E-food Desert Index (EFDI)
Technical report and user guide

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Introduction

Prominent studies in the late 1990s and early 2000s identified the presence of 'food deserts' – neighbourhoods which had been 'abandoned' by the major retailers, resulting in poor access to larger format grocery stores providing fresh, healthy and affordable food. Many of these neighbourhoods were some of the most deprived in England and Wales and were located within inner city areas where residents faced considerable financial and practical (e.g. access to transport) barriers to accessing food store provision.

Considerable retail-led investment during the past 20 years may have largely addressed the issue of urban food deserts. These include rapid growth of inner city and suburban convenience stores operated by the major retailers, plus growth in discount retailers, the latter predominantly favouring sites in proximity to relatively more deprived urban communities. There has also been some recognition that groceries e-commerce (online ordering of groceries for home delivery) could 'limit the extent to which food deserts are a significant problem' (Corfe, 2018).

Urban food deserts may therefore represent an outdated concept. By contrast, declining rural service and public transport provision may be driving new inequalities in access to groceries, with rural areas faring worst. This may be particularly true if these areas also lack provision of groceries home delivery services. Most grocers utilise their existing store infrastructure to pick, pack and deliver e-commerce orders, determining their own 'service areas' (the geographic extent over which they are willing to deliver), usually based on travel time or distance from those stores. Thus the availability of groceries e-commerce home deliveries isn't uniform, with consumers in some (predominantly remote and rural) neighbourhoods less-able to benefit from these services.

A new form of 'e-food desert' may therefore be emerging: remote and rural catchments with poor 'access' to groceries home delivery services. These catchments are already the most remote from physical store provision and may also be faced with withdrawal of physical (retail) services. The e-Food Deserts Index (EFDI) was developed to re-assess the presence of food deserts across Great Britain, accounting for novel notions of groceries home delivery provision.

It ranks rank small areas (LSOAs[1]) across Great Britain according to the degree to which these neighbourhoods experience characteristics associated with poor access to groceries, accounting for the physical and online supply sides and consumers' underlying demographic and socio-economic characteristics.

The data sources and methodology used to create the index are briefly outlined in this document. Further background, context, results and implications will shortly be published in the academic literature and this document will be updated with references to those publications.

Domains and Indicators

In spite of the widespread academic and policy interest in geographical access to food, there isn't a consistent methodology to designate small areas representing food deserts. Identification of food deserts typically involves identifying vulnerable neighbourhoods (e.g. low income) that don't meet a specific threshold measure of accessibility to food retail opportunities.

Whilst some GB-wide measures of foodstore accessibility are available as part of academic studies (e.g. see Smith et al., 2018), published via journey time statistics (such as DfT, 2019) or incorporated within derived small area indicators of accessibility (such as the Index of Multiple Deprivation [GB-wide but with methodological differences between nations]), there is no GB-wide measure of vulnerable neighbourhoods, no existing data product or derived indicator which captures food desert-like characteristics, and no indicator related to the provision or availability of online groceries.

The EFDI comprises four domains and a total of 12 indicators which have been chosen to capture the multi-dimensional nature of groceries accessibility at the neighbourhood level. Each indicator has been drawn from a broader set of candidates and selected based on insight from the literature, the research teams' experience in modelling retail interactions and an awareness of multicollinearity between indicators. Each indicator and domain captures measurable characteristics associated with foodstore accessibility at the neighbourhood level.

Proximity to and density of grocery retail facilities

These measures are widely used in the literature as an indicator of geographic food access (see Charreire et al. (2010) for a detailed overview). We calculate the distance to the nearest large grocery store (greater than 15,000 square foot), the average distance to the nearest three grocery stores and the number of stores within 1km of each neighbourhood, capturing multiple dimensions of store accessibility, choice and competition as experienced by consumers. We also capture a Hansen-style indicator of store accessibility (which additionally accounts for store size and brand, important measures of store attractiveness) derived from our custom-built spatial interaction model (SIM) to simulate GB-wide grocery retail flows at the LSOA level.

