

Low Emission Zones and Social Equity in Scotland: A spatial vulnerability assessment

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Summary

Introducing Low Emission Zones is considered one way to address the poor air quality in certain parts of Scotland. These zones will regulate the transport system in ways that may adversely impacts certain groups. For example a Low Emission Zone could make it more difficult for some groups to travel to the centre of a town or city. The Scottish Government is obliged to consider these issues to ensure it complies with the Scottish Transport Application and Guidance process.

This report outlines a spatial vulnerability assessment which considers exposure, sensitivity, and adaptive capacity to the introduction of a Low Emission Zone. This assessment is built into a Geographical Information System as a site selection tool.

The approach is illustrated through a case study of Edinburgh City evaluating the level of vulnerability across the South-East of Scotland Region. Potentially vulnerable areas are identified and considered alongside the opportunities for residents to switch to active and public transport modes to access the city centre. The assessment suggests that some potentially vulnerable areas at the regional level have close proximity to public transport services which could be used to directly access the city centre. Additionally, the assessment illustrates that certain potentially vulnerable areas at the city level are within a reasonable active travel distance from the city centre, but the populations of these areas have relatively high levels of disability, which may restrict the capability of their residents to travel by walking or cycling.

Introduction

The Cleaner Air for Scotland (CAFS) strategy¹ sets out an ambitious vision for Scotland to achieve the best levels of air quality in Europe. Currently there are thirty-nine Air Quality Management Areas (AQMAs) in operation within Scotland, which cover locations that are exceeding the legal limits for local pollutant concentrations such as nitrogen oxides and particulate matter. These local pollutants can have a detrimental effects on human health, such as a heightened risk of contracting respiratory diseases. As such, the Scottish Government needs to effectively reduces the concentration of these local pollutants, and thereby remove the AQMAs, in order to achieve their air quality vision.

One such strategy currently being considered is introducing Low Emission Zones (LEZs) around existing AQMAs. These LEZs would restrict the entry of vehicles which do not meet a specified emissions standard in order to remove highly polluting vehicles from areas which have air quality problems. The classes of vehicles restricted by a LEZ could cover heavy and light goods vehicles, buses and coaches, as well as private cars. The Department for Food, Environment, and Rural Affairs² has published guidance on which vehicles within each class should be considered for restriction, with a Euro 4 emission standard for petrol cars (i.e. cars registered before 2005) and a Euro 6 emission standard for diesel cars (i.e. cars registered

¹ Available at: <http://www.scottishairquality.co.uk/air-quality/CAFS>

² Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/612592/clean-air-zone-framework.pdf

before 2014) being deemed appropriate. As of 2016, there were a total of 797,292 privately owned diesel cars not compliant to Euro 6 as well as 385,598 privately owned petrol cars not compliant to Euro 4 registered in Scotland, which equates to 53.3% of the total private car stock.

The implementation of LEZs has the potential to significantly alter the operation of transport systems and could be used to promote a shift to more sustainable modes of transport such as public and active travel. However, the policy could also have negative impacts that are unevenly distributed across the population, which raises questions about the social equity effects of the policy. This report sets out an assessment which measures the vulnerability that areas have to the introduction of LEZs. This vulnerability assessment is spatial in nature and evaluates areas based on three criteria which consider the structure of the car fleet, demographic characteristics of the population, travel patterns, and public transport availability to triangulate on the vulnerability of particular areas. In order to illustrate the assessment, a case study of Edinburgh City is presented with the interpretation of the results focusing on how the implementation of a LEZ could be synchronised with a series of supporting policies intended to promote a shift to more sustainable modes of transport.

Background

The transport system is a social asset, enabling citizens to participate in society by getting them to and from jobs, services, and events. The ability of citizens to access the transport system and the opportunities which arise from this access is associated with their degree of social inclusion. Increasing the access can open up new opportunities to citizens, whereas restricting the access may exclude citizens from engaging in social activities. As such, significant changes to the transport system can generate adverse consequences if the possibility of exclusion effects is not assessed.

The Scottish Government is obliged to consider these issues of social access and exclusion when designing transport policy. In the Scottish Transport Appraisal Guidance a series of provisions are established concerning these issues. They cover:

- 1. The distribution of impacts by people group**

Compare impacts for different population groups relevant to local policy objectives.

