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Mapping the population of the Republic of Ireland at building level: a dasymetric approach using Census 2022, building footprints and address data

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Abstract: This paper presents the first building level dasymetric map of the population of the Republic of Ireland, integrating the Census 2022 small area population statistics, the Prime2 building footprints and the Eircode address database. The methodology distributes the published small area population across 1.89 million residential buildings in proportion to their residential address count and applies Empirical Bayesian Kriging to produce a 25 metre population density surface to map the results at national scale. An internal consistency calibration check at small area level returns $R^2 = 0.999$ and RMSE = 0.30 persons, with a national total within 16 persons (0.0003%) of the published census figure, confirming that the disaggregation introduces no material arithmetic error. A synthetic sensitivity analysis quantifies the directional bias introduced by the equal household size assumption, showing apartments overestimated by up to 97% and family homes underestimated by up to 25% per dwelling in typologically mixed small areas, while small area totals are preserved by design. The building level output exposes neighbourhood scale contrasts that aggregated census representations cannot capture, particularly in Dublin city centre, and confirms Dublin's disproportionate dominance within the Irish urban hierarchy. The reproducible workflow provides a foundation for extending building level mapping to other demographic variables released by the CSO at small area level.

Keywords: *dasymetric mapping, population census, Republic of Ireland, geographic information systems, gis, spatial analysis*

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1. Introduction

High resolution population data is essential for a wide range of scientific, planning and policy applications, from transport modelling and health service provision to emergency response and environmental risk assessment (Briggs *et al.*, 2007; Dmowska, 2019). In the Republic of Ireland, the Central Statistics Office (CSO) conducts a national census every five years and collects information at household level, but publishes the results in aggregated geographic units to protect statistical confidentiality and comply with data protection regulations (Central Statistics Office, 1993). This aggregation introduces a systematic analytical limitation: mapping population at census unit level implicitly assumes a uniform distribution of people across the entire polygon, even where large portions are uninhabited, a distortion recognised in the geographical literature as the Modifiable Areal Unit Problem (Openshaw, 1975) and shown by Langford and Unwin (1994) to produce substantial errors in derived measures such as population density. Dasymetric mapping, first formalised by Wright (1936) and developed as a practical GIS technique by Mennis (2003, 2009), addresses this directly by redistributing aggregated population counts to sub-unit geographies using ancillary data that identifies where within each census unit the population is located. Despite the availability of high-resolution national datasets in the Republic of Ireland, no study has applied this approach at building level across the full national territory; this paper presents the first such analysis using the Census 2022, Prime2 building footprints and the Eircode address database.

2. Literature review

2.1 Data sources for population analysis

Traditionally, the analysis of the population has relied on census data, some of which date back to ancient times. The earliest 'modern' censuses were conducted at the beginning of the eighteenth century in Scandinavian countries. The snapshot of a country's population that a census provides is a unique opportunity to gather information about demographic, socioeconomic and housing characteristics and how they vary across small geographic areas. While expensive and criticised for their imperfection, many social scientists agree that national censuses are a unique resource (Boyle and Dorling, 2004). Population data is normally collected and aggregated at census enumeration units, which are subject to change over time (Mennis, 2009). Many fields, including demography, geography, urban planning, environmental modelling, rely on spatially consistent population data, which requires the development of accurate population downscaling methods (Wan *et al.*, 2023).

Over the last two decades new data sources have been incorporated to improve the accuracy of spatial population distribution estimates. For instance, land cover and light emissions (Briggs *et al.*, 2007), building data or micro-spatial analysis (Lwin and Murayama, 2009; Teh *et al.*, 2019), grid square data, surface models (Mennis, 2003; Lloyd and Firoozi Nejad, 2014; Swanwick *et al.*, 2022), remotely sensed temperature and precipitation raster datasets (Stevens *et al.*, 2015) and landscape metrics (Wan *et al.*, 2023), among others.

The same is relevant for the analysis of the population in Ireland. However, most of the data sources rely on the Central Statistics Office, which is responsible for collecting and publishing population data for the Republic of Ireland. The main reference in this regard is the Census of Ireland as it provides population counts and other demographic information for different administrative areas. It is held on a quinquennial basis by the CSO, the most recent was held in April 2022, the next one is planned for 2027. The CSO Small Areas are the lowest level of geographical statistics in the Republic and provide essential insights into neighbourhood population, in 2022 there were almost 19,000 small areas (Central Statistics Office, 2022a). The Irish census data for 2006, 2011, 2016 and 2022 can be downloaded freely from the CSO website (Central Statistics Office, 2024).

Other useful information can be obtained from Tailte Éireann, previously known as Ordnance Survey Ireland (OSi) until March 1st 2023 (Tailte Éireann, 2023a). Land cover data has been used frequently by other authors (Briggs *et al.*, 2007; Sleeter and Gould, 2007), in the case of the Republic of Ireland the National Land Cover Map has a resolution of at least 0.1 hectares, whereas CORINE Land Cover is mapped at 25 hectares resolution (Tailte Éireann, 2018, 2025). Although the Irish map has an unprecedented level of detail, it does not include a classification to differentiate residential buildings from others. In that sense, the Digital Landscape Model extracted from Prime2 database has the building polygons that provide the location, spatial extent and two broad classifications of use (e.g. residence, outbuilding) and type (e.g. detached, terraced), so they can be used to estimate the number of people living per residential building. Overall, it contains 3.7 million buildings, almost 2 million of which are considered residential, and the rest are mainly used for agricultural, industrial or for service purposes (Tailte Éireann, 2023b). These datasets are available for private users and companies at a cost, although public institutions of Ireland can access them free of charge thanks to the National Mapping Agreement (Tailte Éireann, 2017).

Postal addresses are available from GeoDirectory, the Republic of Ireland national address database created by An Post and Tailte Éireann. Postal addresses can be used to identify the location of individual dwellings, to classify these according to the Nomenclature of Economic Activities (NACE) and to estimate the number of people living at each address (An Post GeoDirectory, 2025). Due to the complexity of postal addresses, Eircode was introduced in 2015 to standardise the postal codes across the country and tie them to a spatial location using geographical coordinates. An Eircode is assigned to every residential and business address in the Republic that receives post. Unlike other countries, where postcodes define clusters or groups of addresses, an Eircode identifies an individual address, rural or urban, and shows exactly where it is located. The Eircode database also provides information on buildings use (e.g. residential or commercial), type (e.g. terraced, bungalow, detached) and if it is vacant among other valuable information for population analysis (Eircode, 2024). In 2025, the database contains more than 2.4 million postcodes, receives updates quarterly and it is used together with GeoDirectory by government bodies and companies who have embedded geospatial data as a core variable in their businesses. As with Tailte Éireann's maps, the data is available free of charge for public bodies (Eircode, 2015).

Although derived from a combination of some of the previous datasets and different others, it is worth noting another key source to understand the social gradient in the Republic of Ireland. The HP Deprivation Index uses the CSO census data at small area level and combines three dimensions of relative affluence and deprivation: demographic profile, social class composition and labour market (Haase and Pratschke, 2017; Pratschke and Haase, 2014). The results of this methodology are available through a free Geographic Information System that includes datasets and interactive maps. The tool has been developed by Pobal, an Irish government agency that manages funding to support social inclusion and community development in the Republic (Pobal, 2022a, 2022b).

2.2 Main problems of population data

Population data has been recognised as an essential variable for societal analysis (Baynes *et al.*, 2022), therefore, reliable information is essential for a wide range of applications, for example: transport and urban planning, resources management, disaster mitigation and relief and assessment of human pressure on the environment (Dmowska, 2019). Despite the improvements made in census procedures over recent years, the availability of data showing the actual spatial distribution of the population is limited at a fine level of detail. Without an adequate knowledge of where people live it is quite difficult to model human activities (Briggs *et al.*, 2007).

The quality of population data varies from one country to another, especially between low and high income countries. The former are often lacking population data or have poor quality. Richer countries usually have resources to collect data for each household, but such data is only released in the form of areal aggregates to protect privacy (Boyle and Dorling, 2004; Cook, 2004; Dmowska, 2019). Often, these aggregates are relatively large and of variable population number, shape and size, which highlights a major source of difficulty in mapping the density of population (Langford and Unwin, 1994). This causes substantial differences across a study area in both the visual representation of population distribution and in the reliability of derived measures such as population density (Briggs *et al.*, 2007). The spatial resolution depends on the choice of census units, and the mapped population is distributed uniformly within each census unit, even if most of the area is uninhabited (covered by parks, forest, water, etc.). This problem with aggregated data was coined as the Modifiable Areal Unit Problem (MAUP) by geographers during the 1970s, consisting of the use of different spatial units that may greatly impact the apparent spatial distributions and the analysis results (Openshaw, 1975).

Another problem is that census districts change over time for different reasons, making analysis of long-term trends difficult. In many cases, also, census tracts do not adjust properly to other spatial entities for which information is available, so that population data may need to be transferred between different spatial structures for the purpose of linking data to facilitate analysis (Briggs *et al.*, 2007).

A further practical difficulty relates to the format in which population data are disseminated. Censuses are typically provided as attribute tables linked to vector boundary files, requiring users to perform spatial joins or other preprocessing steps before the data can be analysed effectively in GIS. When working at a national scale or at very fine levels of spatial detail, these operations become computationally demanding, time consuming and likely to produce technical errors (Dmowska, 2019).

There may also be concerns about the type and range of questions that are asked in successive censuses, and the ways in which the census is constructed. There is tension between collecting information that is currently relevant and maintaining contemporary best practice, and yet still enabling comparisons with earlier censuses (Shuttleworth and Lloyd, 2009).

