Fuel Poverty in Scotland: refining spatial resolution in the Scottish Fuel Poverty Indicator using a GIS based multiple risk index

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1.Introduction

Fuel poverty describes a complex interaction between households with low income and energy inefficiency, whereby a household is unable to obtain adequate energy services for less than 10% of its income. The Scottish Executive has charged local authorities in Scotland with the task of eradicating fuel poverty by 2016. In order to direct investment and tackle fuel poverty, a local authority must know which areas are more likely to contain fuel poor households. Currently local area fuel poverty indicators, based on small area statistics, are used to identify target areas. Only one local area indicator is freely available to local authorities in Scotland, however its use may be seen as problematic as data is aggregated to an electoral ward level and information on the energy efficiency of local housing is not taken into account. This paper proposes an innovative methodology for refinement of the Scottish fuel poverty indicator using GIS as a framework for integrating census data with georeferenced energy efficiency data on local housing. We concentrate on one local authority, Stirling Council (see Figure 1). The proposed methodology allows a multi-scale mapping of fuel poverty risk at both a census output area level and an individual dwelling level. This approach highlights small areas susceptible to fuel poverty which were previously masked by the aggregation of statistics to large geographic units.

1.1 Background

In order to effectively set out measures to prevent fuel poverty, a local authority must know where to target its efforts. A tool is therefore required to predict areas where fuel poverty is likely to be prevalent, as the issue differs in many respects to general deprivation (Baker *et al* 2002, Shortt & Rugkasa, 2007). An attempt was made to provide such a tool by Energy Action Scotland in 2003 through their Scottish Fuel Poverty Indicator (SFPI), which classifies all Scottish Electoral Wards according to the risk of their containing fuel poor households. With an average population of around 4000 people per ward however, this indicator can be seen as problematic in terms of the ecological fallacy – small areas or houses which may lie in fuel poverty are ‘masked’ by the characteristics of the area in which they are situated.

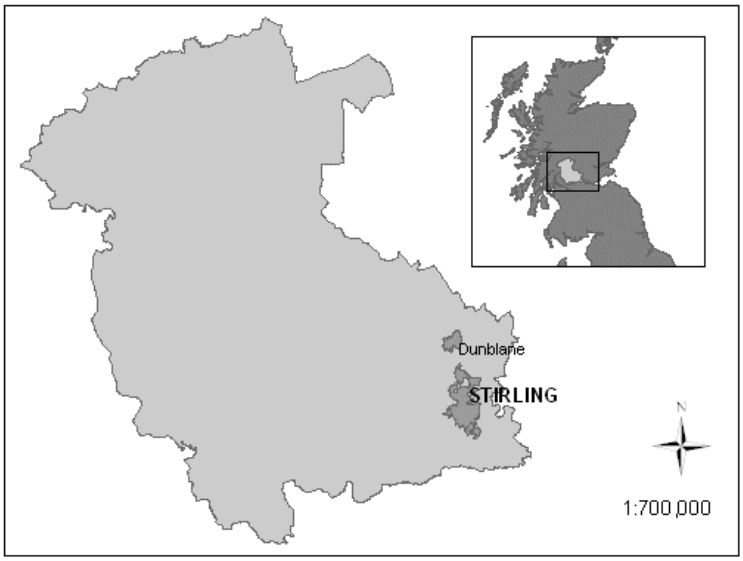

Figure 1. Location of study area

2. Methodology

In light of this, there is a need to look at alternative methodologies for predicting areas susceptible to fuel poverty in Scotland – incorporating both social aspects, in terms of identifying those groups of people most at risk, and physical aspects in terms of those buildings most prone to energy inefficiency. In addition, there is also a need to cost-effectively improve the spatial resolution at which fuel poverty can be predicted so as to ensure all potentially fuel poor households are identified.

In constructing a fuel poverty indicator for Stirling Council it was necessary to ascertain local sources of housing information. Through liaison with Stirling Council, GIS datasets held by Housing Services were made available, opening up the possibility to map the location of almost 30,000 dwellings in the council area in terms of property type and tenure, from a total of almost 38,000. This data was then integrated with a GIS dataset obtained of current and previous local authority housing from the council's intergrated housing management system and referenced geographically using the council's corporate address gazetteer. This dataset offered further variables of energy efficiency (year of construction and type of water heating) for a sample of 9,205 dwellings.

