



Baseline Emissions Inventory

Part of the Cork City
Climate Action Plan 2024-2029



Comhairle Cathrach Chorcaí
Cork City Council

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Executive Summary

Under Ireland's Climate Action and Low Carbon Development Act, each local authority has been mandated to develop Climate Action Plans addressing both mitigation and adaptation measures.

Local Authority Climate Action Plans are expected to further enhance local authorities' ability to lead, engage, coordinate, and become agents of change in response to the ongoing climate change crisis. To inform those efforts, this report describes the modelling and spatial mapping of Cork City's baseline GHG emissions for the base year of 2018. It provides

a summary of emissions modelled across the six sectors. These include households; road transport; commercial services & industry; public services; agriculture, land use, land use change, forestry & fishing; and waste handling & treatment. The following table and sections summarise the key findings from this report.

Sector	CO ₂ -eq in 2018 (ktonne)
Household	332
Road Transport	290
Commercial Services & Industry	216
Public Services	65
Agriculture, Land Use & Fishing	62
Waste Handling & Treatment	22
Total	987

Executive Summary

Key findings overall

GHG emissions per capita were found to be 4.7 tCO₂-eq in Cork City compared to 14.4 tCO₂-eq nationally in the year 2018 [6] - see Appendix B for more details. This lower per capita emissions for Cork City was largely due to the lack of agricultural emissions and industrial activity within the city boundary which are represented in the national emissions estimates.

Total GHG emissions for Cork City were found to be 987 ktCO₂-eq.

Energy-related CO₂ emissions were 91% of GHG emissions (903 ktCO₂-eq). Non-energy emissions were 9% of GHG emissions (84 ktCO₂-eq).

The two largest sources of GHG emissions were found to be homes (332 ktCO₂) and cars (-290 ktCO₂-eq).

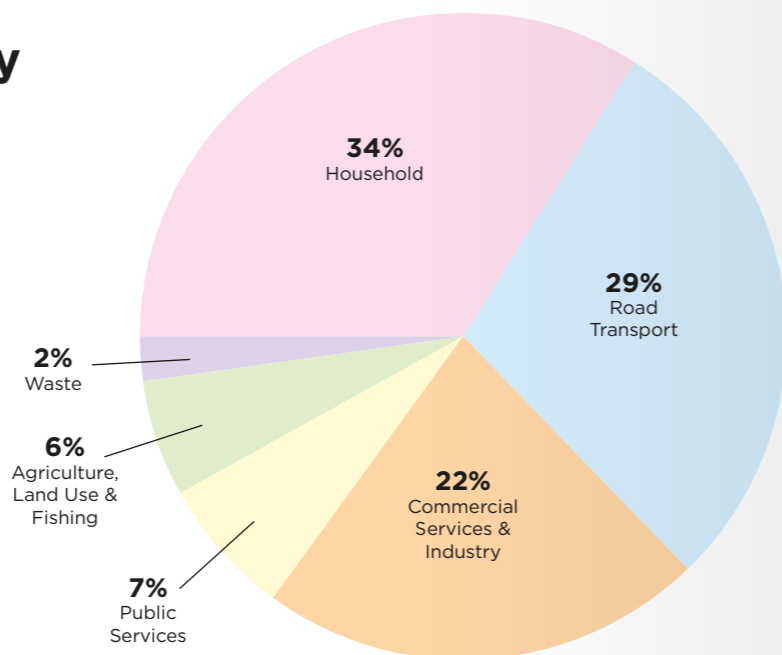
The Decarbonisation Zone (DZ) accounts for 8% of Cork City's GHG emissions and almost 50% of these are from public buildings (universities and hospitals).

In terms of absolute emissions (total ktCO₂), the exurban areas with larger homes and main transport link roads were evident on the maps.

Looking at emission density (per km²), the inner-city areas exhibited a higher concentration of emissions.

Emissions Breakdown by Sector for Cork City

Sector	CO ₂ -eq (ktonnes)
Household	332
Road Transport	290
Commercial Services & Industry	216
Public Services	65
Agriculture, Land Use & Fishing	62
Waste	22
Total	987



Key findings by sector

Household

- In 2018, total energy demand from the households was 1,174 GWh, emitting 332 ktCO₂.
- Household emissions were the single largest source (34%) of GHG emissions overall. Within the household sector, home heating accounted for a majority of energy demand and thus, emissions.
- The housing stock for Cork City in 2018 included 78,856 homes.
- The average BER was a C1, with 58% of the housing stock having a BER of C3 or higher.
- Semi-detached homes made up the highest share (41%) of the housing stock.

Commercial Services & Industry

- The main business activity and subsequent emissions were found to be from offices, the hospitality sector (hotels, bars and restaurants) and the retail sector.
- There was very limited industrial or manufacturing activity within the city boundary.
- The average non-domestic BER in Cork City was found to be a D1.
- Electricity was the most prominent heating source. It was found to be 64% of main space heating systems.

Road Transport

- Cars accounted for almost 90% of road users.
- The exurban areas have the highest rates of car ownership. Some small areas had car ownership rates as high as 800 cars/1,000 people compared to the average of 450 cars/1,000 people nationally.
- The major road links (Lower Glanmire Road, N8 and South Ring Road, N40) are clearly visible on the emissions maps generated.

Public Services

- Universities and hospitals were the largest source of emissions in Cork City's public buildings.
- Street lighting accounted for a significant amount of Cork City Council's electricity usage. It was found to be 9.45 GWh while electricity demand in local authority buildings was found to be 5.9 GWh

Agriculture, Land Use & Fishing

- Very little agricultural land exists within Cork City boundary, and thus it only accounted for 6% of overall GHG emissions compared to 43% nationally in 2018 [6].

Waste

- The main source of emissions was methane. This accounted for 21 ktCO₂-eq out of a total of 22 ktCO₂-eq.



Background

1.1 Policy Context

Under Ireland's Climate Action and Low Carbon Development (Amendment) Act 2021 (hereafter referred to as the 2021 Climate Action Act) each local authority has been mandated to develop Climate Action Plans addressing both mitigation and adaptation measures [1].

Plans are expected to further enhance local authorities' ability to lead, engage, coordinate, and become agents of change in response to the ongoing climate change crisis. They also represent a new opportunity to embed climate mitigation and adaptation in local authority urban planning [2].

To date, local authorities have made considerable progress in accounting for their internal carbon footprint; in energy efficiency improvements in public buildings; and

in developing climate adaptation plans. However, local authorities have made limited progress in climate mitigation beyond their internal carbon footprint.

The new statutory requirement in the 2021 Climate Action Act to provide baseline emissions inventory for the entire administrative area is a significant expansion on the previous role. It requires a detailed understanding of the sources of greenhouse gases in all sectors.



1.2 Objectives of this report

The primary objective of this research was to model and spatially map Cork City's baseline GHG emissions for the base year of 2018. A 'Tier 3 Bottom-up Spatiality-led' approach was applied as set out in the Guidelines for Local Authority Climate Action Plans, Technical Annex C - Climate Mitigation Assessment: Baseline Emissions Inventory [3]. This involved:

- Gathering and processing relevant data on homes, vehicles, and businesses, etc. in each Small Area (SA) in Cork City

- Determining energy demand in each SA for the following sectors: household; commercial and industry; public services; and agriculture & fishing.

- Determining fuel shares in the following sectors: household; commercial and industry; public services; and agriculture, land use & fishing

- Gathering data on electricity and gas use for local authority buildings and public lighting.

- Mapping road transport emissions based on the National Transport Authority Eneval model.

- Proportioning non-energy emissions in agriculture, land use, land use change and fishing emissions based on agricultural areas.

- Computing and mapping the GHG emissions in each small area for the following sectors: household; transport; commercial services & industry; public services; agriculture, land use & fishing; and waste handling and treatment.

- Extracting energy and emissions modelled for the Decarbonisation Zone (DZ) and mapping these..

1.3 Study area

The study domain included the Cork City Council administrative area. This included the expanded Cork City boundary (this expansion occurred in 2019).

1.3.1 Cork City

The expanded Cork City has an area of 187 km² and had a population of approximately 210,000 in the year 2018. Within the new Cork City boundary, there are 856 Small Areas (SAs). SAs are regions which generally contain between 80 and 120 dwellings and are used for the compilation of

Census statistics [4]. With the expansion of the boundary, some SAs fell both within and outside of Cork City. Therefore, it was decided to omit areas where less than 10% of their total area was within the boundary. This removed 13 SAs to give a revised total of 843 SAs.

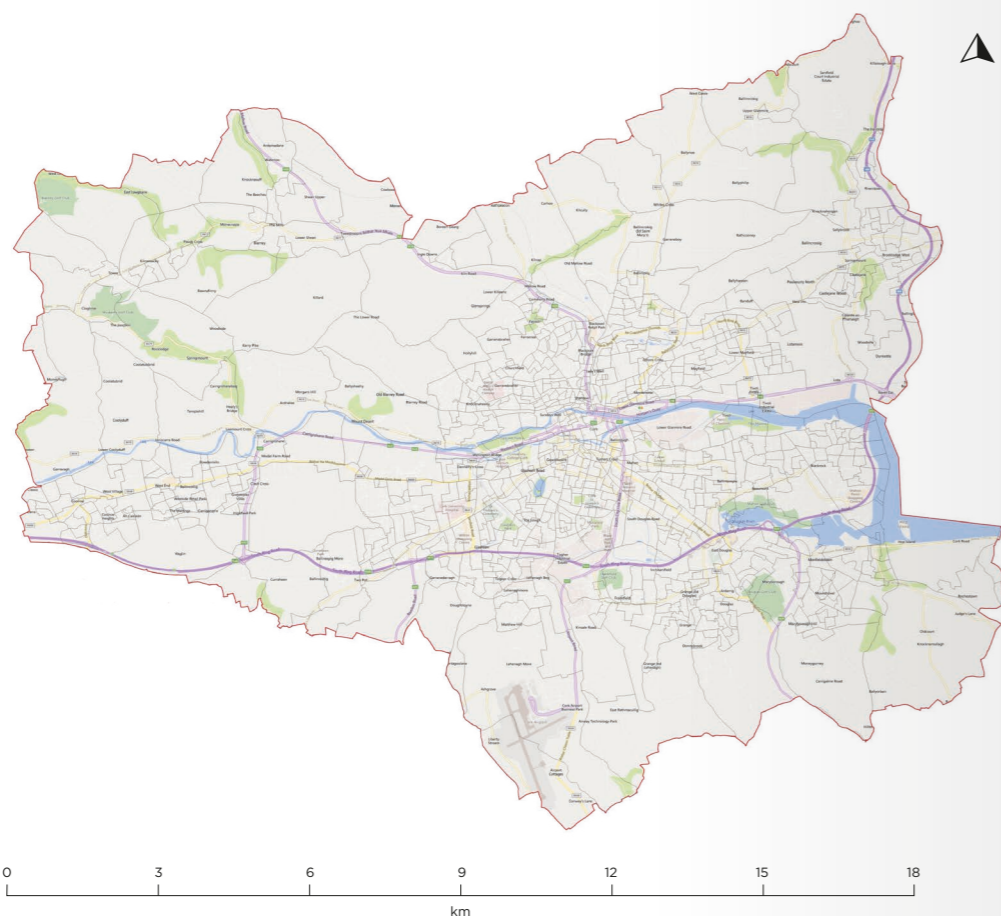


Figure 1. The Cork City Council administrative area with 843 Small Areas shown within its boundary.

1.3.2 Decarbonisation Zone

An area within Cork City, which comprises 52 SAs, was identified as Cork City's Decarbonisation Zone (DZ). The DZ covers a land area of 5km² (approximately 3% of Cork City's total area) and had a population of 13,927 (~11%). It is primarily a residential area with plenty of apartment developments surrounding University College Cork and

Munster Technology University. It also includes Cork City's two large hospitals, namely the Bon Secours Hospital and Cork University Hospital (CUH). Industrial activity within this area is concentrated in the Cork Business and Technology Park on Model Farm Road.



Figure 2. Cork City's Decarbonisation Zone (DZ) boundary.



2

Analyses & Results by Sector

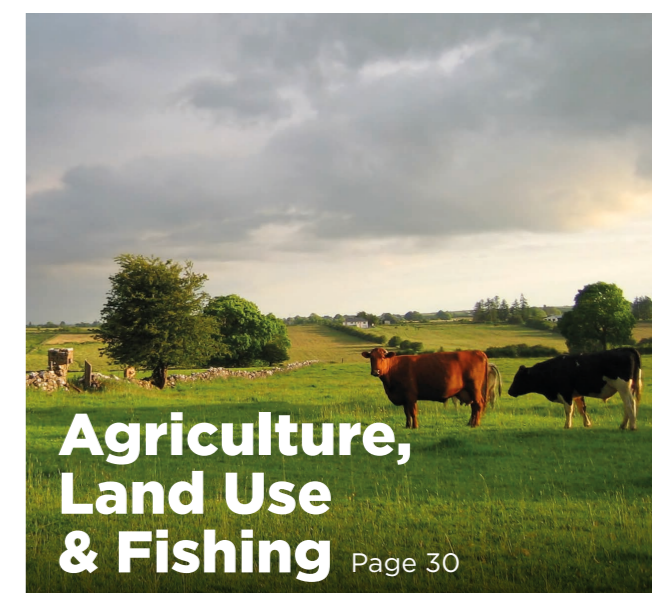
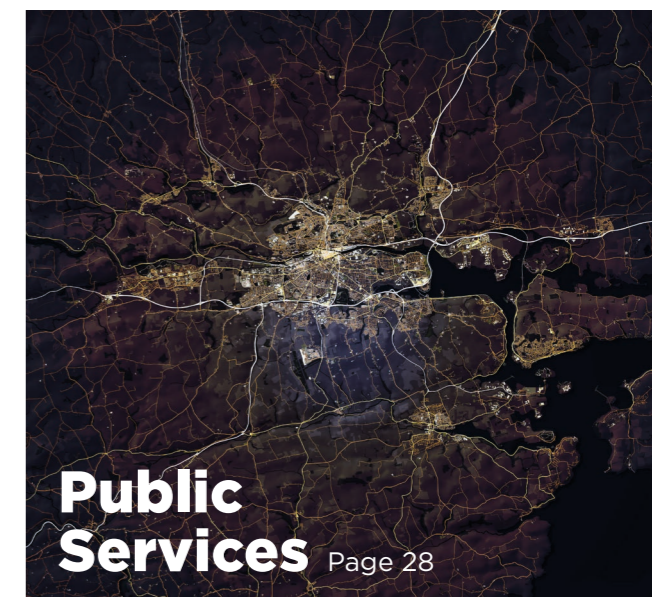
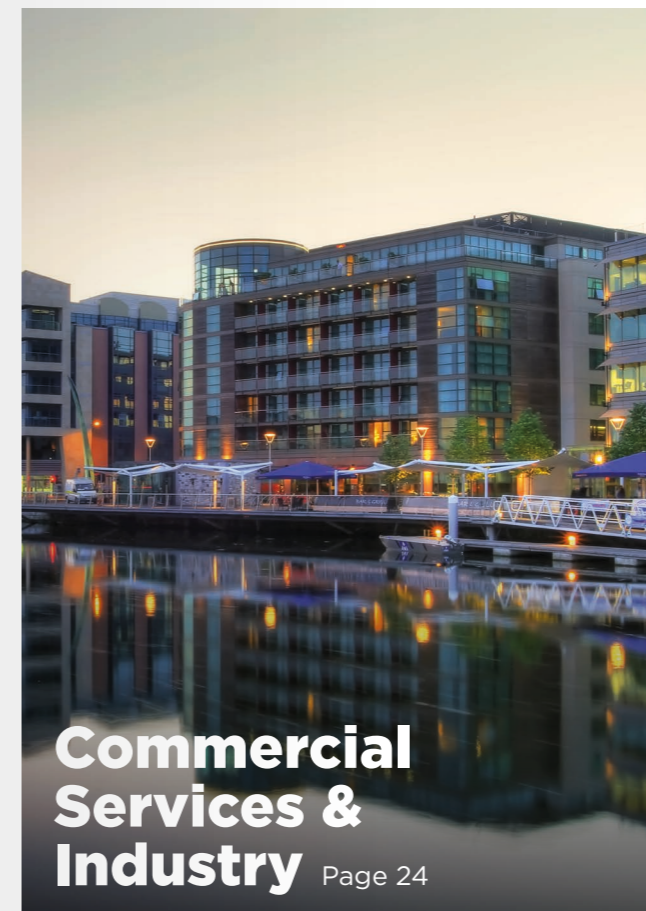
Analyses & Results by Sector

The approach to spatial mapping of energy and emissions was primarily based on Codema’s guidelines [5]. The sectors identified generally followed the categories in EPA’s national reporting [6].

One key difference is the attribution of electricity emissions to the source of demand rather than the power plant. In the national inventory, electricity emissions are within ‘energy industries’, but here they are attributed to the point of

demand (electric appliances or lighting). This classification is more useful for identifying mitigation measures such as those within the Local Authority Climate Action Plan.

Sector	Description
Household	Emissions from both direct fuel burning for space and water heating or cooking as well as those associated with electricity demand
Road Transport	Road transport emissions within Cork City’s boundary based on the National Transport Authority Eneval model
Commercial Services & Industry	Emissions from heating and electricity demand in commercial buildings (e.g. shops, offices, hotels, bars) and industry or manufacturing
Public Services	Emissions from Local Authority owned buildings and street lighting along with other public buildings such as hospitals and schools
Agriculture, Land Use & Fishing	Emissions from livestock, land use, land use change, forestry and machinery
Waste Handling & Treatment	Emissions from waste and the treatment of wastewater



Household

Emissions from the “household” sector, which is sometimes referred to as the “residential” sector, are covered in this sub-section. The drivers of energy demand and CO₂ emissions from households are space and water heating, electrical appliances, cooking and lighting.

A housing stock model for Cork City was developed using the Building Energy Rating (BER) research tool database [7], and Central Statistics Office (CSO) SA statistics [8]. All homes inside the expanded Cork City boundary that were constructed in 2018 or earlier were included. For the purpose of this report, ‘homes’ refer to all dwelling types (e.g. detached house or apartment).

The SEAI-developed BER Research Tool offers insight into the energy demand of homes from typical use of space heating, water heating, and electricity as well as details

on household type, geometry, energy efficiency and fuel consumption. It is utilised in this analysis to determine the average energy needed per square meter of a residential unit. BER data for Cork (City and County) was obtained.

To isolate data for just Cork City, all entries were mapped in GIS software according to their SA code. Of 843 Small Areas in Cork City, just two had no BER entries. The number of entries per small area ranged from 1 to 191. After isolating the Cork City entries and omitting homes entered after 2018, 40,121 BER entries remained.

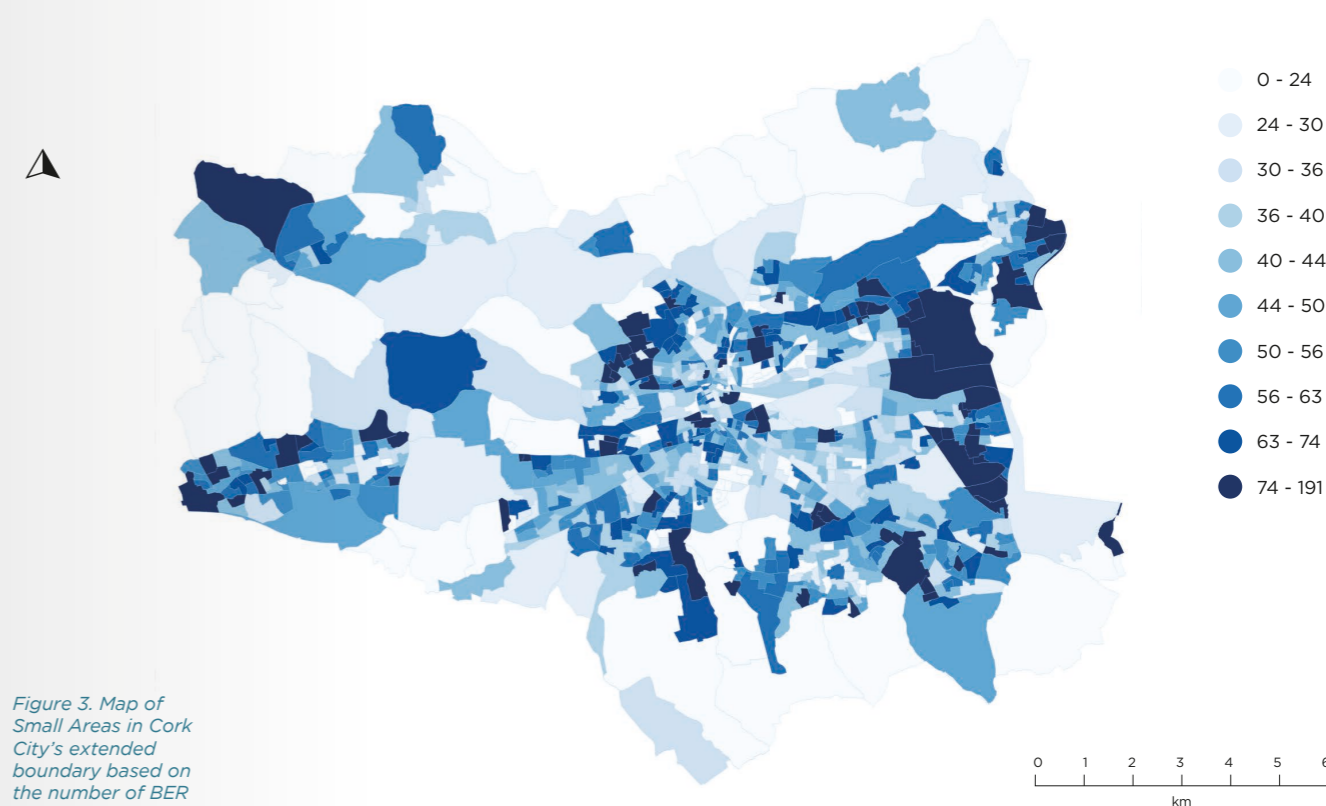


Figure 3. Map of Small Areas in Cork City's extended boundary based on the number of BER entries.