To address these limitations, researchers have developed techniques to overcome them. These methods require exogenous variables at the sub-census tract level to model variation in population density. Some of the most used datasets include remote sensing imagery, land use cover, topographic and climatic variables (e.g. elevation, slope, temperature and precipitation) and socio-economic data (e.g. nighttime lights, roads, and points of interest related to human activity).

2.3 Techniques to analyse population with GIS

Several techniques have been developed to redistribute aggregated census populations to finer spatial units, each with distinct assumptions and limitations.

Area weighting is the simplest and most widely applied approach, redistributing population from a source zone to a target zone in proportion to the overlapping area. It underpins the Gridded Population of the World database and is computationally straightforward, but its fundamental limitation is the assumption that population is uniformly distributed within each source zone (NASA, 2020). This replicates rather than corrects the MAUP: the redistribution produces no new information about where within a zone people live (Openshaw, 1975).

Surface modelling approaches treat population as a spatially continuous variable and fit a smooth surface through census unit centroids or totals using interpolation. Lloyd and Firoozi Nejad (2014) assessed the accuracy of surface models for two population variables in Northern Ireland, finding that the degree of smoothing substantially affects predictive performance and that no single configuration performs consistently well across settlement types. Jega *et al.* (2012) applied pycnophylactic interpolation to small area population estimation at 30 metre resolution. The limitation of surface based methods is that they impose spatial continuity on an inherently discontinuous phenomenon, since population is concentrated in buildings, not distributed uniformly across fields, water bodies or commercial land.

Dasymetric[1] mapping addresses this discontinuity by restricting the redistribution to areas known to be inhabited, using ancillary data as a spatial filter. Wright (1936) formalised the approach using land use categories to confine population to settled land; Langford and Unwin (1994) demonstrated its GIS implementation for density surface generation; and Mennis (2003, 2009) established the computational framework and showed its superiority over choropleth representation for small area analysis. Land cover and remote sensing data have been the most widely used ancillary inputs: Briggs *et al.* (2007) used land cover and light emissions to produce dasymetric estimates in Britain, Sleeter and Gould (2007) applied the technique at state level in the United States, and Swanwick *et al*. (2022) produced a national dasymetric dataset for the conterminous United States using 30 metre impervious surface data. These land cover approaches substantially improve on area weighting but introduce classification uncertainty wherever residential and non-residential buildings are spatially intermixed at fine scales, limiting their precision in densely built urban environments.

Building level approaches extend dasymetric logic to individual structures. Lwin and Murayama (2009) demonstrated that residential building footprints and address counts could disaggregate census population to individual buildings in Japanese urban districts, achieving a spatial precision not possible with land cover data. This approach has since been applied to estimate populations affected by tsunamis for humanitarian logistics and to derive employment estimates from building floor space (Jitt-Aer *et al.*, 2022; Teh *et al.*, 2019). Where building inventories and address registers are available at national coverage, building disaggregation produces estimates that are more precise and more directly interpretable for planning and operational purposes than polygon or raster alternatives.

More recently, machine learning methods have extended population disaggregation to data sparse environments. Stevens *et al*. (2015) used random forests to integrate multiple ancillary inputs in settings where address data are unavailable, and Yankey *et al*. (2024) applied a Bayesian Additive Regression Tree model to similar effect. Baynes *et al*. (2022) showed that combining machine learning with uninhabited area exclusion improves accuracy regardless of the underlying modelling approach. These methods offer flexibility where traditional ancillary data are absent but are less suited to jurisdictions with rich datasets where traceability to authoritative administrative sources is a priority.

The reviewed methods converge on the conclusion that disaggregation accuracy is highest when the ancillary variable directly represents inhabited versus uninhabited space at the finest feasible resolution (Dmowska, 2019). The Republic of Ireland, with authoritative national address registers and building inventories available at national scale, is well positioned for a building level implementation, yet no study has applied this method to the Republic at national scale using the Census 2022.

[1] The term *dasymetric* comes from the Greek words for “density measurement”.

2.4 Previous studies on Ireland's population

A substantial proportion of the work found on population has Northern Ireland as the study area. In 2010 an article explored the use of geographically weighted spatial statistics to examine the degree to which the population of Northern Ireland is spatially concentrated by a range of characteristics such as housing tenure, employment and religion among other factors (Lloyd, 2010). The same author analysed the spatial scale of population concentrations by religion in Northern Ireland using global and local variograms, the first published work to use them for this purpose (Lloyd, 2012).

Following the growing interest in the use of gridded population models which may offer advantages of stability through time and ease of integration with non-population data sources, a paper assessed the accuracy of gridded population models of this nature. Population counts for census output areas were reallocated to a 100 metres grid and then compared with 100 metre cell population counts uniquely available from the 2001 Northern Ireland Census. This work was the first large-scale assessment of gridded population models against true gridded population counts (Martin *et al.*, 2011).

The number of studies that have analysed the population of Ireland applying dasymetric techniques is even lower and from the same small group of authors. A research paper on segregation in Northern Ireland from 1971-2001 showed an increase in the Catholic share of the population in many areas, particularly around South Belfast and Derry. Researchers were able to describe the basic religious geography of Northern Ireland from 1971 to 2001 using a consistent 1 km grid square, which permits better comparisons through time than were possible before (Shuttleworth and Lloyd, 2009). Similarly, an analysis of the spatial structure of population variables was carried out using surface models and Northern Ireland grid square data. The paper assesses how the degree of smoothing associated with population surface modelling relates to the accuracy of predictions made using two variables in Northern Ireland: the number of Catholics and persons with a limiting long-term illness. This research makes use of the counts for the 2001 Census and wards to generate population grids with 100 metres of spatial resolution (Lloyd and Firoozi Nejad, 2014).

The aim of this paper is the creation of a dasymetric map of the population of the Republic of Ireland in 2022. The results are presented applying two complementary methodologies. The first one estimates the number of people per building using the small areas data from the Census 2022 by the CSO, the residential building polygons and the postal address's location in the Eircode database. The second applies kriging techniques to generate a raster of 25 metre spatial resolution that covers the whole country based on the estimated population per building and helps to visualise the population distribution in the Republic of Ireland.

3. Methodology

Table 1. Main steps to create the dasymetric map of the population of the Republic of Ireland in 2022.

Data collection	Data processing	Data analysis
Central Statistics Office: - Small Areas Population Statistics 2022. - Small Areas Population ungeneralised boundaries. Tailte Éireann: - National Land Cover Map. - Digital Landscape Model extracted from the Prime2 database. Eircode: - Eircode Address Database first quarter 2025.	ArcGIS. Save to Geodatabase: - Prime 2 building polygons. - Building polygons' inner centroids. - Prime 2 database domain tables. - Spatial join to transfer SAPS GUIDs to the Prime2 building centroids. - Spatial joint to transfer building centroid GUIDs to the Eircode data.	Manifold. Use SQL to: - Get building statistics. - Calculate the number of addresses per building using the Eircode data. - Compose table to include relevant columns for dasymetric analysis. - Calculate total population per building. ArcGIS: - Run an empirical bayesian kriging to interpolate the total population per building into a continuous smooth surface.

3.1 Data collection

A series of available data sources was collected to assess their appropriateness to complete the task. The small areas population data corresponding to the Census 2022 was downloaded from the Central Statistics Office website. The website provides the boundaries of the 18,919 small areas in ESRI File Geodatabase format and the Census dataset in a Comma Separated Values (CSV) file. The CSV contains 790 different variables in different columns that are grouped in 15 themes. The only variables used for the analysis were the small area unique identifier (GUID) and the total population (T1_1AGETT) (Central Statistics Office, 2023a).

From Tailte Éireann, the National Landcover Map of Ireland was considered to serve as the ancillary data to identify the populated areas. However, although the resource represents the exact location and shape of the building, it was discarded as it does not have any further classification to distinguish between residential or other uses. On the other hand, the Digital Landscape Model extracted from the Prime2 database offers greater level of detail, as it includes attributes that can be used to classify the buildings: "Function_ID" defines residence or outbuildings and "Form_ID" describes most of them as building general but there are others like detached, terraced and apartments. The buildings feature class has 3.69 million records (Tailte Éireann, 2023b).

To obtain the total number of postal addresses per building the Eircode Address Database referred to the first quarter of 2025 was used. It was assumed that the address infrastructure did not change significantly since census night in April 2022. The database is divided into several tables: address, alias, lookup, information and history. Among these, information contains the latitude and longitude values for each Eircode. Other tables define if the address is residential, a holiday home, vacant, type and the NACE code (Eircode, 2024).

3.2 Data processing

When all the data was collected it was imported into a File Geodatabase using ArcGIS Pro. The basic datasets include the Census 2022 small area boundaries and population table, the Prime2 building polygons and the domain tables, and the Eircode tables. The workflow used to process the data is illustrated in Figure 1.

