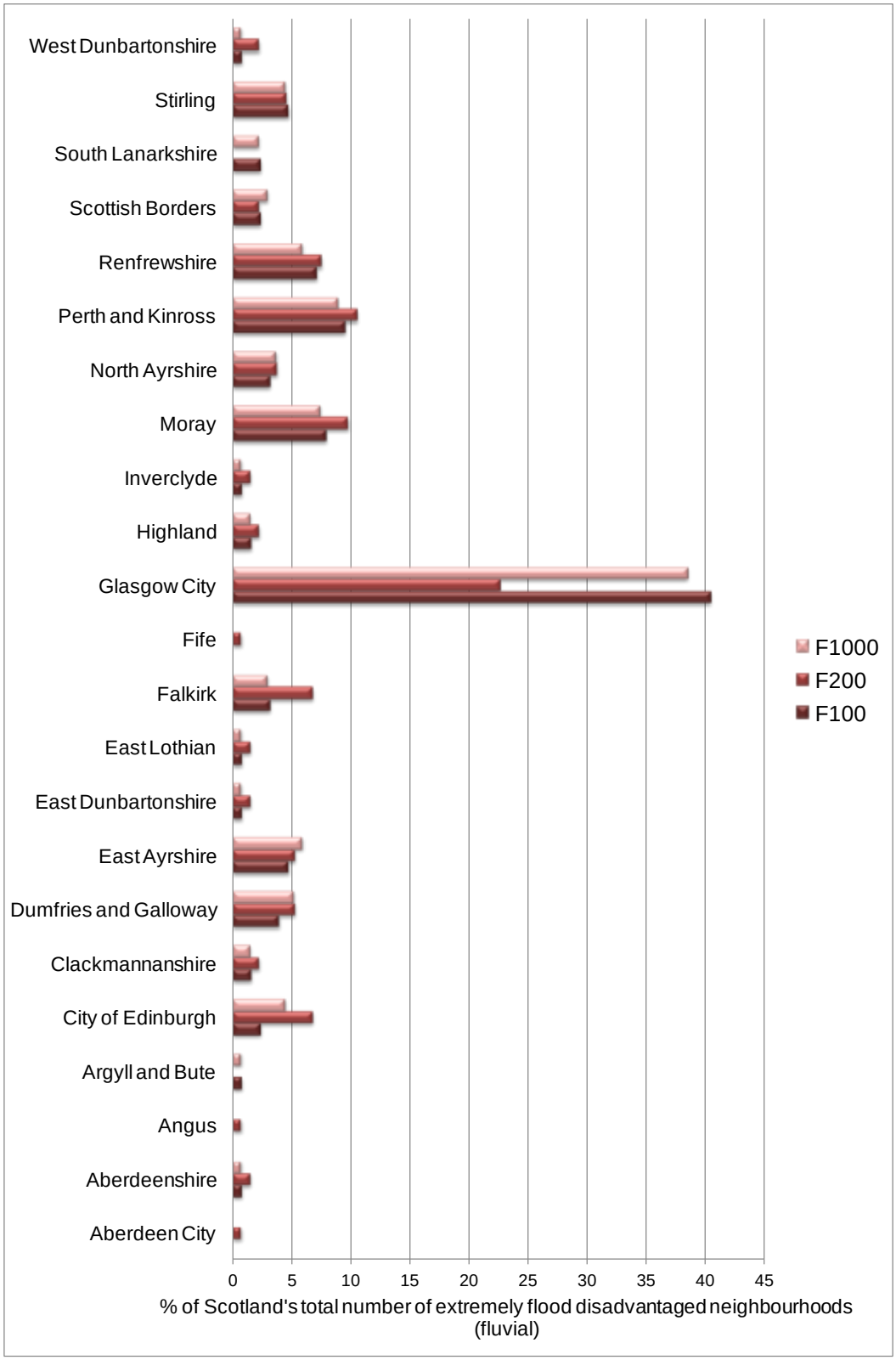
[13] Where local authorities do not have any ‘extremely flood disadvantaged’ neighbourhoods in relation to either coastal or fluvial (river-related) flooding, they are excluded from the Figures.

Figure 5 Relative proportions of all neighbourhoods within the named local authority classed as 'extremely flood disadvantaged' with respect to residential properties and fluvial flood type[14]. Tables 1 and 2 explain the flood recurrence type categories.



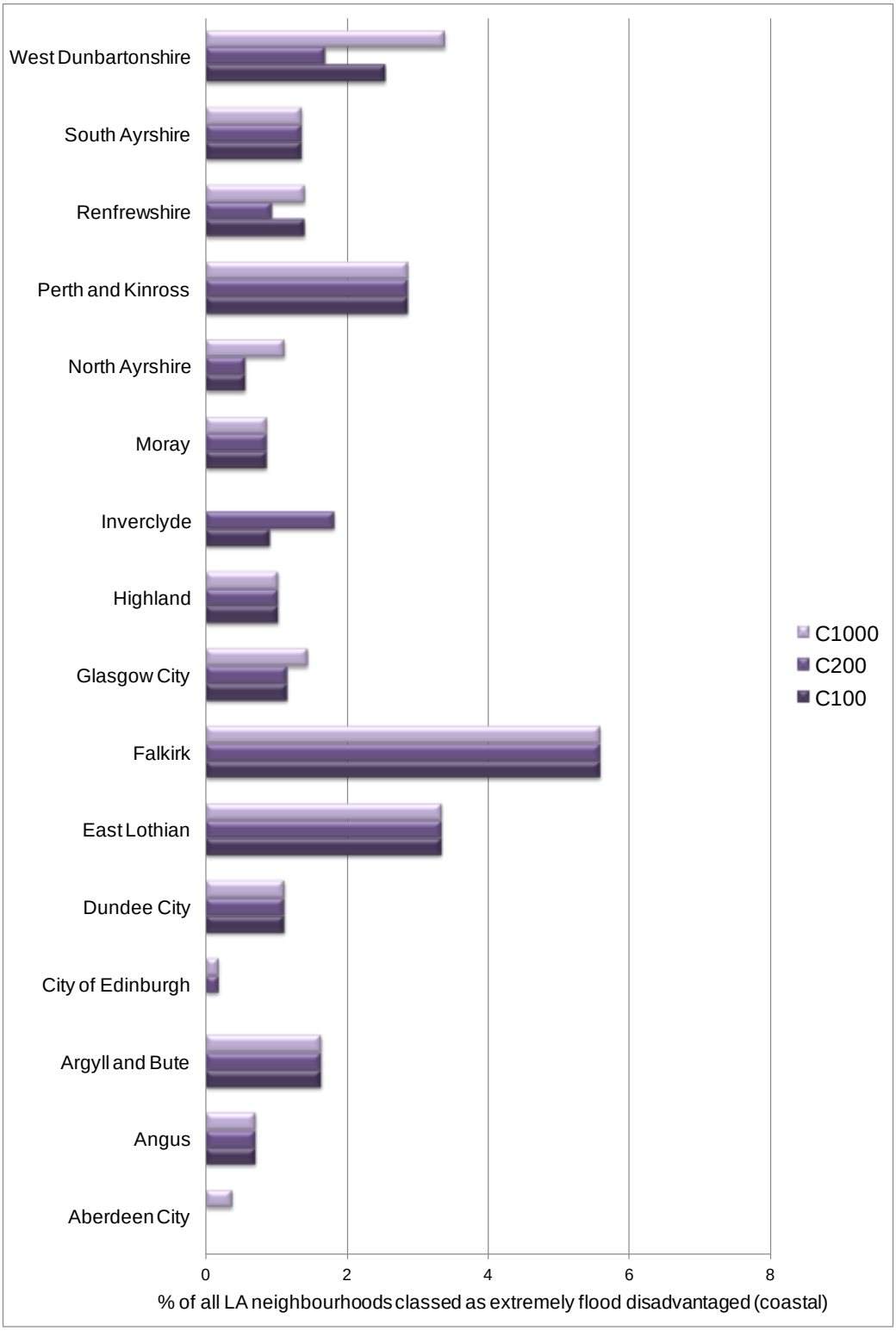
[14] Where local authorities do not have any 'extremely flood disadvantaged' neighbourhoods in relation to fluvial (river-related) flooding, they are excluded from the Figure.