- 2. The distribution of impacts by location**

Compare impacts for policy sensitive locations such as Community Regeneration Areas and areas of deprivation defined by the Scottish Index of Multiple Deprivation.

The implementation of LEZs that restrict the entry of private cars to certain urban areas has the potential to generate such distributional effects. For instance, cars that are not compliant to the standard necessary to attain access to the zone might tend to be owned by a certain social group, which may already be marginalised. Additionally, non-compliant cars may tend to be owned by individuals that reside in areas that are deemed to have low levels of adaptive capacity, such as those which do not have ready access to alternative modes (i.e. non-car) of transport.

Methods

Vulnerability Index

In order to determine the likelihood of such effects resulting from the implementation of a LEZ, a social equity appraisal is required. This report presents a means through which to conduct such an appraisal which focuses on the spatial distribution of citizens that may have their mobility constrained due to the introduction of a LEZ. This appraisal involves developing a spatial vulnerability assessment which incorporates three dimensions of vulnerability covering:

- 3. Exposure to the policy**

An area's exposure represents the degree to which it is subject to the LEZ regulation and is composed of two sub-dimensions. First, the private car fleet registered in an area will have a level of compliance to the set emission standards which regulate access to the zone. Second, an area will have a level of interaction by car with the LEZ (i.e. trips originating from the area with a destination within the LEZ). If an area has a relatively high level of non-

compliance to the set emission standard and a high level of interaction with the LEZ, it would be classified as being highly exposed to the implementation of a LEZ.

4. Sensitivity to the policy

An area’s sensitivity relates to the degree to which its current mobility patterns might be affected by the introduction of a LEZ. One possible option for households with non-compliant vehicles is to purchase a compliant one. The median household income of an area can be used as a proxy for households’ capability to attain access to a car that is compliant to the LEZ emission standard. If an area has a relatively low level of median household income, it would be classified as being highly sensitive to the introduction of a LEZ.

5. Adaptive capacity to the policy

An area’s adaptive capacity reflects the ability of the population to access the LEZ by an alternative means after its introduction and is comprised of two sub-dimensions. Firstly, an area’s proximity to direct public transport links to the LEZ provides insights on the ability of the population to use these services to access the LEZ. Secondly, an area’s proximity to the LEZ and its level of disability signify the capability of the population to use active forms of transport to access the LEZ.

It is the combination of exposure, sensitivity, and adaptive capacity which will allow an area’s vulnerability to the introduction of a LEZ to be estimated. This conceptual framework is illustrated in Figure 1.