The methodology proposed combines census variables used in the SFPI with the data retrieved on individual dwellings. This methodology is based on the use of Principal Components Analysis (PCA) to obtain fuel poverty risk scores. Working from the approach taken by Rudge (2000) in integrating census and housing energy efficiency data, a methodological framework for developing a fuel poverty indicator is outlined in Figure 2. Central to this methodology is the collection of information on local housing stock energy efficiency in order to, where possible, weight the model toward the characteristics of the local area. A key goal behind this approach was to refine the spatial resolution at which predictions of fuel poverty could be made as far as possible. In light of the ability to map fuel poverty risk onto individual dwellings it was decided the data made available could best be utilised using a two part indicator. The proposed methodology combines the mapping of social factors at the output area

scale and energy efficiency characteristics at an individual dwelling scale (Figure 2). PCA was used for both indicators in order to reduce the component variables to a single output score (through the generation of factor scores) for fuel poverty risk. This process showed that for social factors (output area scale) 3 components explained 77% of variance, while for energy efficiency data (individual dwelling scale) 3 components explained 63% of variance. The key benefit of this methodology is centered on the point at which the social and energy efficiency components are brought together. In order to map overall fuel poverty risk at different scales, a final output area fuel poverty 'score' is obtained from the social component PCA and attributed as a variable to any dwelling located within that output area, as a measure of the level of risk of potential inhabitants being groups at risk of fuel poverty. This score is then fed into a second PCA conducted for individual dwellings.

The goal of the project was therefore to identify risk of fuel poverty due to the characteristics of those households found in an area, and using this information to identify those households in such an area whose characteristics would suggest they could be considered energy inefficient. The use of GIS in providing a flexible environment in which all relevant information can be brought together and analysed is key to this methodology.

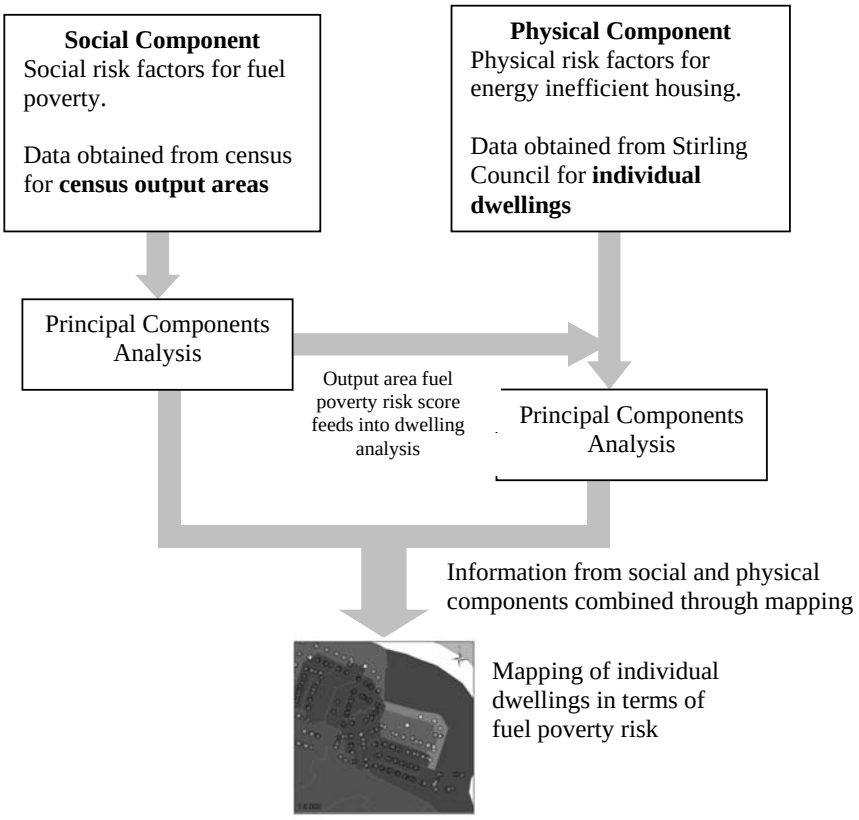

Figure 2. Proposed methodological framework

3. Results and Conclusions

When mapped (see example in Figure 3), 10 of the 139 output areas in the top 2 deciles most at risk from fuel poverty lay within wards classed by the Scottish Fuel

Poverty Indicator as being ‘at least risk from fuel poverty’. A further 53 output areas in the top 2 deciles most at risk from fuel poverty lay in wards classed by the Scottish Fuel Poverty Indicator as having a ‘below average percentage of fuel poor households’. This represents the possibility of around 3,150 households in fuel poverty within wards previously classed as having the least risk of containing fuel poverty.

