



What If? Evaluating decarbonization strategies for maritime cargo flows in Liverpool City Region

Patrick Ballantyne, Alex Singleton



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Today's Talk



Context



Why?



Data



Likely destination estimation



Likely route prediction



Discussion: next steps



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Context



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Context

[2022] LCR CA secured the Liverpool City Region Sustainable Transport Settlement (CRSTS 1):

- Evidence-led transport development pipeline to support transition to net zero and generate positive outcomes for people in LCR.
- Total awarded was £710m, to cover 2022-2027.
- E.g., James St Station, Baltic Triangle (£156m)





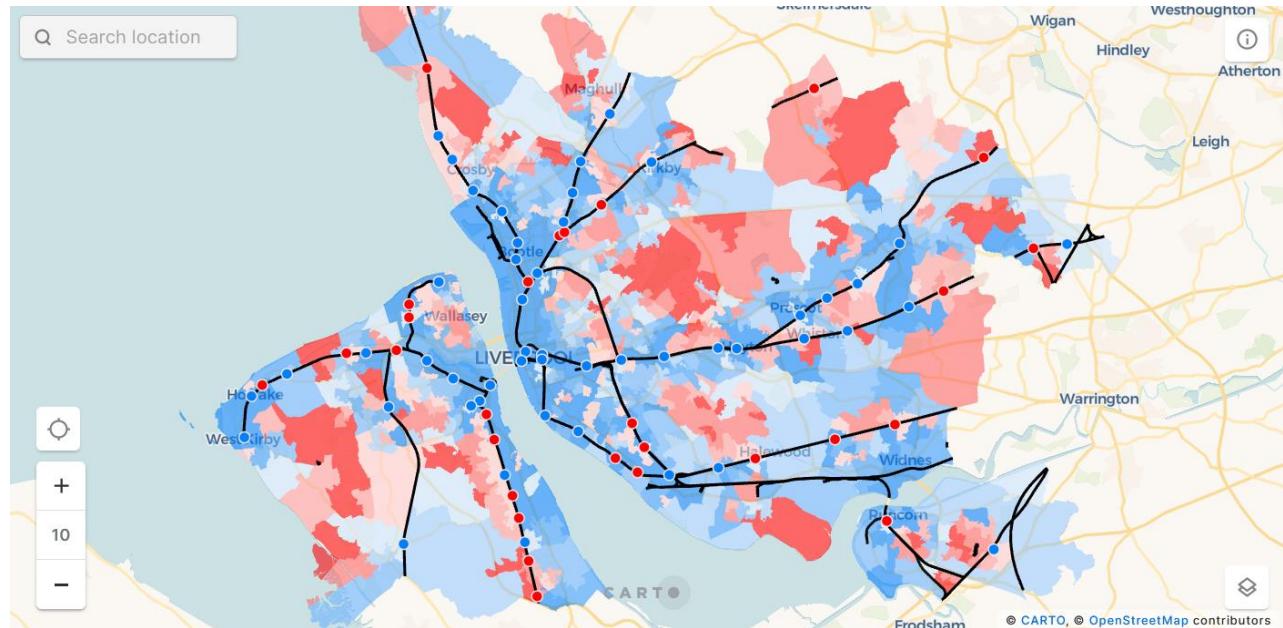
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[2023] CRSTS 2:

- Bidding for similar amount, to cover 2027+
- Less concerned with schemes, more about problems and specific interventions to address these.
- **Place-based** approach: mapping and scoring areas based on priorities





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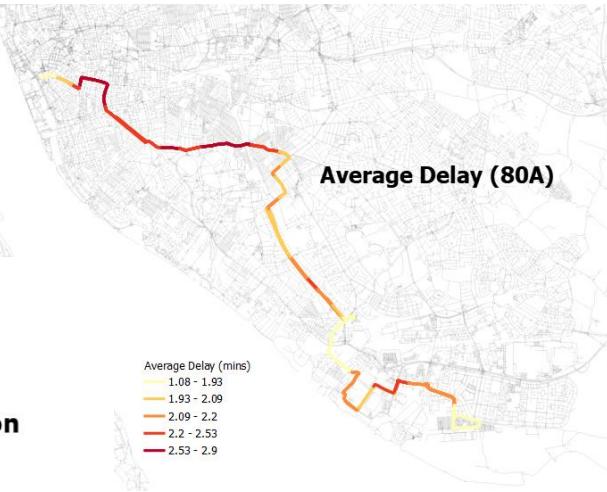
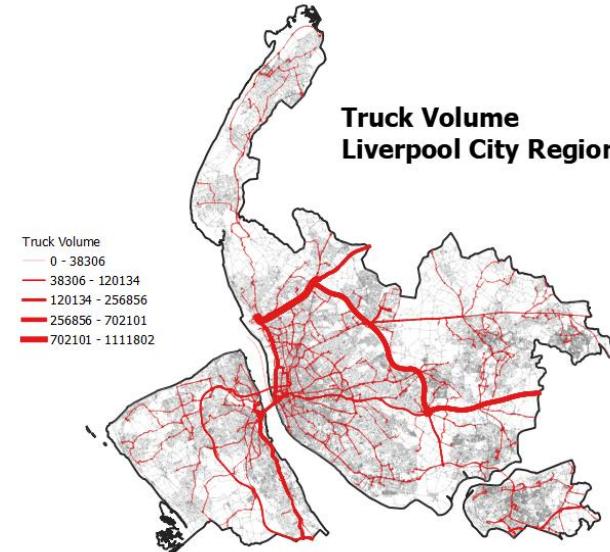
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[2023] CRSTS 2:

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- Less concerned with schemes, more about problems and specific interventions to address these.
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Other outcomes:

- LOTS of data, impact and papers (I hope)...