2.1 Household

BER Entries

With this new dataset (N = 40,121), the BER entries for Cork City were analysed. The entries were separated into sub-categories by BER (A to G) and household type (Table 3).

The BER database also included information about each entry's area for the floor, doors, walls and windows. Each

dwelling type group's average m² values for all ratings were computed. This was used to account for the size differences between the various types of dwellings, i.e., so that relative energy consumption and emissions were considered instead of only the emissions from larger homes.

Dwelling Type	A	B	C	D	E	F	G	Total	Actual Cork City
All households	3%	16%	39%	21%	11%	5%	6%	40,121	78,856
Detached	6%	19%	41%	19%	8%	3%	4%	5,780	11,360
Semi-detached	3%	11%	43%	22%	11%	5%	5%	16,346	32,127
Mid-terrace	2%	15%	36%	21%	13%	6%	7%	10,467	20,572
Apartment	1%	28%	30%	20%	10%	4%	8%	7,528	14,796

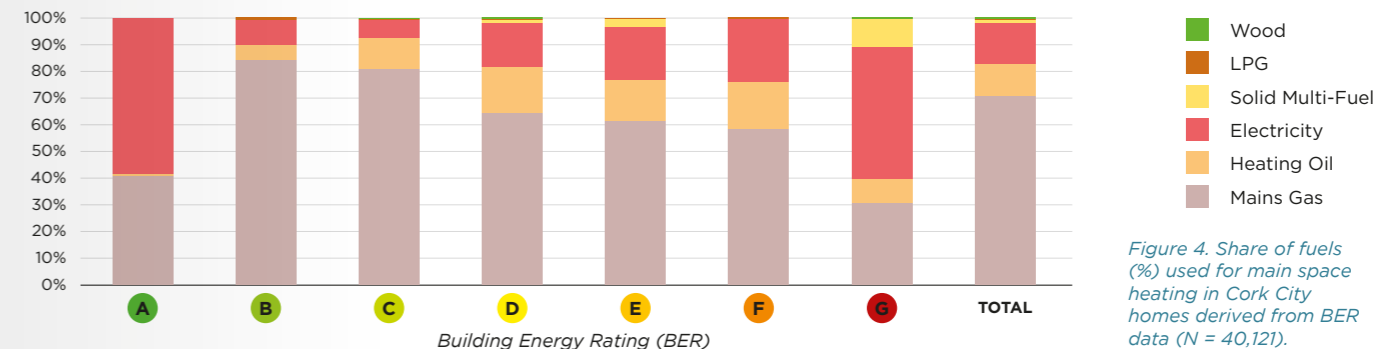
Table 3. All BER household entries categorized by dwelling type and BER rating.

The values for delivered energy of lights, pumps, fans, space heating, water heating etc. were averaged. The average total delivered energy for each BER sub-category was then calculated.

This was then multiplied by the corresponding number of entries in each sub-category to calculate the total energy consumption for the housing type group. The

average annual energy demand for each home was then determined. The same methodology was applied to all housing types, resulting in a total annual energy demand (expressed in GWh) for the household sector of Cork City in 2018, including a breakdown by fuel which could be used to determine emissions based on conversion factors from SEAI's Energy in Ireland Report 2019 [9].

Heating System Types

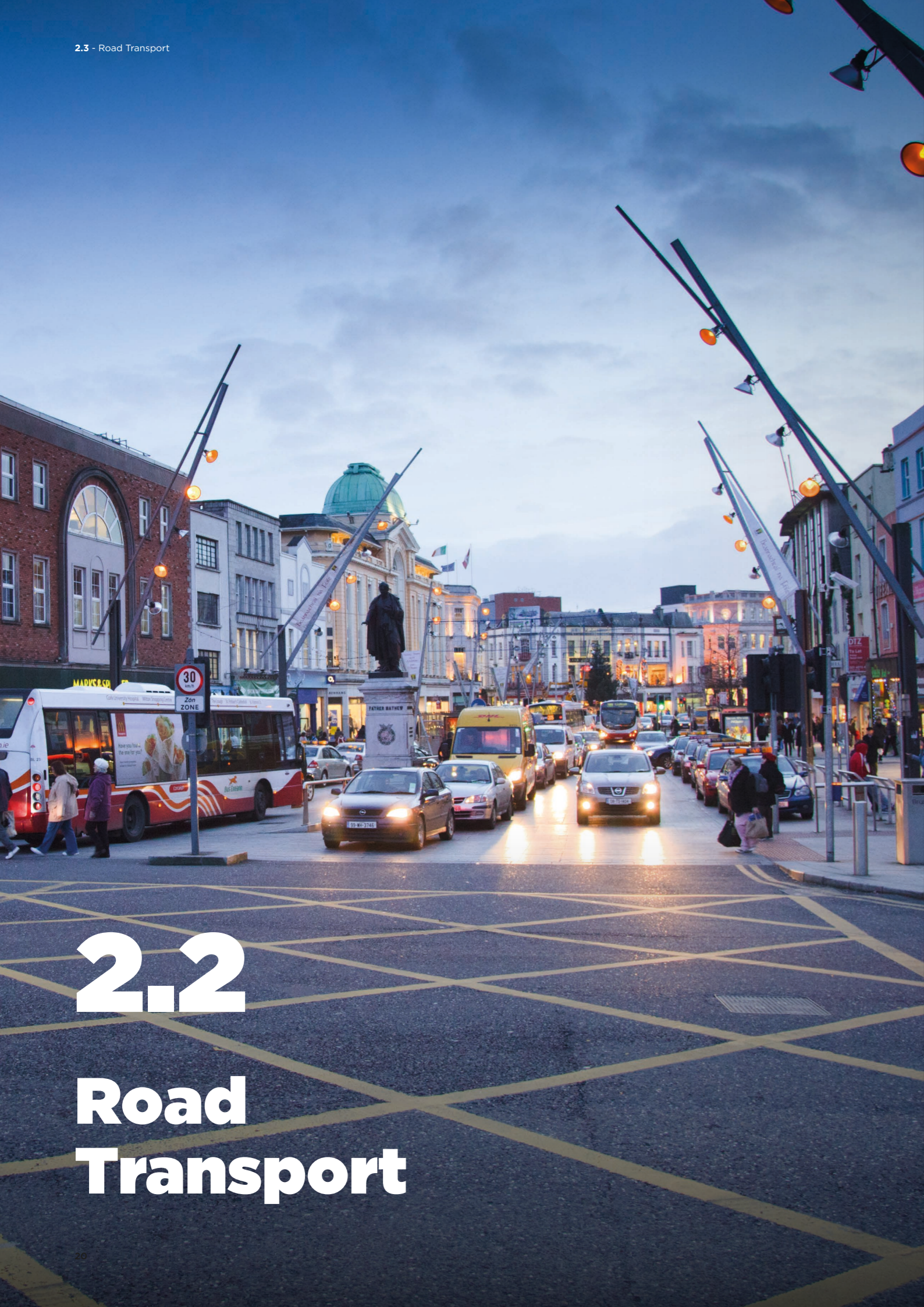


Using BER data, a model was created in Python (version 3.8.16) to determine the profile of housing types for each SA. These profiles were applied to the housing stock to determine the percentage of each housing type in each local area. For Small Areas with no BER data, the overall profile of housing types for Cork City (Figure 4) was employed. The average annual energy demand and emissions computed previously for each housing type was then applied to the number of homes of each housing type in every SA. Using QGIS (version 3.28.1), energy and emissions were then

spatially mapped for Cork City. As the square area of SAs varied widely across the city, expected spatial patterns became skewed when absolute energy or emissions for each SA code were applied to its geographical area. To standardise emissions across SAs, emissions densities in CO₂ per km² were computed and mapped as well as CO₂ per home and per capita. For the purpose of decarbonising the household sector, heat energy density was also mapped to aid in identifying SAs eligible for district heating. Please see accompanying documentation for all mapped results.

Key findings

- Total CO₂ emissions from the household sector were 332 ktCO₂ in 2018.
- Total energy demand from the household sector was 1174 GWh in 2018.
- The housing stock for Cork City in 2018 included 78,856 homes.
- Semi-detached homes made up the highest share (41%) of the housing stock. This was followed by terraced homes (26%), apartments (19%), and detached homes (14%).
- The average BER was a C1, with 58% of the housing stock having a BER of C3 or higher.
- The highest emitting housing type was detached, contributing 5 tCO₂ per home, while the lowest emitting housing type is apartment, contributing 3 tCO₂ per home
- Home heating demand accounted for 71.7% of energy and contributed 62.6% to total emissions.
- Electrical usage accounted for 29% of energy and contributed 38% to total emissions.
- The larger detached homes in exurban SAs outside the city exhibited the highest total energy and emissions estimates. However, when emissions per km² were examined, due the higher density development in the city, the urban SAs exhibited the highest values.
- Higher emissions from larger sub-urban homes and lower emissions from smaller apartments and terraced homes in the city centre was also observed in the maps generated.
- No clear spatial pattern was determined when CO₂ emissions per person (capita) was mapped.



2.2 Road Transport

Road Transport

This sector includes all road transport emissions. In line with national accounting approaches, international aviation and shipping were not included. The vast majority of emissions were thus from private car travel, with some from road freight, public service and other vehicles.

To estimate Cork City's road transport emissions, the National Transport Authority's (NTA) South-West Eneval Model was utilised. As part of the NTA's appraisal toolkit, an environment module which computes emissions along the road network nationally was developed. The Eneval Model predicts emissions based on fleet profile and vehicles speeds

for each road link modelled. The model outputs a number of emissions parameters including GHG emissions, Carbon Dioxide (CO₂) and Methane (CH₄) as well as health relevant emissions, including Nitrogen Dioxide (NO₂) and Particulate Matter (PM_{2.5}). The NTA provided the model output for 2018.

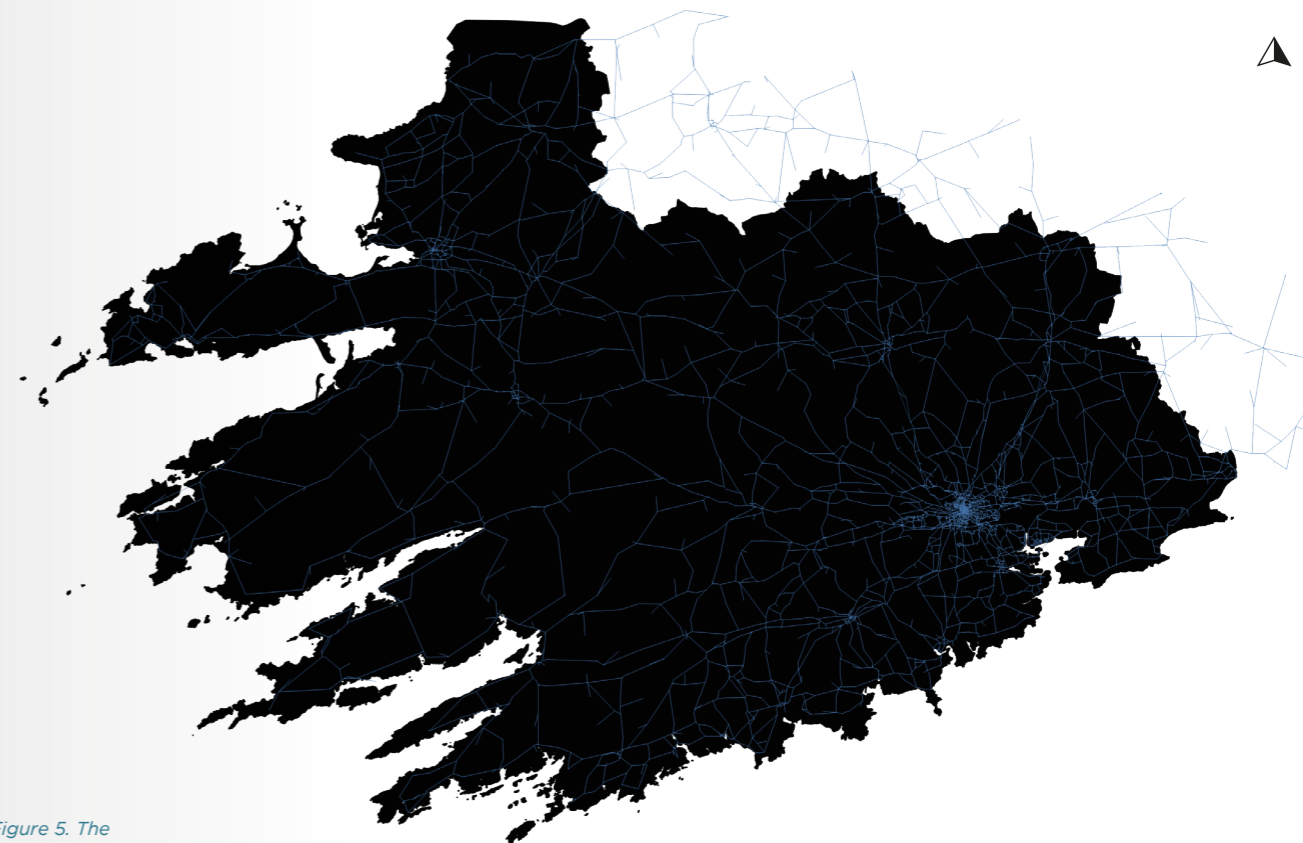
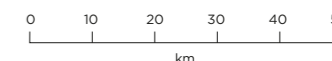


Figure 5. The National Transport Authority South-West Eneval Model coverage.



Tonnes of CO₂ Emissions per km of road

Utilising the NTA's Eneval emissions model, the road links within Cork City were extracted and the associated GHG emissions along these road segments were determined. The total GHG emissions were subsequently computed at

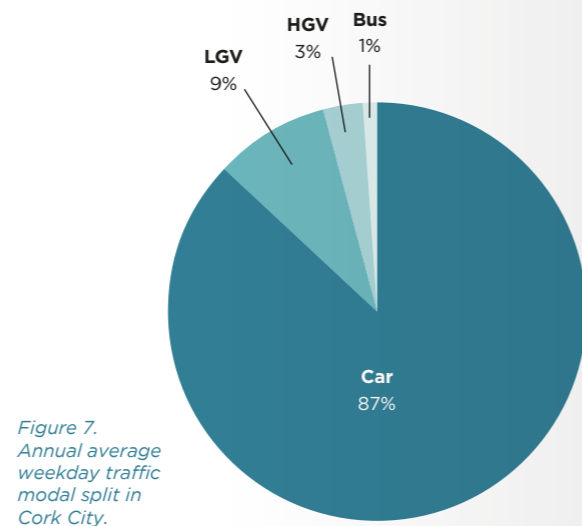
the SA level. In cases where road links were located across two or more SAs, a percentage of the total GHG emissions was attributed to each SA based on the percentage of road which fell within each SA.



Weekday traffic

Additionally, the modal split along the modelled road links in Cork City was determined for the annual average weekday traffic (See Figure 7).

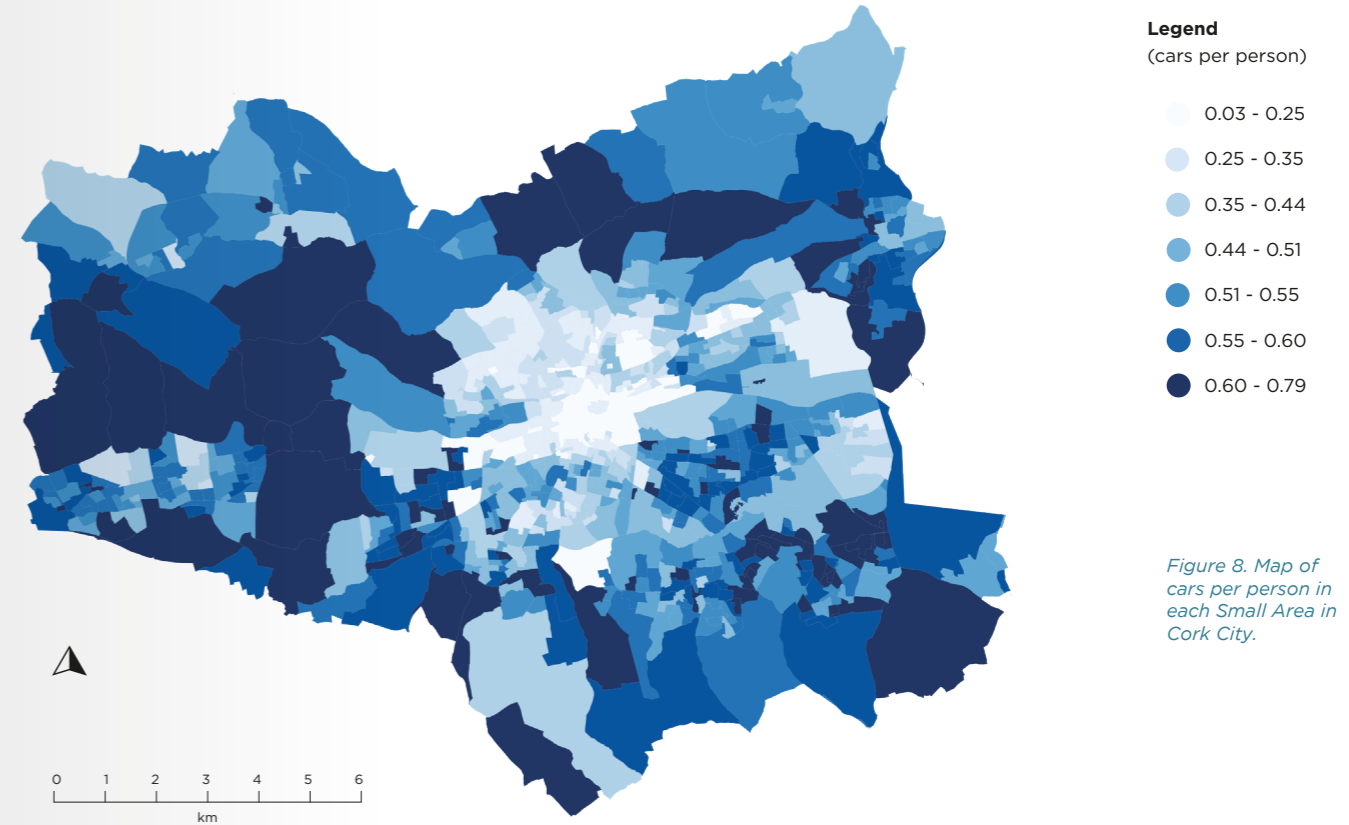
87% of total journeys were made by car while less than 1% were made by bus. The breakdown does not include zero-carbon commuting modes (walking or cycling).



Car ownership

While the Eneval model estimates emissions along the city's road network, it is also important to look at car ownership in Cork City. In Figure 8, the number of cars per person in each SA are mapped. The city centre had very low ownership

of 0.03 - 0.25 cars per person while areas surrounding the city had a much higher car ownership of 0.60 - 0.79 cars per person. Please see accompanying documentation for all mapped results.



Key findings

- Total emissions from road transport were 290 ktCO₂-eq.
- Cork City's modal split was as follows: cars (87%); LGVs (9%); HGVs (4%), and busses (1%).
- Cork City residents owned around 90,000 cars in 2018.
- The major road links (Lower Glanmire Road, N8 and South Ring Road, N40) are clearly visible on Figure 1 and Maps 3.1, 3.2, 3.3 and 3.4.
- Car ownership is significantly higher in the exurban SAs, with some having as high as 800 cars/1,000 people. This compared to a city-wide average of 410 cars/1,000 people and a national average of 450 cars/1,000 people



2.3

Commercial Services & Industry

Commercial Services & Industry

This sector covers all emissions from commercial services including retail, hospitality, offices and industry. The two main sources of energy demand and subsequent emissions considered are heating and electricity

The valuation office provided total floor areas by business type for commercial buildings within Cork City. However, this omitted data for the hospitality sector (hotels, restaurants and bars) and was unavailable per SA.

To fill this data gap, OpenStreetMap data was used. The building classifications from OpenStreetMap provided

another estimate for the total floor area across a range of building uses (e.g. retail, commercial and industrial), which were mapped to the SA. The total energy and emissions were modelled using the UK CIBSE energy benchmarks (kWh/m²) by building use [10]. The breakdown of fuels in space heating were based on CSO's Non-Domestic BER release (Table 4).

	Mains Gas	Heating Oil	Electricity	LPG
Cork City	33%	3%	64%	0%
National	26%	10%	62%	2%

Table 4. Main space heating system fuel in non-domestic buildings in Cork City and nationally [11].

Non-domestic main heating

Despite the gas network in Cork City, according to the non domestic BER database, electricity is the largest source of space heating in non-domestic buildings. This reflects the national average and may in part be explained by the

type of business activity in the city. Nationally, electricity is the dominated source of space heating in retail and office buildings (Table 5). Please see accompanying documentation for all mapped results.