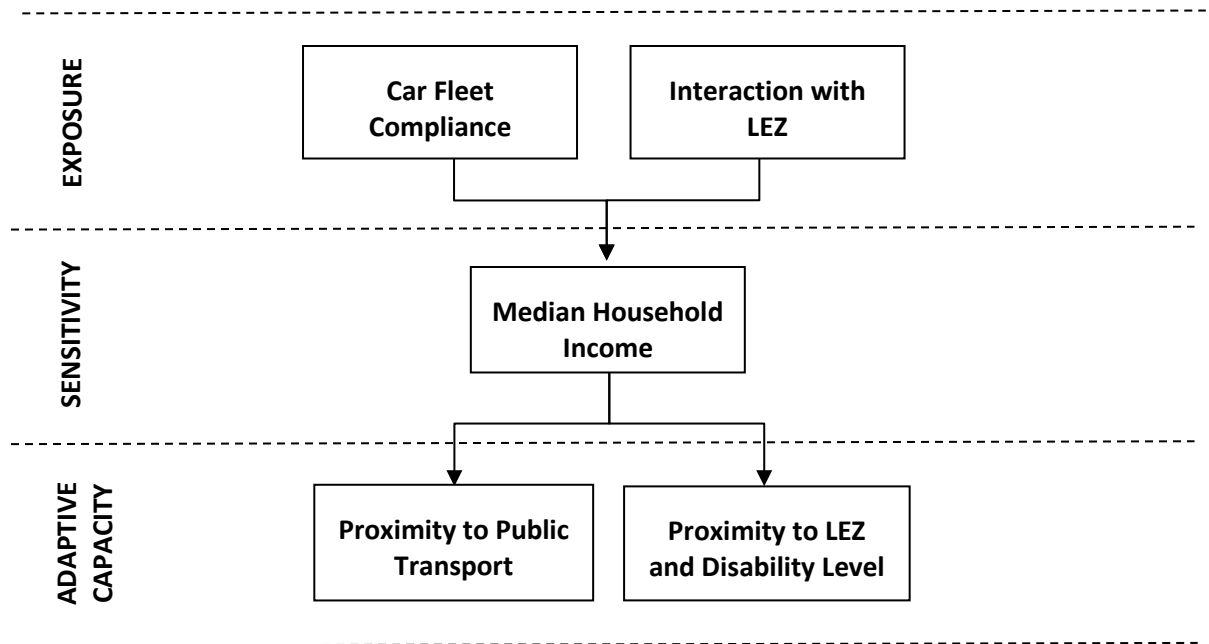


Figure 1: A conceptual framework of the dimensions included in the vulnerability assessment

Data sources

The assessment is based on a series of public record datasets which each contain information relevant to the three dimensions of vulnerability set out in the Background section. These datasets are briefly outlined in Table 1 with reference to additional information.

Table 1: Overview of the datasets utilised in the spatial vulnerability assessment

Dataset	Year	Description
Department for Transport Vehicle Licensing Statistics Database ³	2016	This database holds a record for every vehicle registered for use on the roads of the United Kingdom and includes a series of technical characteristics such as fuel type and year of first registration
National Records of Scotland Population Census ⁴	2011	The census records a series of household characteristics such as disability levels
SESTran Regional Transport Model ⁵	2012	The South East Scotland regional transport model incorporates an Origin-Destination matrix for AM-Peak car trips which allows for the level of interaction between areas to be considered
Scottish Government Local Level Average Household Income Estimates ⁶	2014	Median weekly household income is estimated through a series of ancillary surveys and data sources

Spatial resolution

The analysis is primarily specified at the Datazone level of spatial resolution, which includes spatial units that contain between 500 and 1,000 residents. This allows the analysis to differentiate the vulnerability of areas at a fine grained level and facilitates linkages with other spatial phenomenon such as public and active transport accessibility.

Analysis structure

The vulnerability assessment is built into a Geographical Information System (GIS) as a site-selection tool and involves a two-stage appraisal process.

1. Stage one

Overlays of compliance level, interaction with the LEZ, and median household income are used to identify areas that are in the top two quintiles for each issue and thus are potentially vulnerable to the introduction of a LEZ.

2. Stage two

Two accessibility analyses are conducted to determine the degree to which residents of potentially vulnerable areas have the opportunity travel to the LEZ by an alternative mode of transport. The first examines the availability of direct public transport links between potentially vulnerable areas and the LEZ. The second inspects the proximity of potentially vulnerable areas to the LEZ alongside the level of disability to consider the ability of the population to make use of active travel options.

³ More information available at: <https://www.gov.uk/government/collections/vehicles-statistics>

⁴ More information available at: <http://www.scotlandscensus.gov.uk/>

⁵ More information available at: <https://www.transport.gov.scot/our-approach/industry-guidance/land-use-and-transport-integrations-in-scotland-latis/>

⁶ More information available at: <http://statistics.gov.scot/data/local-level-average-household-income-estimates-2014>

Analysis limitations

The analysis is limited by a series of issues which should be kept in mind which interpreting the findings of the assessment.

1. Temporal disparity

The data utilised in the analysis is sourced from a series of public records which were not conducted at the same time. For instance, the vehicle licensing statistics were observed in 2016 whereas disability levels were recorded in 2011. This can introduce bias into the analysis if substantial changes in the spatial variation in the data has occurred in the intervening time periods (e.g. if the occurrence of disability levels is much changed across the South East of Scotland from its record in the 2011 census).

2. Spatial disparity

The data pertaining to car stock compliance, household income, and disability levels is each recorded at the Datazone level of administrative geography. However, the data which records the level of interaction (i.e. trips by car) across the South East of Scotland region utilises Travelzones which, whilst somewhat similar in size and layout to Datazones, are not exactly analogous. As such, the comparison between the spatial variation in interaction and the remaining data utilised in the assessment follows a best-fit approach.