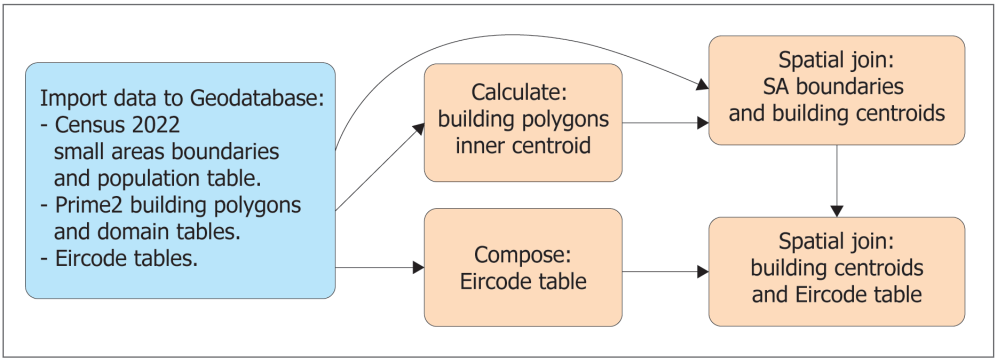

Figure 1. Workflow diagram while processing data.

The next step was to create a SQL query to compile the main attributes of the Eircode database and create a single table with the most relevant attributes of the Eircode tables, some of these attributes are latitude and longitude coordinates, postal address, as well as building and administrative info. The query ran for 80 minutes and resulted in a 2.43 million addresses table that was exported as a point feature class and saved in the geodatabase. This operation was carried out in Manifold System 9, a small yet robust GIS software that can perform spatial analysis using SQL queries without the need to install a fully fledged database engine like PostgreSQL. It can also read and write data directly in ESRI File Geodatabases, allowing a seamless integration with ArcGIS (Manifold Software Limited, 2017).

The last step was to calculate the buildings' inner centroids, which allowed each building to be assigned to the small area that contains its centroid with a spatial join; this avoids splitting buildings between areas. The same process was used to assign the buildings' centroids to the Eircode table. The resulting table was used to calculate the total number of addresses per building by counting the postal addresses falling in the same building polygon. Only the residential addresses were used in the analysis, regardless of being classified as vacant or holiday homes. Including vacant and holiday home addresses in the denominator means the formula distributes the small area census total across a larger number of addresses than were occupied on census night, slightly underestimating the per-address population in areas with elevated vacancy rates. This effect is structurally similar to the dwelling type bias described in the Sensitivity Analysis and is most consequential in small areas with a high proportion of holiday homes, particularly in coastal and rural areas, or with significant apartment vacancy in urban cores. Of the 1,888,176 residential addresses in the dataset, 52,015 (2.76%) corresponded to vacant dwellings and none were classified as holiday-use properties, making the potential bias from unoccupied addresses negligible at national scale. These operations were necessary to perform the dasymetric analysis as they allowed joining with SQL queries all the datasets together using the unique identifiers of small areas, buildings and postal addresses geographic coordinates. The resulting corpus dataset contains nearly 1.89 million records.

3.3 Temporal alignment of input datasets

The three datasets used in this study have different reference dates: the Census 2022 small area population statistics refer to census night in April 2022, the Prime2 Digital Landscape Model is from Q4 2023, and the Eircode address database is from Q1 2025. The analysis therefore combines population counts from April 2022 with building and address infrastructure reflecting conditions up to 33 months later.

Direct quantification of the buildings and addresses added between April 2022 and the dataset reference dates is not feasible as versions before 2022 of Prime2 and Eircode were not available for this study, and neither dataset contains building creation dates that would enable precise identification of postcensus additions. The scope of the temporal mismatch can nonetheless be bounded using two available proxies. Within Prime2, 10,844 buildings (0.29% of the total stock) were recorded as under construction in Q4 2023, establishing a lower bound on residential stock added after April 2022 within the building inventory. Independently, the Housing Agency completion statistics record 148,995 new dwellings completed nationally between April 2022 and Q1 2025, providing an external upper bound on the residential addresses that may not have existed on census night (Housing Agency, 2026).

The geographic concentration of new construction is well established, housing completions in this period were disproportionately concentrated in the western Dublin commuter belt, including Citywest, Lucan and adjacent growth areas, and in expanding suburban zones around Cork and Drogheda. In these areas, the Eircode database may contain addresses assigned to dwellings that were not occupied in April 2022. In the remainder of the country, where the housing stock predates the census by several years, the temporal mismatch has no material effect on the estimates. The analytical consequence is structurally limited, because the disaggregation formula distributes the published census small area total across the residential Eircodes present in the 2025 database, the small area population is preserved regardless of address infrastructure changes. The risk is confined to misallocation within small areas in growth zones, not to errors in the national or county totals.

3.4 Data analysis

As shown in Figure 2, the first task was to calculate several statistical tables with frequencies and percentages to understand the distribution of relevant attributes in the buildings attribute table. The values are codified using domains, so importing the domain tables from the Prime2 were essential to get the equivalencies between the numerical codes and their descriptions. The status column has 8 different categories to describe the current state of the buildings, almost all of which are in use (3.68 million or 99.59% of the total), followed by under construction (10,844 or 0.29%), in ruin (2,667 or 0.072%), and others. The "form id" column offers a high-level classification of building types with 57 categories, among which building general is the most frequent (3.13 million or 84.6%), detached building (257,074 or 6.95%), semi-detached building (149,180 or 4.03%), terraced building (79,207 or 2.14%), end of terrace (44,823 or 1.21%) and apartment building (7,138 or 0.19%) among others. The "function id" column offers a second level classification with 161 building uses, the most relevant category is residence (1.96 million or 52.96%), followed by outbuilding (1.66 million or 44.89%), not applicable (14,353 or 0.38%), commercial/retail (12,373 or 0.33%), and others. The combined classification of type and use of buildings, with 214 unique cases, was initially considered to select the residential buildings. However, several apartment blocks were identified as misclassified after a thorough examination in Dublin and other larger towns, so this approach was discarded in favour of the classification of uses included in Eircode.

The next step was to join into a new table the building polygons with the small area's boundaries and population table, so other relevant statistics could be calculated. These include the total number of residential buildings per small area, the total square metres of residential buildings per small area, using just the footprint, as none of the datasets included the number of floors. The last step was to join the Eircode essence table with the buildings before estimating the people per building.

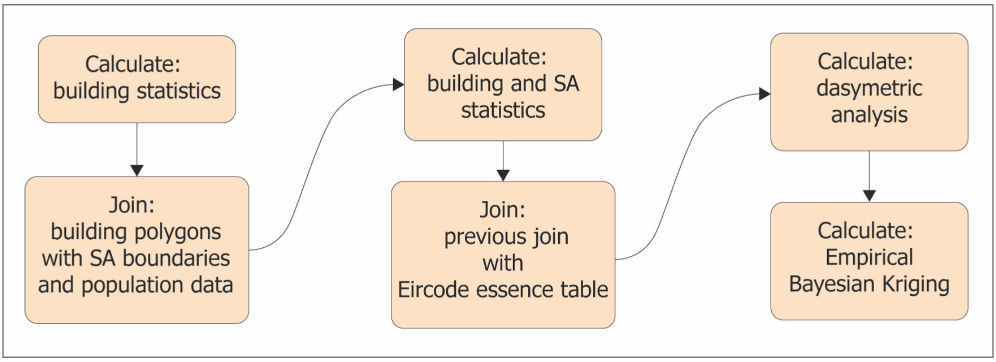

Figure 2. Workflow diagram while analysing the data.

The calculation of the dasymetric analysis is demonstrated by the following mathematical expression modified from Lwin and Murayama (2009). The results were saved into a dedicated column:

$$BP_i = \left(\frac{SAP}{\sum_{k=1}^{n} RECB_k} \right) RECB_i \tag{1}$$

where BP_i = the building population estimate (persons per building) i,

SAP = the small area population,

$RECB$ = the number of residential Eircodes per building.

For example, a small area with a total population of 300 persons (SAP = 300) containing three residential buildings with 10, 5 and 5 Eircodes respectively (∑RECB = 20) yields building estimates of 150, 75 and 75 persons, preserving the small area total by design.

Each building centroid carries the total building population estimate from equation 1, summed across all residential Eircodes within the building polygon, as the input value for interpolation. On a complementary analysis, the building population estimates were interpolated to a continuous population density surface using the Empirical Bayesian Kriging (EBK) geoprocessing tool in ArcGIS Pro. Unlike classical kriging, EBK estimates the semivariogram parameters automatically from the data and accounts for the uncertainty in those estimates by integrating over a Bayesian prior distribution of possible models, reducing the risk of underestimating prediction uncertainty that arises from fitting a single semivariogram to the full dataset (ESRI, 2024). The tool was configured with a linear semivariogram model and no data transformation. Semivariograms were generated from subsets of 100 points with 100 simulations per subset, producing a locally adaptive interpolation that reflects the varying spatial structure of building population across urban and rural areas. The search neighbourhood was defined as a circular area with a radius of 150 metres.

The 150 metre search radius better reflects the typical spatial scale of residential development in Irish settlements, the national average being 110 metres. At this distance, adjacent buildings are likely to share similar demographic characteristics, belonging to the same housing estate, street block or apartment complex. A smaller radius would have tracked individual building estimates too closely, producing a surface too locally variable for a cartographic representation at national scale. A larger radius would have suppressed urban detail by averaging across demographically distinct neighbourhoods. The population density surface was produced at a cell size of 25 metres. This spatial resolution was chosen for two reasons. First, at national scale across the Republic of Ireland (70,265 km²), a 25 metre raster is computationally tractable and produces a file of manageable size. Second, at the DIN-A4 output dimensions used for the national map presented in this study, 25 metre resolution provides sufficient visual detail to distinguish urban concentrations from rural areas without exceeding print resolution. A resolution of 10 metres is not supported by the point spacing of the input data, which reflects the distribution of residential buildings rather than a uniformly sampled field. A resolution of 50 metres would have been adequate for a regional scale analysis but would have obscured building level contrasts in urban areas.