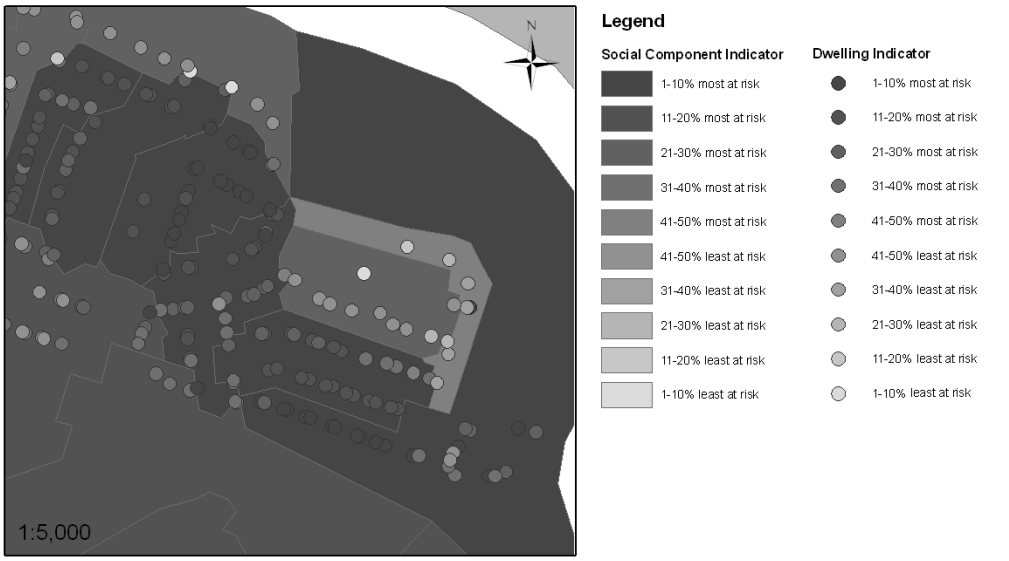

Figure 3. Social component / output area indicator shown with dwelling level indicator superimposed.

When the sample of 9,205 dwellings was mapped as address points, 312 of the 1,871 dwellings in the top 2 deciles most at risk of fuel poverty lay within output areas ranked in the top 2 deciles most at risk of fuel poverty. The remaining 1,559 dwellings in the top 2 deciles most at risk of fuel poverty were therefore spread out in areas which would not have otherwise been highlighted as being at risk from fuel poverty. On inspection of output areas highlighted as most at risk from fuel poverty, a range of different energy efficiency levels were also noticeable in dwellings.

This research has highlighted the dangers of ecological fallacy in the use of local area predictors of fuel poverty, and the generation of fuel poverty risk indices for relatively large spatial units such as electoral wards demonstrated to mask smaller areas at risk of fuel poverty. The problems of ecological fallacy in predicting fuel poverty can therefore be reduced with reduction of the size of the spatial unit to which statistics are aggregated, however this solution is made still more problematic in considering the size of the area for which assumptions about housing can be made (Moore *et al*, 2006). Information on local housing stock energy efficiency is therefore key to the successful identification of such previously masked areas or dwellings susceptible to fuel poverty.

The ability to map fuel poverty risk onto individual dwelling can be seen as important in freeing any subsequent analysis from standard geographical units, thus for example allowing for the identification of individual dwellings likely to be at risk, and complete freedom in building up community profiles at any scale. Such information

would not however be available for all local authorities, therefore this highlights the importance of investigating locally available data on housing stock. While providing a useful tool for the identification of dwellings which may be susceptible to fuel poverty however, this indicator is by no means intended to be an absolute measure of whether a dwelling is in fuel poverty or not, as this can only be determined through a detailed household survey (as identified by Moore *et al* 2006).

Given directives from the Scottish Executive for the eradication of fuel poverty in Scotland by 2016, local authorities are under increasing pressure to effectively and efficiently target those areas within their boundaries where this problem is prevalent in order to set about tackling it. This research therefore represents a step towards improving the accuracy with which areas and dwellings can be targeted, thus improving the efficiency of directing further action against fuel poverty.

4. References

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Biography

Following the completion of an MSc. in GIS at the University of Edinburgh, Colin Morrison is currently employed within Stirling Council's Corporate Research Team. Here his focus is on the implementation of GIS to add value and understanding to a wide range of social and demographic research. Dr. Niamh Shortt is a lecturer in the Institute of Geography, University of Edinburgh and course director for the MSc (by research) in GIS & Society. Niamh's primary research interests are in spatial inequalities in health and geographies of exclusion.