[1] Lower-layer Super Output Areas (LSOAs) for England and Wales, and Data Zones for Scotland, referred to as LSOAs throughout the report

Indicator	Description	Units	Source
Nearest large store	Straight line distance to nearest large store	Km	Calculated using Geolytix Retail Points version 15[2]
Count of stores within 1km	Count of stores within 1 Km (straight line)	Count of stores	
Average distance to stores	Mean distance to the nearest 3 grocery stores	Km	
Accessibility Index	Hansen accessibility index accounting for store size and brand	Relative measure	Custom built SIM (see above)

Transport and accessibility domain

This domain captures additional domains of grocery store accessibility using indicators of travel time to retail services by car and on foot (derived from published statistics) and our own measure of average trip distance for grocery shopping. The latter reflects modelled trip distances to stores used for grocery shopping (which may not be the nearest store) by residents in each LSOA, accounting for brand preferences and store attractiveness (store size) and derived from our custom-built SIM.

Indicator	Description	Units	Source
Drive time	Average minimum drive time to food store[3] by car	Minutes	England: Journey Time Statistics 2017 (Table JTS0507) Wales: Welsh IMD 2019 Physical Access Domain Scotland: Scottish IMD 2020, Geographic Access to Services Indicators
Accessibility via public transport	Average minimum travel time to food store[3] by public transport	Minutes	England: Journey Time Statistics 2017 (Table JTS0507) Wales: Welsh IMD 2019 Physical Access Domain Scotland: Scottish IMD 2020, Geographic Access to Services Indicators
Average trip distance	Average distance travelled to carry out food shop (simulating interrelated factors affecting store choice including size, brand and proximity)	KM	Calculated using a custom-built spatial interaction model capturing all interactions between residential neighbourhoods and the physical grocery retail supply side.

Neighbourhood socio-economic and demographic domain

This domain captures income deprivation (derived from the IMD) (the link between poverty and food insecurity is well documented (Smith et al., 2018)) alongside census-derived measures of car ownership (lack of car ownership may be a barrier to accessing food stores,

[2] https://geolytix.co.uk/

[3] In the case of Scotland the measure captures access to retail centres (clusters of shops) rather than specifically considering food stores. We consider the impact of this further in the EFDI outputs sections.

especially where income barriers may make other sources of transport unaffordable or public transport provision may not be available) and the presence of pensioner households.

Indicator	Description	Units	Source
No car	Proportion of all households within a given neighbourhood that self-report no access to private transport (car or van)	Proportion of households	2011 Census in England and Wales – KS404EW (Car or Van Availability) 2011 Census in Scotland – Question is identical in England, Wales and Scotland.
Pensioners[4]	Proportion of all households that contain Pensioners – either a one person household (sole pensioner) or as part of a family (which may be multi-generational).	Proportion of households	2011 Census in England & Wales and Scotland, accessed via Geolytix 2011 Census Pack[5] derived small area census data variables 149, 151 and 162. Question is identical in England, Wales and Scotland.
Income deprivation	Proportion of LSOA population experiencing deprivation related to low income via low earnings or lack of work.	Percentage of LSOA population	England: English IMD 2019 Income Deprivation Domain Wales: Welsh IMD 2019: Income Domain Scotland: Scottish IMD 2020 Income Domain.

E-commerce domain

This domain comprises two indicators which capture the availability of online groceries home delivery (using the count of retailers providing delivery to each LSOA as derived from our own analysis) and the propensity for residents in each LSOA to shop online for groceries, derived from the Internet User Classification (Alexiou, 2018).

Indicator	Description	Units	Source
Online groceries availability	Total number of retailers providing groceries delivery service	Count of retailers	Custom web-scraping from major UK retailers delivery 'postcode checker'
Propensity to shop online	Relative propensity for households to shop online –from IUC Cluster Centres	Mean attribute values (z-scores)	Internet User Classification 2018

[4] Includes: a) Pensioner One Person Household – this captures the number of households that are a single pensioner (person aged over 65) who live on their own. b) Pensioner Family – these are households that contain pensioners living with other pensioners. c) Pensioner Other - households containing at least one pensioner living with at least one other householder who is not a pensioner.