Figure 6 Relative contributions to Scotland's total number of 'extremely flood disadvantaged' neighbourhoods from the named local authority with respect to residential properties and fluvial flood type. Tables 1 and 2 explain the flood recurrence type categories[15].



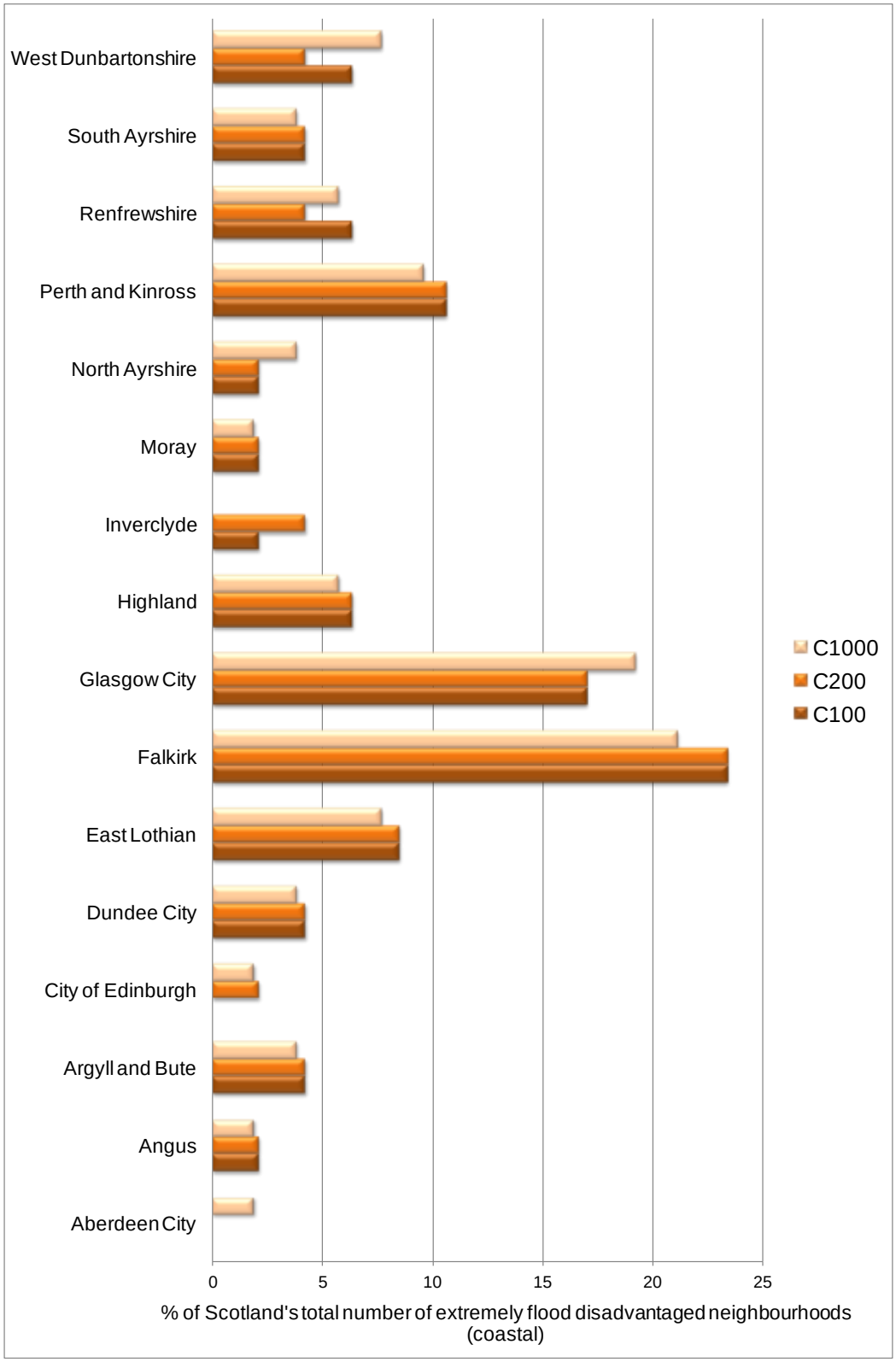
[15] Where local authorities do not have any 'extremely flood disadvantaged' neighbourhoods in relation to fluvial (river-related) flooding, they are excluded from the Figure.

Figure 7 <u>Relative proportions of all neighbourhoods within the named local authority</u> classed as 'extremely flood disadvantaged' with respect to residential properties and coastal flood type. Tables 1 and 2 explain the flood recurrence type categories[16].



[16] Where local authorities do not have any 'extremely flood disadvantaged' neighbourhoods in relation to coastal flooding, they are excluded from the Figure.

Figure 8 Relative contributions to Scotland's total number of 'extremely flood disadvantaged' neighbourhoods from the named local authority with respect to residential properties and coastal flood type. Tables 1 and 2 explain the flood recurrence type categories[17].



[17] Where local authorities do not have any 'extremely flood disadvantaged' neighbourhoods in relation to coastal flooding, they are excluded from the Figure.

3.9 The methodology used in this report is not intended to replace that of SEPA's (2011) National Flood Risk Assessment (NFRA). Rather it is intended to complement it by providing an assessment of where there is most potential for floods to result in losses in well-being based on underlying personal, environmental and social characteristics. These research findings are presented as a basis for discussion and potential further development.

3.10 The NFRA considers a wide range of metrics representing people, businesses, the environment and cultural heritage in order to identify 'Potentially Vulnerable Areas' (PVA) based on river catchments. PVAs are identified where "the total impact of floods in a given area is considered nationally significant" (NFRA, 2011: 12). They are the focus for flood risk management planning in the form of more detailed flood hazard/risk maps and the appraisal of measures to inform flood risk management strategies and local flood risk management plans[18].

3.11 Unsurprisingly, there are some differences between the results presented in this report and the results of the NFRA. This is likely due to SEPA's use of the following: different thresholds to establish extreme cases; different indicators being used to express flood vulnerability and risk; and different underlying data being used as the basis of the assessment. Case Study C, having been selected from one of the areas highlighted as vulnerable by SEPA, is not identified as having extreme socio-spatial flood vulnerability or as being 'extremely flood disadvantaged' in the current study. The discussion of Case Study C (paragraph 3.21) illustrates that useful information can be obtained through the investigation of neighbourhood vulnerability characteristics even where aggregate scores do not highlight neighbourhoods as having extreme socio-spatial flood vulnerability or as being 'extremely flood disadvantaged'.

3.12 Scotland's NFRA (SEPA, 2011: 11) assesses exposure relative to 14 Local Plan Districts. Although not directly comparable to the results produced in this work, estimates of proportions of properties exposed, appear to be in broad agreement. Results are also similar to those reported in GI-SAT (2007). They are not expected to be an exact match due to differences in the Indicative River & Coastal Flood Map (Scotland) versions and Address Point years used, as well as the reasons outlined above. Visual comparison of results with finer scale datasets (such as the NFRA Risk Grid) hosted on the National Flood Risk Assessment online portal (SEPA, 2013) suggest that further comparative work would be valuable. Such work could, for example, take a closer look at the areas identified as vulnerable and at risk in the SEPA analysis, by reviewing aggregate scores and the scores associated with each vulnerability dimension, domain and indicator on a case-by-case basis.

3.13 The neighbourhoods identified as being 'extremely flood disadvantaged', could benefit from targeted adaptation measures. Further detailed consideration of these neighbourhoods is recommended, i.e. the 184 Scottish neighbourhoods which are estimated to be 'extremely flood disadvantaged' with respect to potential coastal or fluvial flooding (see paragraph 3.2). The aims of additional work would be to verify the exposure and vulnerability characteristics of the

[18] SEPA will carry out a further assessment of the population exposed to flooding using a set of revised flood hazard maps, due for release in December 2013.