	Mains Gas	Heating Oil	Electricity	LPG	Other
Retail	17%	4%	78%	1%	1%
Office	31%	7%	60%	1%	1%
Restaurant/public house	28%	24%	41%	4%	2%
Hotel	46%	30%	12%	12%	1%
Warehouses	32%	11%	55%	2%	0%
Workshops/maintenance depot	27%	14%	55%	3%	1%
Industrial process building	30%	27%	36%	3%	3%
Hospitals and primary health care	31%	12%	55%	2%	1%
Community/day centre	37%	26%	31%	4%	2%
Nursing residential homes and hostels	40%	30%	15%	12%	3%
Schools and colleges	42%	26%	23%	6%	3%
Sports facilities	41%	10%	43%	5%	1%
Other	31%	11%	52%	4%	2%
Average	26%	10%	61%	2%	1%

Table 5. Main space heating system fuel in non-domestic buildings in Ireland [11]

Key findings

- Total emissions from the commercial services and industry sector were 216 ktCO₂.
- Total energy demand was 650 GWh. This included Heating (Gas 154 GWh, Oil 14 GWh and Electric 298 GWh) and Electricity (184 GWh).
- There is very little industrial activity (only 2% of the sector total).
- Activity in this sector was mainly concentrated in the city centre where there was a lot of retail and hospitality businesses.
- The average BER for non-domestic buildings in Cork City was a D1 in 2018, which is the same as the national average [11].
- Two key issues in this sector are the lack of data on floor area by different building uses (m²), and reliance on UK energy benchmarks for performance (kWh/m²). Further reflections on this are outlined in Appendix B.

2.4 Public Services

Public Services

This sector covers all emissions from public services including local authority buildings, street lighting, universities, schools, military buildings, health buildings and hospitals.

Cork City Council provided both gas and electricity demand for local authority buildings and street lighting. University College Cork also provided gas and electricity energy data for 2018 for all university buildings. In addition to these, as with the Commercial & Industry sector, OpenStreetMap data

[12] and the CIBSE energy benchmarks were used for various other public services such as military buildings, prisons, health buildings and schools [10]. Please see accompanying documentation for all mapped results.

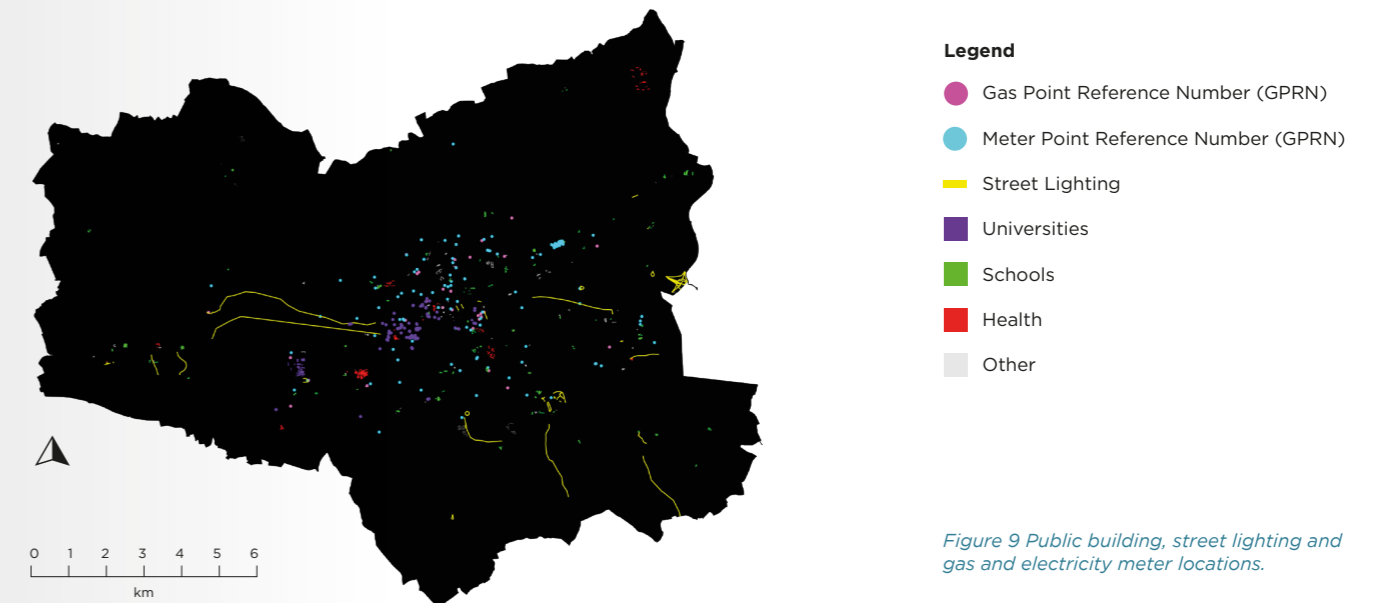


Figure 9 Public building, street lighting and gas and electricity meter locations.

Key findings

- Total CO₂ emissions from public services were 65 kt.
- The public service emissions accounted for 7% of Cork City's total emissions. This compared to less than 2% nationally.
- The universities and hospitals were significant sources of energy-related CO₂ emissions .
- The emissions in this sector were quite dispersed across the study area, although there was generally a concentration of higher emissions in the city centre.



2.5

Agriculture, Land Use & Fishing

Agriculture, Land Use & Fishing

Nationally, agriculture is the single largest source of GHG emissions. However, due to the urban nature of Cork City Council’s district, there is very little area available for farming. Emissions considered in this sector are both energy and non-energy emissions in agriculture, fishing and Land Use, Land Use Change and Forestry (LULUCF).

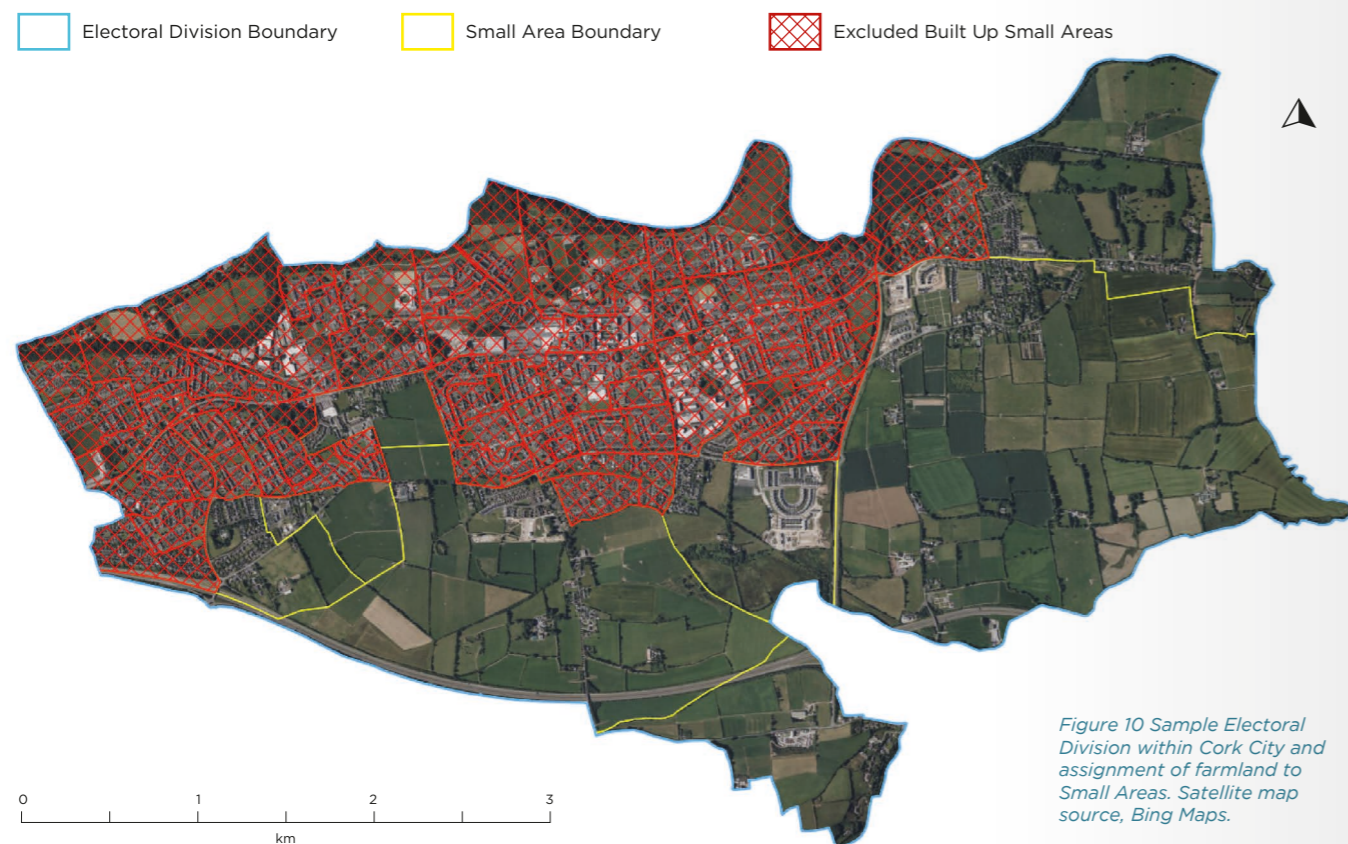
The national energy [13] and non-energy (agriculture and LULUCF) emissions [6] were proportioned based on the area of farmland in each Electoral Division (ED) as per the 2020 Census of Agriculture [14]. The EDs were overlapped with the SAs, and based on the area of the SA’s, a percentage of the total Electoral Divisions farmland was assigned. SAs

within the EDs which included built-up areas were not assigned farmland (See Figure 10). SAs within each ED that included built-up areas were omitted. The extended Cork City boundary contains a very small amount of farmland. This is 0.2% of Ireland’s total farm area.

	Farmland 2020 (ha)	Energy Emissions 2018 (kt CO ₂ -eq)		Non-energy Emissions 2018 (kt CO ₂ -eq)
		Heating Oil	Electricity	
Ireland	4,509,272	0.54	0.27	29,914
Cork City	9,326	0.0011	0.0006	62

Table 6 Hectares of farmland as per the Census of Agriculture and its associated energy consumption and emissions.

Assignment of farmland



Key findings

- Total emissions from agriculture, LULUCF and fishing were 62 ktCO₂-eq.
- Energy-related emissions in agriculture and fishing are very little at 0.4 ktCO₂ and 0.2 ktCO₂ respectively.
- Cork City Council represents just 0.2% of Ireland's farmland.
- There were only five fishing boats registered to Cork City.



Fishing boats

The number of fishing boats registered within Cork City was obtained from the Irish Fishing Fleet Register [15]. This totalled just five boats.

This was then used to apportion diesel use from the national energy balance [13]. The emissions were assigned to the port of Cork, which is within 3 SAs. Please see accompanying documentation for all mapped results.



2.6

Waste

Waste

This sector covers emissions associated with both biological treatment (e.g. landfill or compost) and incineration of all waste within the case study area as well as wastewater handling. It considers carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O) emissions.

MapEire data for the waste sector was obtained at a 1km x 1km grid cell spatial resolution [16], [17]. Figure 11 shows the MapEire 1km x 1km grid. The percentage of grid cells which fell within each SA was determined and subsequently

the CO₂-eq emissions were computed for each SA. CO₂-eq emissions were computed as per Table 3. Please see accompanying documentation for all mapped results.

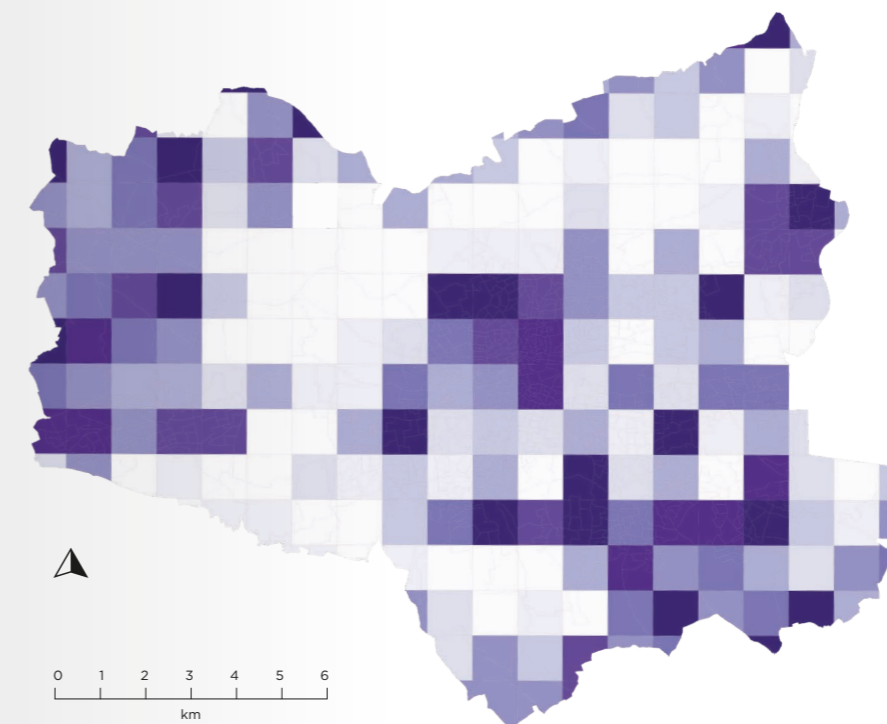


Figure 11. Mapped MapEire 1km x 1km grid GHG Emissions for the waste sector.

Key findings

- Total CO₂-eq emissions from waste management and treatment were 22 kt.
- The main source of emissions was methane (21 ktCO₂-eq out of a total of 22 ktCO₂-eq).
- The emissions in this sector were concentrated around waste disposal sites.

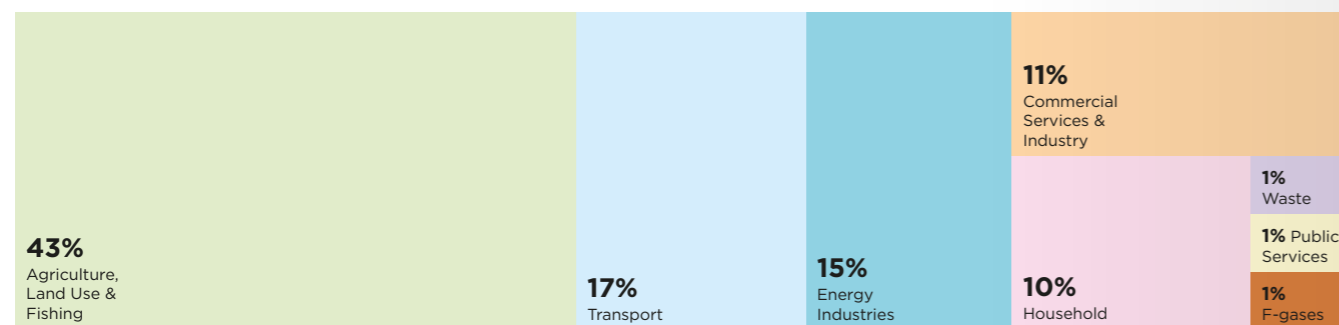
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Cork City & Cork City's Decarbonisation Zone

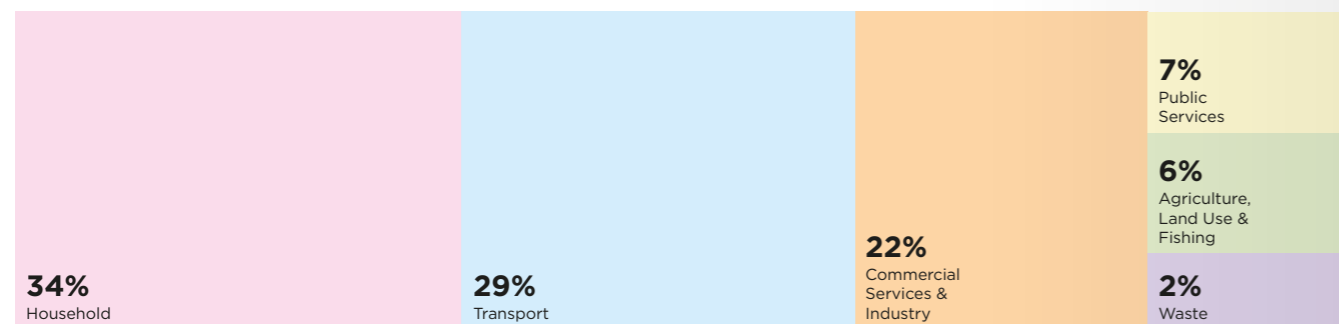
Cork City & Cork City's Decarbonisation Zone

The sectoral breakdown of emissions for Cork City and within the DZ are quite different, and these also differ to the national profile (Figure 12). Please see accompanying documentation for all mapped results.

Ireland



Cork City



Cork City Decarbonisation Zone

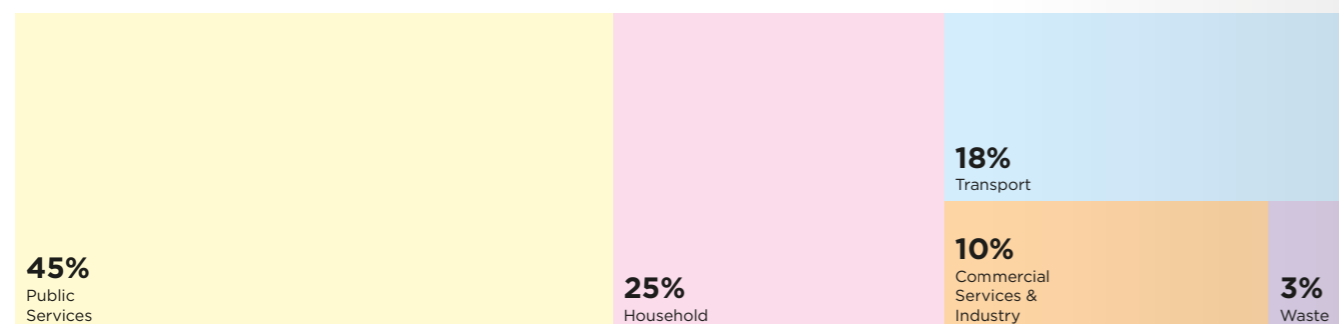


Figure 12. GHG emissions by sector in 2018 nationally [6], for Cork City and for Cork City's Decarbonisation Zone.

Cork City

- Household and transport emissions were the two largest sources of emissions within Cork City. A key priority for the city on its journey to net zero emissions should thus be the decarbonisation of heating and private travel.
- The hospitality and retail sectors contribute large shares of emissions.
- Within the public sector, the large universities and hospitals would be important buildings to target for emissions reductions.

Cork City Decarbonisation Zone

- The public sector was by far the largest source of emissions within the DZ. It contributed 45% of GHG emissions compared to 1% nationally. This is mainly due to buildings associated with University College Cork and Munster Technical University, as well as Cork University Hospital.
- Households accounted for a quarter of GHG emissions. There are several student accommodation apartment complexes within the DZ. Another key consideration will be reducing emissions from rented student houses.



Key findings overall

GHG emissions per capita were found to be 4.7 tCO₂-eq in Cork City compared to 14.4 tCO₂-eq nationally in the year 2018 according to the EPA [6]. This lower per capita emissions for Cork City was largely due to the lack of agricultural emissions and industrial activity within the city boundary which are represented in the national emissions estimates.

Total GHG emissions for Cork City were found to be 987 ktCO₂-eq.

Energy-related CO₂ emissions were 91% of GHG emissions (903 ktCO₂-eq). Non-energy emissions were 9% of GHG emissions (84 ktCO₂-eq).

The two largest sources of GHG emissions were found to be homes (332 ktCO₂) and cars (-290 ktCO₂-eq).

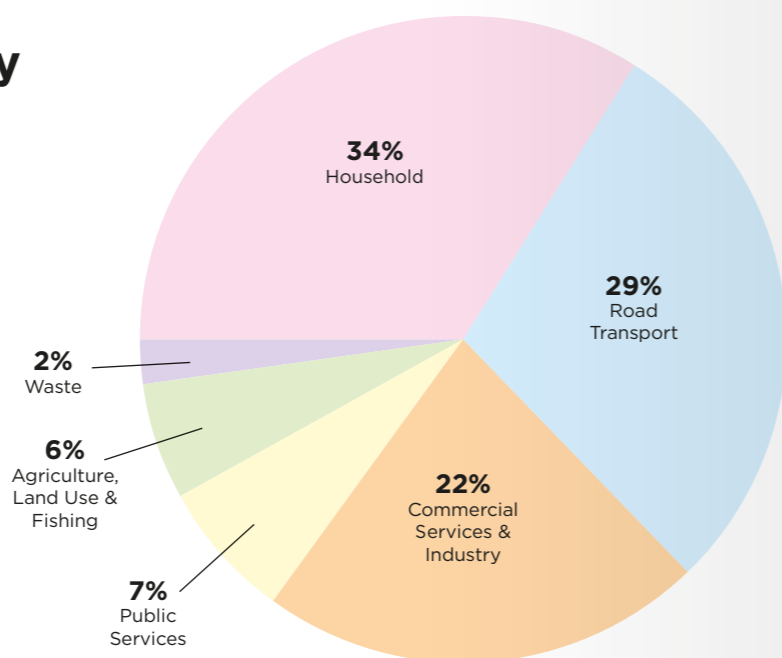
In terms of absolute emissions (total ktCO₂), the exurban areas with larger homes and main transport link roads were evident on the maps.