Cross validation across all 1,888,176 input buildings assesses how closely the interpolated raster surface reproduces the building population estimates used as its input points, not the accuracy of the disaggregation formula itself, which is confirmed in the calibration below. The mean prediction error of -0.057 persons indicates no systematic tendency for the surface to over or underestimate the input building values. The root mean square prediction error of 3.58 persons reflects the average deviation between the interpolated surface and the input building estimates at each point; this figure is expected to exceed the average building population because kriging smooths across space and cannot reproduce isolated buildings with a high building population estimate surrounded by housing with a lower one. The prediction interval coverage provides a more appropriate uncertainty diagnostic: 96.6% of buildings fall within the 90% prediction interval and 97.3% within the 95% interval, slightly exceeding the nominal targets and confirming that the model uncertainty estimates are conservative rather than overconfident. The interpolated raster is used in this paper for the cartographic visualisation of broad national population patterns and should not be interpreted as a substitute for the building level estimates, which are the primary analytical output of the study.

To check the internal consistency of the dasymetric procedure, building population estimates were aggregated back to the 18,919 small area level and compared against the known Census 2022 totals. This calibration step follows Lwin and Murayama (2009), whose disaggregation formula underpins this study, and confirms whether the procedure preserves population totals at the small area level as designed.

The results are summarised in Table 2. The coefficient of determination (R^2) between estimated and observed small area populations was 0.999, indicating an almost perfect correspondence between the dasymetric estimates and the census figures. The root mean square error (RMSE) was 0.30 persons per small area, equivalent to a relative RMSE of 0.11% of the mean small area population of 272 persons. The mean absolute error (MAE) of 0.24 persons and a maximum absolute error of 1.75 persons across all 18,919 small areas confirm that discrepancies are negligible in absolute terms. The mean bias of 0.001 persons indicates no systematic tendency to over or underestimate population. At national level, the sum of the dasymetric estimates (5,149,155 persons) differs from the Census 2022 total (5,149,139 persons) by 16 persons, a discrepancy of 0.0003% attributable to an error resulting from rounding decimal places throughout the calculations.

Table 2. Calibration statistics comparing dasymetric estimates aggregated to small area level against Census 2022 totals (n = 18,919 small areas).

Statistic	Value
R^2	0.999
RMSE (persons)	0.30
% RMSE	0.11
Mean absolute error (persons)	0.24
Maximum absolute error (persons)	1.75
Mean bias per small area (persons)	0.001
Total census population	5,149,139
Total dasymetric estimate	5,149,155
Total absolute discrepancy (persons)	16
Total % discrepancy	0.0003

It should be noted that because the dasymetric formula distributes the census population of each small area proportionally across its residential Eircodes, aggregating the resulting building estimates back to small area level should, by design, recover the original census totals in most cases. The near perfect R^2 and negligible RMSE therefore reflect the internal consistency of the procedure rather than an independent assessment of predictive accuracy. A more rigorous cross-validation, involving the withholding of small areas and the prediction of their populations from surrounding data, would constitute a stronger test of predictive performance. However, this falls outside the scope of the present study, as the disaggregation formula requires population totals for all small areas as inputs, leaving no observations available for genuine out of sample testing. Other than this limitation, the calibration confirms that the disaggregation procedure introduces no material numerical error and that the building estimates are fully coherent with the official census geography at small area level.

3.5 Sensitivity Analysis

To illustrate the directional bias introduced by the equal household size assumption, a synthetic sensitivity analysis was constructed using three representative small area configurations spanning the range of typological heterogeneity observed across Irish settlements. The first represents a homogeneous rural small area composed entirely of detached family homes. The second represents a suburban fringe small area combining family housing with a minority share of apartment units, consistent with outer Dublin commuter estates where county household size averages exceed the national figure. The third represents an urban core small area where terraced houses and apartments occur in equal proportions, consistent with inner city areas in Dublin where the county average household size of 2.48 falls substantially below the national average of 2.74. Dwelling specific household sizes were derived from CSO county-level averages for Census 2022: 3.2 persons per detached house, 3.0 persons per terraced house, and 1.5 persons per apartment (Central Statistics Office, 2023b).

For each configuration, the per Eircode population value produced by the equal household size assumption was compared against the type-specific value to quantify the population redistribution within the small area. Full empirical testing of this assumption at small area level would require a dwelling type classification capable of distinguishing apartment units from houses. Inspection of the Eircode type field, which classifies addresses by architectural form rather than internal dwelling type, confirms that apartment units within terrace or standalone blocks are recorded as “terraced” or “detached” respectively; no apartment category exists in the matched dataset. Household microdata disaggregated by dwelling type, which would allow the distinction to be made directly, is not released publicly by the CSO. Synthetic scenarios therefore constitute the only feasible approach for quantifying the directional bias.

The Census 2022 Small Area Population Statistics (SAPS) include population counts by accommodation type at small area level, distinguishing persons living in houses or bungalows, flats or apartments, bedsits, and caravans or mobile homes (Central Statistics Office, 2023a). This source was investigated to assess whether it could substitute for the synthetic scenarios. The SAPS data confirms, for a given small area, how many persons live in each accommodation type in aggregate, but does not indicate which of the residential Eircode addresses within that small area correspond to those persons. Distributing type-specific populations to individual buildings would still require a reliable correspondence between each Eircode address and its dwelling type, and the Eircode type field cannot supply this for the reasons described above. The SAPS data therefore corroborates the direction and approximate magnitude of the bias identified by the synthetic scenarios, confirming that apartments are systematically overestimated and family homes underestimated wherever both types are present within the same small area, but it cannot replace the type-specific address register that a fully data-driven allocation would require.

4. Results

4.1 Dasymetric map of population of the Republic of Ireland in 2022

The building values presented in this study are statistical estimates derived from aggregated census data and should not be interpreted as records of actual household occupancy. For illustration purposes, it was decided to select the three main cities in the Republic to illustrate some examples and explain briefly the distribution of population in these areas. Dublin’s map is presented at a scale of 1:25,000, compared to 1:15,000 for Cork and Galway. Although the use of a consistent scale across all three maps would be preferable, Dublin’s larger urbanised extent means that applying 1:15,000 at the same page dimensions would crop out the inner suburbs and commuter areas that are integral to the city's population distribution. Readers should bear this scale difference in mind when making visual comparisons of building population density between cities, as buildings appear smaller in the Dublin map and finer spatial contrasts are less apparent than in the Cork and Galway figures.

Figure 3 illustrates Dublin, where the highest population counts per building are concentrated in the city centre, particularly in areas with high building population estimates, such as the Docklands, inner suburbs around Mountjoy Square, Smithfield and The Liberties, where there are 240 buildings having more than 100 residents and one building reaching 632. These highly populated areas contrast with others where there is almost no population. The best example is the area defined by College Green at the North, Merrion Square at the East, St. Stephen's Green at the South and Grafton Street at the West, which is predominantly commercial with few residential addresses in the Eircode database, so the dasymetric estimate reflects this absence of residential input data rather than an absence of residents. Similarly, Parnell Street, O'Connell Street, Abbey Street and Henry Street present an analogous situation. Both cases are clear examples of long standing commercial land use that has displaced residential uses and kept residential population low in these areas. In the outer suburbs and peri-urban areas, the map progressively shows a lighter shading, reflecting fewer people per building. This pattern corresponds to housing with lower residential built density (e.g. cottages, detached or terraced homes) typical of suburban neighbourhoods such as Cabra, Stoneybatter, Phibsborough, East Wall, Ranelagh, Rathmines, Harold's Cross or Rialto. The dasymetric estimates for these areas usually fall below the national average household size of 2.74 people per private household (Central Statistics Office, 2022b). Some exceptions within these areas of lower residential built density are Island Bridge and certain parts of Kilmainham where there is a moderate presence of apartment blocks.

Cork, the second largest city in the Republic, is shown in Figure 4. The map shows a substantial spatial variation in the number of people per building across the city. The highest numbers of people per building are concentrated in and around Cork city centre, particularly near the River Lee and University College Cork, including the area around the southern channel. These areas contain buildings with high residential built density, such as apartments and student housing, leading to high building population estimates. Moving away from the city centre, the shading becomes lighter in inner suburban areas like St. Luke's, Ballymacthomas and Greenmount, where housing with medium residential built density predominates and the number of residents per building is moderate. The less populated areas are found on the outer fringes and surrounding countryside, such as Fairhill, Ard Sionnach, Gurranabraher and Deerpark, where detached and semi-detached houses dominate.

The third example is Galway, which is shown in Figure 5. The dasymetric map reveals a clear concentration of population per building in the central urban core, particularly near Eyre Square, the University of Galway, and the Claddagh, where housing with high residential built density is frequent. Moving outwards, the number of people per building decreases in suburban areas, where family housing and estates with lower residential built density prevail. The only exception to this is Salthill, a seaside area to the Southwest of Galway. The rural outskirts show very low building population estimates, consistent with scattered dwellings and agricultural land use.