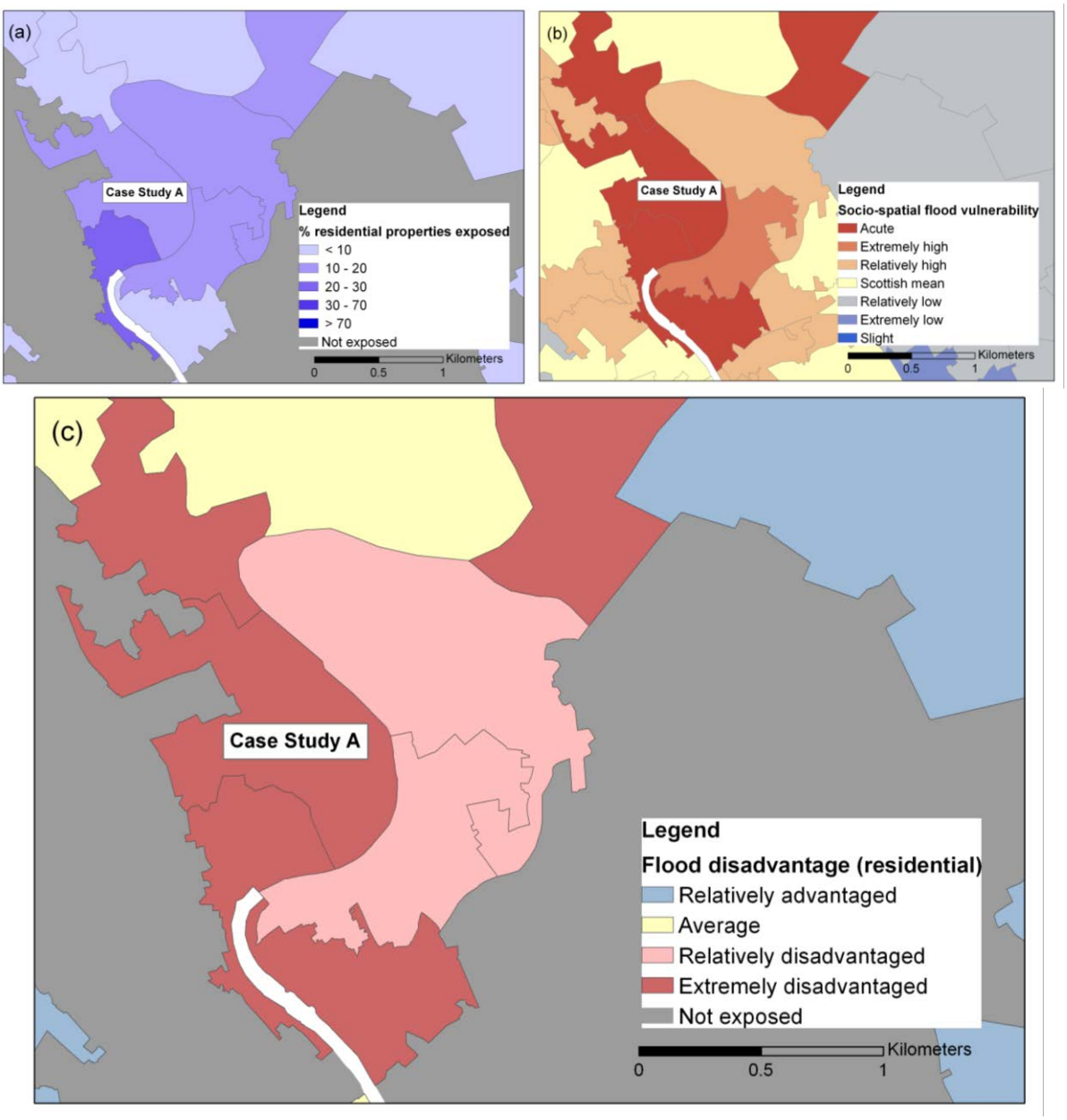
exposed people and places and if confirmed, to establish the most appropriate suite of adaptation measures. The measures can be informed by the personal, social and environmental characteristics of individuals and their neighbourhoods as well as the probability and severity of flooding itself.

Case study examples

3.14 Two case study areas (A and B), are among the 184 extremely disadvantaged neighbourhoods identified in paragraph 3.2. These are used as examples to demonstrate how socio-spatial flood vulnerability data can help highlight the specific drivers of social vulnerability in an area and ultimately inform the design of appropriate adaptation strategies. A third case study has been selected as a less extreme example, as explained in 3.11.

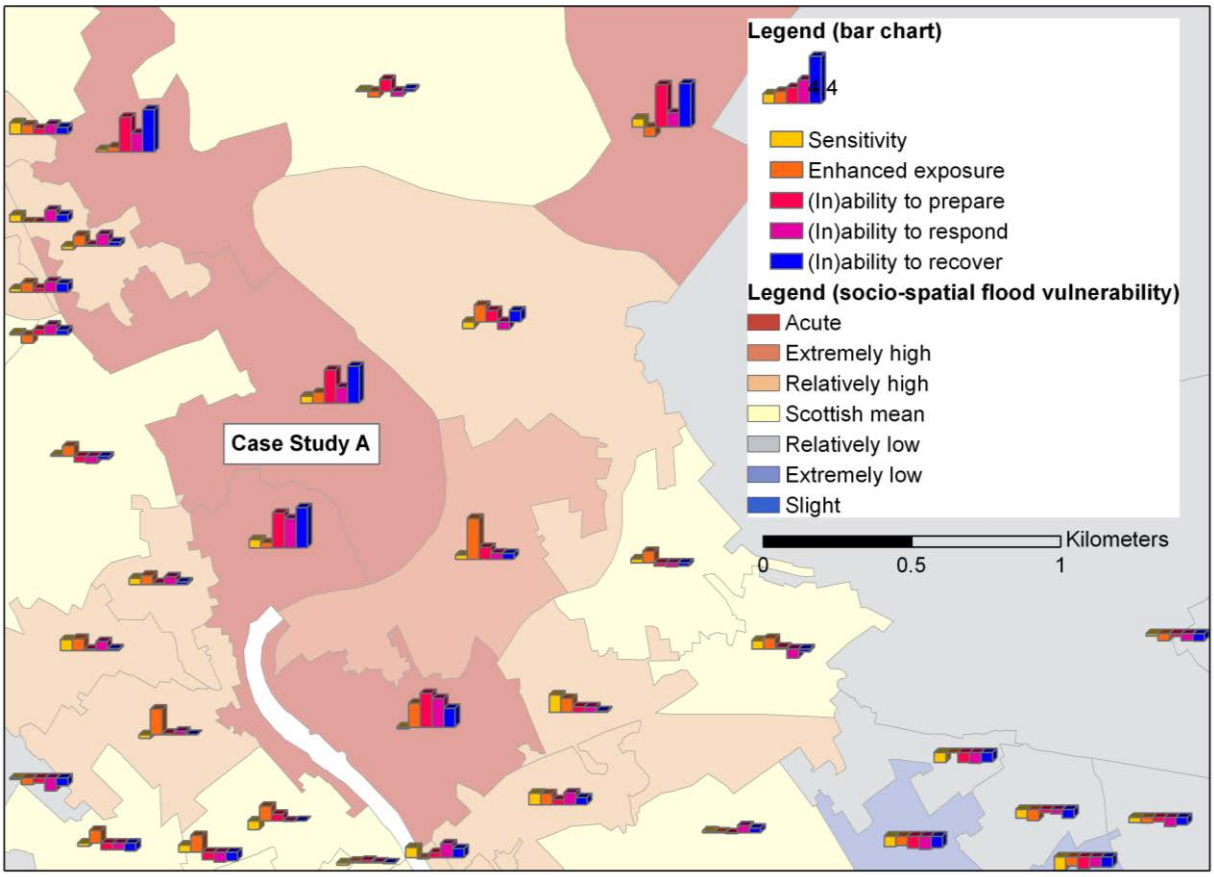
Figure 9 Flood disadvantage characteristics for Case Study A

(a) Flood hazard exposure (residential property exposure to any coastal or fluvial flooding recurrence type);
(b) socio-spatial flood vulnerability; and
(c) associated flood disadvantage.



3.15 Case Study A is a neighbourhood in south-west Scotland. Around 10% of all residential properties in the neighbourhood are exposed to coastal or fluvial flooding (Figure 9a) and there is acute socio-spatial flood vulnerability which is three standard deviations (three classes) above the Scottish mean (Figure 9b). This explains the extreme flood disadvantage identified by the analysis (Figure 9c).

Figure 10 Dimensions of socio-spatial vulnerability in Case Study A[19]



3.16 Figure 10 provides a breakdown of Case Study A's socio-spatial vulnerability characteristics. It shows the relative contributions of the five dimensions of vulnerability identified in Lindley et al. (2011): sensitivity; enhanced exposure; ability to prepare; ability to respond; and ability to recover. This information is layered over the socio-spatial flood vulnerability map from Figure 9b.