Looking at emission density (per km²), the inner-city areas exhibited a higher concentration of emissions.

The Decarbonisation Zone (DZ) accounts for 8% of Cork City's GHG emissions and almost 50% of these are from public buildings (universities and hospitals).

Emissions Breakdown by Sector for Cork City

Sector	CO ₂ -eq (ktonnes)
Household	332
Road Transport	290
Commercial Services & Industry	216
Public Services	65
Agriculture, Land Use & Fishing	62
Waste	22
Total	987



Key findings per sector

Household

- In 2018, total energy demand from the households was 1,174 GWh, emitting 332 ktCO₂.
- Household emissions were the single largest source (34%) of GHG emissions overall. Within the household sector, home heating accounted for a majority of energy demand and thus, emissions.
- The housing stock for Cork City in 2018 included 78,856 homes.
- The average BER was a C1, with 58% of the housing stock having a BER of C3 or higher.
- Semi-detached homes made up the highest share (41%) of the housing stock.

Commercial Services & Industry

- The main business activity and subsequent emissions were found to be from offices, the hospitality sector (hotels, bars and restaurants) and the retail sector.
- There was very limited industrial or manufacturing activity within the city boundary.
- The average non-domestic BER in Cork City was found to be a D1.
- Electricity was the most prominent heating source. It was found to be 64% of main space heating systems.

Road Transport

- Cars accounted for almost 90% of road users.
- The exurban areas have the highest rates of car ownership. Some small areas had car ownership rates as high as 800 cars/1,000 people compared to average of 450 cars/1,000 people nationally.
- The major road links (Lower Glanmire Road, N8 and South Ring Road, N40) are clearly visible on the emissions maps generated. (41%) of the housing stock.

Public Services

- Universities and hospitals were the largest source of emissions in Cork City's public buildings.
- Street lighting accounted for a significant amount of Cork City Council's electricity usage. It was found to be 9.45 GWh while electricity demand in local authority buildings was found to be 5.9 GWh

Agriculture, Land Use & Fishing

- Very little agricultural land exists within Cork City boundary, and thus it only accounted for 6% of overall GHG emissions compared to 43% nationally in 2018.

Waste

- The main source of emissions was methane. This accounted for 21 ktCO₂-eq out of a total of 22 ktCO₂-eq.

Acknowledgements

This research was commissioned and funded by Cork City Council.

Thanks to Cork City Council's Paul McGuirk, Daniel Carr, Micheál Lyons, Claire Davis and Fearghal Reidy for their input during the analysis and Damian Williams for providing access to the council's energy data.

Thanks to Rebecca Cachia from Codema for providing advice on the methodology and data sources.

Thanks to Wen Zhang from the National Transport Authority for sharing with us the outputs of their Eneval model for Cork City, Pat Mehigan from UCC's Building Services & Estates for providing the energy data from all UCC buildings and Conor McNamara from Valuations Public Office for providing data on floor area of businesses in Cork City.

Appendices

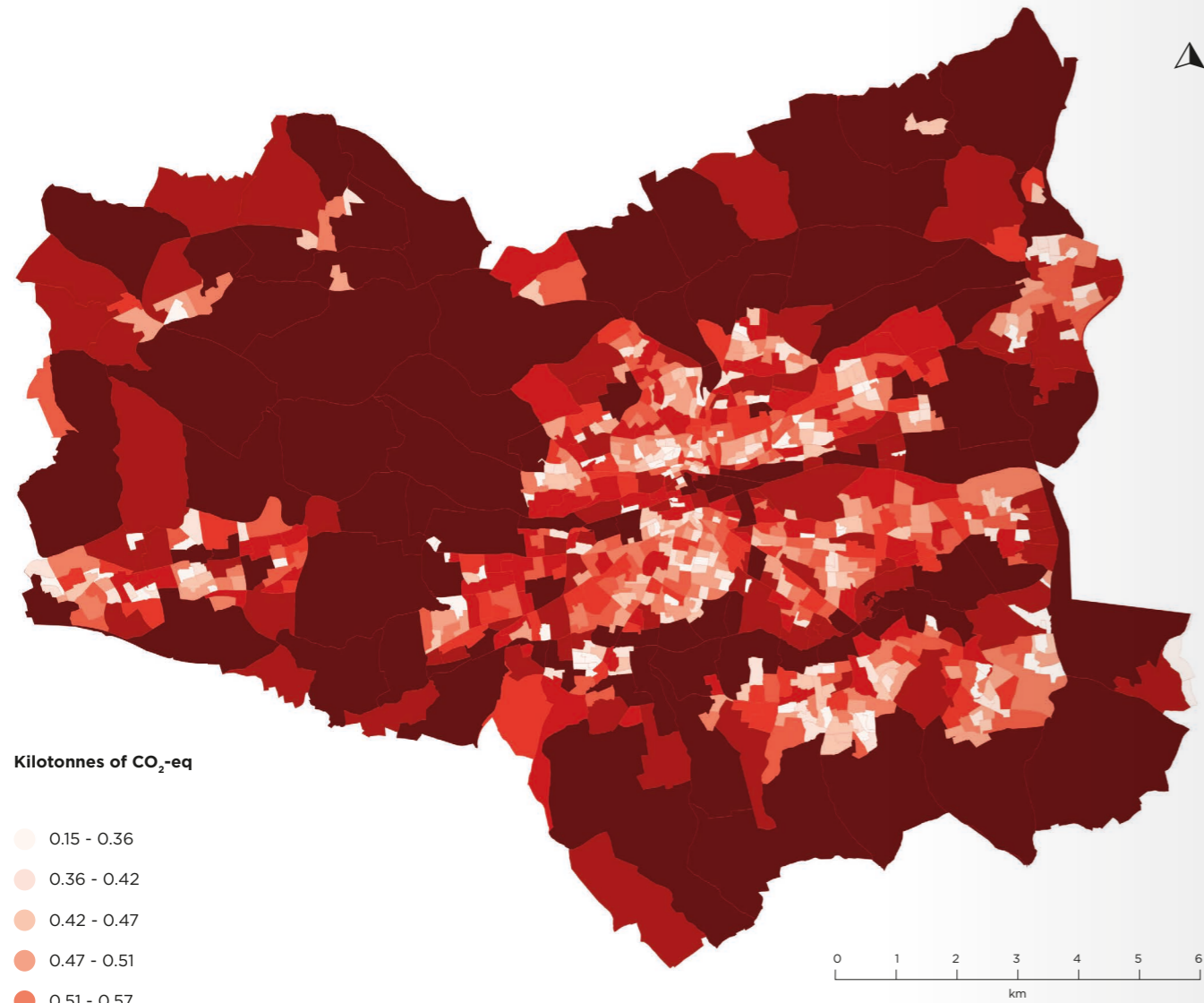
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Map 1.1

CO₂-eq Emissions from all Sectors in Cork City

Per Small Area



Kilotonnes of CO₂-eq

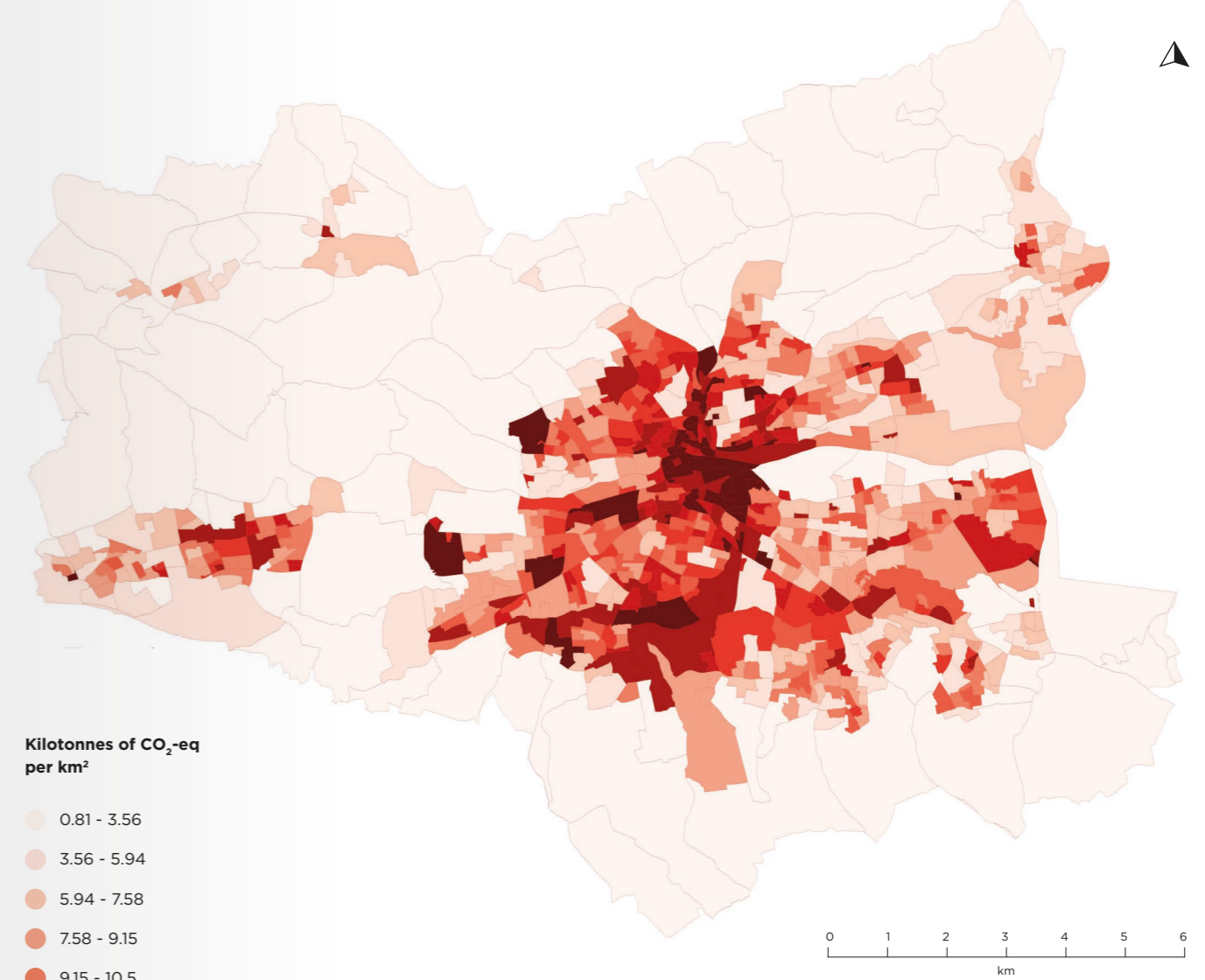
- 0.15 - 0.36
- 0.36 - 0.42
- 0.42 - 0.47
- 0.47 - 0.51
- 0.51 - 0.57
- 0.57 - 0.66
- 0.66 - 0.81
- 0.81 - 1.12
- 1.12 - 2.42
- 2.42 - 15.6

O'Regan AC, Purcell L, McGookin C, Nyhan MM, 2023. Baseline Emissions Inventory: Part of the Cork City Climate Action Plan 2024 - 2029. University College Cork and Cork City Council, Ireland.

Map 1.2

CO₂-eq Emissions per km² from all Sectors in Cork City

Per Small Area



Kilotonnes of CO₂-eq per km²

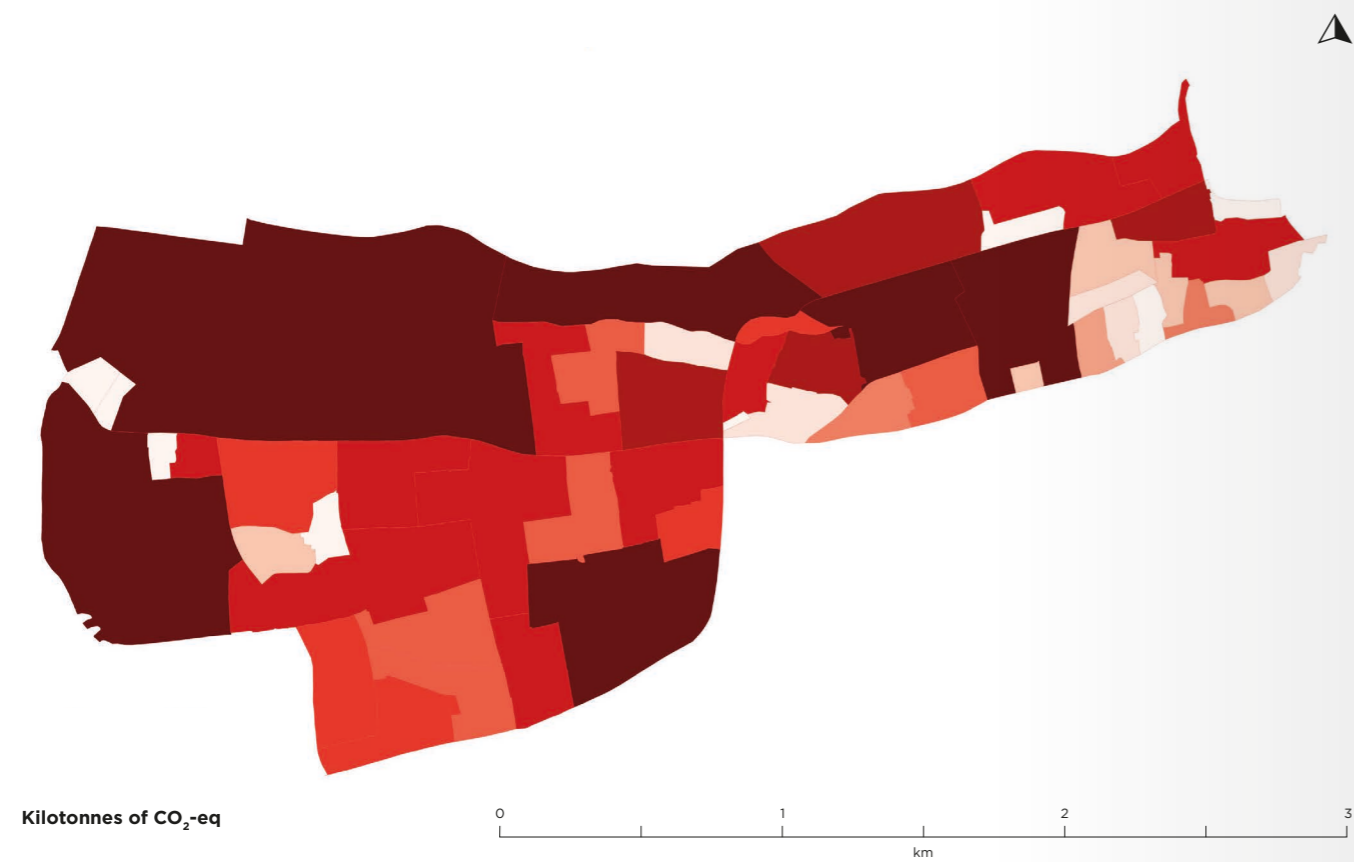
- 0.81 - 3.56
- 3.56 - 5.94
- 5.94 - 7.58
- 7.58 - 9.15
- 9.15 - 10.5
- 10.5 - 12.1
- 12.1 - 14.6
- 14.6 - 18.5
- 18.5 - 27.5
- 27.5 - 127

O'Regan AC, Purcell L, McGookin C, Nyhan MM, 2023. Baseline Emissions Inventory: Part of the Cork City Climate Action Plan 2024 - 2029. University College Cork and Cork City Council, Ireland.

Map 1.3

Total CO₂-eq Emissions from all Sectors in the Decarbonisation Zone

Per Small Area



Kilotonnes of CO₂-eq

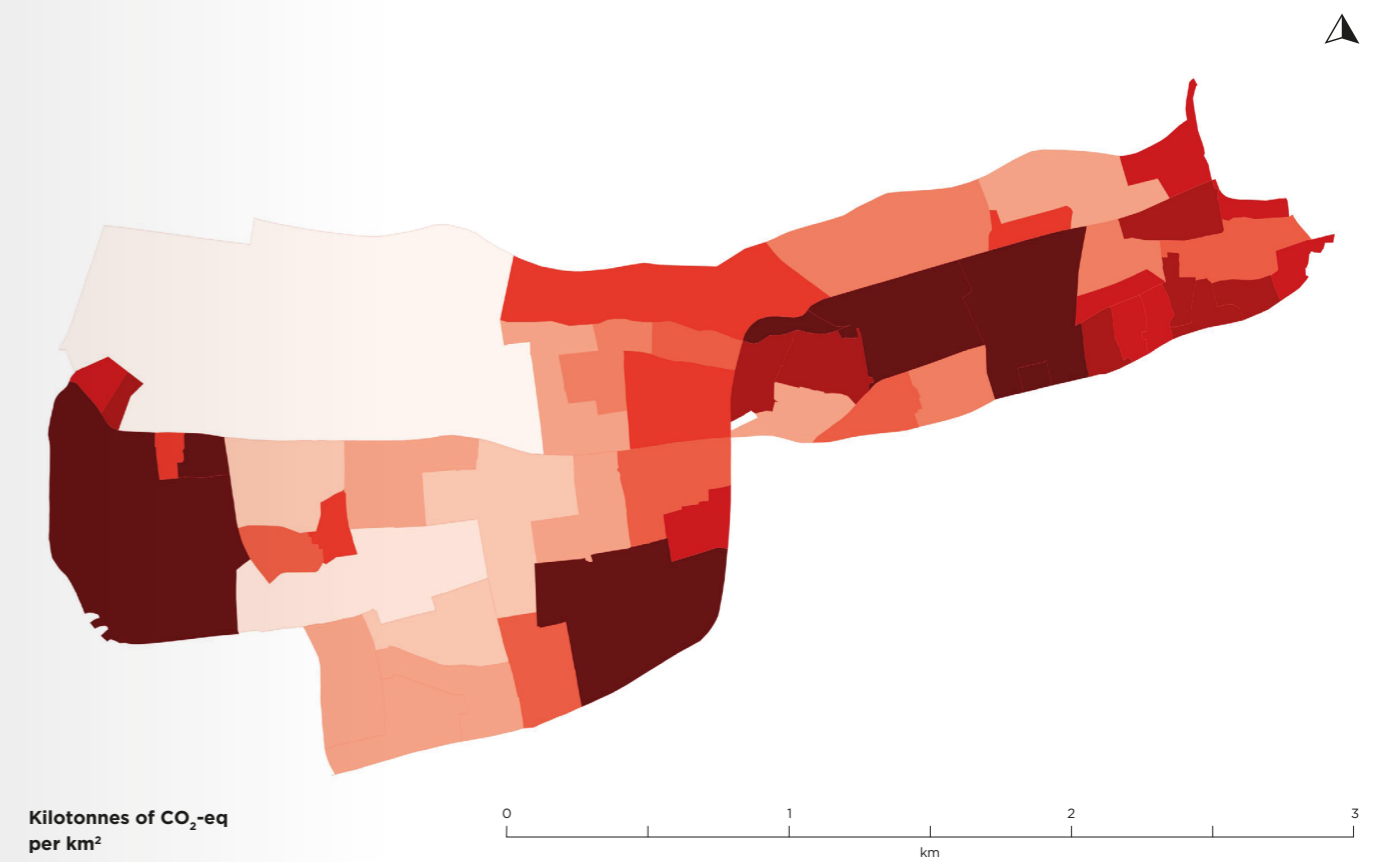
- 0.15 - 0.36
- 0.36 - 0.42
- 0.42 - 0.47
- 0.47 - 0.51
- 0.51 - 0.57
- 0.57 - 0.66
- 0.66 - 0.81
- 0.81 - 1.12
- 1.12 - 2.42
- 2.42 - 15.6

O'Regan AC, Purcell L, McGookin C, Nyhan MM, 2023. Baseline Emissions Inventory: Part of the Cork City Climate Action Plan 2024 - 2029. University College Cork and Cork City Council, Ireland.