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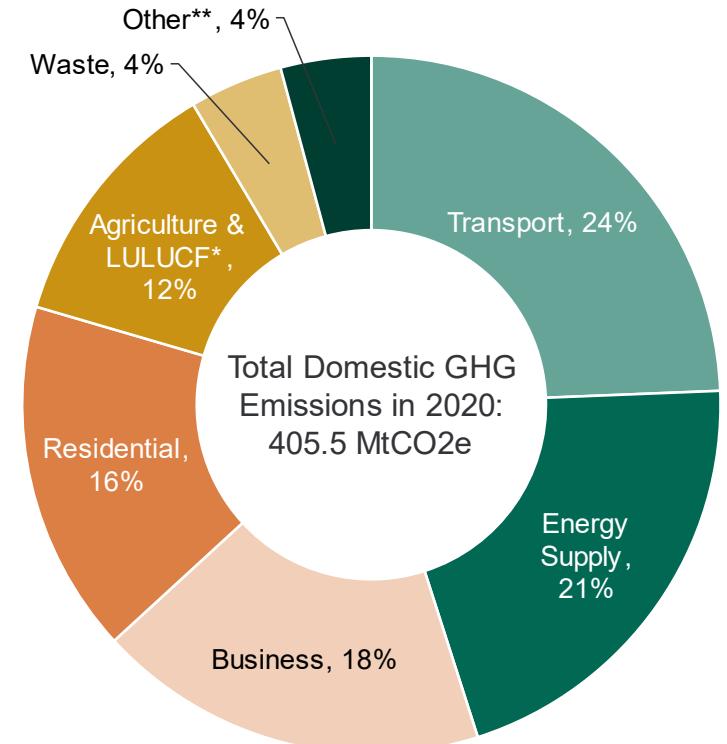
Why?





Why?

Transport is the **largest emitting sector of GHGs** in the UK:
24% of GHG emissions come from the sector

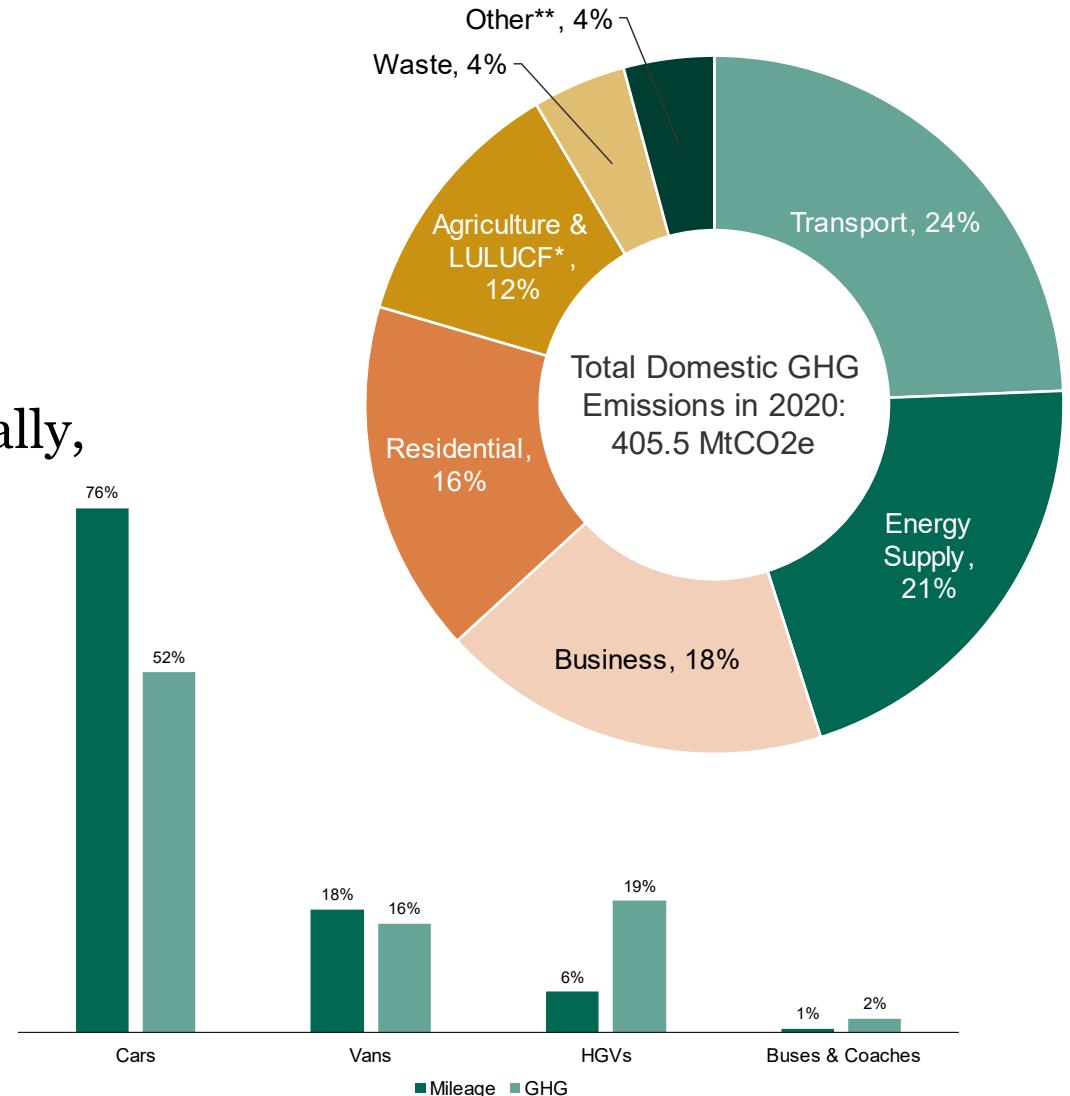




Why?