- **Sensitivity:** This neighbourhood has an above average proportion of people over 75 (9%) and reporting ill-health (25%), compared to the Scottish neighbourhood average of 7% and 20%, respectively.

- **Enhanced Exposure:** The neighbourhood is more urban than most, which can enhance the impacts of flood events relative to other areas. However, the area does benefit from a lower than average proportion of basement dwellings (dwellings where the lowest floor level is basement or semi-basement – see Table A1.2), so the building stock does not enhance flood impacts.

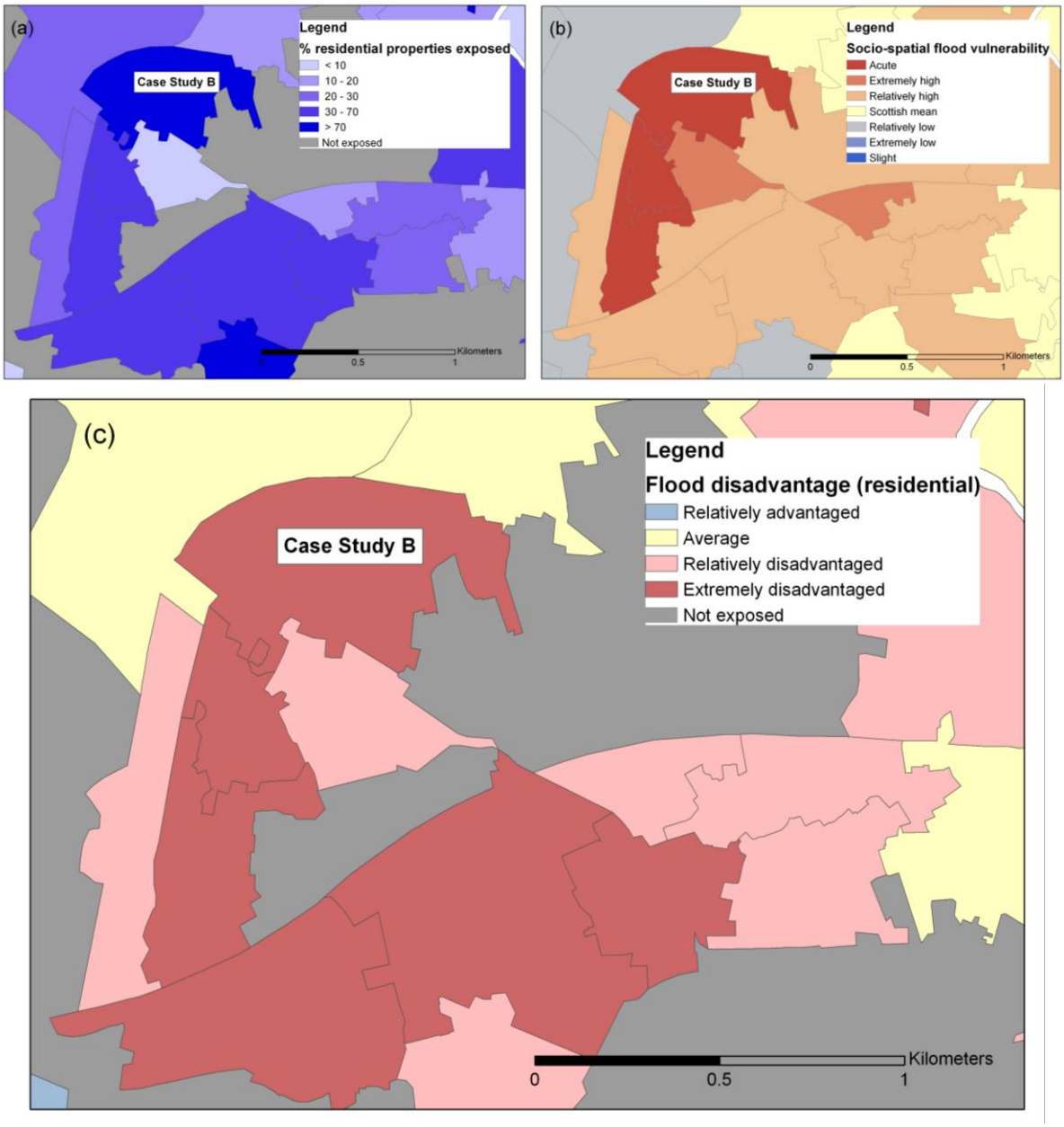
[19] The coloured blocks represent vulnerability dimension scores relative to the average Scottish neighbourhood (represented by the horizontal axis). Bars above the horizontal axis show positive vulnerability dimension scores (greater than the Scottish average socio-spatial flood vulnerability on each of the five dimensions shown in the legend). Bars below the horizontal axis show negative vulnerability dimension scores (lower than Scottish average socio-spatial flood vulnerability on each of the five dimensions shown in the legend).

- **Adaptive capacity:** Most of the vulnerability in this neighbourhood results from social factors.
    - Relatively low household incomes restrict the extent to which people have resources to assist with flood preparation, response and recovery.
    - There are low private tenancy rates, but the large proportion of social renters (48% compared to a mean of 26%) indicates that many in the neighbourhood may be restricted in terms of adapting their homes. While this is a restriction for householders, it presents an opportunity for local authorities to assist with adapting building stock appropriately.
    - Insurance access may be difficult or expensive due to historical flood events in the area. The effects of income and tenure that are relevant to insurance access are discussed further in 3.17 below.
    - The area is associated with a slightly larger rate of transience than in many Scottish neighbourhoods, but local awareness of flood issues may still be reasonably high compared with neighbourhoods where the population is subject to a very high turnover rate.
    - There is the possibility for some social isolation due to higher than usual proportions of lone parents with dependent children. This and a lack of access to private transport (45% of households without access to a car or van), may make responding to flood events difficult for some in the community.
    - Mobility issues are also suggested due to the higher than average proportions of disability in the neighbourhood (10% compared to 7% for the Scottish average).

3.17 Case Study B is a neighbourhood in the central lowlands. Around 74% of all residential properties in the neighbourhood are exposed to coastal or fluvial flooding (Figure 11a) and there is acute socio-spatial flood vulnerability which is over three standard deviations (three classes) above the Scottish mean (Figure 11b). Consequently, this neighbourhood is classed as ‘extremely flood disadvantaged’ (Figure 11c).