Map 1.4

CO₂-eq Emissions per km² from all Sectors in the Decarbonisation Zone

Per Small Area



Kilotonnes of CO₂-eq per km²

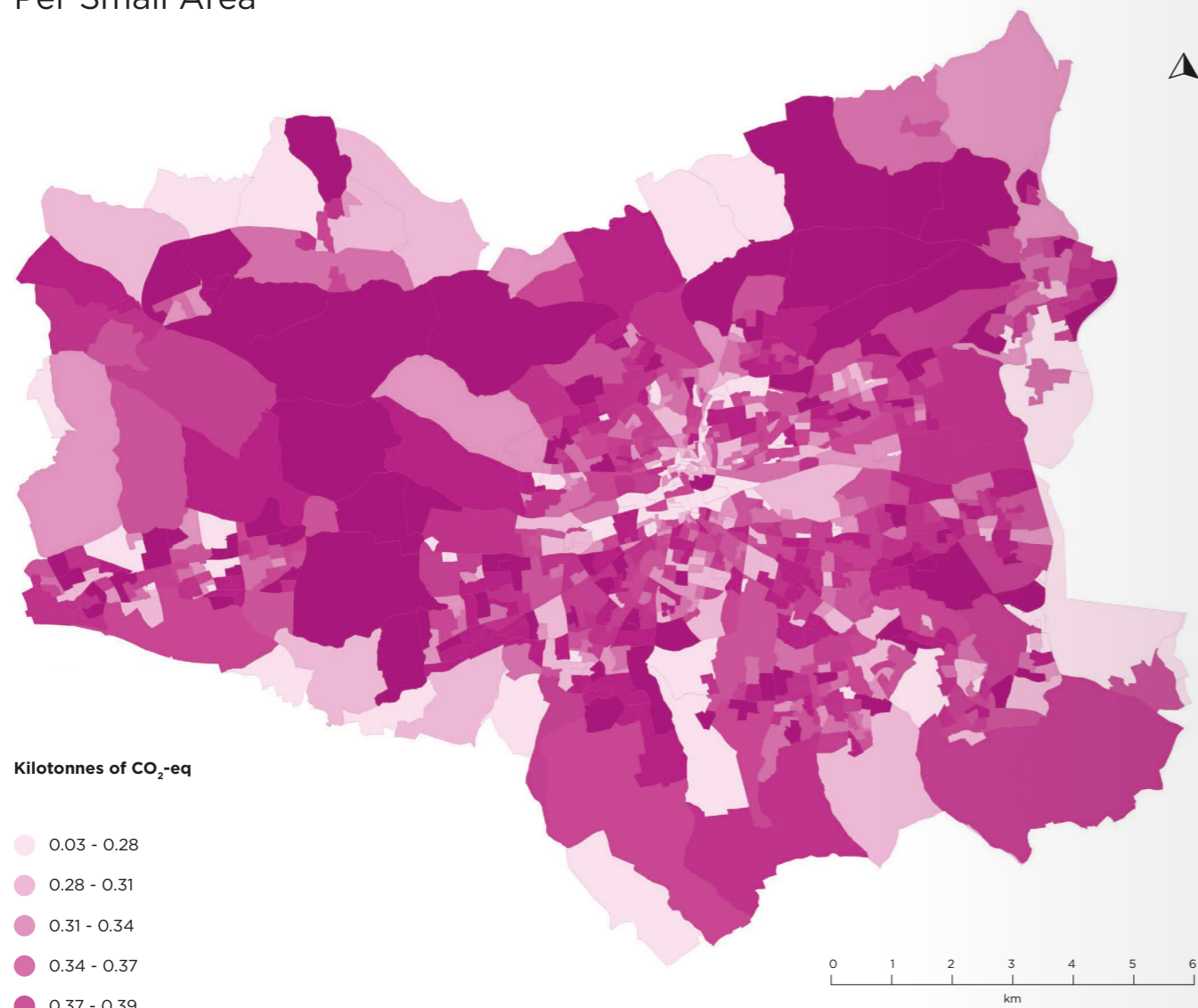
- 0.81 - 3.56
- 3.56 - 5.94
- 5.94 - 7.58
- 7.58 - 9.15
- 9.15 - 10.5
- 10.5 - 12.1
- 12.1 - 14.6
- 14.6 - 18.5
- 18.5 - 27.5
- 27.5 - 127

O'Regan AC, Purcell L, McGookin C, Nyhan MM, 2023. Baseline Emissions Inventory: Part of the Cork City Climate Action Plan 2024 - 2029. University College Cork and Cork City Council, Ireland.

Map 2.1

Total Household CO₂-eq Emissions

Per Small Area



Kilotonnes of CO₂-eq

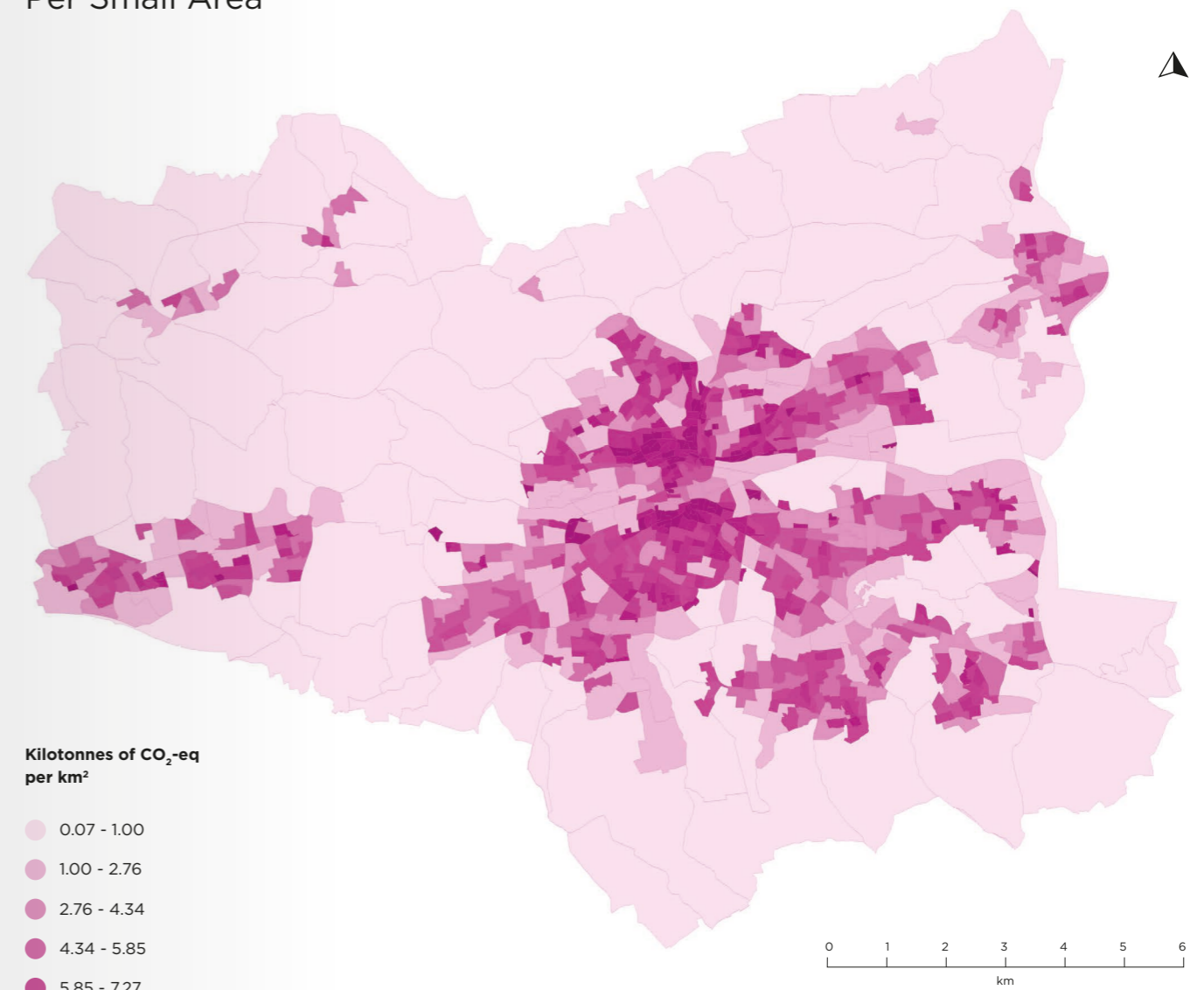
- 0.03 - 0.28
- 0.28 - 0.31
- 0.31 - 0.34
- 0.34 - 0.37
- 0.37 - 0.39
- 0.39 - 0.41
- 0.41 - 0.44
- 0.44 - 0.48
- 0.48 - 0.52
- 0.52 - 0.96

O'Regan AC, Purcell L, McGookin C, Nyhan MM, 2023. Baseline Emissions Inventory: Part of the Cork City Climate Action Plan 2024 - 2029. University College Cork and Cork City Council, Ireland.

Map 2.2

Household CO₂-eq Emissions per km²

Per Small Area



Kilotonnes of CO₂-eq per km²

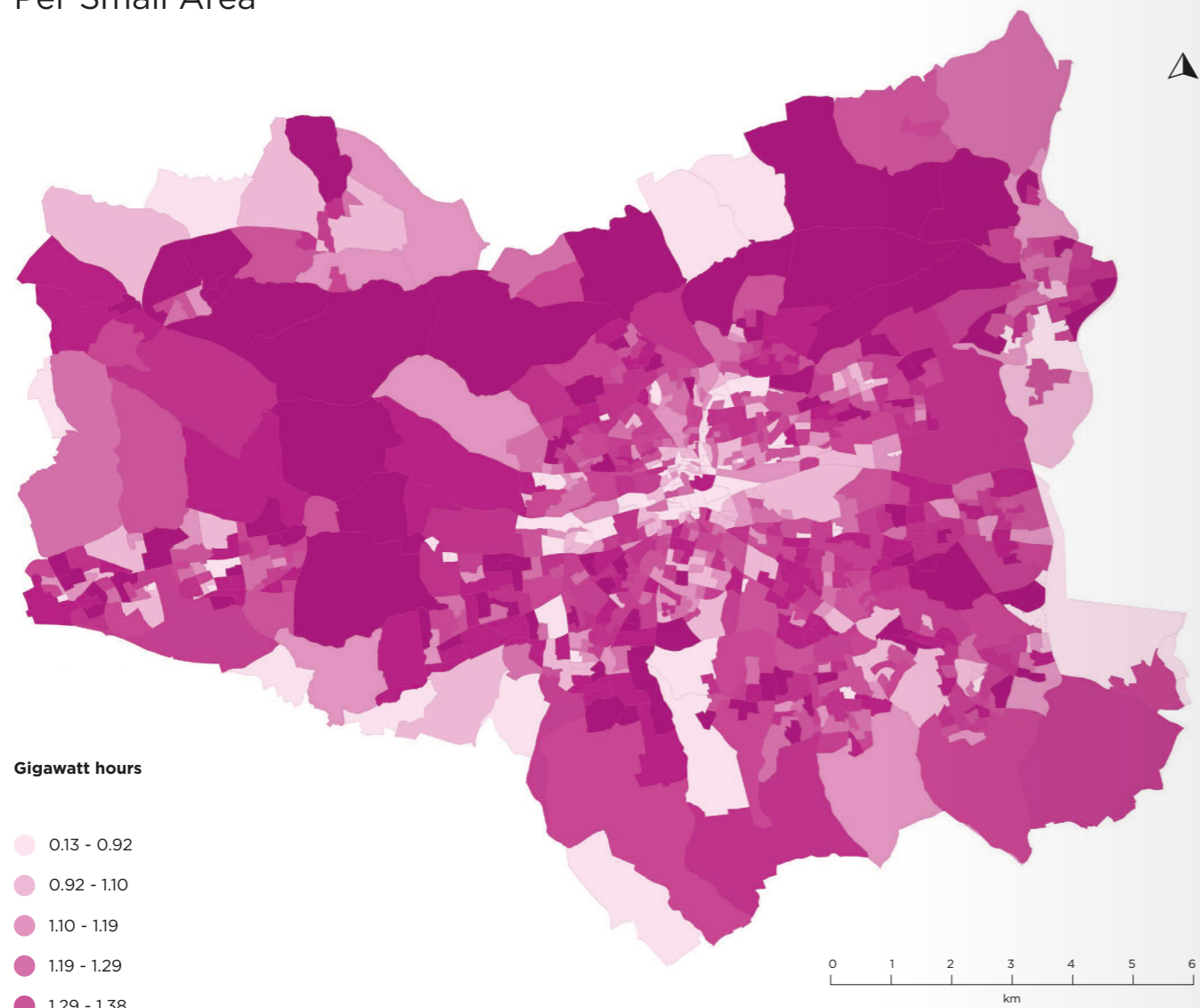
- 0.07 - 1.00
- 1.00 - 2.76
- 2.76 - 4.34
- 4.34 - 5.85
- 5.85 - 7.27
- 7.27 - 8.59
- 8.59 - 9.99
- 9.99 - 11.9
- 11.9 - 16.1
- 16.1 - 106

O'Regan AC, Purcell L, McGookin C, Nyhan MM, 2023. Baseline Emissions Inventory: Part of the Cork City Climate Action Plan 2024 - 2029. University College Cork and Cork City Council, Ireland.

Map 2.3

Total Household Energy Demand

Per Small Area



Gigawatt hours

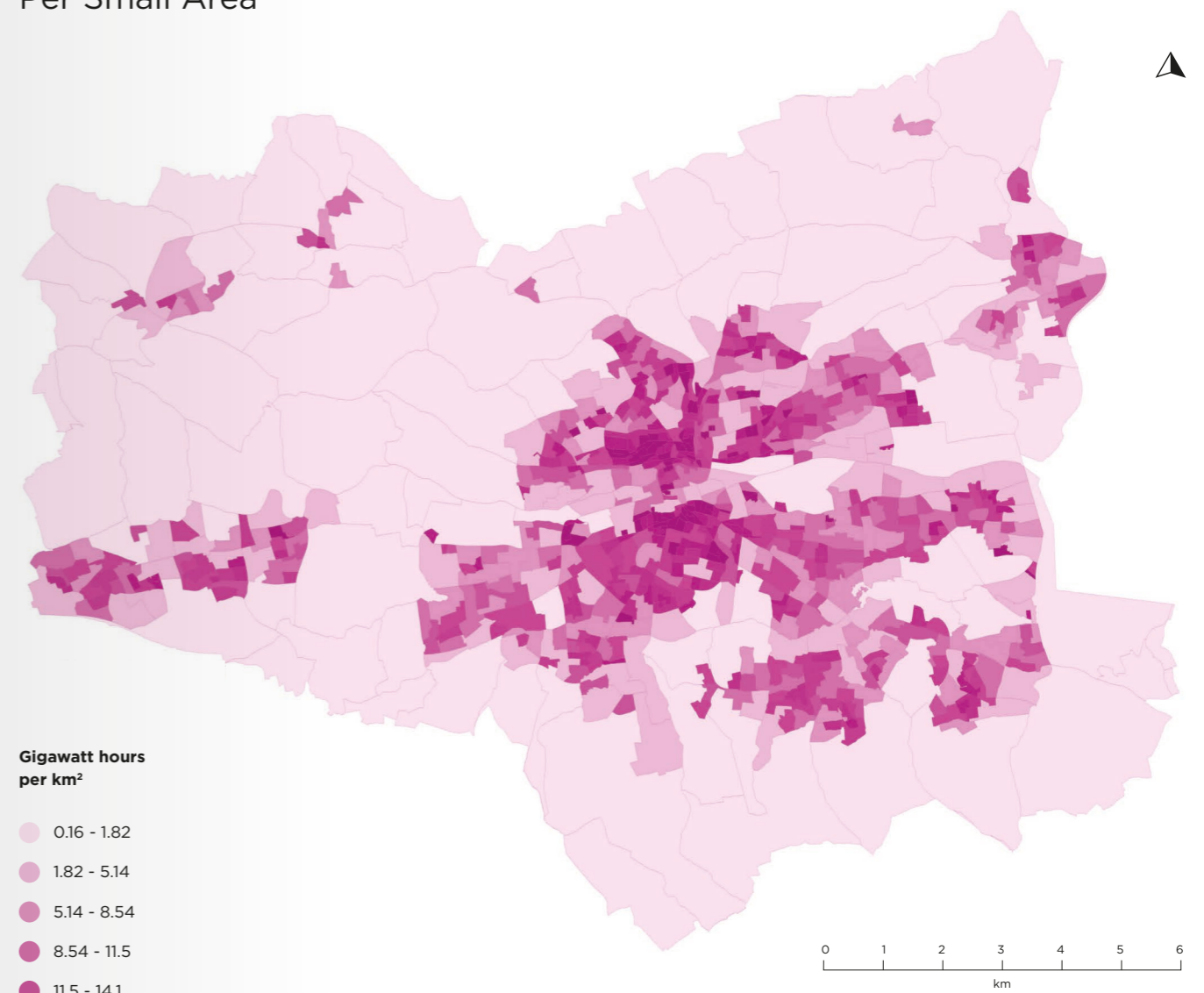
- 0.13 - 0.92
- 0.92 - 1.10
- 1.10 - 1.19
- 1.19 - 1.29
- 1.29 - 1.38
- 1.38 - 1.47
- 1.47 - 1.58
- 1.58 - 1.69
- 1.69 - 1.86
- 1.86 - 3.52

O'Regan AC, Purcell L, McGookin C, Nyhan MM, 2023. Baseline Emissions Inventory: Part of the Cork City Climate Action Plan 2024 - 2029. University College Cork and Cork City Council, Ireland.

Map 2.4

Household Energy Demand per km²

Per Small Area



Gigawatt hours per km²

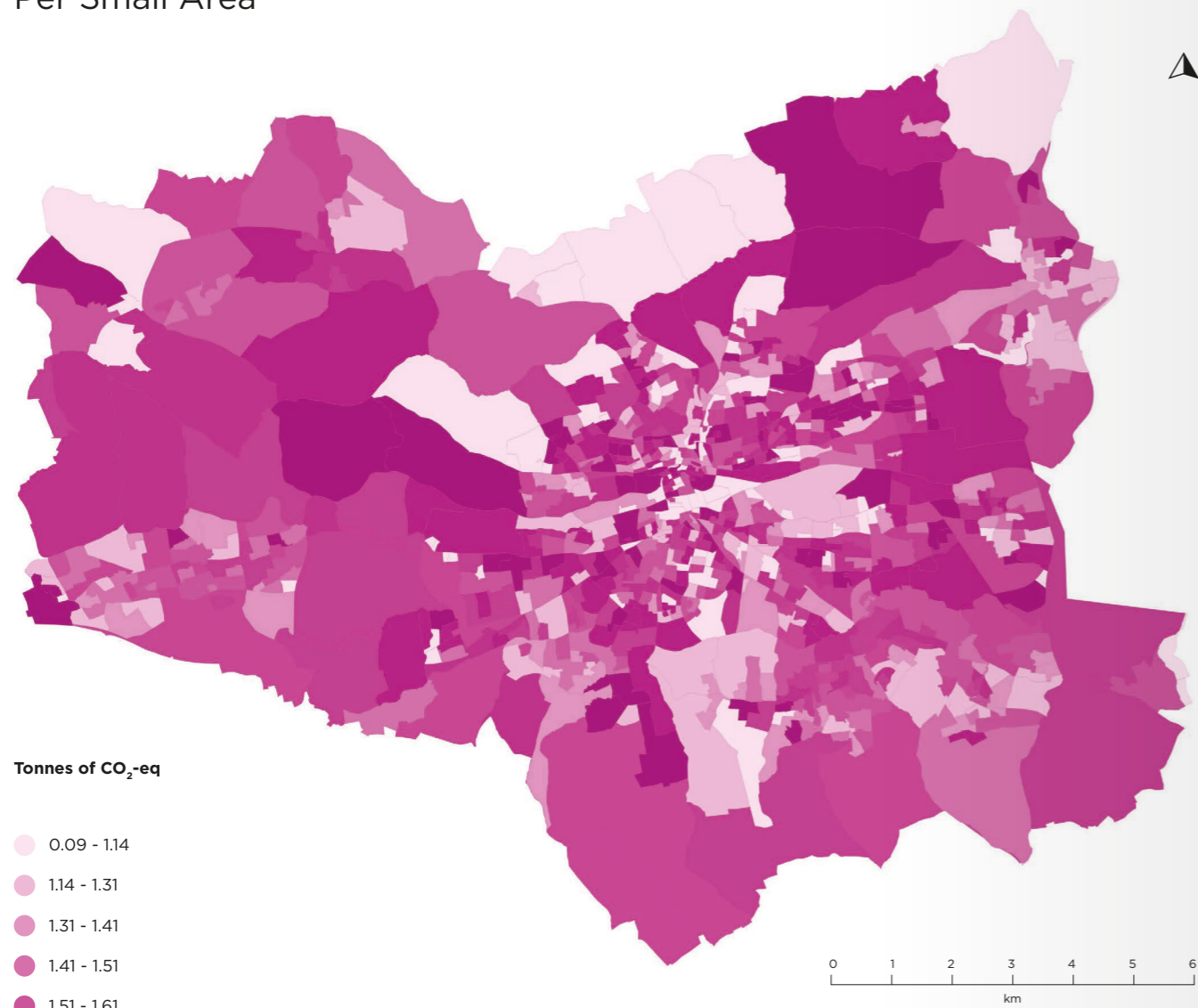
- 0.16 - 1.82
- 1.82 - 5.14
- 5.14 - 8.54
- 8.54 - 11.5
- 11.5 - 14.1
- 14.1 - 16.3
- 16.3 - 18.9
- 18.9 - 21.4
- 21.4 - 26.9
- 26.9 - 268

O'Regan AC, Purcell L, McGookin C, Nyhan MM, 2023. Baseline Emissions Inventory: Part of the Cork City Climate Action Plan 2024 - 2029. University College Cork and Cork City Council, Ireland.