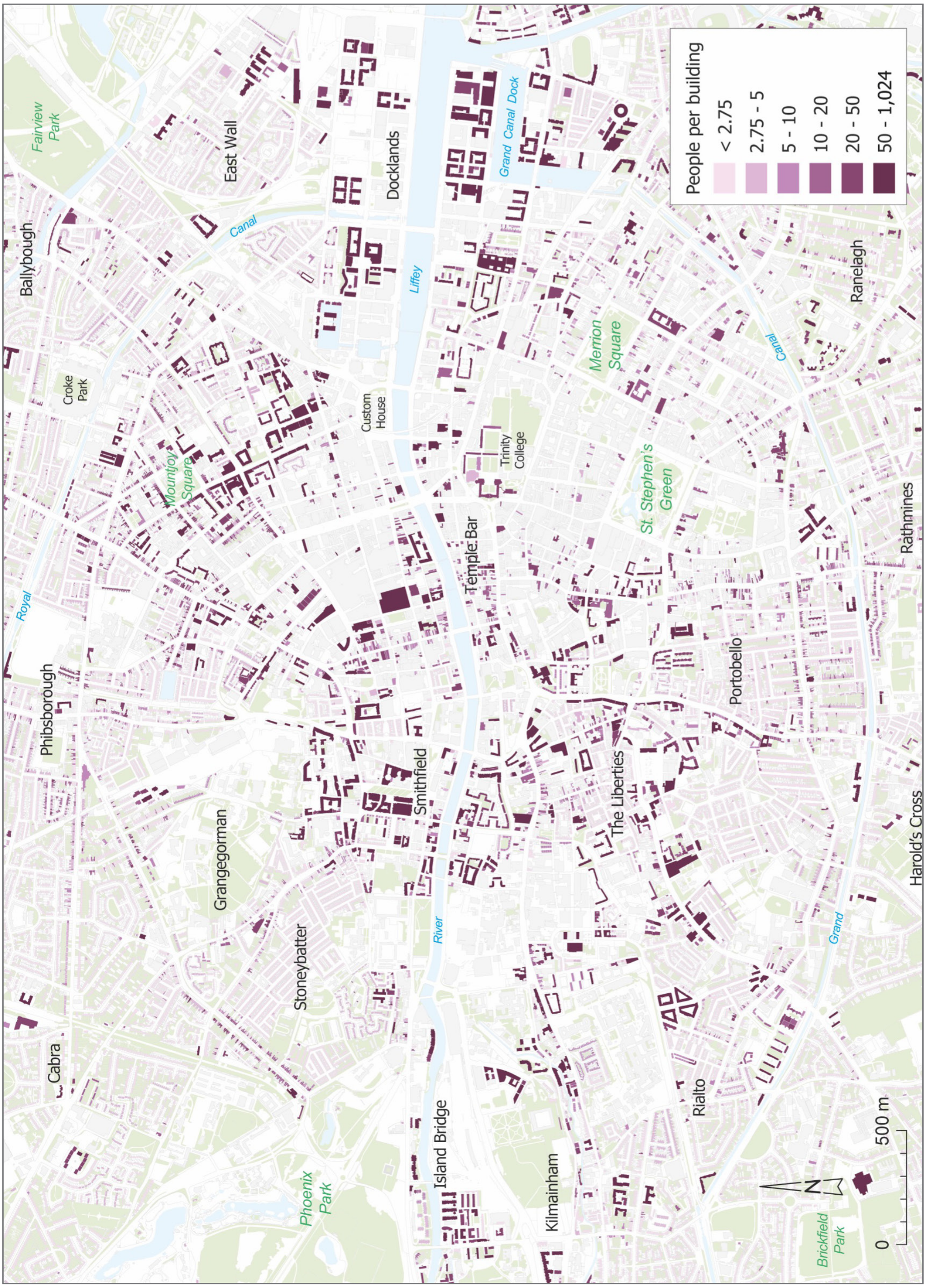

Figure 3. Dasymetric map of Dublin in 2022. Data source: CSO, Tailte Éireann and Eircode.

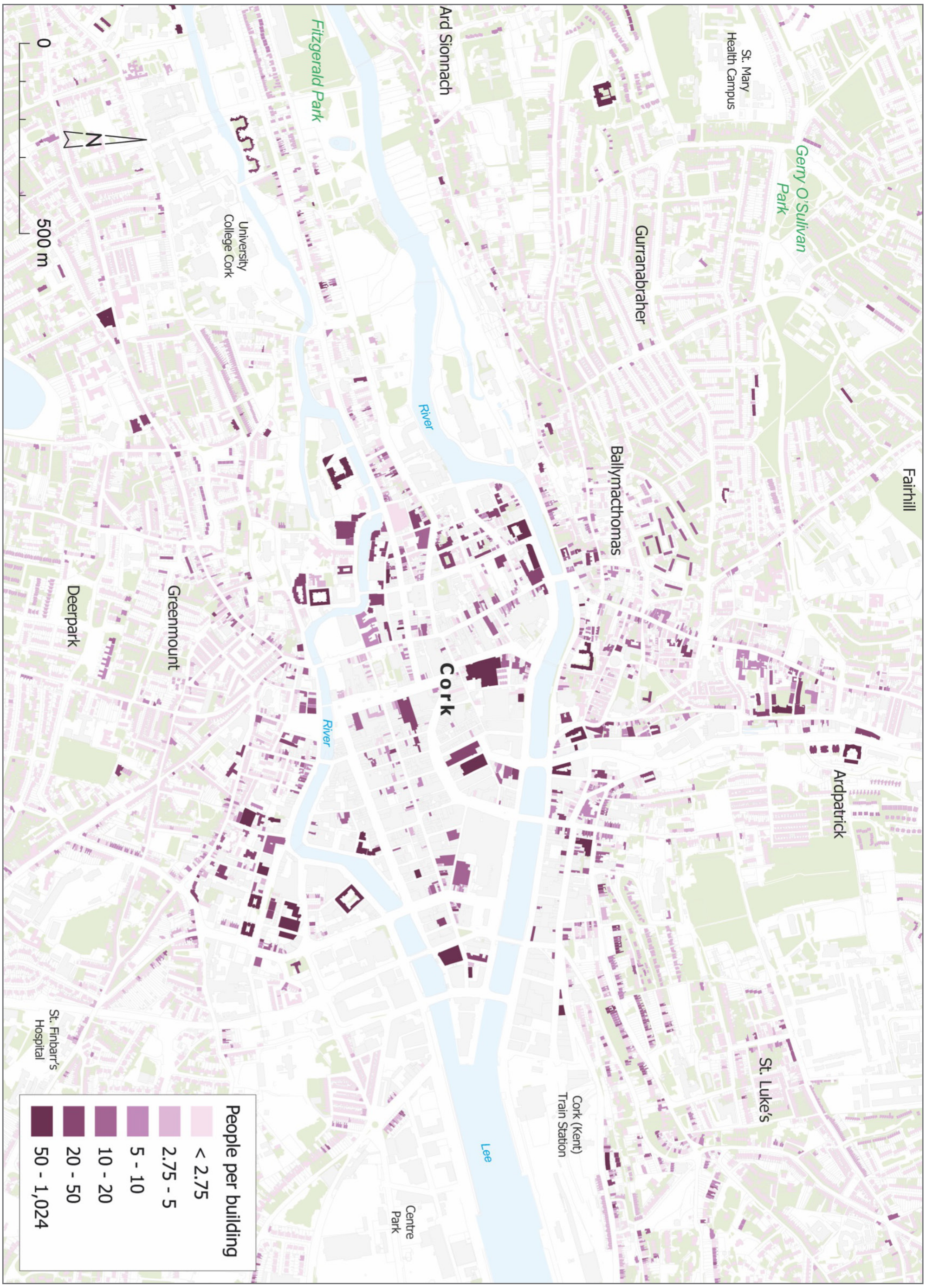

Figure 4. Dasymetric map of Cork in 2022. Data source: CSO, Tailte Éireann and Eircode.