Figure 11 Flood disadvantage characteristics for Case Study B

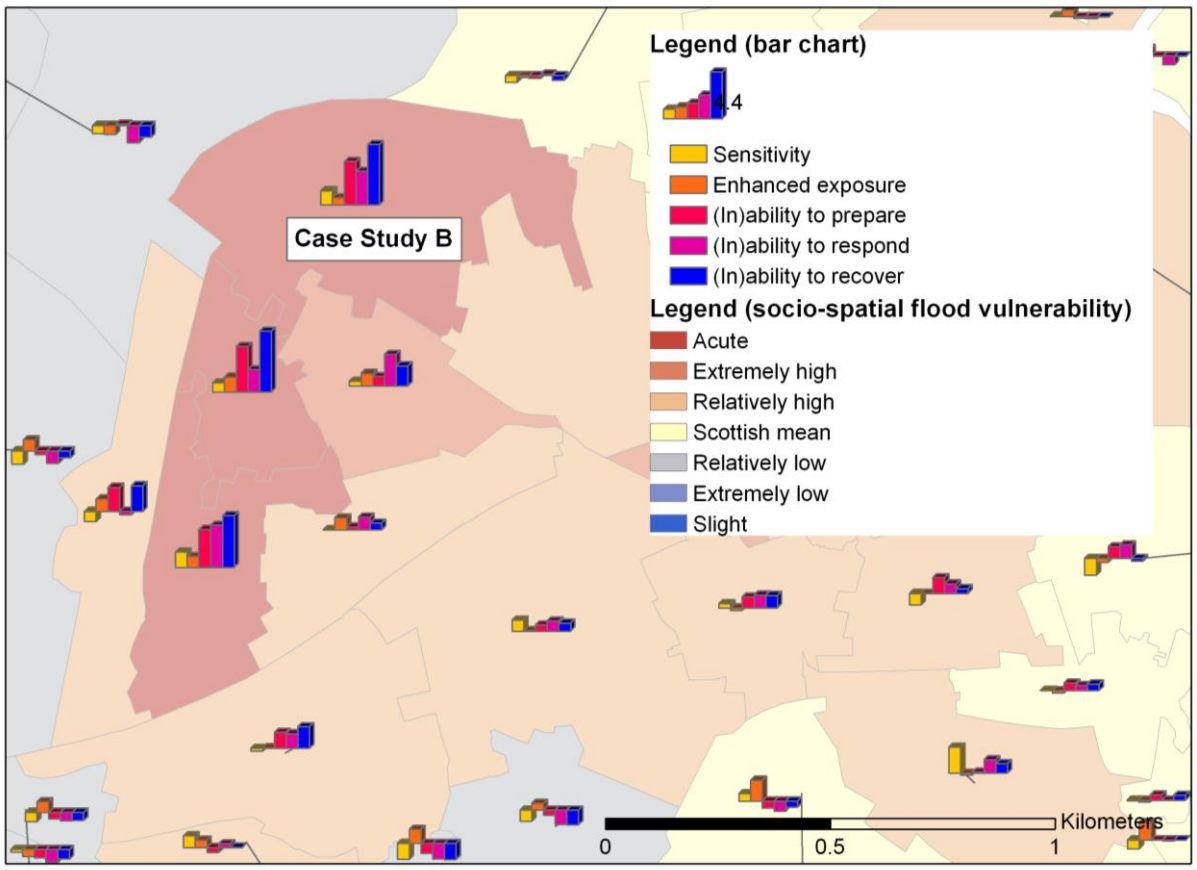
(a) Flood hazard exposure (residential property exposure to any coastal or fluvial flooding recurrence type);
(b) socio-spatial flood vulnerability; and
(c) associated flood disadvantage.



3.18 Figure 12 (page 22) provides a breakdown of Case Study B's socio-spatial vulnerability characteristics. It shows the relative contributions of the five dimensions of vulnerability identified in Lindley et al., 2011: sensitivity; enhanced exposure; ability to prepare; ability to respond and ability to recover. This information is layered over the socio-spatial flood vulnerability map from Figure 10b.

- **Sensitivity:** Sensitivity in this neighbourhood is primarily driven by two factors: a larger than usual proportion of children under 5 (8%) and reported ill-health (29%), compared to Scottish averages of 7% and 20%, respectively. There is a much lower proportion of residents over 75, at just 3% compared to 7% for the Scottish average. Community level health information could be targeted at children and families and through existing routes, such as doctors and health visitors. Some consideration of other sensitive groups on an individual basis would still be necessary, as is the case in all neighbourhoods.

Figure 12 Dimensions of socio-spatial vulnerability in Case Study B[20]



- **Enhanced Exposure:** The local environment of this neighbourhood has only a slight tendency to enhance the potential impacts of flooding. The neighbourhood is not associated with a disproportionately large amount of dwellings where the lowest floor level is basement or semi-basement. However, the area is generally more built up than the average Scottish neighbourhood.

[20] The coloured blocks represent vulnerability dimension scores relative to the average Scottish neighbourhood (represented by the horizontal axis). Bars above the horizontal axis show positive vulnerability dimension scores (greater than the Scottish average socio-spatial flood vulnerability on each of the five dimensions shown in the legend). Bars below the horizontal axis show negative vulnerability dimension scores (lower than Scottish average socio-spatial flood vulnerability on each of the five dimensions shown in the legend).

- **Adaptive capacity:** In common with Case Study A, most of the vulnerability in this neighbourhood is socially determined.
    - Around two-thirds (66%) are classified as income deprived compared to 17% in the average Scottish neighbourhood. People can therefore be expected to have few or no resources available for long-term preparation, may be less able to respond to flooding and may also find recovery extremely difficult.
    - Given the history of past events in the area, access to affordable flood insurance may be an issue. Insurance uptake is also likely to be affected by the high proportion of low income households. The 2007 Scottish Household Survey showed 60% of households in the lowest income decile have contents insurance, compared to 96% of those in the two highest income deciles (Hayton et al., 2007, 4.46). Moreover, given the very large proportion of social tenants (74% compared to 26%), the level of uptake for contents insurance will be lower than that for owner-occupiers. The 2007 Scottish Household Survey also found that 56% of local authority tenants and 50% of housing association, cooperative or private tenants had contents insurance, compared to 98% of owner-occupiers with a mortgage (Hayton et al., 2007, 4.48; O'Neill and O'Neill, 2012:5). Low-cost 'insurance-with-rent' schemes with minimal or no excess charges and security conditions have been directed at the rented sector, although their uptake has been mixed (Hood et al., 2009). Social tenants may be assisted with appropriate modifications of building stock.
    - Indicators suggest that the area is associated with low transience, so local community knowledge of flood problems may be relatively good.
    - There are very large proportions of lone parents with dependent children (22%). Some within this group may be socially isolated and many may find responding to flood events challenging. Separated and single people are also less likely to have home contents insurance (72% and 66%, compared to 94% of married couples) (Hayton et al., 2007).
    - Rates of disability and households without access to private transport are more than twice the Scottish average. This and a strong dependency on public transport for work (31% compared to 18%), may also make responding difficult. Any relocation of householders following an event could cause additional problems.

3.19 The final two case studies are located in the north. Case Study C is a large rural neighbourhood and Case Study D shows a number of neighbourhoods associated with a town.

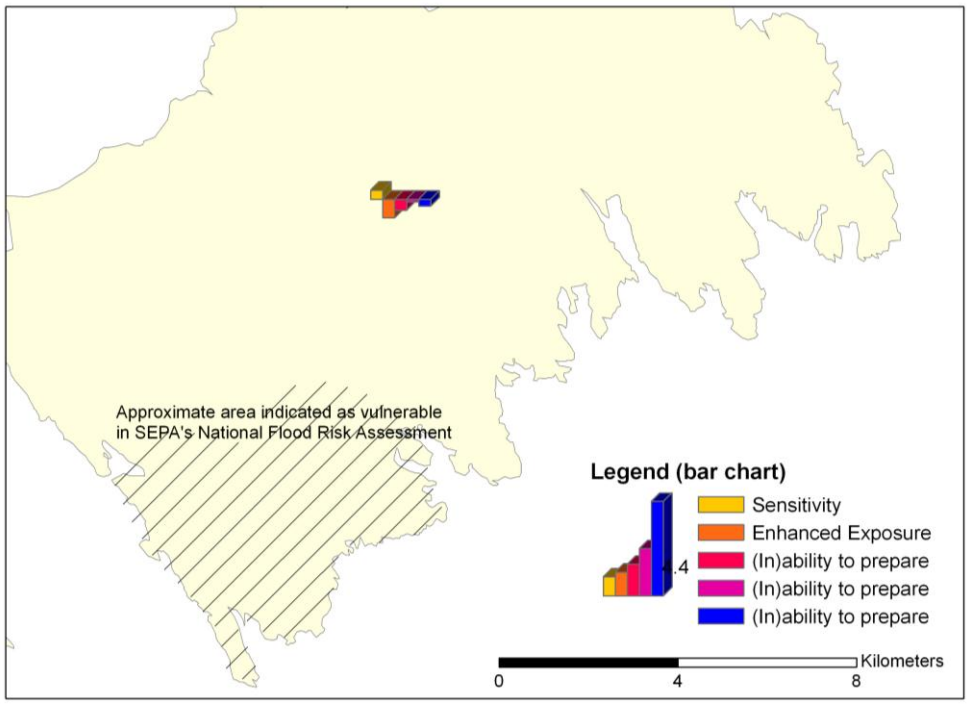
3.20 Figure 13 (page 25) shows that although overall, Case Study C is not an especially socially vulnerable area, the community in this area has a higher than average sensitivity. This is driven by a higher than average proportion of

people over 75 years of age. Part of this neighbourhood is also highlighted in SEPA's NFRA.

3.21 Case Study C illustrates that the use of an aggregate index alone can mask some important social flood vulnerability characteristics. It should also be noted that area-based averages do not apply to all individuals within neighbourhoods, even where boundaries have been initially designed to take account of social characteristics (see 2.6). All Scottish neighbourhoods are likely to contain some socially vulnerable people, even where the neighbourhoods that they live in are assessed as having low or extremely low socio-spatial flood vulnerability. Assessments like this can help to target some adaptation responses to areas of particular need. However, such area-based targeting should only form part of a wider suite of adaptation actions, including carrying out activities which target vulnerable groups more generally.