[5] Available at: https://www.geolytix.co.uk/

Construction of the index

The index was constructed utilising the methodology outlined in the OECD 'Handbook on Constructing Composite Indicators' (OECD, 2008), with the key steps outlined briefly below.

Indicators

The indicators were firstly normalised using the min-max approach, which brings the data to a common scale between 0 and 1. A weighted average was used to aggregate the indicators to their respective domains. All indicators carry equal weight with the exception of the *nearest_lstore* (distance to the nearest large store) and *avgdist3stores* (average distance to the nearest three stores) which each carry half-weight to compensate for the high correlation exhibited between them, thus avoiding double counting proximity to the nearest store.

Domains

Each domain was ranked and normalised using an exponential transformation. This approach ensures that one 'high' scoring domain cannot completely cancel out a 'low' score in another domain, ensuring that the index places emphasis on those neighbourhoods with food desert-like characteristics (Welsh Government (2020) provides an excellent overview and justification for this exponential transformation approach).

EFDI variables, domains and weightings summary table

Domain	Domain weight	Indicator	Indicator weight	Food desert promoting	
				Low value	High value
Proximity to and density of grocery retail facilities	1/4	Nearest large store	1/6	-	+
		Average distance to stores	1/6	-	+
		Count of stores within 1km	1/3	+	-
		Accessibility index	1/3	-	+
Transport and accessibility	1/4	Drive time	1/3	-	+
		Accessibility via public transport	1/3	-	+
		Average travel distance	1/3	-	+
Neighbourhood socio-economic and demographic	1/4	No car	1/3	-	+
		Pensioners	1/3	-	+
		Income deprivation	1/3	-	+

E-commerce	1/4	Online groceries availability	1/2	+	-
		Propensity to shop online	1/2	+	-

To create the final index, the domains were aggregated (averaged, using equal weights), generating a single score for each LSOA, with higher values representing neighbourhoods with more food desert-like characteristics.

The EFDI Outputs

The final index enables LSOAs/DZs to be ranked or grouped into deciles, with lower ranks and decile groupings reflecting that an area exhibits more characteristics typically associated with food deserts. Due to slight differences in some of the accessibility measures in the Transport and Accessibility domain between England & Wales and Scotland, it is not possible to directly compare EFDI scores or ranks between England & Wales and Scotland.

In the case of Scotland, there are no direct measures of access (by car or public transport) to food stores – instead these access measures are reported only for 'retail centres' which are larger clusters of stores and don't account for stand-alone food stores. These access measures still provide an excellent indication of relative accessibility of retail services between LSOAs and enable us to generate a robust classification for Scotland. Nevertheless, this means that DZs in Scotland should not be directly compared to LSOAs in England and Wales in terms of ranks or raw scores from the EFDI.

Figures 1 and 2 highlight the raw index (EFDI Scores) for England & Wales and also for Scotland, with Scotland shown separately (as outlined above). We recognise that the detail is difficult to see (especially in urban areas) and we recommend users refer to the interactive version available as part of CDRC Maps

We highlight that a number of major cities (including Leeds, Newcastle and Cardiff) which featured prominently in the urban food deserts debate of the late 1990s and early 2000s still exhibit considerable pockets of neighbourhoods exhibiting food desert-like characteristics. Yet we also find that contemporary food deserts are an important concept in rural areas too, driven by comparatively poorer access to physical foodstore provision in many of these localities, exacerbated by poorer coverage (at times no availability) of online groceries.

We created the EFDI as a by-product of research primarily focussed on online groceries home delivery. Specifically we considered the extent to which the incorporation of online groceries delivery availability influenced food desert-like characteristics at the neighbourhood level.