3. Data synchronicity

The analysis structure relies on the co-occurrence of a series of un-connected area characteristics in order to assess vulnerability to the implementation of a LEZ. The possibility exists for these co-occurrences to be coincidental, meaning that areas may be identified as vulnerable when in fact they are not. For instance, an area may have a relatively high level of non-compliance to the LEZ emission standard and have a high level of interaction with the LEZ, but this does not necessarily mean that those non-compliant cars that are registered in that area are the ones being driven into the LEZ. As such, when an area is identified as potentially vulnerable, this finding is at best indicative of the fact that there might be a concentration of vulnerable households in that area.

4. Data accuracy

Each of the datasets utilised in the analysis have their own sampling or estimation process, which may lead to the accuracy of the statistics which they report being hindered. For example, the dataset recording the median household income uses an estimation procedure derived from analysis of ancillary datasets which use characteristics of the household to predict their income. While this procedure has been calibrating to optimise its accuracy, an error will be present between what the procedure estimates and what the real figure is.

Case study: City of Edinburgh

A case study of Edinburgh demonstrate the insights that can be generated from the vulnerability assessment. This case study assumes the introduction of a LEZ into the centre of the City of Edinburgh which restricts cars that are not compliant to the Euro 4 emission standard if fuelled by petrol and the Euro 6 emission standard if fuelled by diesel. The case study covers the South East of Scotland region in order to illustrate how the effects of implementing a LEZ may extend beyond the boundaries of the city.

Exposure to the Low Emission Zone

The proportion of the private car fleet which is not compliant to the emission standards which allow access to the LEZ is displayed in Figure 2a. It is clear that the areas towards the south of the region (i.e. the Scottish borders) and to the north of the region (i.e. the Kingdom of Fife) contain private car fleets that have higher non-compliance. This is a result of these areas being more inclined to register diesel cars. In terms of interaction with the LEZ, Figure 2b illustrates the AM peak car flow between each Travelzone and Edinburgh city centre for the top 40% of flows. It is apparent that zones located within the city and towards the west and east of the city have relatively high levels of interaction with the area in which a LEZ may be introduced.