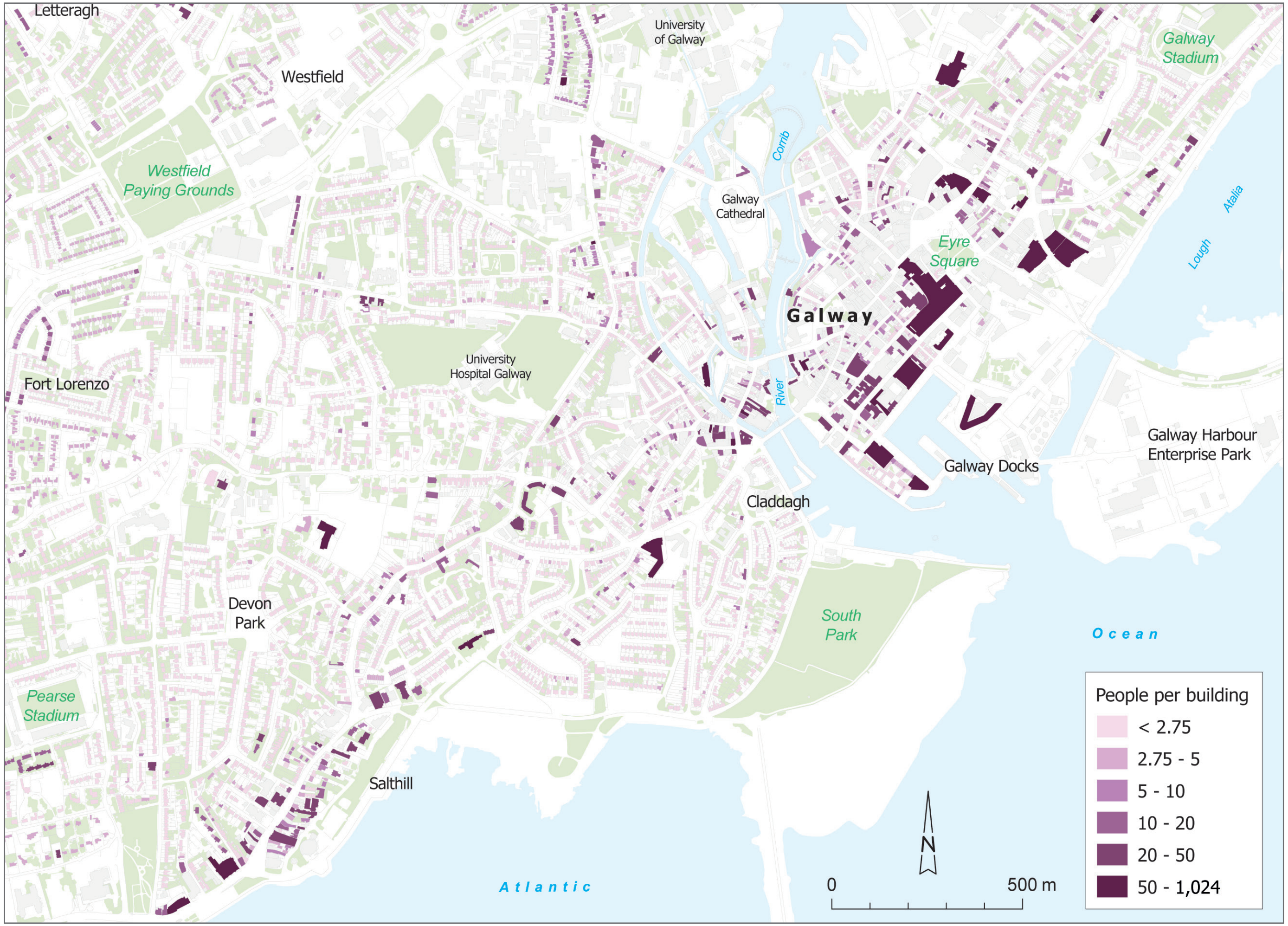

Figure 5. Dasymetric map of Galway in 2022. Data source: CSO, Tailte Éireann and Eircode.

The dasymetric maps of Dublin, Cork and Galway reveal similar patterns in the distribution of population per building, but they also reflect each city's urban structure and housing morphologies. In all three cities, the highest number of people per building occur in the city centre, where apartments, student residences and multi-occupancy housing dominate. In the suburbs, the number of people per building decreases steadily through inner and outer suburban areas, where housing with lower residential built density becomes more common. While Dublin shows the most extensive area of high building population estimates due to its larger size and urbanisation level, Cork and Galway have similar but smaller scale patterns reflecting their more compact city structures.

4.2 Interpolation of the dasymetric map of Ireland

The data contained in the dasymetric map presented in the previous section was used to produce a population density surface to show the population at national level, the result is shown in Figure 6. The first impression is how strikingly uneven the population is distributed across the Republic, with clear hierarchical patterns dominated by Dublin and other secondary concentrations in other urban centres. Dublin's overwhelming concentration appears as a dark purple hotspot in the East coast, with interpolated population density values exceeding 1,000 persons per 25 metre cell in some areas. Dublin's conurbation spreads beyond Swords in the North, reaching to Navan and Mullingar in the Northwest, Tullamore in the West, Portlaoise and Carlow in the Southwest, and Greystones in the South. Although it is not a continuous urban cover, when the results are observed at the national level those towns form the outer boundaries of the commuter belt around the Irish capital. This reflects Dublin's role as the capital and primary economic engine, drawing population and investment far beyond the national average. The intensity is qualitatively different from anywhere else in the country, illustrating the marked population imbalance between Dublin and the rest of the Irish urban system.

Beyond Dublin, secondary clusters emerge around other major urban centres: Cork, Galway and Limerick, although these are noticeably lighter in colour, indicating substantially lower density. This creates a pattern of urban islands connected by lower-density areas, with the West coast showing slightly more dispersed settlement than the Midlands. Other smaller urban clusters can be found in less populated areas like Kerry, with internal centres like Killarney and Tralee, together with Waterford, Wexford and Clonmel and Kilkenny in the southern half of the country. Similarly, Castlebar, Roscommon, Longford, Cavan, Monaghan, Sligo, Donegal and Letterkenny would be perfect examples in this regard in the northern half of the Republic. However, the map highlights significant demographic voids that deserve attention. Wicklow and Connemara stand out as conspicuous pale zones surrounded by otherwise inhabited territory. Wicklow's emptiness is particularly remarkable given its proximity to Dublin. The Wicklow Mountains explains this demographic desert, as the topography has historically constrained settlement and development. Connemara in County Galway

Figure 6. Dasymetric map of the Republic of Ireland 2022. Data source: CSO, Tailte Éireann and Eircode.

similarly reflects the challenging terrain of western Connacht, where boggy, mountainous conditions have limited population concentration despite the region's cultural and scenic significance.

More broadly, the western coast shows persistently lower densities compared to the eastern side of the country. Perfect examples of this would be the Ring of Kerry and most of County Donegal, reflecting historical settlement patterns, economic opportunities concentrated around Dublin and the Irish Sea, and the ongoing challenge of rural depopulation in peripheral areas. This East-West gradient, combined with urban concentration, underscores the Republic's demographic imbalance and the marginalising effect of distance from Dublin's economic pull.

To illustrate the previous points with some relevant values, Table 3 summarises the areas occupied by the residential buildings according to the classes defined in the dasymetric map. Almost three quarters of these buildings are below the national average of 2.74 people per household, they represent almost 150 km^2 or 0.21% of the overall area of the country. The buildings with up to 5 persons per building occupy 48 km^2, representing almost a quarter of all the residential building areas in Ireland, and 0.068% of the country's area. On the other hand, only 5.52% of the residential buildings have more than 5 people, which represents 0.017% of the country. Therefore, most of the population is extremely dispersed in the Republic, with only a marginal footprint of highly populated buildings.

Table 3. Area occupied by the different population per building categories.

Population per building	km^2	% Residential buildings	% ROI
< 2.75	148.28	71.37	0.211
2.75 – 5	48.02	23.11	0.068
5 – 10	3.87	1.86	0.006
10 – 20	2.20	1.06	0.003
20 – 50	2.53	1.22	0.004
50 – 1,024	2.87	1.38	0.004
Total residential buildings area:	207.77	100	0.296
Total non-residential areas:	70,057.26		99.704
Total Republic of Ireland area:	70,265.03		100

Figure 7 shows the distribution of people per building groups across Irish counties in 2022. This Figure confirms that urbanisation strongly influences the number of people per building, with the Republic's population concentrated in a few urban cores with high building population estimates and more dispersed, low population housing elsewhere. The pattern demonstrates a clear urban to rural gradient in building population estimates across the country. Most counties have a high proportion of buildings with fewer than 2.75 people per building, confirming the Republic's generally low household size and prevalence of single-family homes.

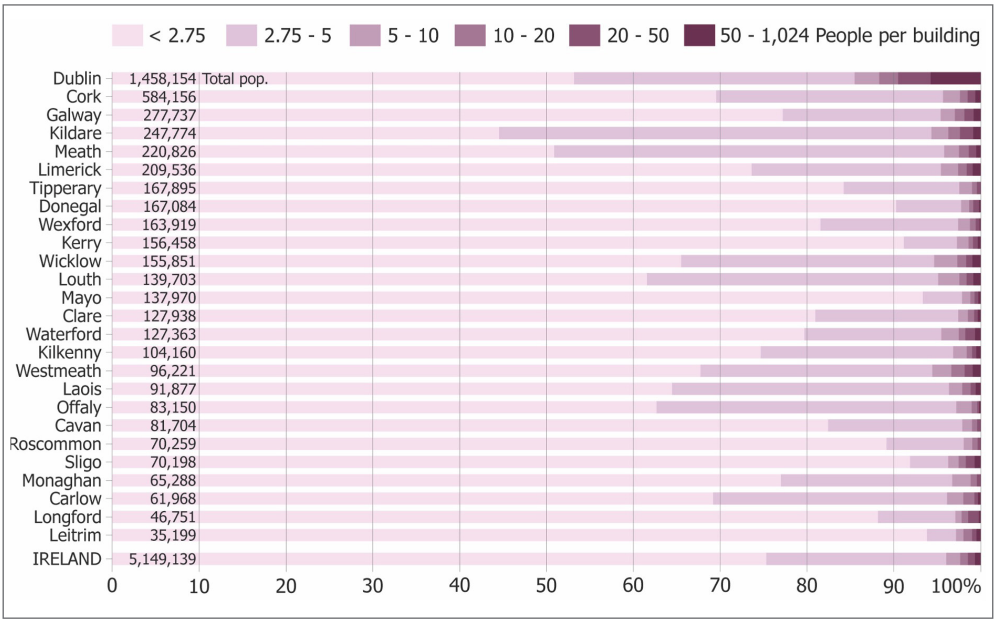

Figure 7. Distribution of people per building groups at county and national levels in 2022. Data source: CSO, Tailte Éireann and Eircode.

However, clear urban and rural contrasts emerge. Dublin, followed by Cork and Galway display noticeably larger shares of buildings in the highest population per building ranges (10-50 and 50-1,024). This reflects the concentration of multi-occupancy dwellings, apartment blocks, and student housing in these urban centres. In contrast, rural counties such as Leitrim, Longford, and Roscommon are dominated by the lowest categories, indicating predominantly single household and housing with lower residential built density.