Map 2.5

Household CO₂-eq Emissions per Capita

Per Small Area



Tonnes of CO₂-eq

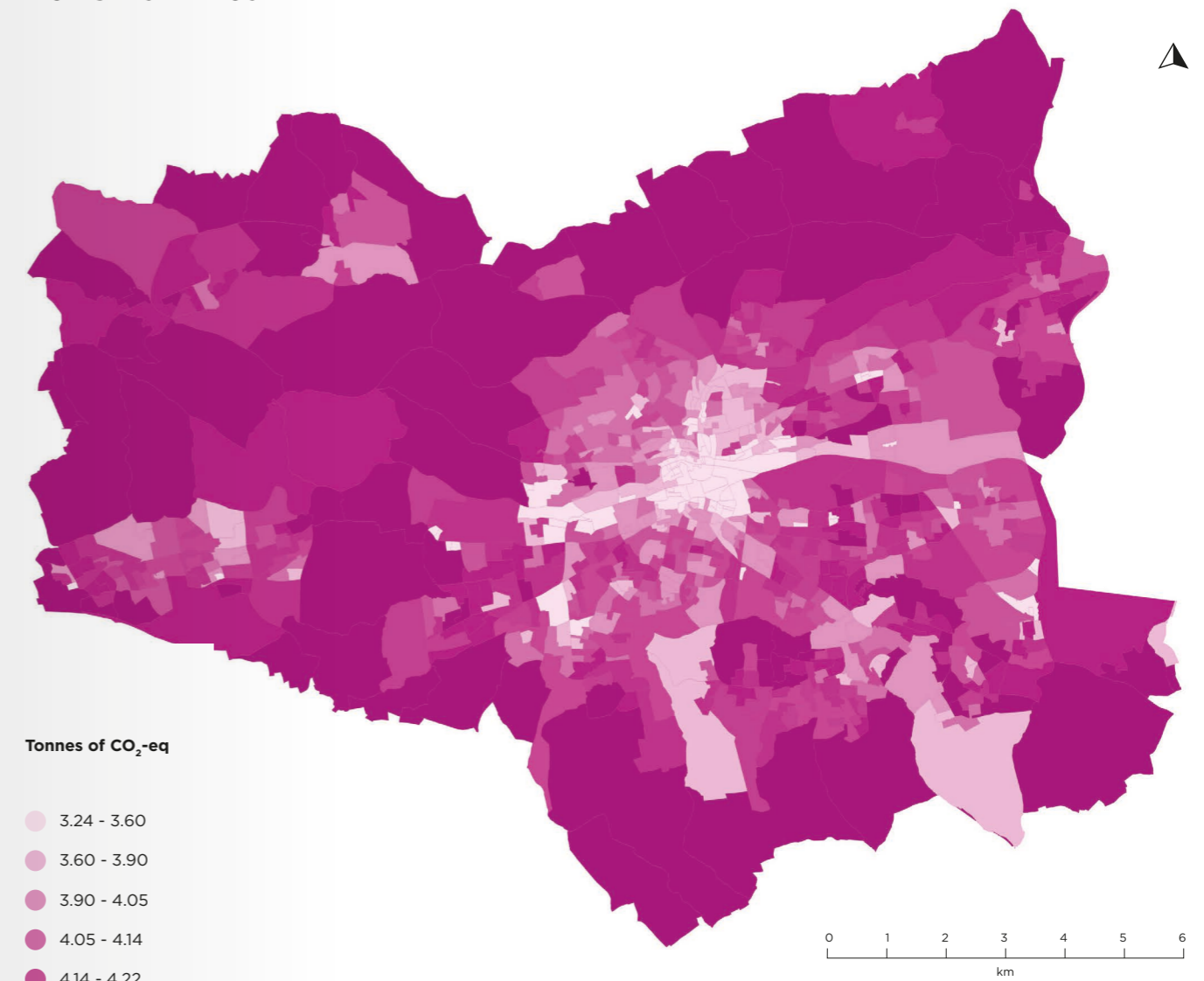
- 0.09 - 1.14
- 1.14 - 1.31
- 1.31 - 1.41
- 1.41 - 1.51
- 1.51 - 1.61
- 1.61 - 1.72
- 1.72 - 1.87
- 1.87 - 2.12
- 2.12 - 2.47
- 2.47 - 17.7

O'Regan AC, Purcell L, McGookin C, Nyhan MM, 2023. Baseline Emissions Inventory: Part of the Cork City Climate Action Plan 2024 - 2029. University College Cork and Cork City Council, Ireland.

Map 2.6

Household CO₂-eq Emissions per Home

Per Small Area



Tonnes of CO₂-eq

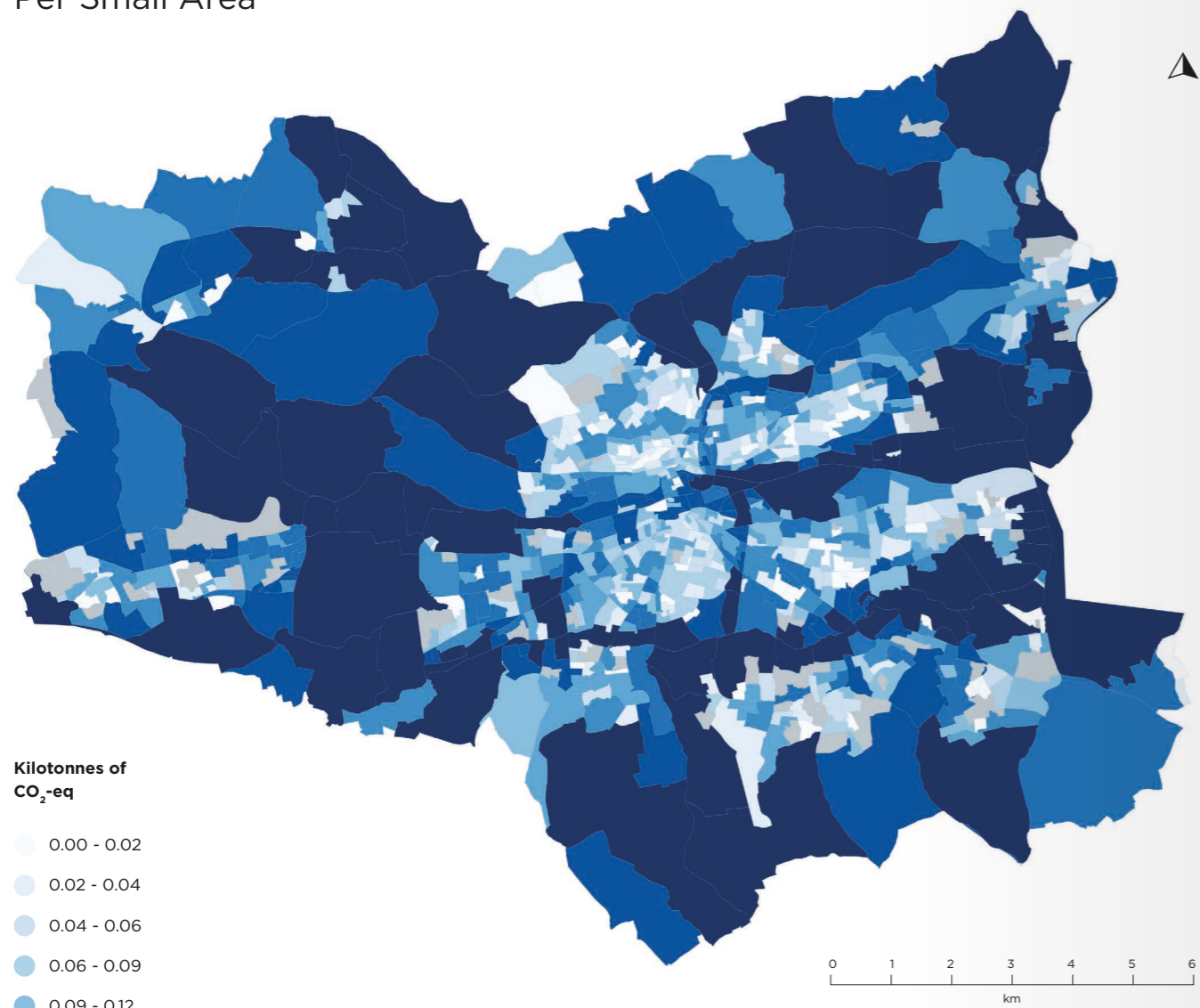
- 3.24 - 3.60
- 3.60 - 3.90
- 3.90 - 4.05
- 4.05 - 4.14
- 4.14 - 4.22
- 4.22 - 4.34
- 4.34 - 4.41
- 4.41 - 4.52
- 4.52 - 4.78
- 4.78 - 5.31

O'Regan AC, Purcell L, McGookin C, Nyhan MM, 2023. Baseline Emissions Inventory: Part of the Cork City Climate Action Plan 2024 - 2029. University College Cork and Cork City Council, Ireland.

Map 3.1

Total Road Transport CO₂-eq Emissions

Per Small Area



Kilotonnes of CO₂-eq

- 0.00 - 0.02
- 0.02 - 0.04
- 0.04 - 0.06
- 0.06 - 0.09
- 0.09 - 0.12
- 0.12 - 0.17
- 0.17 - 0.24
- 0.24 - 0.38
- 0.38 - 1.00
- 1.00 - 8.76

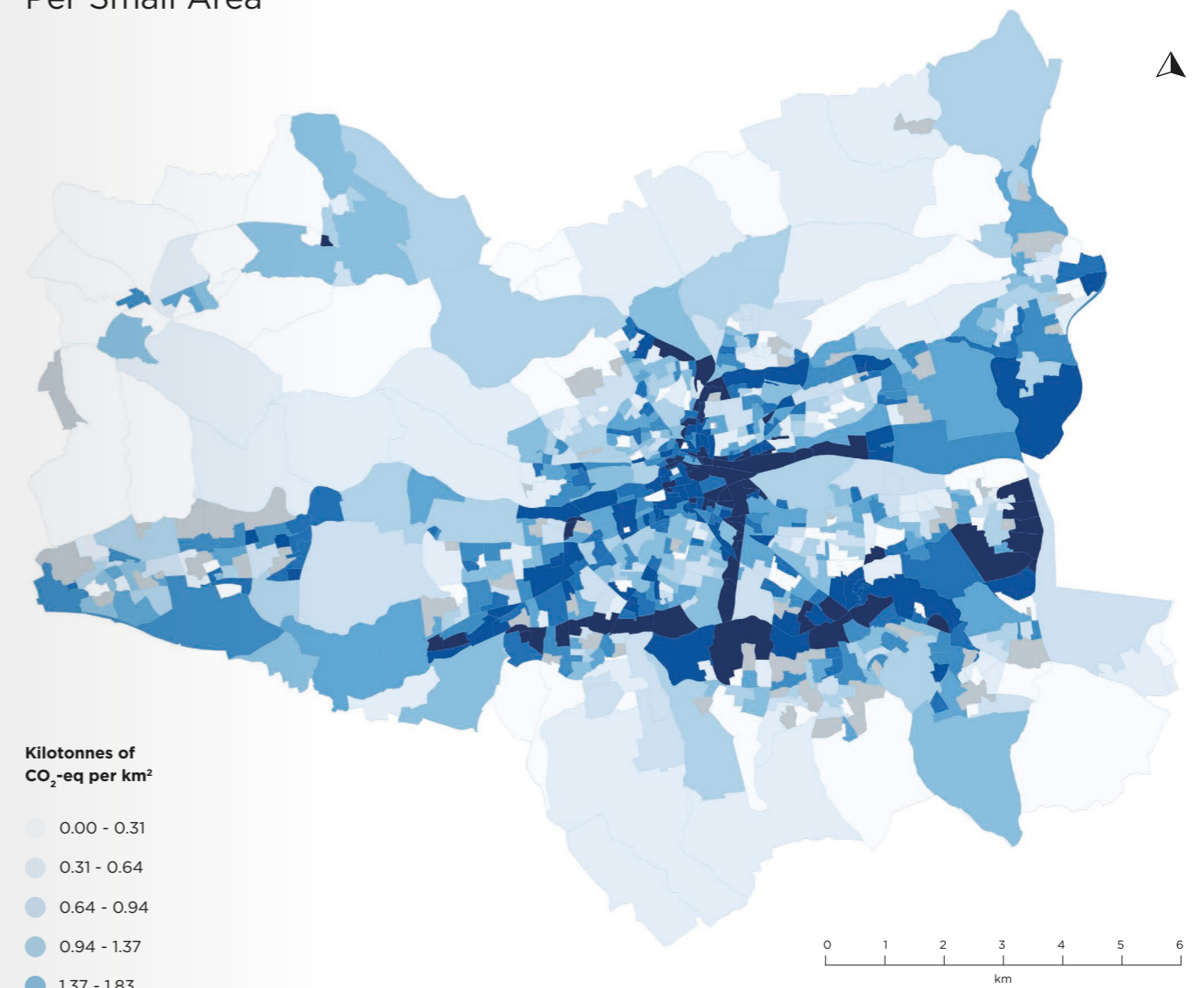
Note: Any Small Areas mapped in grey have no emissions data for that sector.

O'Regan AC, Purcell L, McGookin C, Nyhan MM, 2023. Baseline Emissions Inventory: Part of the Cork City Climate Action Plan 2024 - 2029. University College Cork and Cork City Council, Ireland.

Map 3.2

Road Transport CO₂-eq Emissions per km²

Per Small Area



Kilotonnes of CO₂-eq per km²

- 0.00 - 0.31
- 0.31 - 0.64
- 0.64 - 0.94
- 0.94 - 1.37
- 1.37 - 1.83
- 1.83 - 2.43
- 2.43 - 3.29
- 3.29 - 4.74
- 4.74 - 8.53
- 8.53 - 47.3

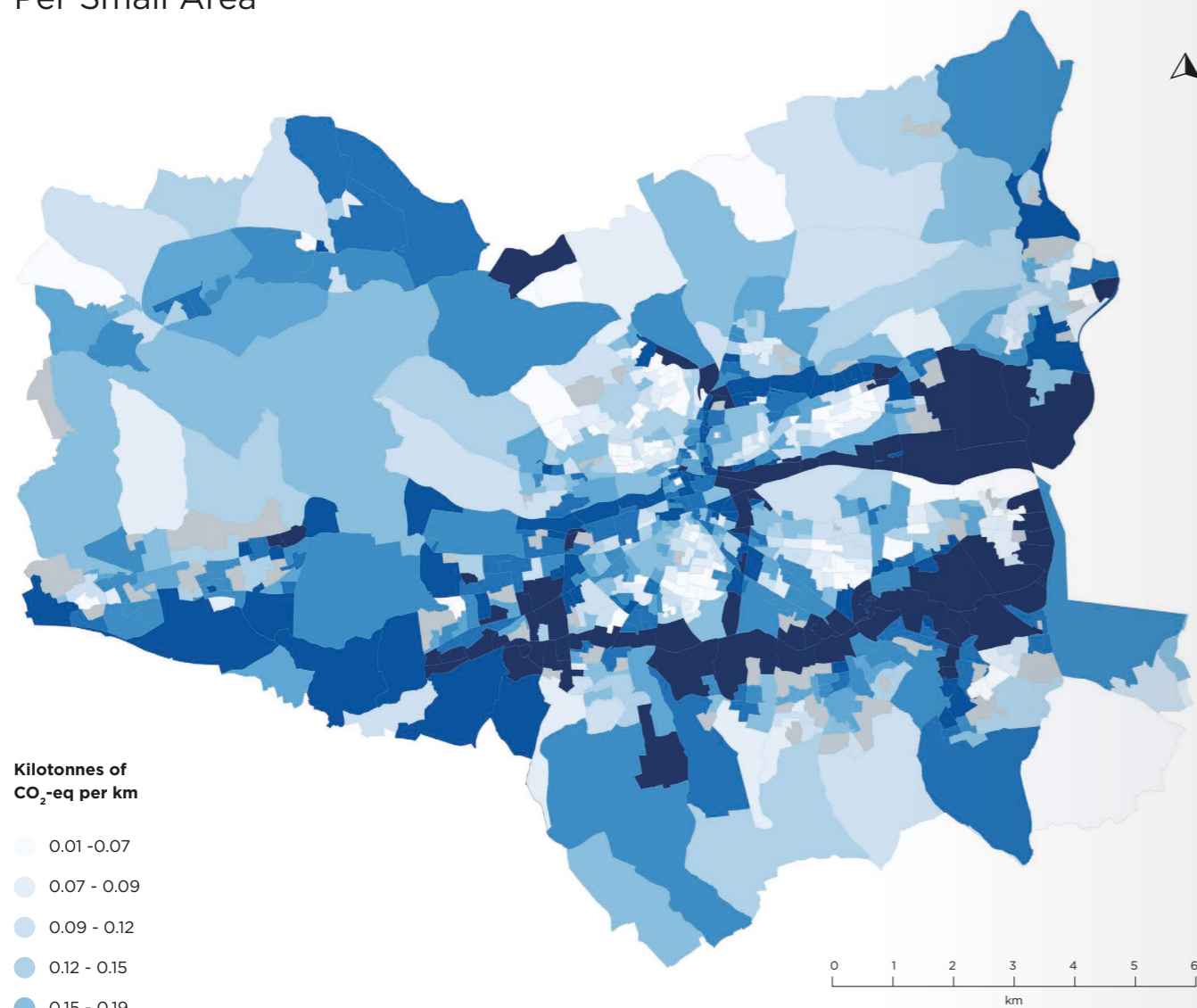
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O'Regan AC, Purcell L, McGookin C, Nyhan MM, 2023. Baseline Emissions Inventory: Part of the Cork City Climate Action Plan 2024 - 2029. University College Cork and Cork City Council, Ireland.

Map 3.3

Road Transport CO₂-eq Emissions per km of Road

Per Small Area



Kilotonnes of CO₂-eq per km

- 0.01 - 0.07
- 0.07 - 0.09
- 0.09 - 0.12
- 0.12 - 0.15
- 0.15 - 0.19
- 0.19 - 0.23
- 0.23 - 0.29
- 0.29 - 0.38
- 0.38 - 0.57
- 0.57 - 2.80

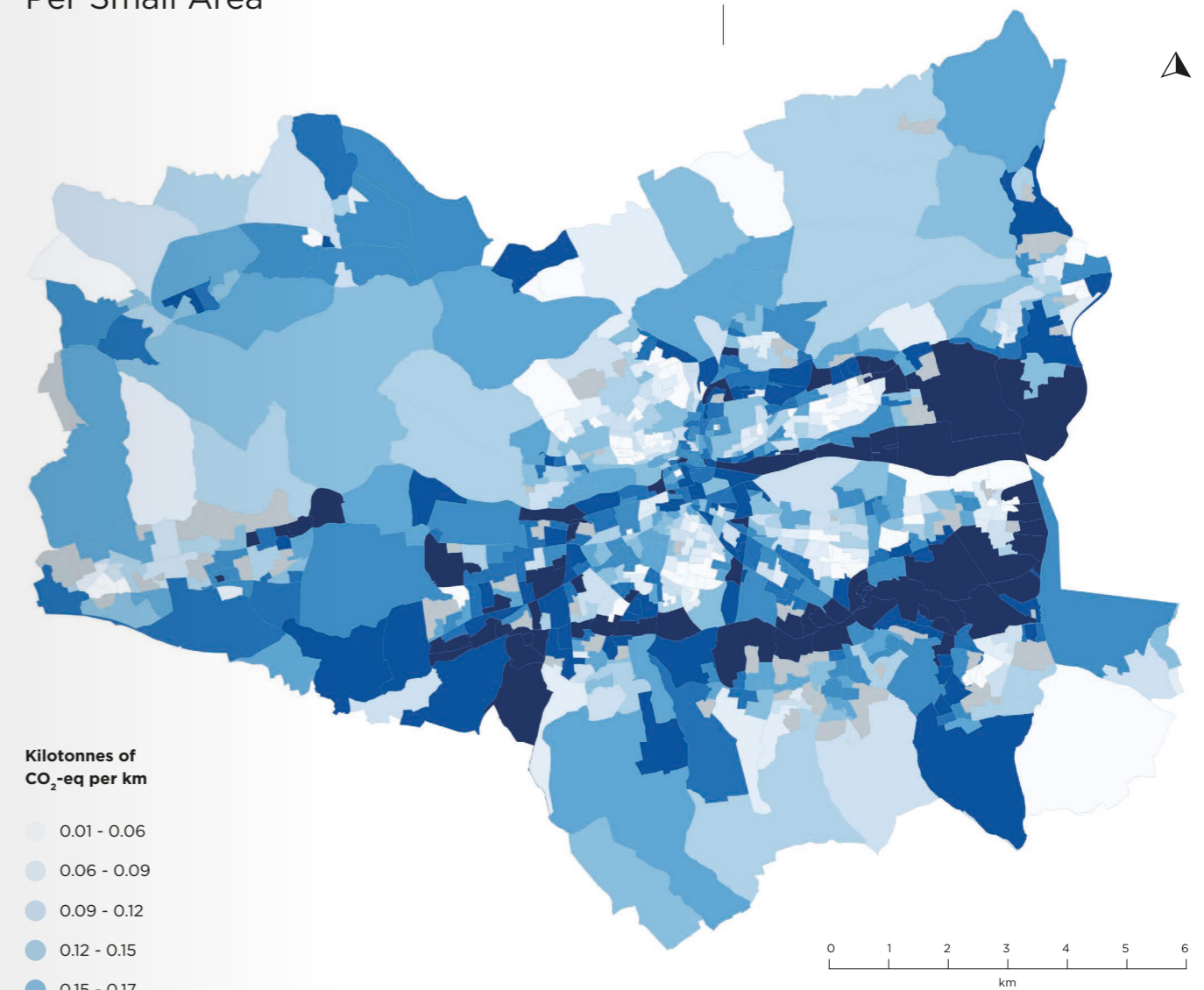
Note: Any Small Areas mapped in grey have no emissions data for that sector.

O'Regan AC, Purcell L, McGookin C, Nyhan MM, 2023. Baseline Emissions Inventory: Part of the Cork City Climate Action Plan 2024 - 2029. University College Cork and Cork City Council, Ireland.