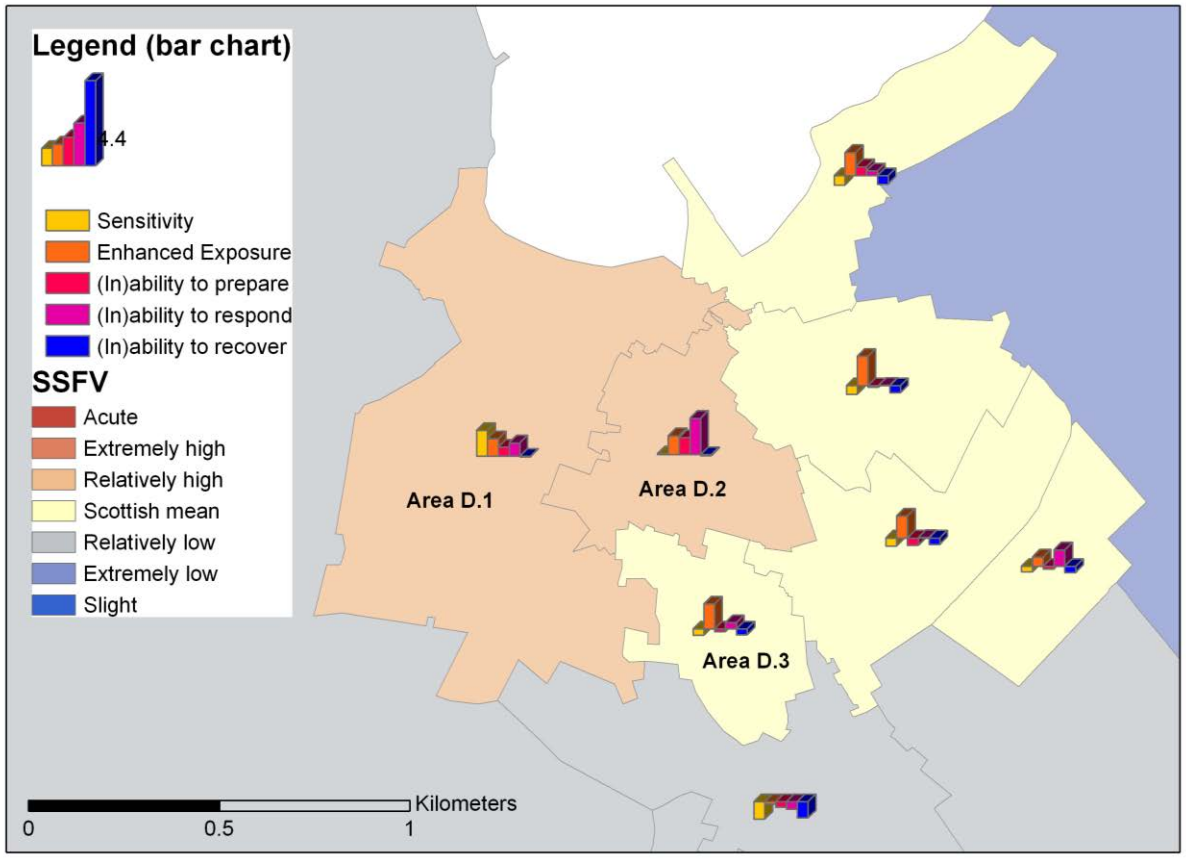
3.22 Case study D (Figure 14 page 26) illustrates how there can be different contributions from the different socio-spatial flood vulnerability dimensions across a town. Some neighbourhoods contain a relatively sensitive population (Area D.1) while the population in others may have relatively poor adaptive capacity (Area D.2). Areas D.1-D.3 all show relatively high enhanced exposure, but this is especially marked in Area D.3 and others towards the east of the town.

Figure 13 Dimensions of socio-spatial vulnerability in Case Study C[21] (average socio-spatial vulnerability)



[21] The coloured blocks represent vulnerability dimension scores relative to the average Scottish neighbourhood (represented by the horizontal axis). Bars above the horizontal axis show positive vulnerability dimension scores (greater than the Scottish average socio-spatial flood vulnerability on each of the five dimensions shown in the legend). Bars below the horizontal axis show negative vulnerability dimension scores (lower than Scottish average socio-spatial flood vulnerability on each of the five dimensions shown in the legend).

Figure 14 Dimensions of socio-spatial vulnerability in Case Study D[22]. Key: SSFV: Socio-spatial flood vulnerability.



[22] The coloured blocks represent vulnerability dimension scores relative to the average Scottish neighbourhood (represented by the horizontal axis). Bars above the horizontal axis show positive vulnerability dimension scores (greater than the Scottish average socio-spatial flood vulnerability on each of the five dimensions shown in the legend). Bars below the horizontal axis show negative vulnerability dimension scores (lower than Scottish average socio-spatial flood vulnerability on each of the five dimensions shown in the legend).

4 CONCLUSION

4.1 Climate disadvantage is determined not only by the likelihood and degree of exposure to a hazard such as flooding, but also individual and group vulnerability with regard to such hazards. Vulnerability is a matter of how the external event converts into losses in well-being. A wide range of distinct personal, environmental and social factors are involved in the conversion of extreme weather events into losses in well-being. Different locations can require different policy interventions, depending on the specific local conversion factors that are most at play.

4.2 The results presented in this report provide a first focused look at flood disadvantage in Scotland. A flood disadvantage map associated with coastal and fluvial flooding has been produced for Scottish neighbourhoods and summarised according to local authority. This contrasts with many previous approaches where the main emphasis is on understanding detailed patterns of potential flood exposure with a less extensive consideration of how that exposure may translate into losses of well-being in neighbourhoods and their communities.

4.3 The mapping work presented in this report was undertaken with the following objectives:

- To provide information about where the main concentrations of disadvantage associated with coastal and fluvial flooding are to be found.

- To provide fine-grained information on the specific sources of flood disadvantage and socio-spatial flood vulnerability in different locations.

4.4 A flood disadvantage map associated with coastal and fluvial (river-related) flooding has been produced for Scottish neighbourhoods. It combines existing neighbourhood level estimates of ‘socio-spatial vulnerability’ with an estimate of flood hazard-exposure. The measure of flood hazard-exposure is based on the percentage of residential addresses within each neighbourhood that are potentially affected by coastal or fluvial (river-related) flooding. Results have been summarised according to local authority.

4.5 The results presented in this report suggest that 34% of Scottish neighbourhoods contain residential properties which are potentially exposed to some form of coastal or fluvial (river-related) flooding, covering areas where there is only a very low likelihood of flooding in any particular year (a 0.1% chance) up to those with a higher likelihood (1.0% chance). Within these potentially exposed neighbourhoods, 8.2% are estimated to be ‘extremely flood disadvantaged', i.e. they typically have a high potential for losses in well-being and a high proportion of residential properties potentially affected by flood events, relative to the Scottish average. They represent 2.8% of all Scottish neighbourhoods. It is recommended that the personal, environmental and social factors affecting vulnerability in these

neighbourhoods are considered further, in order to establish appropriate responses in each area.

4.6 The local authorities of Moray, Falkirk, Perth and Kinross and Glasgow City have the largest proportions of their total number of neighbourhoods classed as being ‘extremely flood disadvantaged’ with respect to coastal and fluvial (river-related) flooding. These local authorities may require additional support in order to build resilience within identified neighbourhoods and their associated communities.

4.7 Four case study examples have been presented to illustrate how fine-grained information may allow adaptation policy to be better targeted to the specific needs of different localities and populations. Such targeting should be part of a wider adaptation strategy which addresses the needs of socially flood vulnerable people across Scotland as a whole.

4.8 It is recommended that Scottish Government consider carrying out additional assessment work involving:

- Combination of the existing socio-spatial flood vulnerability index data with updated flood exposure model outputs, including estimates of pluvial flooding and the impacts of flood defences.
- Development of updated socio-spatial flood index data using data from the 2011 Census.
- Further consideration of dwelling type in the exposure assessment.