4.3 Sensitivity of the equal household size assumption

Table 4 presents the outcomes of the three synthetic scenarios considering the following household size assumptions: detached houses 3.2 persons, terraced houses 3.0 persons, apartments 1.5 persons, derived from CSO county averages (Central Statistics Office, 2023b). In the homogeneous rural configuration, all dwellings are of the same type and the equal household size assumption does not introduce population redistribution within the small area, every residential Eircode is assigned the actual average of 3.20 persons, which matches exactly the household type specific value. In the suburban fringe configuration, a 15% apartment share causes the method to underestimate family homes by 0.25 persons per address (8%) and overestimate apartments by 1.45 persons per address (97%). In the urban core configuration, where apartments and terraced houses occur in equal proportions, the method underestimates family homes by 0.75 persons per address (25%) and overestimates apartments by 0.75 persons per address (50%). In all three scenarios the small area population total is preserved by design.

Table 4. Synthetic sensitivity analysis of the equal household size assumption. Errors are expressed per dwelling; small area totals are preserved in all cases.

Scenario	Eircodes	Housing mix	Method avg (persons)	House error (persons)	Apartment error (persons)	Small area error
1: Homogeneous rural	40	100% detached house	3.20	0.00	n/a	0
2: Suburban fringe	100	85% det. house, 15% apt	2.95	-0.25 (8%)	+1.45 (97%)	0
3: Urban core	80	50% ter. house, 50% apt	2.25	-0.75 (25%)	+0.75 (50%)	0

The results confirm that the equal household size assumption introduces no arithmetic error at small area level but redistributes population within small areas wherever dwelling typologies are heterogeneous. The magnitude of redistribution increases with typological mixing. The directional pattern is consistent, apartments are systematically overestimated and family homes systematically underestimated in every mixed typology configuration. The bias is most consequential in areas where apartments account for a high share of the local housing stock, particularly Dublin inner city, where the household size average of 2.48 falls substantially below the national average of 2.74 (Central Statistics Office, 2022b).

5. Discussion

The value of the building level approach is not uniform across the country, but depends on how closely the choropleth representation already approximates the actual distribution of population within each small area. At neighbourhood scale, the approach exposes the spatial co-occurrence of residential buildings with high building population estimates and commercial lots with near zero residential population, precisely the unit heterogeneity that Mennis (2003) identifies as the primary justification for dasymetric mapping over choropleth representation. The comparison that follows tests this proposition directly against the Census 2022 small area geography, identifying where the two representations converge and where they diverge.

The choropleth representation of Census 2022 small area totals assigns a single average population per building to each small area and applies it uniformly across the polygon boundary using the CSO published data. The dasymetric approach distributes that same population to individual buildings in proportion to their residential address count, exposing variations inside the small area that the choropleth cannot represent. The two approaches use the same source data and the same metric; the difference is the spatial unit at which the value is expressed. Figure 8 presents both representations simultaneously for Dublin city centre, with small area average values as the background layer and building dasymetric estimates as the foreground layer. Where a building polygon matches the colour of the small area behind it, both representations assign the same value and agree. Where a building is substantially darker, that building contains more residential addresses than the small area average and the choropleth would have underrepresented its population by spreading it across the whole polygon, when in reality the population is highly concentrated.

The contrast is most pronounced in small areas with heterogeneous building stock. In the Docklands and inner northside, large apartment blocks with high residential address counts appear substantially darker than the small area average behind them, confirming that the choropleth, while broadly indicating a high population per building in these areas, does not identify which specific buildings account for that concentration. In contrast, the commercial core delimited by College Green, Merrion Square, St Stephen's Green and Grafton Street shows small area backgrounds with modest average values; the dasymetric layer reveals that residential population is concentrated in a small number of buildings at the edges of these small areas, with the commercial interior returning very low building level estimates. In inner suburban areas such as Stoneybatter, Portobello and Ranelagh, where housing stock is more homogeneous, building polygons closely match their small area backgrounds, indicating that both representations convey equivalent information at this scale.

To quantify the variation within the small areas that the dasymetric approach exposes, the coefficient of variation (CV) of building population estimates was calculated across all 18,919 small areas. The median CV nationally is 0.13, indicating that for the typical small area, individual building populations vary by approximately 13% around the small area mean. The mean CV of 0.39 substantially exceeds the median, confirming a strongly right skewed distribution, which indicates that most small areas are homogeneous, while a minority of urban small areas with highly varied building typologies drive the average upward. A quarter of the small areas (24.4%) have a CV above 0.5, indicating moderate to high heterogeneity where the dasymetric representation adds more detail compared to the choropleth. In 13.4% of the small areas the CV is above 1.0, and these are concentrated predominantly in urban small areas. At county level, Galway City shows the highest median CV (0.50), followed closely by Dublin (0.48), which is consistent with their small areas containing buildings with substantially different residential address counts. Rural counties show the lowest median CV values, for example, Leitrim (0.08), Mayo (0.09) and Roscommon (0.09), reflecting predominantly detached housing in dispersed small areas where the choropleth and dasymetric representations converge.
The dasymetric approach therefore adds most value in urban settings where small areas contain buildings with a greater variety of residential address counts, and where the

choropleth representation would mislead any analysis requiring knowledge of where within a small area people live. For analyses operating at small area scale or lower, such as county level demographic comparisons, national population totals, or applications where the unit of interest aligns with census geography, the choropleth representation of CSO small area totals is adequate and substantially simpler to produce. The choice between the two should be guided by the spatial detail of the research question and the degree of heterogeneity in the study area's small areas.

The building estimates dataset produced by this study cannot be made publicly available. The Prime2 building polygons are distributed under the National Mapping Agreement between Tailte Éireann and Irish public bodies and the Eircode address database is supplied under the Public Sector Licence. Neither agreement permits redistribution of the underlying data to third parties. Researchers with equivalent licensed access can reproduce the building level estimates by following the workflow described in the Methodology section. The 25 metre population density surface derived from these estimates is published as open data (Fernández Noguerol, 2026).

A further limitation concerns the absence of floor count data from both Prime2 and Eircode. Because the disaggregation formula weights each building by its residential address count rather than its total residential floor area, a ten-storey apartment block and a single-storey house with an identical Eircode count receive the same population estimate. This systematically underweights tall buildings in areas where high-rise residential development is concentrated, most notably in parts of Dublin city centre, where the true population per building is likely to be higher than the dasymetric estimate indicates.

The building level approach removes the distorting effect of uninhabited land (parks, commercial areas, water bodies) from small area representations, a limitation that choropleth mapping imposes on any variable in the CSO dataset, not only the population count. The workflow provides a replicable foundation for extending building mapping to the 790 variables available in the CSO small area dataset, including age structure, household composition and housing tenure. Integration with the Pobal HP Deprivation Index, which draws on the same source data, would enable fine scale analysis of the relationship between residential density and social disadvantage (Haase and Pratschke, 2017; Pratschke and Haase, 2014). Census 2027 will provide a temporally aligned set of inputs to update the estimates and enable intercensal comparison. Beyond Ireland, the method is transferable to any jurisdiction maintaining a national address register with residential classification and a building inventory with use attributes, and as Wan *et al*. (2023) demonstrate, an administratively defined address variable represents a principled ancillary choice wherever such data is available at national coverage.

Figure 8. People per building estimates and small area averages in Dublin 2022. Data source: CSO, Tailte Éireann and Eircode.

6. Conclusions

This study produced the first building level dasymetric map of the population of the Republic of Ireland, demonstrating that authoritative national datasets can be combined to disaggregate published census counts to individual residential buildings across the full national territory.

The outputs reveal a strongly hierarchical settlement structure. Dublin's population concentration is qualitatively different in scale from any other urban centre, with interpolated densities exceeding 1,000 persons per 25 metre cell in parts of the city centre and commuter influence extending to Navan, Mullingar and Greystones. Beyond the capital, secondary clusters around Cork, Galway and Limerick are substantially smaller in both extent and intensity, while the west coast and midlands show persistently low building population estimates. The coefficient of variation analysis confirms that the dasymetric representation adds most value in urban small areas, where a quarter of all small areas nationally have a CV above 0.5, and is largely equivalent to the choropleth in rural areas dominated by detached housing.

The workflow is designed for replication. Census 2027 will provide a temporally aligned set of inputs to update the estimates and enable intercensal comparison of building level population change. The same disaggregation logic applies to any of the 790 variables in the CSO small area dataset, with age structure, housing tenure and household composition as immediate priorities. Integration with the Pobal HP Deprivation Index would extend the analysis to fine scale social disadvantage, and the method is transferable to any jurisdiction maintaining a national address register and building inventory with comparable attributes.

7. Acknowledgements

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References

An Post GeoDirectory, 2025. "Geo Directory", available at: https://www.geodirectory.ie/about-us (accessed 22 September 2025).

Baynes, J., Neale, A. and Hultgren, T., 2022. "Improving intelligent dasymetric mapping population density estimates at 30 m resolution for the conterminous United States by excluding uninhabited areas", *Earth System Science Data*, Copernicus Publications, Vol. 14 No. 6, pp. 2833–2849, doi: 10.5194/ESSD-14-2833-2022.

Boyle, P. and Dorling, D., 2004. "Guest Editorial: The 2001 UK Census: Remarkable Resource or Bygone Legacy of the 'Pencil and Paper Era'?", *Area, Royal Geographical to help with the study of Society with IBG*, Vol. 36 No. 2, pp. 101–110.

Briggs, D.J., Gulliver, J., Fecht, D. and Vienneau, D.M., 2007. "Dasymetric modelling of small area population distribution using land cover and light emissions data", *Remote Sensing of Environment*, Elsevier, Vol. 108 No. 4, pp. 451–466, doi: 10.1016/J.RSE.2006.11.020.