Transport is the largest emitting sector of GHGs in the UK:
24% of GHG emissions come from the sector

Whilst HGVs make up a smaller share of total miles nationally,
the emissions they generate are disproportionately greater*



*HGVs are less fuel efficient than private cars, and travel longer distances with greater loads

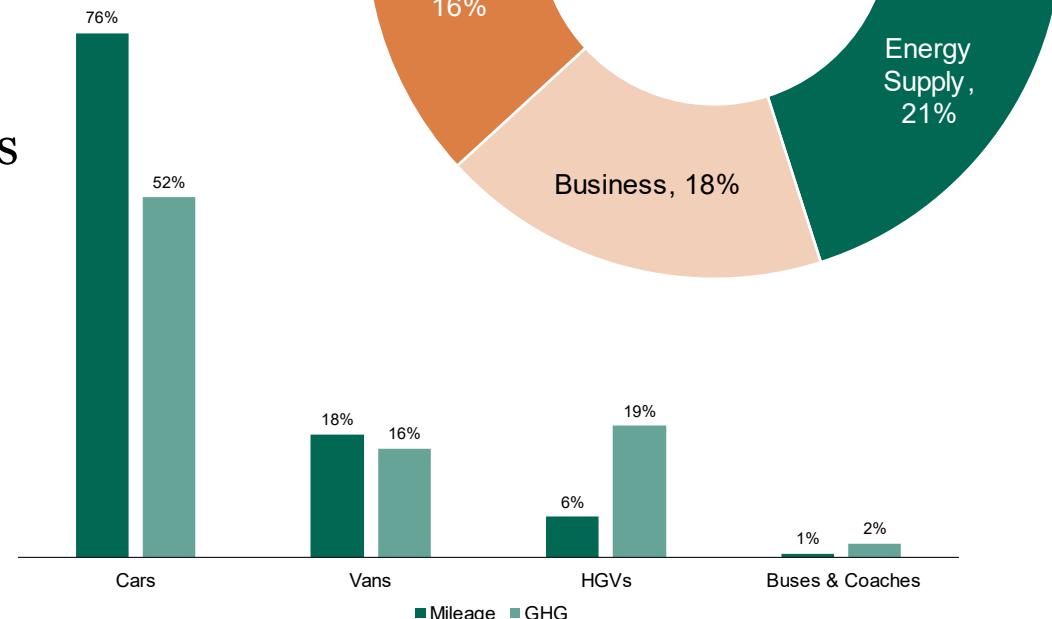


Why?

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Lots of evidence linking these emissions to negative impacts
for public and environmental health[†]



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[†] Teixeira et al., 2021; Tang et al., 2020; Mak and Ng, 2021.



Why?

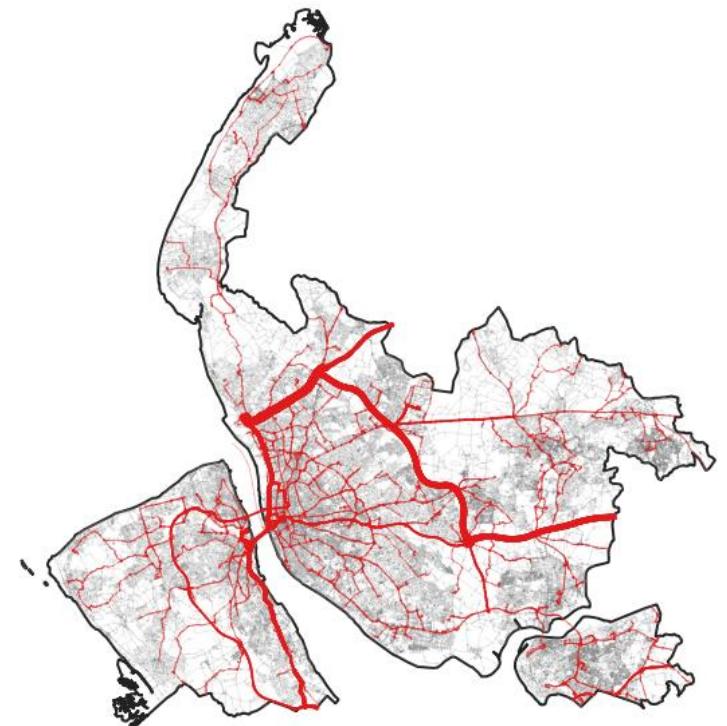
Transport is the largest emitting sector of GHGs in the UK:
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New Report: Transition to Zero-Emission Trucks Could Save More Than 66,000 Lives

Move to zero-emission trucks could result in \$735 billion in public health benefits over the next 30 years and a more equitable future



HGV routes (and emissions) are **spatial** and could result in social and spatial inequalities

*HGVs are less fuel efficient than private cars, and travel longer distances with greater loads

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Data



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Data

OD Data for Freight at Port of Liverpool (and Birkenhead):

- Provided by MDS Transmodal, via LCR CA.
- Destinations are **GBFM Zones***
- **Truck volumes** along OD pairs
- Temporal scale: '1 year'



*Great Britain Freight Model (GBFM), <https://www.gov.uk/government/publications/great-britain-freight-model-version-5-2022-updates>.