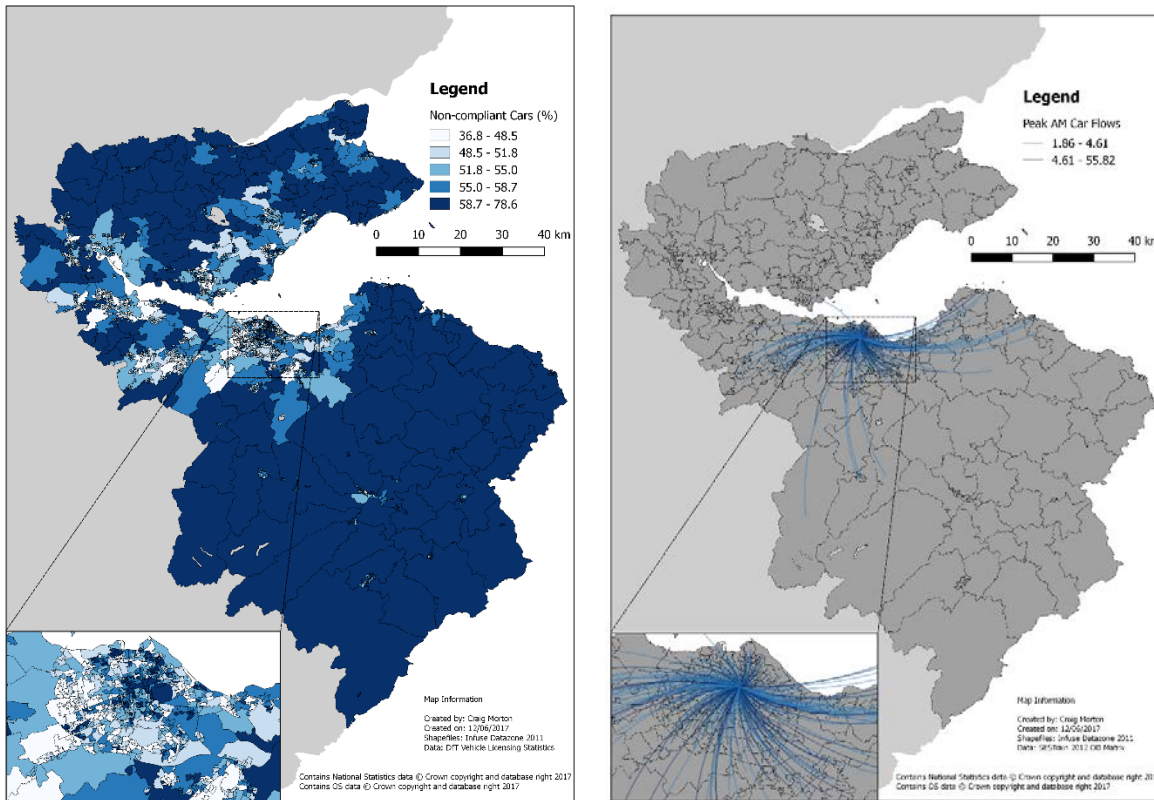


Figure 2: Maps displaying the (a) proportion of the private car fleet that is not compliant to the LEZ emission standard and (b) the number of AM peak car flows that are travelling to Edinburgh City centre

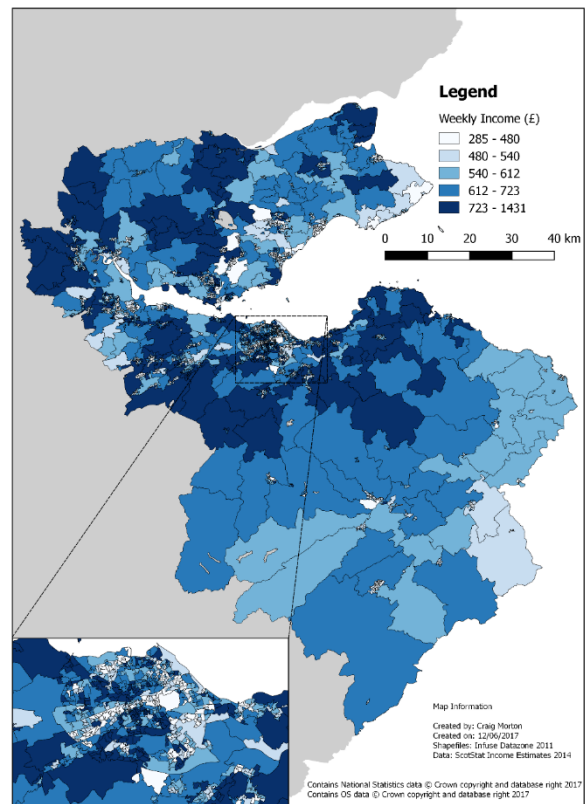
Exposure to the Low Emission Zone

Median weekly household income is displayed in Figure 3. Areas that display relatively high levels of income tend to be located in the peri-urban area surrounding the City of Edinburgh, parts of the City of Edinburgh, and areas within Fife. Areas that display medium levels of income are more prevalent in rural areas such as the Scottish Borders and Fife, whilst areas that have relatively low levels of income are more apparent in urban areas such as parts the City of Edinburgh, Kirkcaldy, Methil, and Leven.

Figure 3: Map displaying median weekly household income

Adaptive capacity

The first stage of the analysis identified a number of areas that are potentially vulnerable to the introduction of a LEZ (i.e. they have relatively high levels of non-compliance to the LEZ emission standard in their local car fleets, high levels of interaction by car with Edinburgh city centre, and low levels of median weekly household income). Focusing on two of these areas in the peri-urban region of the City of Edinburgh as examples, the settlement of Pumpherston to the west and Straiton to the south are described in Table 2 which outlines their absolute scores and



relative positions on the dimensions of vulnerability assessed in the first stage of the analysis.

Table 2: Descriptive statistics of potentially vulnerable areas

		Pumpherstun	Straiton
Datazone		S01013300	S01010962
Regulated Cars (%)	Value	56.29	59.12
	Percentile	67	83
Interaction with LEZ (Peak AM Car Flows)	Value	3.07	1.99
	Percentile	77	71
Household Income (£)	Value	500.80	416.48
	Percentile	28	5

In order to determine if these potentially vulnerable areas have the capability to access the LEZ by an alternative (i.e. non-car) means, the public transport links from these areas to Edinburgh city centre are evaluated. Figure 4 demonstrates that both areas are near to direct public transport routes to the city centre, with Pumpherstun being close to a rail station (Uphall) that has train services to Edinburgh while Straiton has a park-and-ride station with bus services to Edinburgh. As such, the residents of both Pumpherstun and Straiton have nearby alternatives to gain access to the city centre and thus appear to have adaptive capacity to the introduction of a LEZ. This suggests that high levels of exposure and sensitivity may be mitigated by high adaptive capacity, thus resulting in only moderated levels of vulnerability.