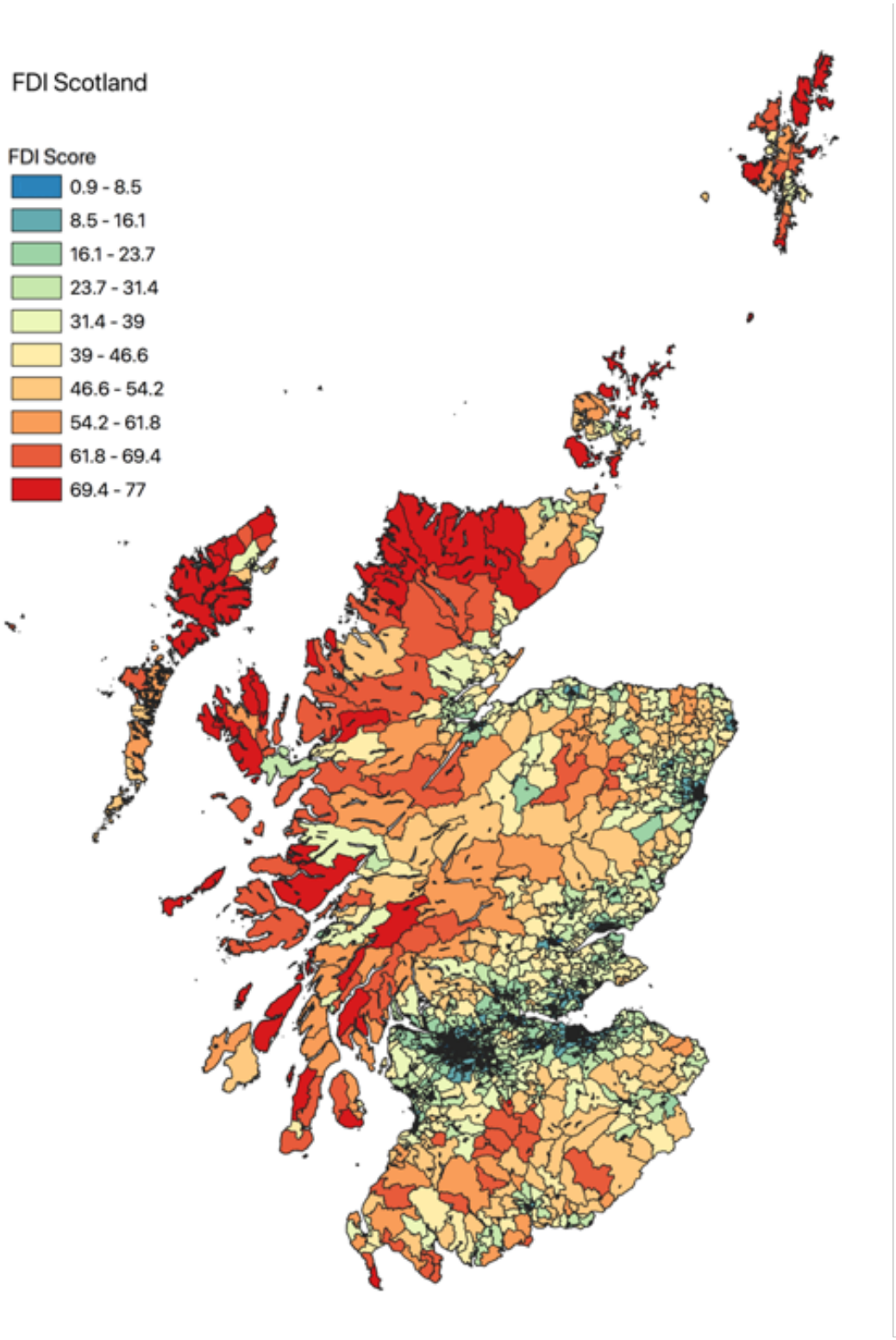

Figure 1 – EFDI Scores for Scottish Data Zones (higher score denotes more evidence of food desert-like characteristics)

Although we plan to apply the EFDI in ongoing work, we recognise that it could be of considerable benefit to other researchers and hope that making it freely available via the CDRC will encourage researchers and policy makers to:

- Consider contemporary notions of food deserts, particularly the important role of e-commerce and online groceries as a component of groceries accessibility.
- Attach the EFDI to survey or transactional data in order to identify variations in consumer behaviour which may be driven by food desert-like characteristics.