5 REFERENCES

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6 APPENDIX 1

Table A1.1 Domains associated with each of the five dimensions of socio-spatial flood vulnerability[23]

Dimension	Domain	Example explanation
Sensitivity *Biophysical characteristics*	Age	old & young are more physically susceptible to harm
	Health	those with pre-existing illnesses are more susceptible
	Special care	those in care environments already require additional support
Exposure *Physical neighbourhood attributes*	Physical environment	amount of green or blue space; availability of gardens
	Housing characteristics	type of building (basement & street level dwellings)
Preparation *Taking precautions*	Income	ability to obtain technical solutions (e.g. flood gates)
	Tenure	ability to modify living environments
	Information use	ability to use/access information
	Local knowledge	availability of personal or community experience from past events in the local area
	Insurance	likelihood of insurance being available
Response *Avoiding losses*	Income	ability to use technical and other solutions
	Information use	language & education affecting the ability to respond to warnings
	Local knowledge	availability of personal or community experience from past events in the local area
	Insurance	likelihood of insurance being available
	Social networks	availability of personal or community networks
	Mobility	availability of personal/household mobility
	Crime	ability to deploy adaptive measure, e.g. flood gates
	General accessibility	general neighbourhood accessibility
Recovery *Recovering from a flood event*	Income	ability to replace lost goods, find temporary accommodation
	Information use	ability to understand what help is available and what to do (language & education)
	Insurance	ability to claim for damages and re-insure
	Social networks	availability of personal/community networks (if isolated less likely to obtain assistance)
	Mobility	general mobility/disability
	Housing mobility	ability to move away from an area

[23] Not all domains represented for Scotland (see Table A1.2)

Table A1.2: List of indicators used for Scotland. *Differences in indicators to England are shown in bold font.*

Dimension	Domain	Indicator	Locations		Groups	
			Heat	Flood	Heat	Flood
Sensitivity	Age	% very young (<5)	Y	Y	Y	Y
Sensitivity	Age	% old (> 65)			Y	Y
Sensitivity	Age	% very old (> 75)	Y	Y	Y	Y
Sensitivity	Health	% with Limiting Long Term Illness	Y	Y	Y	Y
Sensitivity	Health	% with Limiting Long Term Illness but working			Y	Y
Sensitivity	Health	% in poor health			Y	Y
Sensitivity	Health	% HHs with at least one person with a LLTI	Y	Y	Y	Y
Sensitivity	Care	% in nursing care			Y	Y
Sensitivity	Care	% in residential care			Y	Y
Enhanced Exposure	Physical Environment	**% urban**[a]	Y	Y	Y	Y
Enhanced Exposure	Physical Geography	**Average distance to coast of zone**[b]	Y		Y	
Enhanced Exposure	Physical Geography	**Minimum distance from coast in the zone**[b]			Y	
Enhanced Exposure	Physical Geography	**Average elevation for the zone (low = high exposure)**[c]	Y		Y	
Enhanced Exposure	Physical Geography	**Maximum elevation for the zone (low = high exposure)**[c]			Y	
Enhanced Exposure	Housing	% HHs Lowest floor level: Basement or semi-basement		Y		Y
Enhanced Exposure	Housing	% HHs Lowest floor level: Ground floor (street level)		Y		Y
Enhanced Exposure	Housing	% HHs Lowest floor level: Fifth floor or higher	Y		Y	
Prepare	Income	% unemployed	Y	Y	Y	Y
Prepare	Income	% in low income work (routine/manual)	Y	Y	Y	Y
Prepare	Income	**Workless Client Group: % of Working Age Population** [d]			Y	Y
Prepare	Income	**% unemployed Never worked/LTUemp**	Y	Y	Y	Y
Prepare	Income	% HHs with no adults working and with dependent children	Y	Y	Y	Y
Prepare	Income	% HHs with no adults working with no dependent children			Y	Y
Prepare	Income	**Percentage of Households Income Deprived (Decile, 2004/05)** [e]	Y	Y	Y	Y
Prepare	Income	% all pensioner HHs	Y	Y	Y	Y
Prepare	Income	% pensioners	Y	Y	Y	Y
Prepare	Tenure	% renting from social landlords	Y	Y	Y	Y
Prepare	Tenure	% renting from private landlords	Y	Y	Y	Y
Prepare	Tenure	% renting from social landlords	Y	Y	Y	Y
Prepare	Tenure	% renting from private landlords	Y	Y	Y	Y
Prepare	Tenure	% HHs not owner occupied (reverse of formal variable)			Y	Y
Prepare	Tenure	% HHs not owned outright (reverse of formal variable)			Y	Y
Prepare	Info use	% Born outside UK	Y	Y	Y	Y
Prepare	Info use	% born in other EU countries			Y	Y

Prepare	Info use	% born Elsewhere (Outside Europe)			Y	Y
Prepare	Info use	New migrants from overseas (People with <1 yr residency coming from outside UK)	Y	Y	Y	Y
Prepare	Info use	% with basic education (no or level 1)			Y	Y
Prepare	Local knowledge	New migrants from outside the local area		Y		Y
Prepare	Local knowledge	**% None White HHs with <1 yr residency in area**				Y
Prepare	Insurance	**Past flood events (% area associated with past events)[f]**		Y		Y
Response	Income	% unemployed	Y	Y	Y	Y
Response	Income	% in low income work (routine/manual)	Y	Y	Y	Y
Response	Income	**Workless Client Group: % of Working Age Population [d]**			Y	Y
Response	Income	**% unemployed Never worked/LTUemp**	Y	Y	Y	Y
Response	Income	% HHs with no adults working and with dependent children	Y	Y	Y	Y
Response	Income	% HHs with no adults working with no dependent children			Y	Y
Response	Income	**Percentage of Households Income Deprived (Decile, 2004/05) [e]**	Y	Y	Y	Y
Response	Income	% all pensioner HHs	Y	Y	Y	Y
Response	Income	% pensioners	Y	Y	Y	Y
Response	Info use	% Born outside UK	Y	Y	Y	Y
Response	Info use	% born in other EU countries			Y	Y
Response	Info use	% born Elsewhere (Outside Europe)			Y	Y
Response	Info use	New migrants from overseas (People with <1 yr residency coming from outside UK)	Y	Y	Y	Y
Response	Info use	% with basic education (no or level 1)			Y	Y
Response	Local Knowledge	New migrants from outside the local area		Y		Y
Response	Local Knowledge	**% None White HHs with <1 yr residency in area**				Y
Response	Insurance	**Past flood events (% area associated with past events)[f]**		Y		Y
Response	Social Networks	% Single pensioner household	Y	Y	Y	Y
Response	Social Networks	% female lone parent households			Y	Y
Response	Social Networks	% Single person households (non-pensioner)			Y	Y
Response	Social Networks	% Lone parent households with dependent children	Y	Y	Y	Y
Response	Social Networks	% households with dependent children			Y	Y
Response	Social Networks	% people who do not provide unpaid care (reverse of formal variable)	Y	Y	Y	Y
Response	Mobility	% disabled	Y	Y	Y	Y
Response	Mobility	**Avg Yearly Incapacity Benefit/Severe Disablement Allowance claimants [d]**	Y	Y	Y	Y
Response	Mobility	% households with no car/van	Y	Y	Y	Y
Response	Mobility	% HHs without more than one car/van (reverse of formal variable)			Y	Y
Response	Mobility	% not home workers (resident pop)		Y		Y
Response	Mobility	% travel to work by public transport				Y