Central Statistics Office, 1993. "Statistical Confidentiality", available at: https://www.cso.ie/en/aboutus/lgdp/csodatapolicies/statisticalconfidentiality/ (accessed 17 October 2024).

Central Statistics Office, 2022a. *Census of Population of Ireland 2022 Form*, Dublin.

Central Statistics Office, 2022b. "Household Size and Marital Status Census of Population 2022", available at: https://www.cso.ie/en/releasesandpublications/ep/p-cpsr/censusofpopulation2022-summaryresults/householdsizeandmaritalstatus/ (accessed 17 October 2025).

Central Statistics Office, 2023a. "Census 2022 Small Area Population Statistics", available at: https://www.cso.ie/en/census/census2022/census2022smallareapopulationstatistics/ (accessed 29 September 2025).

Central Statistics Office, 2023b. "Census of Population 2022 Summary Results", available at: https://www.cso.ie/en/releasesandpublications/ep/p-cpsr/censusofpopulation2022-summaryresults/householdsizeandmaritalstatus/ (accessed 22 May 2026).

Central Statistics Office, 2024. "Census", available at: https://www.cso.ie/en/census/ (accessed 24 September 2025).

Cook, L., 2004. "The Quality and Qualities of Population Statistics, and the Place of the Census", *Area, Royal Geographical Society with IBG*, Census and Society, Vol. 36 No. 2, pp. 111–123.

Dmowska, A., 2019. "Dasymetric modelling of population distribution – Large data approach", *Quaestiones Geographicae*, Vol. 38(1), pp. 15–27, doi: 10.2478/quageo-2019-0008.

Eircode, 2015. *Pricing Effective from March 2015*, Dublin.

Eircode, 2024. *Eircode Address Database Product Guide. Edition 2, Version 17*, Dublin.

ESRI, 2024. "What is empirical Bayesian kriging?", available at: https://doc.esri.com/en/arcgis-pro/latest/help/analysis/geostatistical-analyst/what-is-empirical-bayesian-kriging-.html (accessed 27 May 2026).

Fernández Noguerol, S., 2026. *Dasymetric map of the Republic of Ireland 2022* [Dataset], Zenodo, https://doi.org/10.5281/zenodo.22012533.

Haase, T. and Pratschke, J., 2017. *A Performance Measurement Framework for Drug and Alcohol Task Forces Final Report*.

Housing Agency, 2026. "New Dwelling Completions", available at: https://www.housingagency.ie/data-hub/new-dwelling-completions (accessed 25 May 2026).

Jega, I.M., Comber, A. and Brunsdon, C., 2012. "Population estimation in small areas: combining dasymetric mapping with pycnophylactic interpolation", paper presented at GISRUK 2012, 20th GIS Research UK Conference, Lancaster University, Lancaster, 11 to 13 April.

Jitt-Aer, K., Wall, G., Jones, D. and Teeuw, R., 2022. "Use of GIS and dasymetric mapping for estimating tsunami-affected population to facilitate humanitarian relief logistics: a case study from Phuket, Thailand", *Natural Hazards*, Springer Science and Business Media B.V., Vol. 113 No. 1, pp. 185–211, doi: 10.1007/S11069-022-05295-X/FIGURES/11.

Langford, M. and Unwin, D.J., 1994. "Generating and mapping population density surfaces within a geographical information system", *The Cartographic Journal*, Informa UK Limited, Vol. 31 No. 1, pp. 21–26, doi: 10.1179/000870494787073718.

Lloyd, C.D., 2010. "Exploring population spatial concentrations in Northern Ireland by community background and other characteristics: an application of geographically weighted spatial statistics", *International Journal of Geographical Information Science*, Taylor & Francis, Vol. 24 No. 8, pp. 1193–1221, doi: 10.1080/13658810903321321.

Lloyd, C.D., 2012. "Analysing the spatial scale of population concentrations by religion in Northern Ireland using global and local variograms", *International Journal of Geographical Information Science*, Taylor & Francis, Vol. 26 No. 1, pp. 57–73, doi: 10.1080/13658816.2011.563743.

Lloyd, C.D. and Firoozi Nejad, B., 2014. "Surface models and the spatial structure of population variables: Exploring smoothing effects using Northern Ireland grid square data", *Computers, Environment and Urban Systems*, Pergamon, Vol. 48, pp. 64–72, doi: 10.1016/J.COMPENVURBSYS.2014.07.001.

Lwin, K.K. and Murayama, Y., 2009. "A GIS approach to estimation of building population for micro-spatial analysis", *Transactions in GIS*, Blackwell Publishing Ltd, Vol. 13 No. 4, pp. 401–414, doi: 10.1111/J.1467-9671.2009.01171.X.

Manifold Software Limited, 2017. "Manifold System 9", available at: https://manifold.net/ (accessed 3 October 2025).

Martin, D., Lloyd, C. and Shuttleworth, I., 2011. "Evaluation of Gridded Population Models Using 2001 Northern Ireland Census Data", *Environment and Planning A*, SAGE Publications UK, London, England, Vol. 43 No. 8, pp. 1965–1980, doi: 10.1068/A43485.

Mennis, J., 2003. "Generating Surface Models of Population Using Dasymetric Mapping", *The Professional Geographer*, Taylor & Francis Group, Vol. 55 No. 1, pp. 31–42, doi: 10.1111/0033-0124.10042.

Mennis, J., 2009. "Dasymetric Mapping for Estimating Population in Small Areas", *Geography Compass*, John Wiley & Sons, Ltd, Vol. 3 No. 2, pp. 727–745, doi: 10.1111/J.1749-8198.2009.00220.X.

NASA, 2020. "Gridded Population of the World", available at: https://www.earthdata.nasa.gov/data/projects/gpw (accessed 24 September 2025).

Openshaw, S., 1975. *The Modifiable Areal Unit Problem*, edited by Institute of British Geographers, *Concepts and Techniques in Modern Geography*, London.

Pobal, 2022a. *Pobal Strategic Plan 2022-2026*, Government of Ireland.

Pobal, 2022b. "Pobal Maps", available at: https://data.pobal.ie/Portal/apps/sites/#/pobal-maps (accessed 22 September 2025).

Pratschke, J. and Haase, T., 2014. "A longitudinal study of area-level deprivation in Ireland, 1991–2011", *Environment and Planning B: Planning and Design*, Pion Limited, Vol. 42 No. 3, pp. 384–398, doi: 10.1068/b130043p.

Shuttleworth, I.G. and Lloyd, C.D., 2009. "Are Northern Ireland's Communities Dividing? Evidence from Geographically Consistent Census of Population Data, 1971–2001", *Http://Dx.Doi.Org/10.1068/A40163*, SAGE Publications UK, London, England, Vol. 41 No. 1, pp. 213–229, doi: 10.1068/A40163.

Sleeter, R. and Gould, M., 2007. *Geographic Information System Software to Remodel Population Data Using Dasymetric Mapping Methods*, Denver.

Stevens, F.R., Gaughan, A.E., Linard, C. and Tatem, A.J., 2015. "Disaggregating Census Data for Population Mapping Using Random Forests with Remotely-Sensed and Ancillary Data", *Plos One*, Public Library of Science, Vol. 10 No. 2, p. e0107042, doi: 10.1371/JOURNAL.PONE.0107042.

Swanwick, R.H., Read, Q.D., Guinn, S.M., Williamson, M.A., Hondula, K.L. and Elmore, A.J., 2022. "Dasymetric population mapping based on US census data and 30-m gridded estimates of impervious surface", *Scientific Data*, Nature Publishing Group, Vol. 9 No. 1, pp. 1–7, doi: 10.1038/s41597-022-01603-z.

Tailte Éireann, 2017. "MapGenie Mapping Services", available at: https://tailte.ie/services/mapgenie/ (accessed 24 September 2025).

Tailte Éireann, 2018. *National Landcover Map of Ireland 2018. Final Report*, Dublin.

Tailte Éireann, 2023a. "Tailte Éireann: Need Help?", available at: https://store.osi.ie/need-help (accessed 13 January 2025).

Tailte Éireann, 2023b. *Digital Landscape Model (DLM) Core Release Notes 2023Q4*, Dublin.

Tailte Éireann, 2025. "National Landcover Map of Ireland", available at: https://tailte.ie/a-new-national-landcover-map-for-ireland/ (accessed 25 September 2025).

Teh, B.T., Shinozaki, M., Chau, L.W. and Ho, C.S., 2019. "Using Building Floor Space for Station Area Population and Employment Estimation", *Urban Science*, Multidisciplinary Digital Publishing Institute, Vol. 3 No. 1, p. 12, doi: 10.3390/URBANSCI3010012.

Wan, H., Yoon, J., Srikrishnan, V., Daniel, B. and Judi, D., 2023. "Landscape metrics regularly outperform other traditionally-used ancillary datasets in dasymetric mapping of population", *Computers, Environment and Urban Systems*, Pergamon, Vol. 99, p. 101899, doi: 10.1016/J.COMPENVURBSYS.2022.101899.

Wright, J.K., 1936. "A method of mapping densities of population: With Cape Cod as an example", *Geographical Review*, American Geographical Society, Vol. 26 No. 1, pp. 103–110, doi: 10.2307/209467.

Yankey, O., Utazi, C.E., Nnanatu, C.C., Gadiaga, A.N., Abtot, T., Lazar, A.N. and Tatem, A.J., 2024. "Disaggregating census data for population mapping using a Bayesian Additive Regression Tree model", *Applied Geography*, Vol. 172, p. 15, doi: 10.1016/j.apgeog.2024.103416.