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GBFM Zone	D-Latitude	D-Longitude	ImportExport	SeaMode	Port	O-Latitude	O-Longitude	TotalUnits
1	53.6235	-2.2042	Imp	Unaccompanied Trailer	Liverpool	53.4067	-2.9945	12.803
1	53.6235	-2.2042	Imp	Shipborne port-to-port trailer	Liverpool	53.4067	-2.9945	1.367
1	53.6235	-2.2042	Exp	Accompanied HGV	Liverpool	53.4067	-2.9945	0.282
1	53.6235	-2.2042	Exp	Unaccompanied Trailer	Liverpool	53.4067	-2.9945	0.776
1	53.6235	-2.2042	Exp	Shipborne port-to-port trailer	Liverpool	53.4067	-2.9945	0.077
1	53.6235	-2.2042	Imp	Accompanied HGV	Liverpool	53.4067	-2.9945	4.713
2	53.6109	-2.1967	Imp	Unaccompanied Trailer	Liverpool	53.4067	-2.9945	3.671
2	53.6109	-2.1967	Imp	Shipborne port-to-port trailer	Liverpool	53.4067	-2.9945	0.383
2	53.6109	-2.1967	Exp	Accompanied HGV	Liverpool	53.4067	-2.9945	0.566
2	53.6109	-2.1967	Exp	Unaccompanied Trailer	Liverpool	53.4067	-2.9945	1.562
2	53.6109	-2.1967	Exp	Shipborne port-to-port trailer	Liverpool	53.4067	-2.9945	0.155
2	53.6109	-2.1967	Imp	Accompanied HGV	Liverpool	53.4067	-2.9945	1.346

*Great Britain Freight Model (GBFM), <https://www.gov.uk/government/publications/great-britain-freight-model-version-5-2022-updates>.



