HITRANS INDEX OF SPARSITY: A TOOL FOR ENSURING REGIONAL EQUITY

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1 INTRODUCTION

Rural areas provide particular challenges for transport planners in terms of delivering sustainable passenger transport solutions that meet the needs of residents and visitors alike. The Highlands and Islands of Scotland present a demand that is even more unique. With large swaths of the area designated as Very Remote or Remote Rural under the Scottish Executive’s (SE’s) Urban/Rural Eightfold Classification there was a need to move to a more ‘fine grain’ measure of typology which allows comparable zones to be identified. In such a way best practice, from within and outwith the region, could be transferred between zones of a similar type, ensuring equity of provision for all.

The Highlands and Islands of Scotland is one of the most sparsely populated regions in Europe. Journey times, particularly by public transport, to key services and opportunities are often extended, making accessibility a prime concern for local authorities. Yet within this region is a wealth of diversity between different areas, meaning broad brush solutions are not appropriate. By relating measures of geography, accessibility and need in one tool, it is believed that the most appropriate and cost effective solution can be consistently arrived at.

The HITRANS Index of Sparsity combines measures of accessibility (by journey purpose/destination), population density and car ownership, as the key indicator of transport need, to produce an integrated tool for identifying areas of a similar typology. It moves beyond the SE Classification by disaggregating the existing rural typologies in order to produce a finer grain analysis of transport needs. Through the Index, census data zones are allocated to one of eight new classifications for remote rural areas.

When this new classification is combined with a matrix of best practice for each area type and journey purpose/destination, solutions can be developed which are transferable across large areas of the HITRANS region. In addition to the new classification, a straightforward ‘indicator of need’ score is also provided, allowing investment to be prioritised across competing zones. The Index helps to ensure that throughout the region no one resident is more disadvantaged by transport provision than those in comparable zones.
2 CONTEXT

2.1 Scottish Transport Policy

The Highlands & Islands Regional Transport Strategy (HITRANS, 2008) and Scotland's National Transport Strategy (Scottish Executive, 2006) set the context in which the Index of Sparsity for the Highlands and Islands was developed. In each, ensuring people have the opportunity to access education, training and employment as well as key services such as health, cultural, sporting and leisure activities is a central tenet of economic prosperity, and maintaining and improving quality of life.

"Improving connectivity is central to all the problems and constraints that have been identified through analysis of the issues and during consultation with stakeholders around the region." (HITRANS, 2008)

The National Strategy recognises that accessibility is a particular challenge in the more remote or rural areas of the country. Whilst there are many overlaps with other public service sectors, transport is recognised as having a key contribution to make to ensure that “Scotland becomes an inclusive and just society by providing high quality and affordable public transport which will enable access to key services and life opportunities”.

2.2 Urban/Rural Classification

The sheer scale of this challenge for the Highlands and Islands region becomes apparent when the Scottish Executive's (SE’s) Eightfold urban/rural classification is examined. The SE’s underlying methodology is based on:

- population density; and
- drive times to the nearest settlement with a 10,000 plus resident population.

Population density splits Census areas into one of four settlement types. There are few urban areas within the Highlands & Islands, so we were primarily concerned with the latter categories, namely:

- Small towns: Settlements of 3,000 or over and below 10,000. These are likely to be smaller towns which are unlikely to contain a full range of services; and
- Rural: Settlements below 3,000 and those not living in settlements. These are unlikely to contain many services.

These categories are then segmented into under 30 (accessible), 30 to 60 (remote), and over 60 minutes (very remote) drive time bands in order to allocate Census zones into one of eight overall categories. The resulting classification for the Highlands & Islands is presented in Figure 1 below.
Figure 1: Highlands & Islands SE Eightfold Urban/Rural Classification

Large swathes of the region are designated as remote rural, with any accessible rural (under 30 minutes drive time) primarily limited to Inverness’s hinterland. Ensuring that no one resident is disadvantaged by locality, in comparison to other residents in a similar type of area, becomes a significant challenge, ie making sure there is no penalty through geography.
For passenger transport, the SE’s classification, whilst an invaluable starting point, did not appear to be a suitable mechanism for ensuring equity of provision across the region. It was felt that significant underlying diversity was likely to be present across remote rural areas and small towns in the region and that a more fine-grained approach was required in order to identify areas of a similar typology or with the same characteristics.

Such a fine-grained approach was perceived to have two principal benefits, namely the:

- identification of areas with similar transport needs (or requirements), and thus a means of ensuring that they receive equitable levels of support; and
- means of transferring best practice in passenger transport delivery (by area type and journey purpose), from within and outwith the region.