		(resident pop)				
Response	Mobility	mean hours worked				Y
Response	**Crime**	**Total no. of SIMD crimes04**			Y	Y
Response	**Crime**	**No. SIMD crimes per 10,000-2004** [e]	Y	Y	Y	Y
Response	**General Access**	**Average Distance (km) Travelled to Place of Work or Study** [d]	Y	Y	Y	Y
Recovery	Income	% unemployed		Y		Y
Recovery	Income	% in low income work (routine/manual)		Y		Y
Recovery	Income	**Workless Client Group: % of Working Age Population** [d]				Y
Recovery	Income	**% unemployed Never worked/LTUemp**		Y		Y
Recovery	Income	% HHs with no adults working and with dependent children		Y		Y
Recovery	Income	% HHs with no adults working with no dependent children				Y
Recovery	Income	**Percentage of Households Income Deprived (Decile, 2004/05)** [e]		Y		Y
Recovery	Income	% all pensioner HHs		Y		Y
Recovery	Income	% pensioners		Y		Y
Recovery	Info Use	% Born outside UK and Ireland	Y	Y	Y	Y
Recovery	Info Use	% born in other EU countries (excluding Ireland)			Y	Y
Recovery	Info Use	% born Elsewhere (Outside Europe)			Y	Y
Recovery	Info Use	% People with No or level 1 qualification			Y	Y
Recovery	Info Use	People with <1 yr residency coming from outside UK	Y	Y	Y	Y
Recovery	Insurance	**Past flood events (% area associated with past events)**[e]		Y		Y
Recovery	Social Networks	% Single pensioner household	Y	Y	Y	Y
Recovery	Social Networks	% female lone parent households			Y	Y
Recovery	Social Networks	% Single person households (non-pensioner)			Y	Y
Recovery	Social Networks	% Lone parent households with dependent children	Y	Y	Y	Y
Recovery	Social Networks	% households with dependent children <4			Y	Y
Recovery	Social Networks	% people who do not provide unpaid care (reverse of formal variable)	Y	Y	Y	Y
Recovery	Mobility	% disabled	Y	Y	Y	Y
Recovery	Mobility	**Avg Yearly Incapacity Benefit/Severe Disablement Allowance claimants** [d]	Y	Y	Y	Y
Recovery	Mobility	% households with no car	Y		Y	
Recovery	Mobility	% HHs without more than one car (reverse of formal variable)			Y	
Recovery	Mobility	% not home workers (resident pop) (reverse of formal variable)	Y		Y	
Recovery	Mobility	% travel to work by public transport (resident pop)			Y	
Recovery	Mobility	mean hours worked			Y	
Recovery	**Service Access**	**Mean distance to GP surgery** [d]	Y		Y	

Table Notes and Data Acknowledgements:

All data are from or derived from the UK Census 2001, except for:

a: calculated from urban footprint boundaries Edina UK Borders.
b: calculated from Edina UK Borders coastline data. Estimates are based on “as-the-crow-flies” (Euclidean) distances.
c: mean elevation, calculated from the same source as for the other devolved nations.
d: Scottish National Statistics.
e: Scottish Index of Multiple Deprivation 2004/5, Scottish National Statistics.
f: Scottish Environment Protection Agency historical flood zones.

7 APPENDIX 2

Table A2.1 Classification scheme for flood disadvantage data

Score[1]	Label
≥ 1.5	Extremely disadvantaged/ extremely high disadvantage
0.5 to 1.5	Relatively disadvantaged/ relatively high disadvantage
-0.5 to 0.5	Average
≤ -0.5	Relatively advantaged/ relatively low disadvantage

1. Scores are mapped on standard deviations around the mean (a value of zero). They are created through combining socio-spatial vulnerability and flood exposure scores. The 'average' category is within ±0.5 of a standard deviation around the mean.

Table A2.2 Classification scheme for socio-spatial flood vulnerability data

Score[1]	Label
≥ 2.5	Acute
1.5 to 2.5	Extremely high
0.5 to 1.5	Relatively high
-0.5 to 0.5	Average
-0.5 to -1.5	Relatively low
-1.5 to -2.5	Extremely low
≤ -2.5	Slight

1. Scores are mapped on standard deviations around the mean (a value of zero). The 'average' category is within ±0.5 of a standard deviation around the mean. The methodology for the creation of the socio-spatial vulnerability scores is explained in Lindley et al (2011).

8 APPENDIX 3

Table A3.1 Relative proportions of extremely disadvantaged neighbourhoods with respect to residential properties by fluvial and coastal flood type and local authority (LA). Key: Count: the number of neighbourhoods (Data Zones, DZs) affected by the given flood recurrence type. **%LA:** neighbourhoods affected as a proportion of all neighbourhoods within the named LA. **% All:** neighbourhoods affected as a proportion of all extremely disadvantaged neighbourhoods in Scotland for the named flood recurrence type.

	LOCAL AUTHORITY		FLUVIAL 100			FLUVIAL 200			FLUVIAL 1000			COASTAL 100			COASTAL 200			COASTAL 1000		
UA code	LA Name	Total DZs	Count F100	%LA	% All	Count F200	%LA	% All	Count F1000	%LA	% All	Count C100	%LA	% All	Count C200	%LA	% All	Count C1000	%LA	% All
QA	Aberdeen City	267	0	0.0	0.0	1	0.4	0.8	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	1	0.4	1.9
QB	Aberdeenshire	301	1	0.3	0.8	2	0.7	1.5	1	0.3	0.7	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
QC	Angus	142	0	0.0	0.0	1	0.7	0.8	0	0.0	0.0	1	0.7	2.1	1	0.7	2.1	1	0.7	1.9
QD	Argyll and Bute	122	1	0.8	0.8	0	0.0	0.0	1	0.8	0.7	2	1.6	4.3	2	1.6	4.3	2	1.6	3.8
QP	City of Edinburgh	549	3	0.5	2.4	9	1.6	6.8	6	1.1	4.4	0	0.0	0.0	1	0.2	2.1	1	0.2	1.9
QF	Clackmannanshire	64	2	3.1	1.6	3	4.7	2.3	2	3.1	1.5	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
QH	Dumfries and Galloway	193	5	2.6	4.0	7	3.6	5.3	7	3.6	5.2	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
QJ	Dundee City	179	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	2	1.1	4.3	2	1.1	4.3	2	1.1	3.8
QK	East Ayrshire	154	6	3.9	4.8	7	4.5	5.3	8	5.2	5.9	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
QL	East Dunbartonshire	127	1	0.8	0.8	2	1.6	1.5	1	0.8	0.7	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
QM	East Lothian	120	1	0.8	0.8	2	1.7	1.5	1	0.8	0.7	4	3.3	8.5	4	3.3	8.5	4	3.3	7.7
QN	East Renfrewshire	120	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
QQ	Falkirk	197	4	2.0	3.2	9	4.6	6.8	4	2.0	3.0	11	5.6	23.4	11	5.6	23.4	11	5.6	21.2
QR	Fife	453	0	0.0	0.0	1	0.2	0.8	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
QS	Glasgow City	694	51	7.3	40.5	30	4.3	22.6	52	7.5	38.5	8	1.2	17.0	8	1.2	17.0	10	1.4	19.2
QT	Highland	292	2	0.7	1.6	3	1.0	2.3	2	0.7	1.5	3	1.0	6.4	3	1.0	6.4	3	1.0	5.8
QU	Inverclyde	110	1	0.9	0.8	2	1.8	1.5	1	0.9	0.7	1	0.9	2.1	2	1.8	4.3	0	0.0	0.0
QW	Midlothian	112	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
QX	Moray	116	10	8.6	7.9	13	11.2	9.8	10	8.6	7.4	1	0.9	2.1	1	0.9	2.1	1	0.9	1.9
RJ	Na H-Eileanan an Iar	36	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
QY	North Ayrshire	179	4	2.2	3.2	5	2.8	3.8	5	2.8	3.7	1	0.6	2.1	1	0.6	2.1	2	1.1	3.8
QZ	North Lanarkshire	418	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
RA	Orkney Islands	27	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
RB	Perth and Kinross	175	12	6.9	9.5	14	8.0	10.5	12	6.9	8.9	5	2.9	10.6	5	2.9	10.6	5	2.9	9.6
RC	Renfrewshire	214	9	4.2	7.1	10	4.7	7.5	8	3.7	5.9	3	1.4	6.4	2	0.9	4.3	3	1.4	5.8
QE	Scottish Borders	130	3	2.3	2.4	3	2.3	2.3	4	3.1	3.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
RD	Shetland Islands	30	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
RE	South Ayrshire	147	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	2	1.4	4.3	2	1.4	4.3	2	1.4	3.8
RF	South Lanarkshire	398	3	0.8	2.4	0	0.0	0.0	3	0.8	2.2	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
RG	Stirling	110	6	5.5	4.8	6	5.5	4.5	6	5.5	4.4	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
QG	West Dunbartonshire	118	1	0.8	0.8	3	2.5	2.3	1	0.8	0.7	3	2.5	6.4	2	1.7	4.3	4	3.4	7.7
RH	West Lothian	211	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Total classed as extreme disadvantage			126		100	133		100	135		100	47		100	47		100	52		100

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