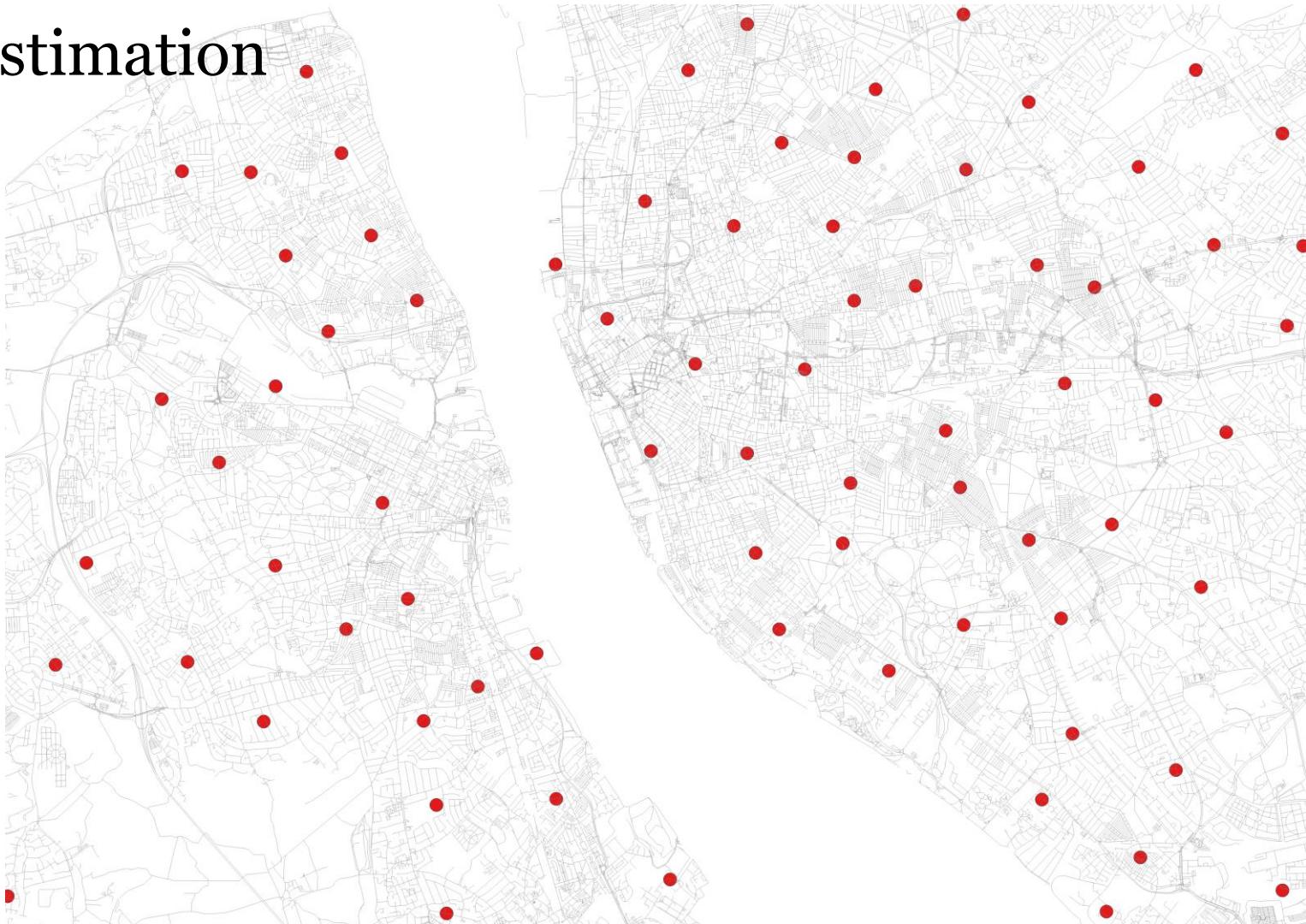
Likely destination estimation



Likely destination estimation

GBFM Zones, i.e., destinations

- Lots of problems





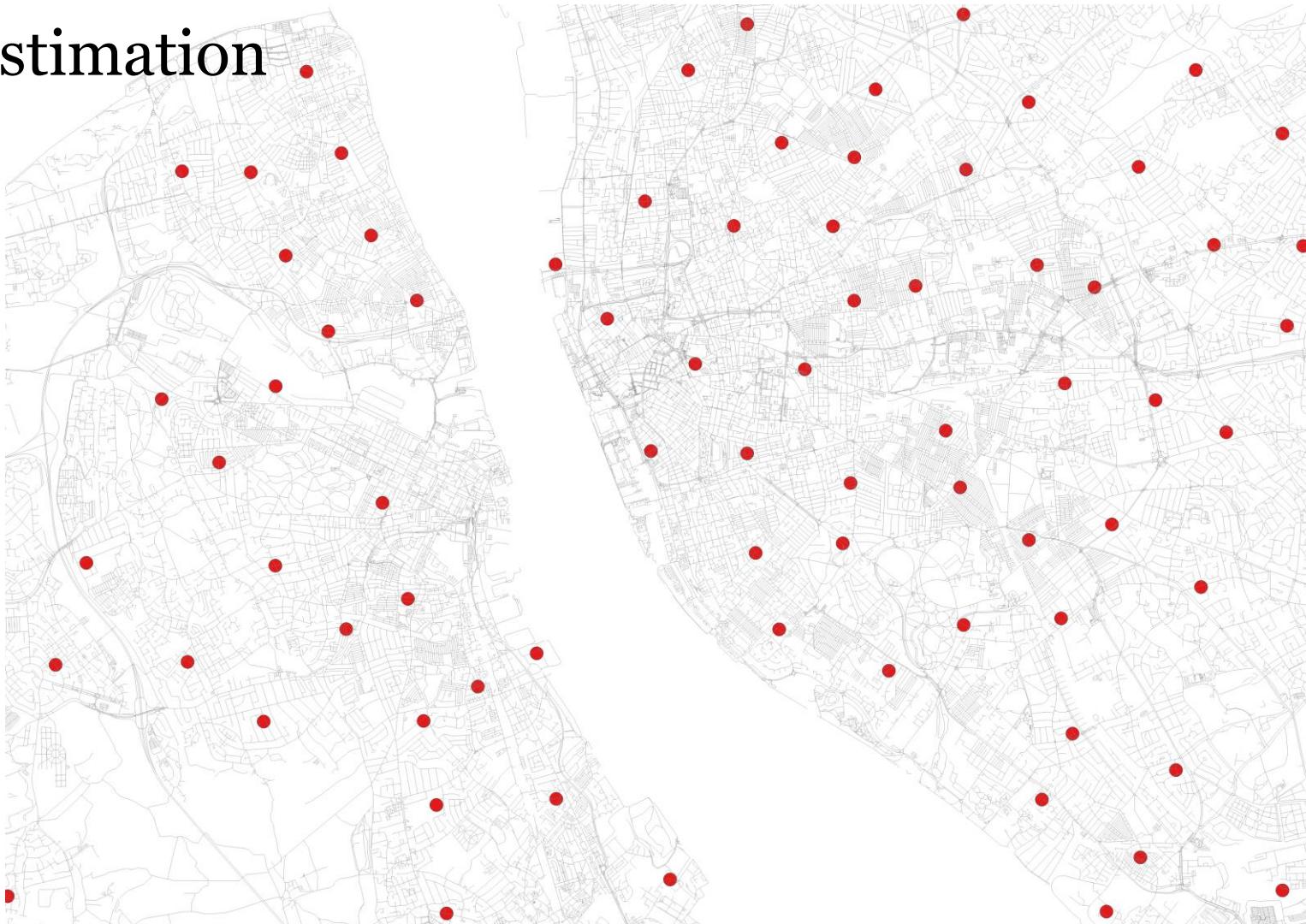
Likely destination estimation

GBFM Zones, i.e., destinations

- Lots of problems

Accurate destinations?