2.3 Accessibility Planning

The importance of the interaction between transport and social inclusion has long been recognised, but it was the Social Exclusion Unit’s (SEU’s) report “Making the Connections: Final Report on Transport and Social Exclusion” (SEU, 2003) that really placed it firmly in the political spotlight. The report highlights the role that transport can play as a barrier to social inclusion, and the specific relationships between public transport and the locations of services and opportunities in overcoming such barriers.

From this report, a new agenda of accessibility planning was born, requiring new skills sets and analysis techniques amongst practitioners. To assist in the process, the UK Department for Transport (DfT) produced a new accessibility modelling program ‘Accession’, which calculates network-based time to access a pre-specified set of destinations. Use of the program is now widespread, particularly for mapping (using intermediary Geographic Information Systems (GIS)) and dissemination of analysis to a wider audience. In addition, voluminous reports are also produced which detail access from each origin (typically a postcode point) to each destination (e.g. a hospital, college or local/regional centre).

With no detailed network model of the region from which to ‘skim’ travel times, costs etc, Accession provided an invaluable starting point for understanding existing levels of accessibility across the region. The decision was therefore made to use this as a starting point for compiling an Index (of Sparsity) which would lead to a more fine-grain area classification and a means of identifying and prioritising locations for investment.

3 CONCEPTS AND FUNCTIONALITY

Figure 2 illustrates the functionality with the Index of Sparsity, which combines Accession outputs with:

- further information on baseline passenger transport provision;
best practice from national guidance and LA officer knowledge; and

underlying Census data on the area and its population.

Figure 2: Overview of the Functionality of the Index of Sparsity

A host of potential variables were considered for inclusion in the Index as potential indicators of sparsity and need across the population. Table 1 provides a breakdown of the variables included and the destination sets used in the Accession component. All data was collated at a data zone level, where $N = 554$ for the Highlands & Islands region. Some a priori judgment had to be made regarding the key variables of interest, as there is no prior measure of the sparseness of an area and thus no dependent variable upon which a regression model could be built.

In addition to the variables in Table 1, data was also collated on the population aged 65 and over, jobseekers and Scottish Index of Multiple Deprivation (SIMD) indicators; however, a key consideration at the first iteration of the Index was to keep it transparent and user friendly for practitioners. Additionally, inclusion of additional variables runs the risk of ‘diluting’ the importance of key variables if they are not weighted appropriately.

**Table 1: Highlands & Islands Index of Sparsity Variables**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population Density</td>
<td>The inverse of total population over area</td>
<td>The true indicator of sparseness and dispersion of the population</td>
</tr>
<tr>
<td>Category</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>----------------------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Non Car Ownership</td>
<td>Number of non car owning households in an area</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Key indicator of transport need, with households dependent upon passenger transport and lift giving for longer trips</td>
<td></td>
</tr>
<tr>
<td>One Car Ownership</td>
<td>Number of one car owning households in an area</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Main breadwinner may use the car to access employment (etc) in the AM leaving remaining household members without car availability for large proportion of day</td>
<td></td>
</tr>
<tr>
<td>Access to Education</td>
<td>University of Highland &amp; Islands facilities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Access to specialised further and higher education opportunities is at the heart of the economic strategy for the region</td>
<td></td>
</tr>
<tr>
<td>Access to Health (10:00 to 16:00)</td>
<td>Accident &amp; Emergency (A&amp;E) departments (plus selected others)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Access to key A&amp;E and outpatients departments is central to ensuring quality of life for the region’s residents</td>
<td></td>
</tr>
<tr>
<td>Access to Key Settlements (10:00 to 16:00)</td>
<td>Regional and Local Centres (as defined in the Regional Transport Strategy)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Centres are likely to be the site of many of the key services and opportunities that are essential to everyday life</td>
<td></td>
</tr>
<tr>
<td>Access to Employment</td>
<td>Hansen weighted measure of access to all jobs in region</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Accounts for the relative attraction of a given area ($\sum jobs$) and the deterrence of travelling there (journey time by public transport) to produce a weighted measure</td>
<td></td>
</tr>
<tr>
<td>Return Journey</td>
<td>Return journey to nearest key settlement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Some services may restrict ability of</td>
<td></td>
</tr>
</tbody>
</table>
Within defined timeframe residents to perform all necessary tasks at destinations due to irregular scheduling

DRT/Community Transport Coverage

Whether a registered demand responsive or community transport scheme is in operation in the area

DRT and community transport are not included in the Traveline data that feeds into Accession. Residents’ travel needs may be being met by such schemes

Data for each of the above variables was compiled at a data zone level and a composite indicator created, taking the form:

\[ I_{s_i}^j = \text{Pop} D_i + \sum_j \left( C_i^0 + C_i^1 \right) + JTave_i^j \]  \hspace{1cm} (1)

where:

\( I_{s_i}^j \) = the Index of Sparsity (out of 100) for zone \( i \) and journey purpose \( j \)

\( \text{Pop} D_i \) = the (inverse) population density of zone \( i \)

\( C_i^0 \) = the number of non car owning households in zone \( i \)

\( C_i^1 \) = the number of one car owning households in zone \( i \)

\( JTave_i^j \) = the average journey time from zone \( i \) for journey purpose \( j \)

In order to reflect the differing importance of the variables to the overall concept of sparsity, weights were introduced into equation (1), such that:

\[ I_{s_i}^j = \alpha \text{Pop} D_i + \sum_j \left( \beta C_i^0 + \chi C_i^1 \right) + \delta JTave_i^j \]  \hspace{1cm} (2)

where:

\( \alpha, \beta, \chi, \) and \( \delta \) are parameters to be defined by the practitioner.

Not all areas or zones in the region will be sparse, with some having high levels of car ownership, being (relatively) densely populated or having short public transport journey times to key destinations. Thresholds were therefore defined, whereby values above or below (as appropriate) were allocated to being ‘non sparse’ and their relative contribution to the journey-specific Index eliminated.

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The four journey specific indices are then combined into the final Index of Sparsity. In order to reflect regional priorities from, for example, “A Smart, Successful Highlands and Islands” (Highlands & Islands Enterprise, 2005) each purpose can also be weighted. In such a way, access to employment can be given greater priority, or should an increasingly aging population represent a greater priority, access to healthcare can take precedent. The journey specific indices in Equation (2) are thus combined in the final Index (again out of 100) with the form:

$$I_s = \sum_{j} \gamma_j I_{s,j}$$

(3)

where $\gamma_j$ is a weighting parameter to be defined by practitioners.

Figure 3 shows how the four journey-specific components of the Index are brought together into the aggregate Index. This is used to drive an area definition (described in Section 4). Each area type has an underlying passenger transport provision matrix which has a sliding scale of types of provision (from best to worst) by journey purpose. This is informed by current provision, including patronage and costs/revenue to provide, and an ongoing best practice review to maintain cost effectiveness.

From the matrix a series of options (packages of services) are generated and these are then synergised across journey purposes and area boundaries. The former recognises that in many localities there are already public service vehicles or taxi schemes providing for accessibility needs, but these may often be limited to certain journey purposes. The latter recognises that adjacent areas (data zones or across local authority boundaries) may already have certain services in place, and extension of these may represent the most effective means of ensuring equity in terms of both meeting need and costs.
A preferred option, or package, is subsequently defined for appraisal against STAG criteria.

The final Index produces two key outputs, namely the identification of:

- areas with similar characteristics or typology for ensuring equity of provision; and
- basic levels of sparsity/need (regardless of area type).
In the following sections each of this discussed in further detail.

4 HOMOGENOUS AREAS AND EQUITY OF PROVISION

The key driver for production of the Index was the attempt to ensure equity of provision and a means of transferring best practice (by journey purpose) across areas of similar typology. A range of different possible area segmentations were sense tested using both the Sixfold and Eightfold Urban/Rural classifications. As each must be supported by data collection and the definition of best practice, it was felt that whilst a very fine grain classification had its obvious merits in picking up area characteristics, an initial workable and transparent tool was a priority.

Using the aggregate Index score for a given area, $I_{ij}$, the remote rural and remote small towns were broken down into four further categories each. For each, a broad definition was produced of its defining characteristics. Whilst the descriptions are by no means uniform they provide a reference point for the practitioner when attempting to understand the categorisation. Figures 4 and 5 illustrate the outputs for two sample areas: Caithness, and Inverness and Moray.

Figure 4 (Caithness) shows the zones around John o’ Groats, and south of Wick have been designated as the sparsest. That is they have the lowest car ownership, longest journey times by public transport, or lowest population densities (or some combination thereof). A large swathe of the Caithness area, broadly bisected by the Far North Rail Line and the A882/A9, is designated as Remote Rural Two (the second sparest category). The central tenet of the area classification is that all residents in such areas should be receiving a broadly comparable level (and type) of public transport service, and that no one HITRANS resident should be disadvantaged by their locality in comparison to other residents in similar areas.
Figure 4: HITRANS Area Classification in Caithness
Figure 5: HITRANS Area Classification around Inverness and Moray

5 IDENTIFYING NEED AND APPROPRIATE FUNDING ALLOCATION

In addition to the area classification, the basic Index score (out of 100) can be used outwith of the SE’s urban/rural classification to identify zones of need, or those that suffer from lower levels of accessibility to immediately adjacent...
zones. In such a way, zones in Inverness, regardless of their designation as a urban area in the SE classification, can be analysed to identify those with higher/poorer levels of accessibility by purpose. Outliers or clusters of zone can then be analysed in greater detail to pinpoint equity issues, and again ensure that locality or geography does not diminish opportunities and quality of life.