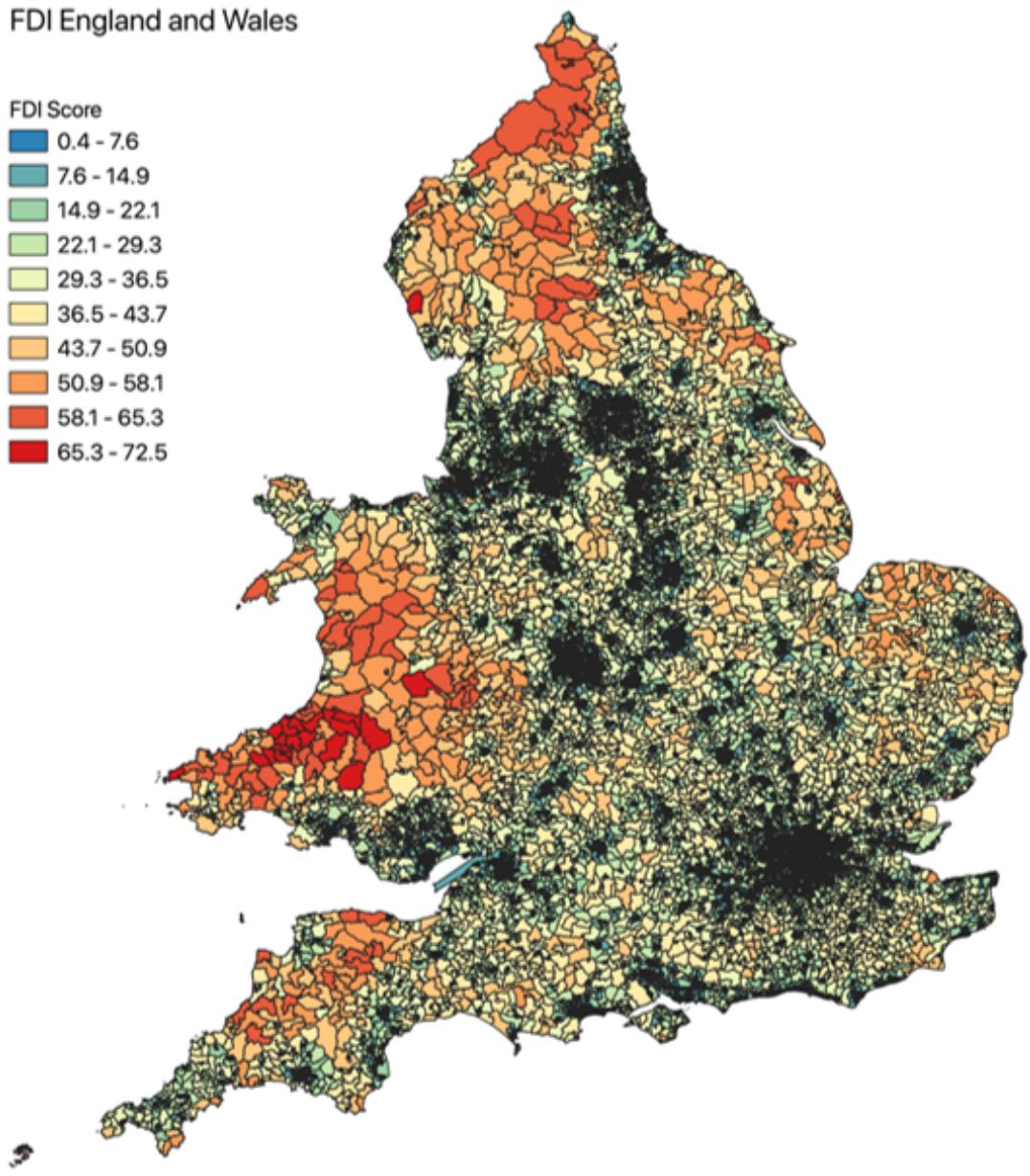

Figure 2 – EFDI Scores for LSOAs in England and Wales (higher score denotes more evidence of food desert-like characteristics)

The research team would be delighted to hear how the EFDI is used and can be contacted via a.newing@leeds.ac.uk

References

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