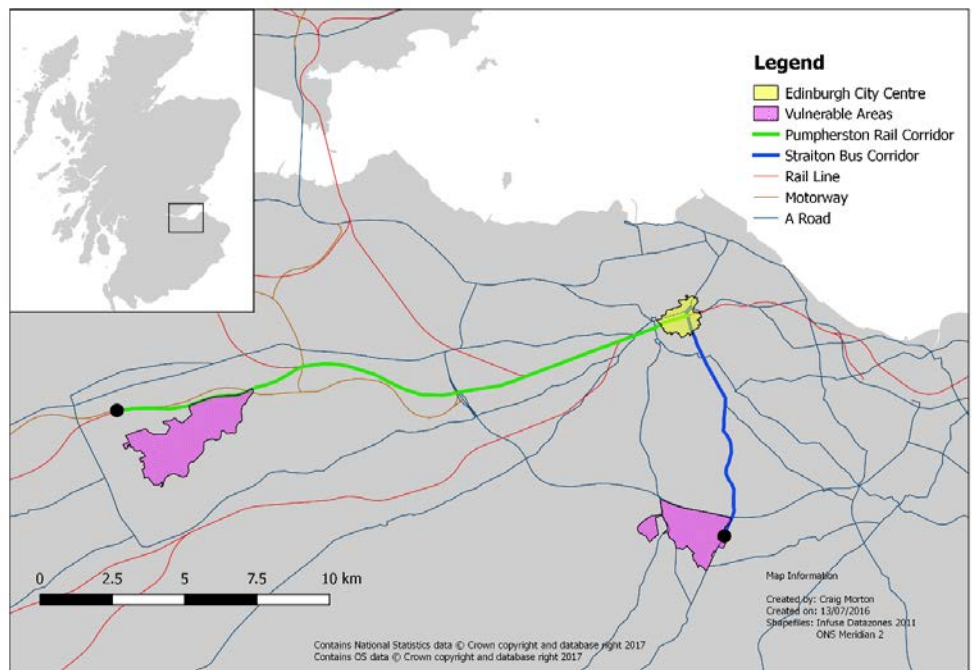
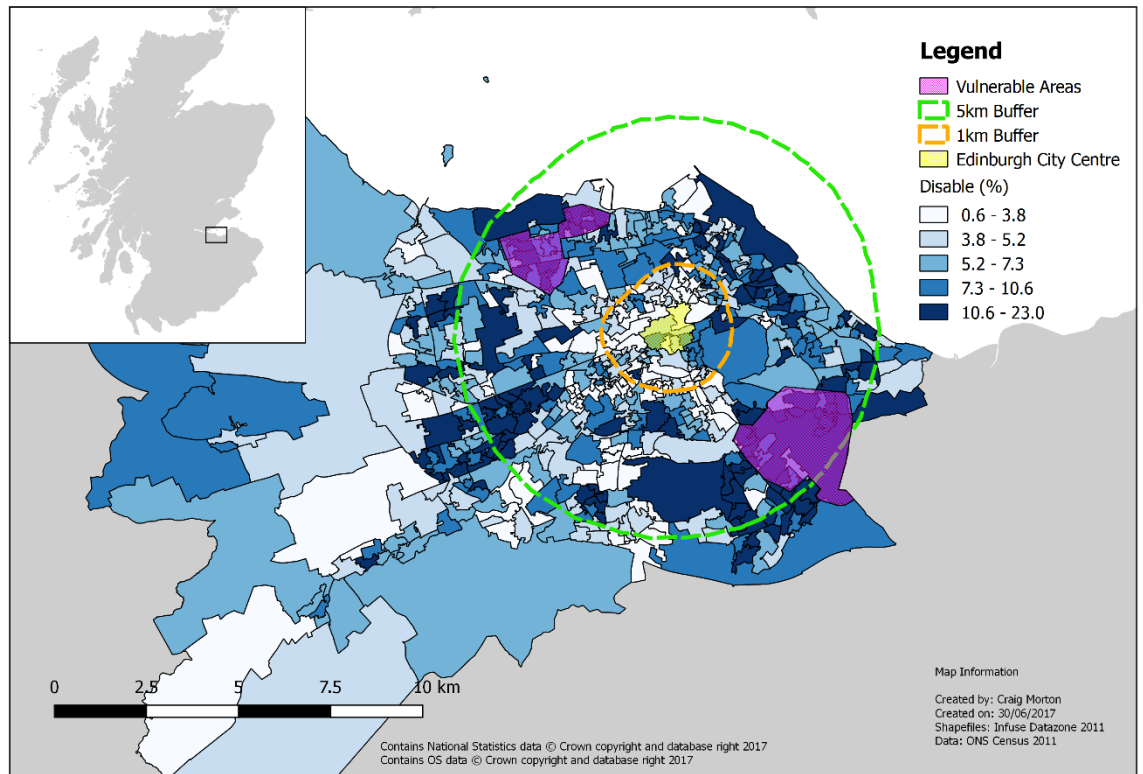