Figures 6 and 7 present some examples of the raw output from the Index score for the Isle of Lewis and Wester Ross/North West Sutherland. Figure 6 shows one area on the northern coast of Lewis which scores particularly lowly in the Index, and is surrounded by zones with significantly higher scores. Similarly in Figure 7 we can see three zones with noticeably lower scores, although here it would appear to be driven by relative isolation from sizeable settlements rather than, perhaps, low car ownership. These isolated scores provide an indicator of the zones with the greatest transport need, and therefore a potential means of allocating out funding to meet social inclusion objectives and targets.
Figure 6: HITRANS Index of Sparsity Scores on the Isle of Lewis
6 RATIONALE, EXTENSIONS AND CONCLUSIONS

The rationale for the Index was the development of a tool to assist the constituent local authorities within HITRANS in delivering equity of provision throughout their region. Whilst the Accession mapping provided useful context for the overarching Passenger Transport Strategy, it did not begin to
identify underlying transport need amongst the resident population and how the type of service would have to differ to take account of population dispersion. It did however produce postcode level analysis of accessibility which could be aggregated to form the foundation for a tool which took account of a wider range of issues and factors.

The level chosen for this was Scottish Data Zone, primarily due to the number within the region, with Census Output Areas proving too plentiful for what was meant to be an accessible tool. By identifying areas with similar need (car ownership), geography (population density) and current provision/accessibility (journey purposes) it was felt that groups of such areas could be defined. The SE’s urban/rural classification schemes provided a ready made starting point for this process. Once areas/zones had been disaggregated into a finer grain classification, this was a means of looking afresh at the region and attempting to ensure that area/zone within a given classification received a comparable level of service and/or funding. In addition, there was also a substantial secondary benefitting of identifying areas where proven solutions from both within and outwith the region could be transferred in the knowledge that they were likely to be successful in meeting needs and cost effectiveness criteria.

The Index provides:

• a means of extending Accession analysis to account for underlying need and geography;

• a score to indicate basic need and define appropriate levels of support;

• a classification for the identification of similar areas and the delivery of equity/transferral of best practice;

• ranking systems for the prioritisation of areas/zones and thus investment/support; and

• local evidence based analysis for the development of solutions and appropriate service levels and a means of communicating the decision-making processes to wider audiences.

The development of the Index was never the primary focus of the overarching study, and there therefore exist a number of possible extensions to its use, methodology, and coverage, including:

• the use of alternatives to Accession, due to its limitation to journey times and its exclusion of fares, frequency of service, vehicle quality etc. Techniques have now been developed elsewhere which utilise conventional model outputs and a generalised cost approach to provide a more realistic picture of the deterrence to travel;

• Accession’s selection of thresholds, above which residents are unlikely or unwilling to travel, is arbitrary. Although there are some publicly available sources for such thresholds, they are likely to vary substantially by area type. Calibration of the necessary parameters to
real world data sources (eg the Scottish Household Survey) using deterrence functions would more accurately represent the true accessibility;

• there is not account of the relative attraction of the destinations (eg college places or hospital beds). The techniques discussed previously have taken account of the relative production of a zone (eg population in a certain group) and attraction of the destination zone (eg jobs, or number of shops);

• there is further work to be done on defining best practice by area type and journey purpose, and this is very much an iterative process;

• there is currently limited scope for assessing testing public service led interventions, eg bringing services to the residents through mobile GP and nurses surgeries or remote education through broadband;

• a more fine-grain area classification; and

• re-calibration of the Index to make it more attractive for testing changes in the public transport network. This is, in part, a result of the weights attached to each component of the Index, eg journey time represents 50% of the overall Index score. As it stands, the Index is a tool for ensuring equity rather than a network tool for testing the impact of timetable and service revisions. Iterations of the Index can be made if substantial changes to timetabling are undertaken.

Bibliography


HIGHLANDS AND ISLANDS ENTERPRISE (2005) A Smart, Successful Highlands and Islands.


Notes
1 By diversity we mean variations in demographics, local economies, geography and particular societal and community-based issues that are often specific to a limited number of localities.

2 Gray advanced eight different typologies and noted that ‘90% of the UK population are probably contained in typologies such as peri-conurbation, peri-urban or market town. Available at: http://www.cfit.gov.uk/docs/2001/rural/index.htm (Gray, 2001).

3 Accession’s travel time calculation includes access, wait, in-vehicle and egress times.