- Centroid reconfiguration

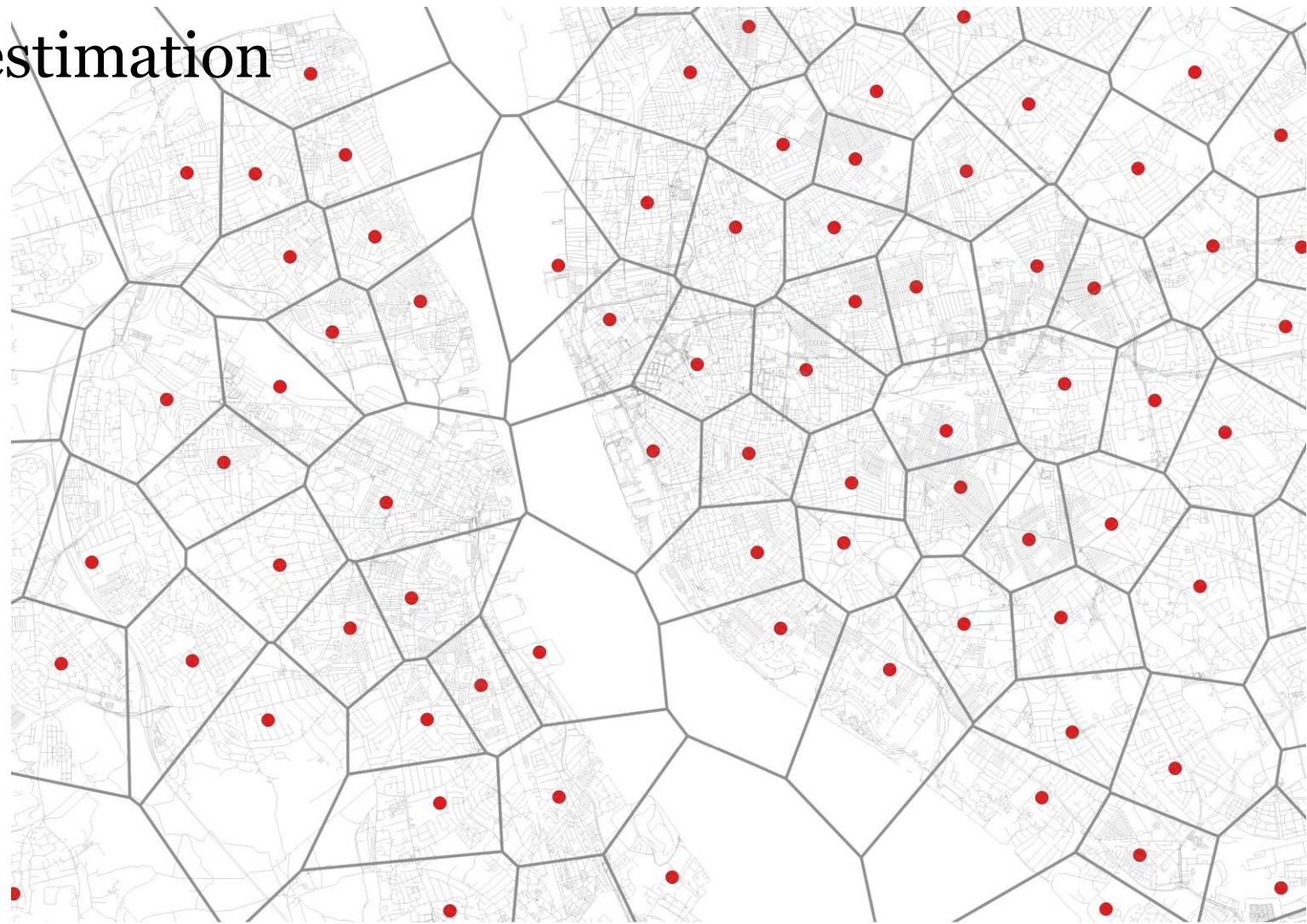




Likely destination estimation

Voronoi tessellation:

```
## Build voronoi polygons from points to create zones
tesselate <- function(x) {
  xg = st_combine(st_geometry(x))
  xt <- st_voronoi(xg)
  xv = st_collection_extract(xt)
  return(xv)
}
```