Figure 4: Two areas classified as potentially vulnerable to the introduction of a LEZ and their proximity to direct public transport links to Edinburgh city centre

Potentially vulnerable areas that are present within the City of Edinburgh may have opportunity to shift to active modes of transport (e.g. walking and cycling) to access the city centre. Two areas within the City of Edinburgh, one located to the north-west and the other to the south-east, are categorised as potentially vulnerable. Figure 5 situates these potentially vulnerable areas in reference to two buffers from the city centre that cover 1 kilometre and 5 kilometre distances. These buffers are selected to illustrate the distances that could be easily travelled by walking and cycling. Additionally, Figure 5 displays the proportion of the population that is classified as having their day-to-day activities limited a lot, which provides an indication of the ability of the population to engage with active travel. The findings of this active travel appraisal imply that, whilst the two potentially vulnerable areas identified are within a distance from the city centre that allows for active

travel, their populations have a higher prevalence of physical disability. As such, these areas warrant further attention as their residents, whilst within a distance from the city centre that allows for active travel, may not be able to switch to active modes.

Figure 5: Two areas classified as potentially vulnerable to the introduction of a LEZ, their proximity to the city centre, and their level of physical disability



Conclusions

This report demonstrates a spatial vulnerability assessment of the introduction of Low Emission Zones in Scotland. This assessment considers the exposure, sensitivity, and adaptive capacity of areas in order to evaluate their level of vulnerability to the policy. Through a case study of the City of Edinburgh, the assessment demonstrates the ease of application of the approach and how it can produce insights that can guide government action.

The Government could make use of the assessment in the following ways in order to facilitate the implementation of LEZs:

1. The assessment can locate areas of interest that require further analysis to develop a complete understanding of their vulnerability. For instance, the use of surveys applied in the area of interest or focus groups with residents could assist in producing a richer understanding of how residents would be effected by and react to a LEZ.
2. The assessment can assist in targeting investment at areas that would likely benefit in terms of their ability to travel to the city centre by sustainable modes. For instance, the frequency of service on certain bus corridors may need to be increased in order to adequately cater for city centre trips that will be displaced from the car. Additionally, flexible mobility solutions (e.g. car clubs and bicycle hire schemes) could be deployed in certain areas to increase the variety of options available to them in order to access the city centre.
3. Active travel coordinators could be deployed in areas that are potentially vulnerable to the introduction of a LEZ but have the opportunity to access the city centre either by walking or cycling. For instance, guided cycle rides between areas and the city centre could demonstrate to residents the safest routes to travel to the city centre to address any hesitancy to undertake cycling.
4. The outputs of the assessment can be used during public engagement events concerning the LEZ to illustrate how the policy is being considered. For instance, events could be organised in areas that are potentially vulnerable to the introduction of a LEZ to demonstrate the situation that is present there and the alternative transport options.

that are available. Overall, this may help mitigate public concerns towards the LEZ, and increase levels of public acceptance.

An important point to keep in mind when considered the analysis presented in this report is that it is static, in so much as the maps that are displayed are not interactive. One of the strengths of the assessment is that it allows dynamic interrogation of the data when loaded into a Geographical Information System. This dynamic interrogation allows users to cross-examine the assessment by zooming into areas of interest, superimposing additional characteristics, and contrasting multiple areas in order to generate a richer perspective on the issue. With this in mind, one recommendation is that the Scottish Government consider adopting this assessment procedure in their policy development process in order to gain the most benefit from it.

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