Map 3.4

Road Transport CO₂-eq Emissions per km of Driveable Road

Per Small Area



Kilotonnes of CO₂-eq per km

- 0.01 - 0.06
- 0.06 - 0.09
- 0.09 - 0.12
- 0.12 - 0.15
- 0.15 - 0.17
- 0.17 - 0.21
- 0.21 - 0.26
- 0.26 - 0.33
- 0.33 - 0.44
- 0.44 - 0.95

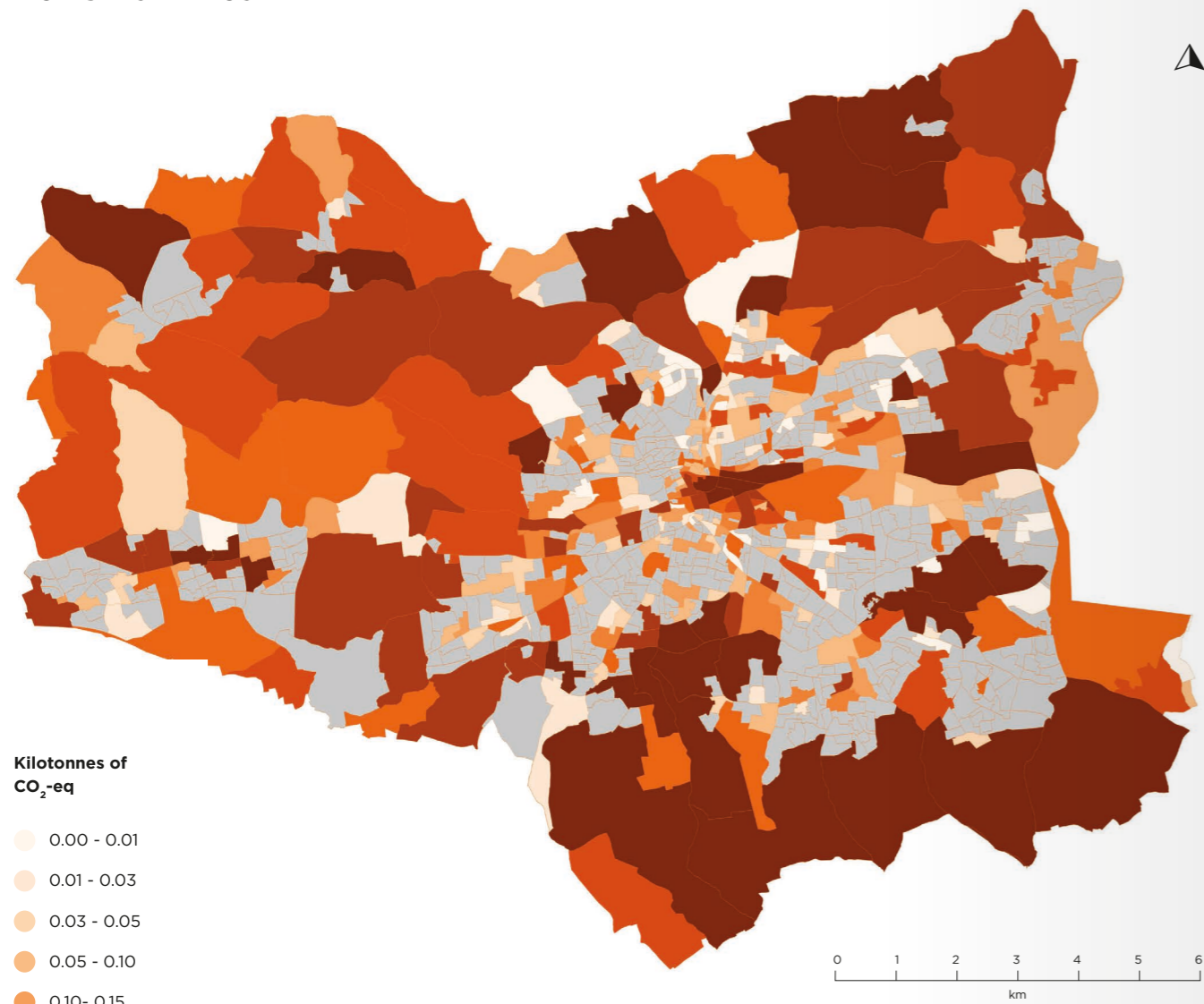
Note: Any Small Areas mapped in grey have no emissions data for that sector.

O'Regan AC, Purcell L, McGookin C, Nyhan MM, 2023. Baseline Emissions Inventory: Part of the Cork City Climate Action Plan 2024 - 2029. University College Cork and Cork City Council, Ireland.

Map 4.1

Total Commercial and Industry CO₂ Emissions

Per Small Area



Kilotonnes of CO₂-eq

- 0.00 - 0.01
- 0.01 - 0.03
- 0.03 - 0.05
- 0.05 - 0.10
- 0.10 - 0.15
- 0.15 - 0.22
- 0.22 - 0.39
- 0.39 - 0.68
- 0.68 - 1.58
- 1.58 - 9.98

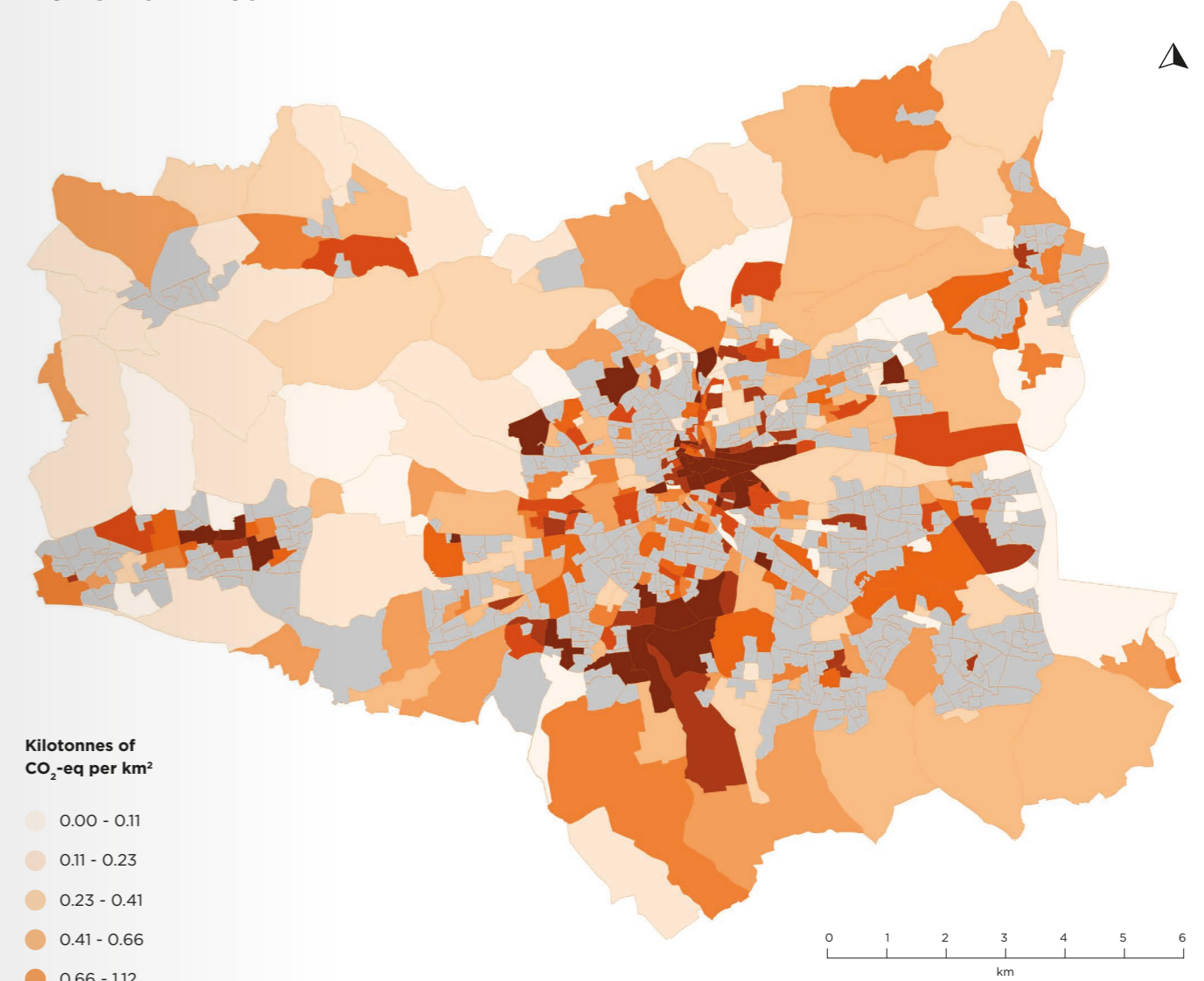
Note: Any Small Areas mapped in grey have no emissions data for that sector.

O'Regan AC, Purcell L, McGookin C, Nyhan MM, 2023. Baseline Emissions Inventory: Part of the Cork City Climate Action Plan 2024 - 2029. University College Cork and Cork City Council, Ireland.

Map 4.2

Commercial and Industry CO₂ Emissions per km²

Per Small Area



Kilotonnes of CO₂-eq per km²

- 0.00 - 0.11
- 0.11 - 0.23
- 0.23 - 0.41
- 0.41 - 0.66
- 0.66 - 1.12
- 1.12 - 1.77
- 1.77 - 2.80
- 2.80 - 4.57
- 4.57 - 10.9
- 10.9 - 38.4

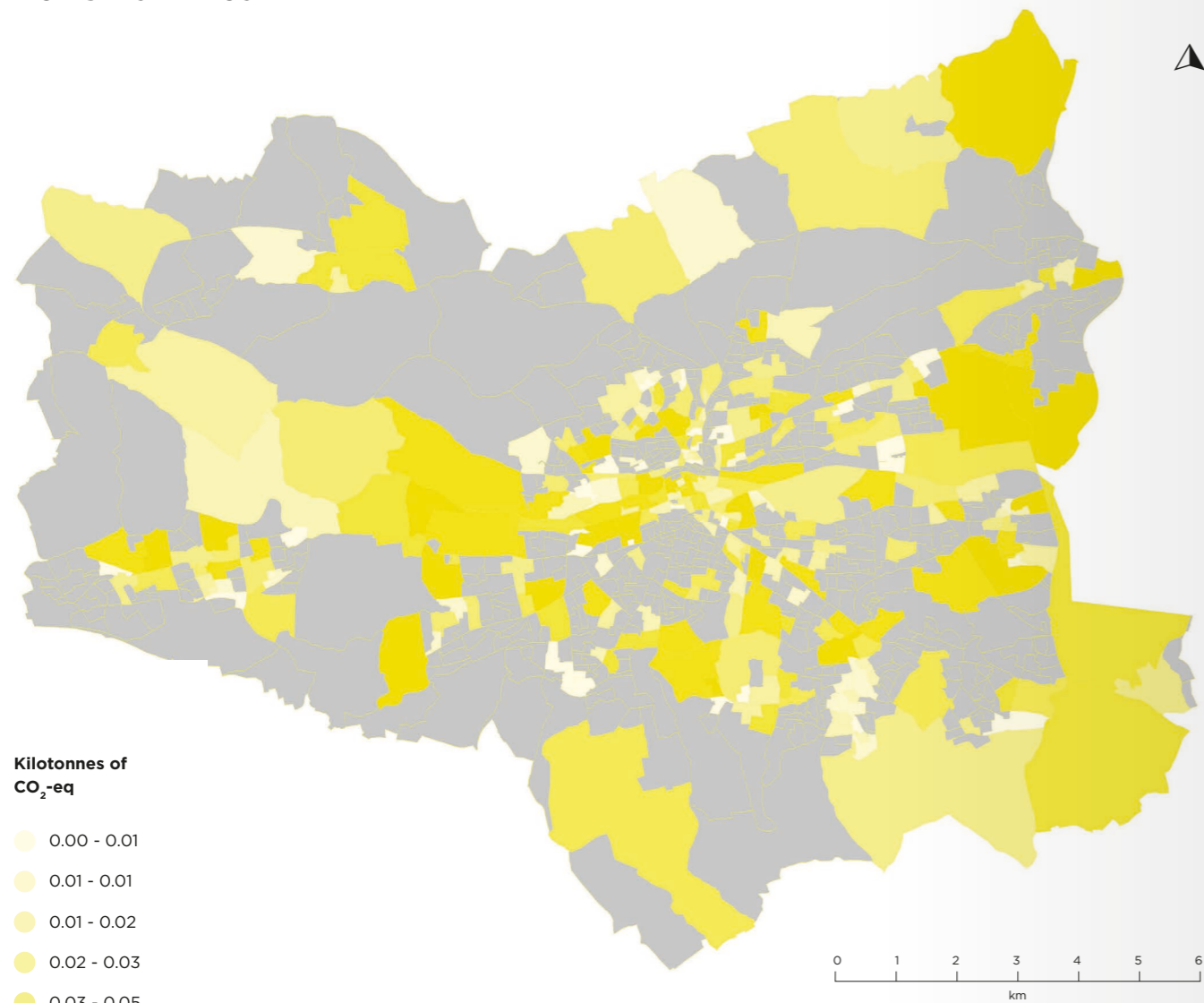
Note: Any Small Areas mapped in grey have no emissions data for that sector.

O'Regan AC, Purcell L, McGookin C, Nyhan MM, 2023. Baseline Emissions Inventory: Part of the Cork City Climate Action Plan 2024 - 2029. University College Cork and Cork City Council, Ireland.

Map 5.1

Total Public Services CO₂ Emissions

Per Small Area



Kilotonnes of CO₂-eq

- 0.00 - 0.01
- 0.01 - 0.01
- 0.01 - 0.02
- 0.02 - 0.03
- 0.03 - 0.05
- 0.05 - 0.07
- 0.07 - 0.10
- 0.10 - 0.16
- 0.16 - 0.29
- 0.29 - 10.7

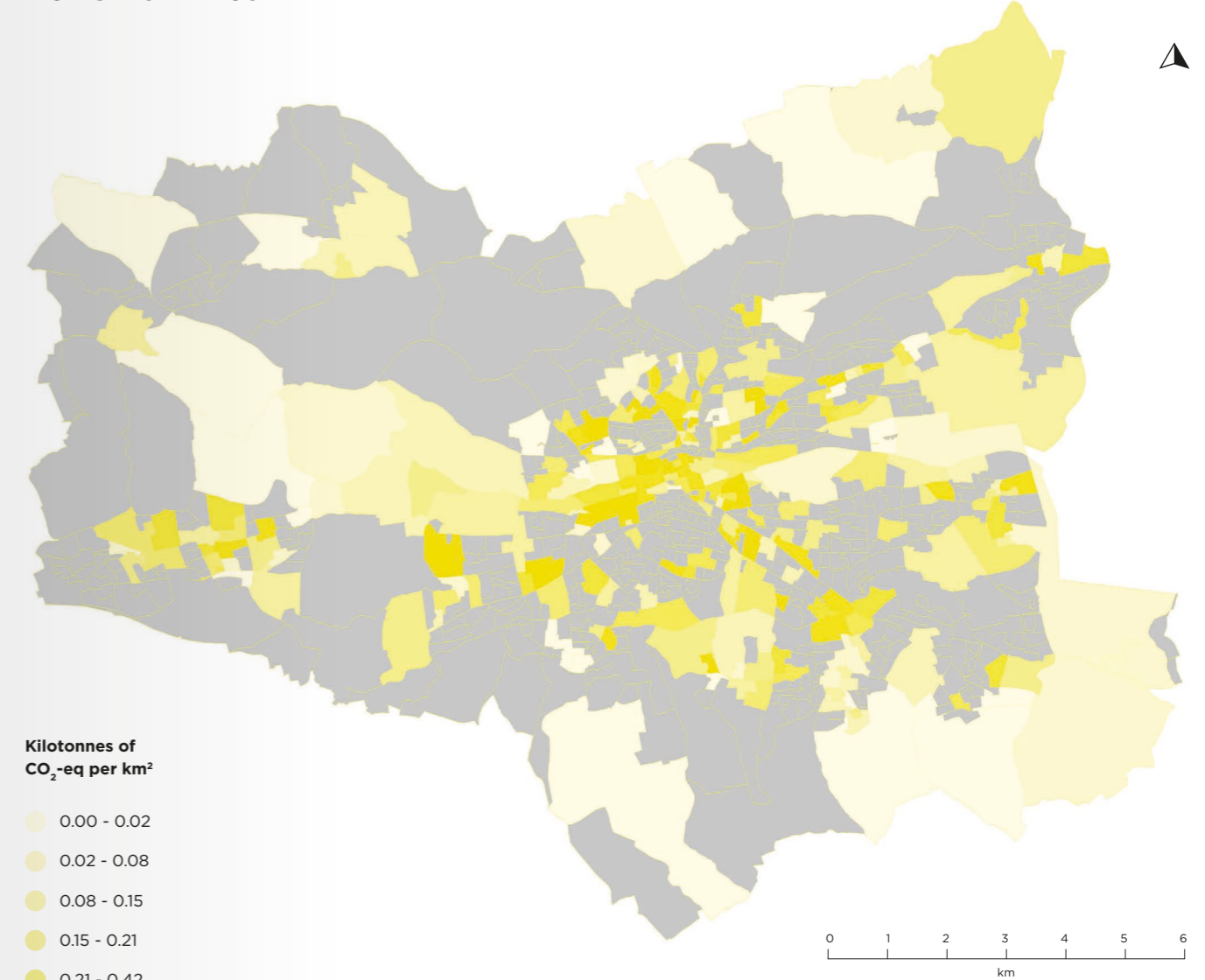
Note: Any Small Areas mapped in grey have no emissions data for that sector.

O'Regan AC, Purcell L, McGookin C, Nyhan MM, 2023. Baseline Emissions Inventory: Part of the Cork City Climate Action Plan 2024 - 2029. University College Cork and Cork City Council, Ireland.

Map 5.2

Public Services CO₂ Emissions per km²

Per Small Area



Kilotonnes of CO₂-eq per km²

- 0.00 - 0.02
- 0.02 - 0.08
- 0.08 - 0.15
- 0.15 - 0.21
- 0.21 - 0.42
- 0.42 - 0.71
- 0.71 - 0.98
- 0.98 - 1.59
- 1.59 - 2.99
- 2.99 - 48.1

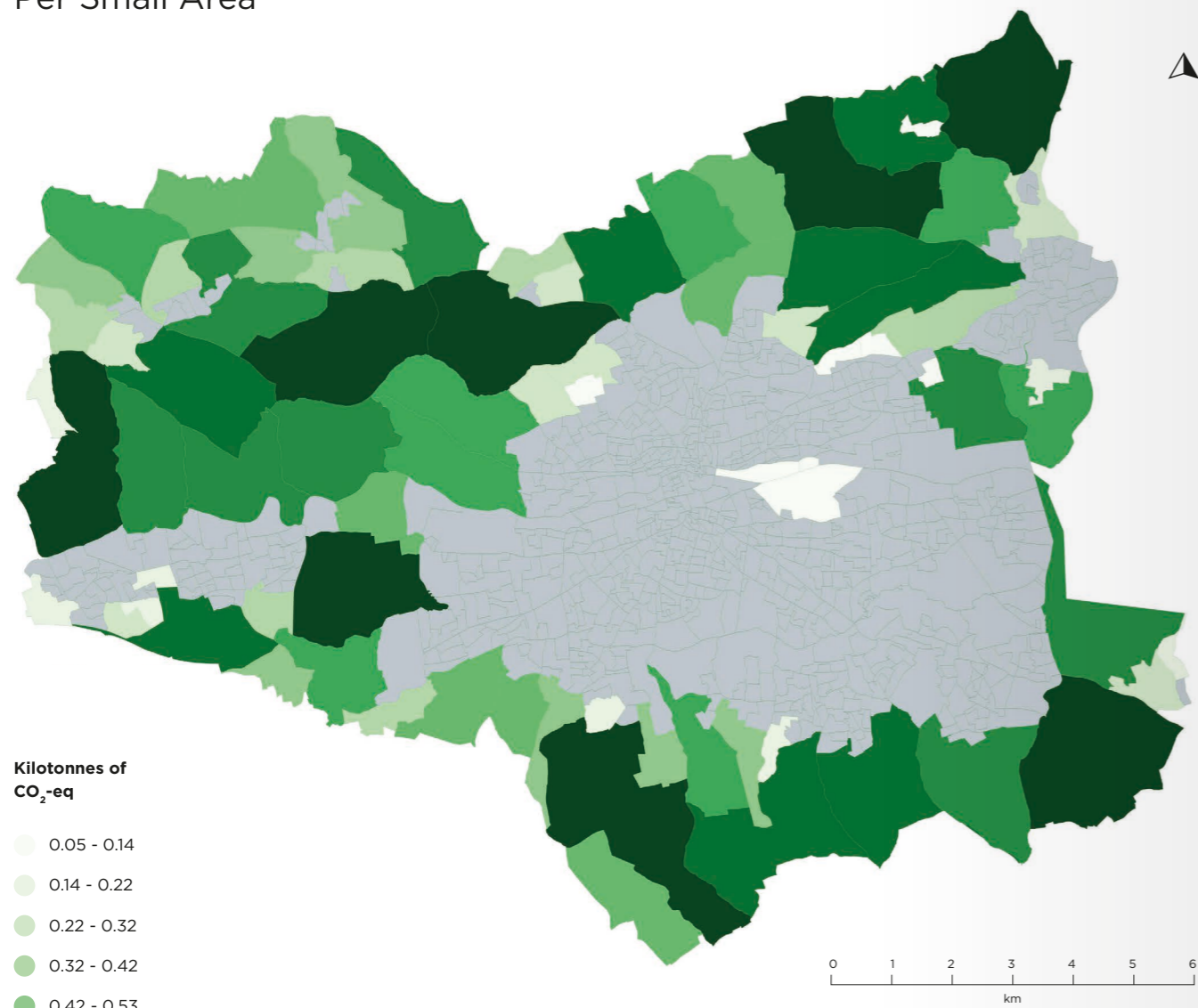
Note: Any Small Areas mapped in grey have no emissions data for that sector.

O'Regan AC, Purcell L, McGookin C, Nyhan MM, 2023. Baseline Emissions Inventory: Part of the Cork City Climate Action Plan 2024 - 2029. University College Cork and Cork City Council, Ireland.

Map 6.1

Total Agriculture and Fishing CO₂-eq Emissions

Per Small Area



Kilotonnes of CO₂-eq

- 0.05 - 0.14
- 0.14 - 0.22
- 0.22 - 0.32
- 0.32 - 0.42
- 0.42 - 0.53
- 0.53 - 0.94
- 0.94 - 1.08
- 1.08 - 1.21
- 1.21 - 1.62
- 1.61 - 3.31

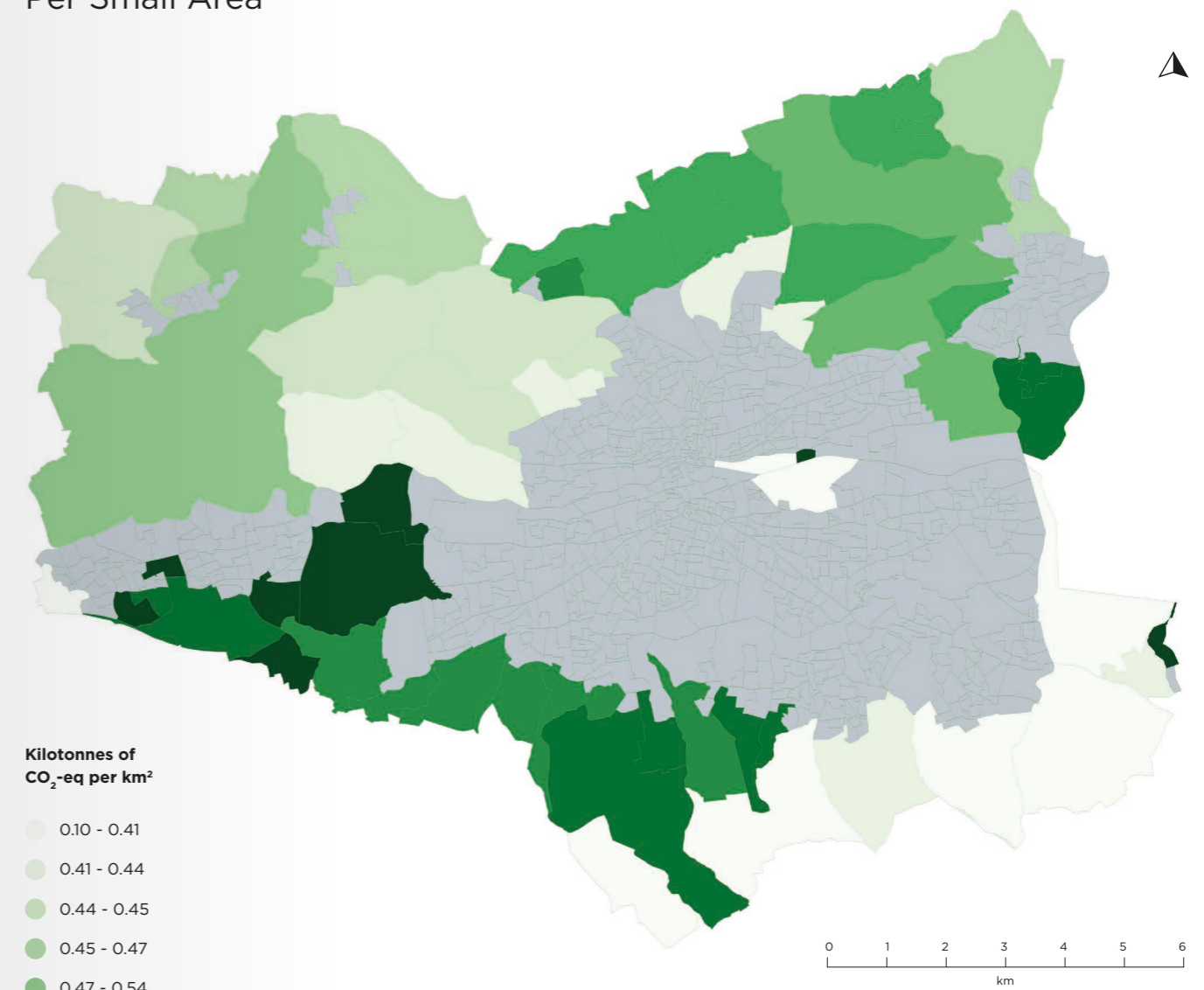
Note: Any Small Areas mapped in grey have no emissions data for that sector.

O'Regan AC, Purcell L, McGookin C, Nyhan MM, 2023. Baseline Emissions Inventory: Part of the Cork City Climate Action Plan 2024 - 2029. University College Cork and Cork City Council, Ireland.

Map 6.2

Agriculture and Fishing CO₂-eq Emissions per km²

Per Small Area



Kilotonnes of CO₂-eq per km²

- 0.10 - 0.41
- 0.41 - 0.44
- 0.44 - 0.45
- 0.45 - 0.47
- 0.47 - 0.54
- 0.54 - 0.57
- 0.57 - 0.58
- 0.58 - 0.63
- 0.63 - 0.75
- 0.75 - 0.88

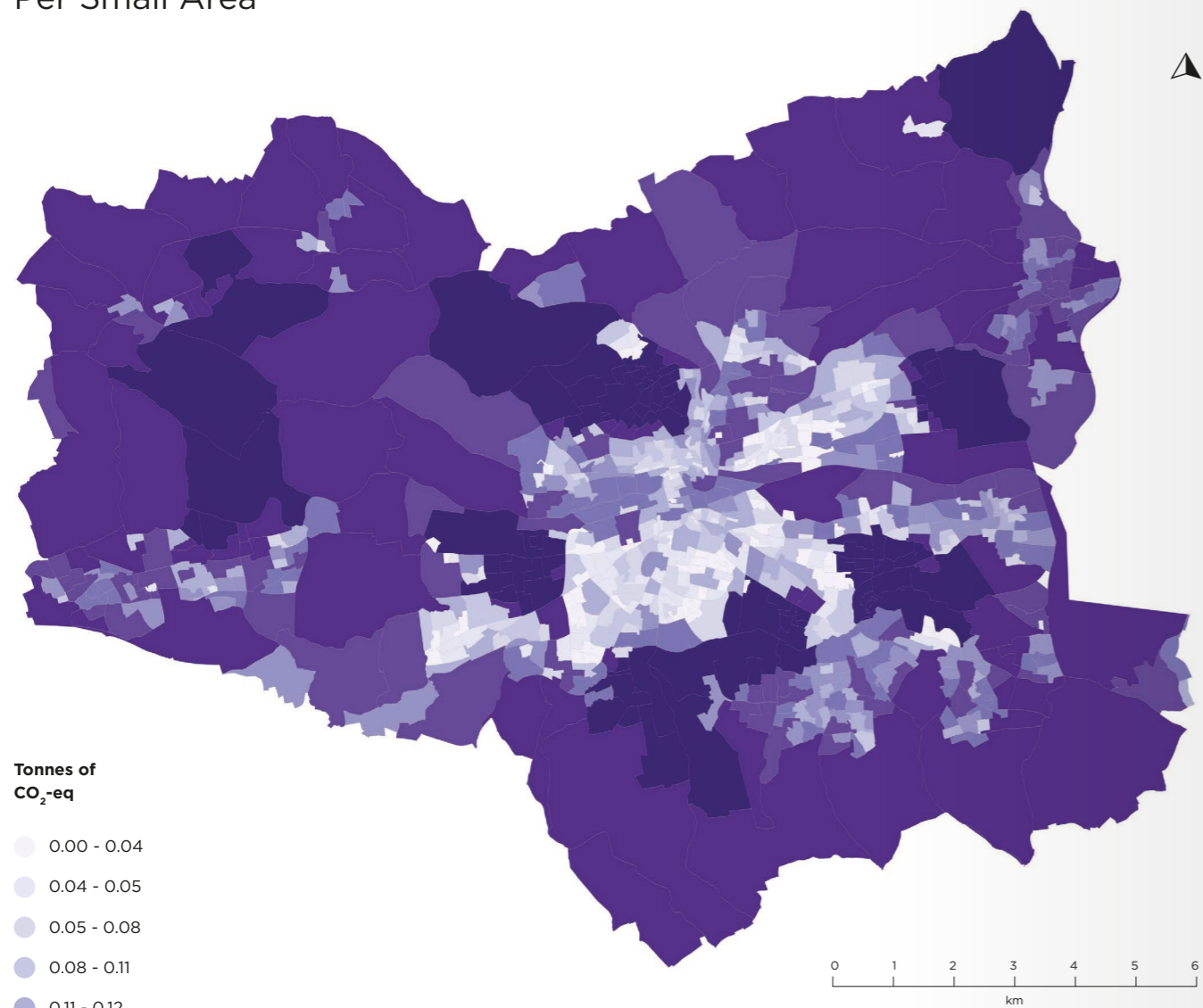
Note: Any Small Areas mapped in grey have no emissions data for that sector.

O'Regan AC, Purcell L, McGookin C, Nyhan MM, 2023. Baseline Emissions Inventory: Part of the Cork City Climate Action Plan 2024 - 2029. University College Cork and Cork City Council, Ireland.

Map 7.1

Total Waste Handling and Treatment CO₂-eq Emissions

Per Small Area



- Tonnes of CO₂-eq**
- 0.00 - 0.04
 - 0.04 - 0.05
 - 0.05 - 0.08
 - 0.08 - 0.11
 - 0.11 - 0.12
 - 0.12 - 0.23
 - 0.23 - 0.40
 - 0.40 - 0.82
 - 0.82 - 27.7
 - 27.7 - 176

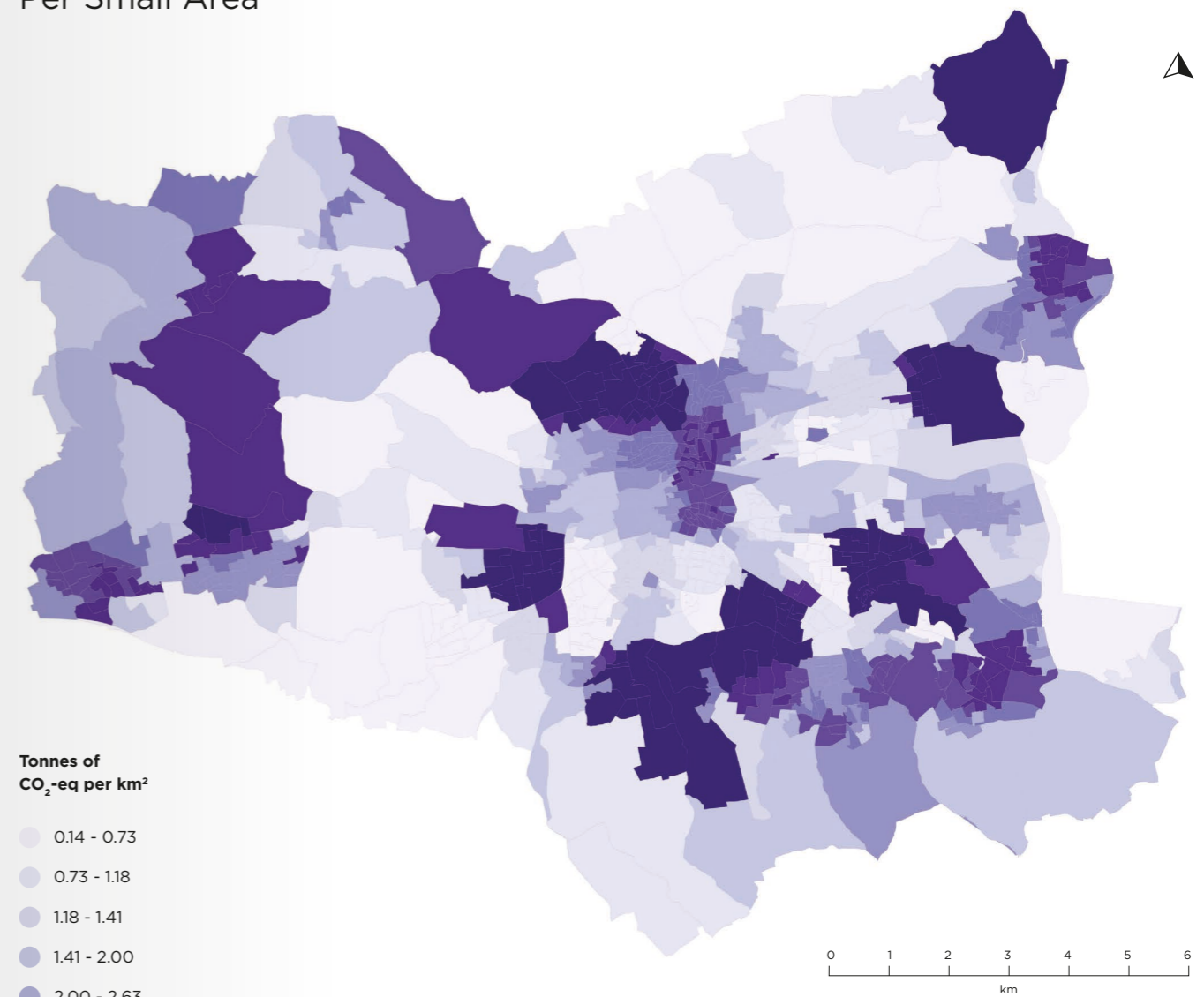
O'Regan AC, Purcell L, McGookin C, Nyhan MM, 2023. Baseline Emissions Inventory: Part of the Cork City Climate Action Plan 2024 - 2029. University College Cork and Cork City Council, Ireland.

Note: Any Small Areas mapped in grey have no emissions data for that sector.

Map 7.2

Waste Handling and Treatment CO₂-eq Emissions per km²

Per Small Area



- Tonnes of CO₂-eq per km²**
- 0.14 - 0.73
 - 0.73 - 1.18
 - 1.18 - 1.41
 - 1.41 - 2.00
 - 2.00 - 2.63
 - 2.63 - 3.45
 - 3.45 - 4.28
 - 4.28 - 5.37
 - 5.37 - 294
 - 294 - 3813

O'Regan AC, Purcell L, McGookin C, Nyhan MM, 2023. Baseline Emissions Inventory: Part of the Cork City Climate Action Plan 2024 - 2029. University College Cork and Cork City Council, Ireland.

Note: Any Small Areas mapped in grey have no emissions data for that sector.

Appendices

Appendix B – Assumptions and Limitations

Key Data

- National emissions in 2018 were taken from the EPA's National Inventory Report ^[6]
- Energy demand and supply in each sector is primarily based on the SEAI's National Energy Balance ^[13].
- The following conversion factors from SEAI's Energy in Ireland Report 2019 were applied to compute emissions from energy demand ^[9]. The solid fuel factor is based on a 50/50 split between peat and coal.

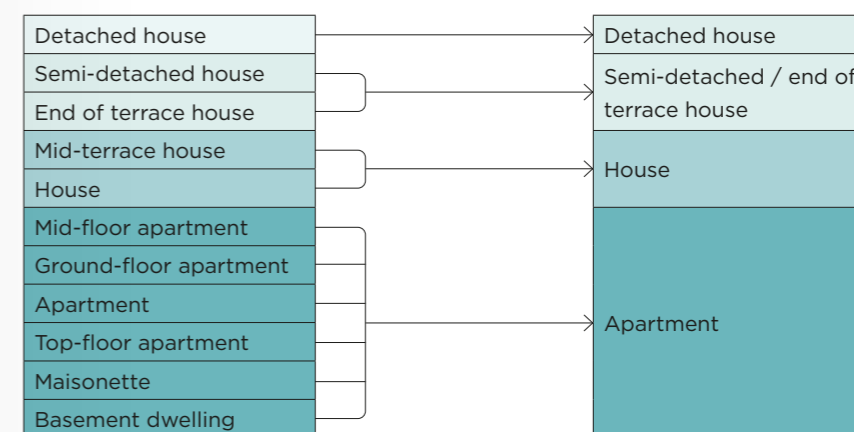
Fuel	ktCO ₂ /GWh
Natural Gas	0.205
Kerosene	0.257
LPG	0.229
Electricity	0.375
Solid Fuel	0.348
Diesel	0.264

Mapping

- The extended city boundary didn't perfectly align with the SAs, which meant some data on the outskirts had to be proportioned based on % share of SA size within the boundary. This assumes the data is uniform across the area, which is unlikely to be the case.
- SAs with less than 10% of their area inside the boundary were excluded, removing 13.

Household

- BER database used to build a housing stock profile of energy demand and fuel share by different end uses, 51% of houses in Cork City have a BER [7].
- The classification of housing types in the Census and BER database are different.
- The 11 dwelling types in the BER dataset were combined into 4 housing categories: detached, semi-detached, mid-terrace and apartment as below.



- Similarly, the 15 BER ratings, from A1 to G, were combined into 7 BER ratings, e.g. A1 and A2 were combined to just A.
- Some SAs had no BERs, and there was a large share with less than 10% of coverage.
- It is well known that the BER is a bad proxy for actual energy demand. The below correction factors (from Figure 27 in [18]) were used to adjust the kWh/m² values for space and secondary heating.

A	B	C	D	E	F	G
84%	79%	66%	60%	57%	53%	47%

Transport

- In using the NTA model, only road transport was considered, which thus omitted aviation, rail and navigation. There is a lack of clear methodology for attributing the GHG emissions of these sectors on such a small scale. For example, many people may travel from outside Cork City to take international flights from Cork airport.
- The breakdown of diesel and petrol within the vehicle categories was not available from the Eneval data, only the total emissions on each road.
- Travel outside the county was not included. For example, if someone drove from Cork City to Waterford, once they cross the border their driving would no longer be within the study area. In contrast, a Tier 2 approach based on the km travelled by cars registered to Cork City would capture all travel even when the cars leave the city boundary, and thus would result in a higher estimate for total emissions.

Commercial Services & Industry

- The Valuation Office provided total floor area by different business types in Cork City, but this was not available at the small area level and omitted hospitality buildings (hotels, B&Bs, bars, restaurants and Cafes).
- Floor area by business type was estimated using OpenStreetMap data ^[12], but there were issues with how some buildings were classified. The 62,864 buildings had to be manually verified to correct those that had been wrongly classified or had no classification. This was a very time intensive process. The vast majority were residential, with 2,611 commercial and industry buildings following several reviews of the data.
- OpenStreetMap data provides building footprint rather than total floor area, i.e. it doesn't include the extra floor area associated with two or three stories. Based on the average number of stories within the SEAI's 'Extensive survey of the commercial buildings stock in the Republic of Ireland' ^[19], a floor area ratio (ratio of floor area to building footprint) of 1.58 was determined.

Stories	Number of buildings
1	877
2	449
3	125
4	38
5	5
6	7

- The non-domestic BER release from CSO gives fuel source in main space heating within each county. However, this data is incomplete. In 2018, only 491 (19%) commercial and industry buildings had a BER out of 2,611 identified [11].
- There are no Irish energy benchmarks, so UK CIBSE guidelines were used [10].

Public Sector

- Buildings that didn't have metered data available (e.g. hospitals, schools) had the same issues as commercial & industry above.
- Floor area for the main hospital buildings was assumed to be 4 stories based on a site assessment of the Cork University Hospital and Mercy Hospital buildings.
- Public lighting data was incomplete, 80% of metered connections had zero values and 9.2 GWh out of 9.45 GWh of the electricity demand is currently unmetered. The unmetered value was evenly spread over the connections with zero values. However, there is likely differences across the city in the level of lighting and thus electricity demand.

Agriculture, Land Use & Fishing

- Livestock and land use emissions portioned based on farm area, which doesn't capture the type of activity within the study area.
- Emissions calculated based on production rather than consumption. This means that the GHG footprint of food consumed (in shops, restaurants or bars) is not included, but rather the very small amount of food produced within the city boundary. The vast majority of food and drinks consumed likely come from outside the study area.

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Abbreviations

BEI	Baseline Emissions Inventory
BER	Building Energy Rating
CO₂	Carbon Dioxide
CH₄	Methane
CSO	Central Statistics Office
DZ	Decarbonisation Zone
ED	Electoral Division
EPA	Environmental Protection Agency
GHG	Greenhouse Gas Emission
GIS	Geographic Information system
HGV	Heavy Goods Vehicle
LGV	Light Goods Vehicle
LPG	Liquid Petroleum Gas
LULUCF	Land Use, Land Use Change and Forestry
N₂O	Nitrous Oxide
NTA	National Transport Authority
SA	Small Area
SEAI	Sustainable Energy Authority of Ireland



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