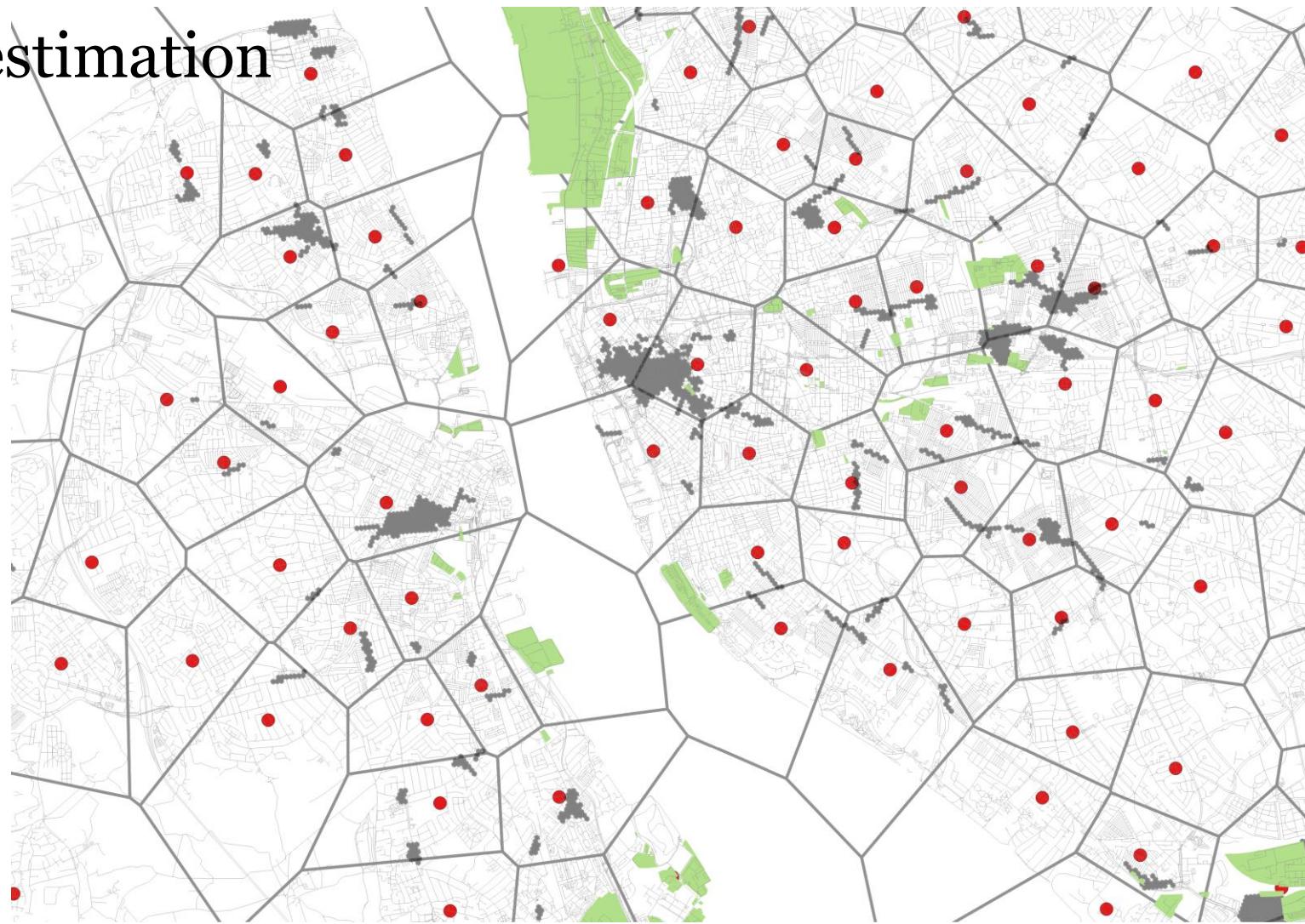




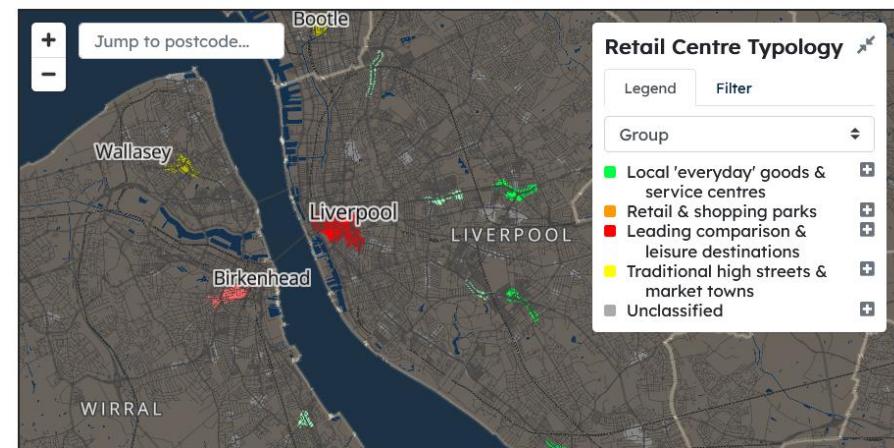
Likely destination estimation

Industrial land-uses:

```
## Function for downloading Land use
getIndLU <- function(place = "Liverpool, UK") {
  bb <- place
  ind_lu <- bb %>%
    opq() %>%
    add_osm_feature(key = "landuse", value = "industrial") %>%
    osmdata_sf()
  poly <- ind_lu$osm_polygons
  poly <- st_as_sf(poly)
  poly <- poly %>%
    select(osm_id, geometry)
  return(poly)
}
```



Retail centres:



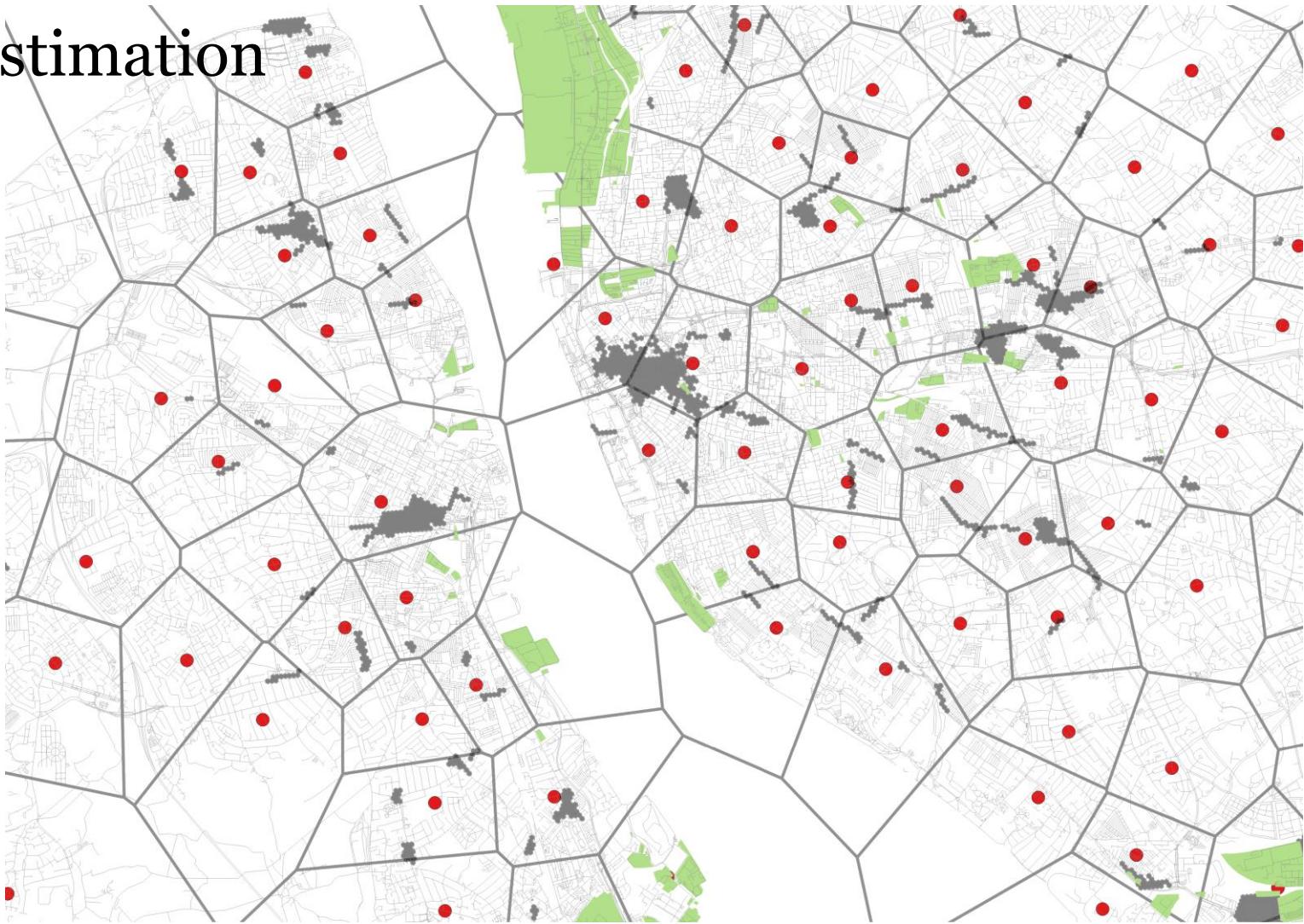


Likely destination estimation

A decision tree (sort of):

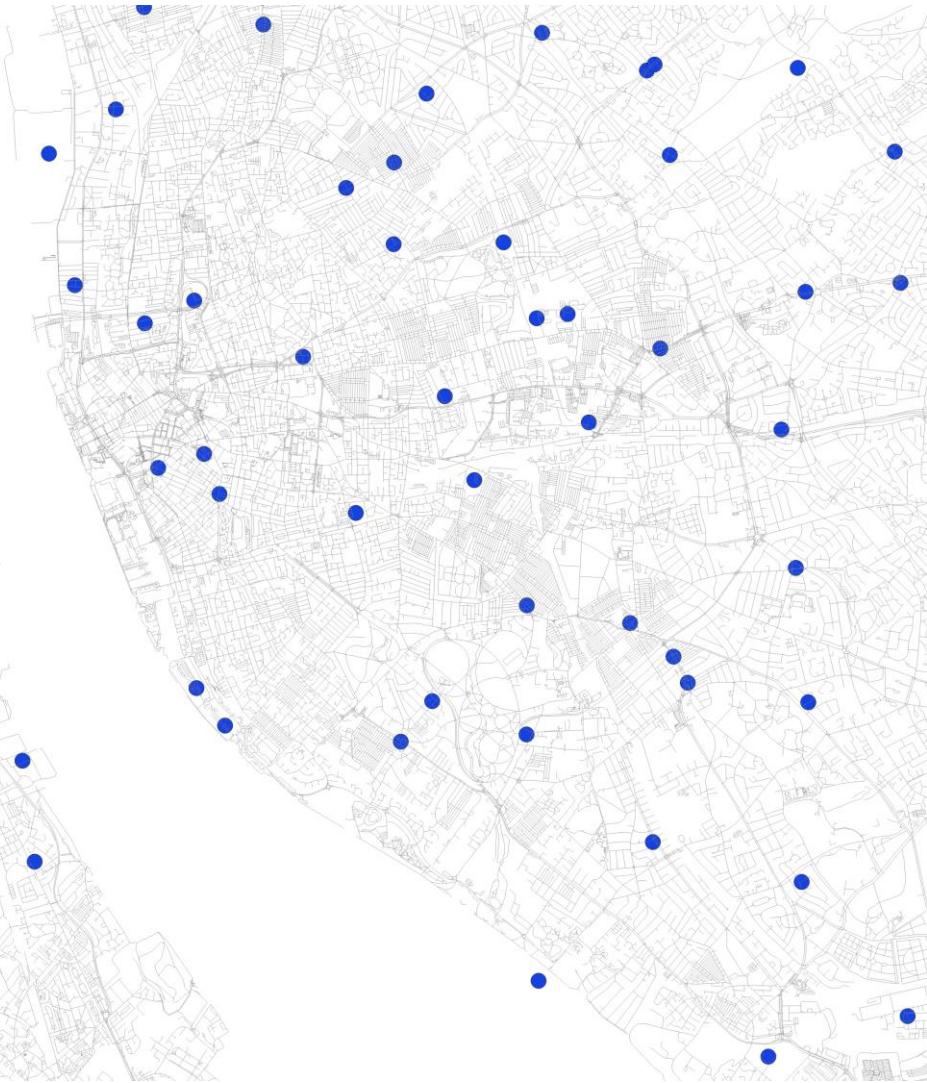
```
## Function for re-adjusting freight centroids
identifyNewCentroids <- function(tz) {

  tz_lu <- st_intersection(lu, tz)
  if(nrow(tz_lu) > 0) {
    lu_cent <- st_centroid(tz_lu)
    lu_cent$centroidType <- "Industrial Land-Use"
    return(lu_cent)
  } else {
    tz_rc <- st_intersection(rc, tz)
    tz_rc <- tz_rc %>%
      filter(!is.na(nUnits)) %>%
      filter(nUnits == max(nUnits)) %>%
      select(tzID, geom)
    if(nrow(tz_rc) > 0) {
      rc_cent <- st_centroid(tz_rc)
      rc_cent$centroidType <- "Retail Centre"
      return(rc_cent)
    } else {
      tz_cent <- st_centroid(tz)
      tz_cent <- tz_cent %>%
        select(tzID, geom)
      tz_cent$centroidType <- "GBFM Centroid"
      return(tz_cent)
    }
  }
}
```



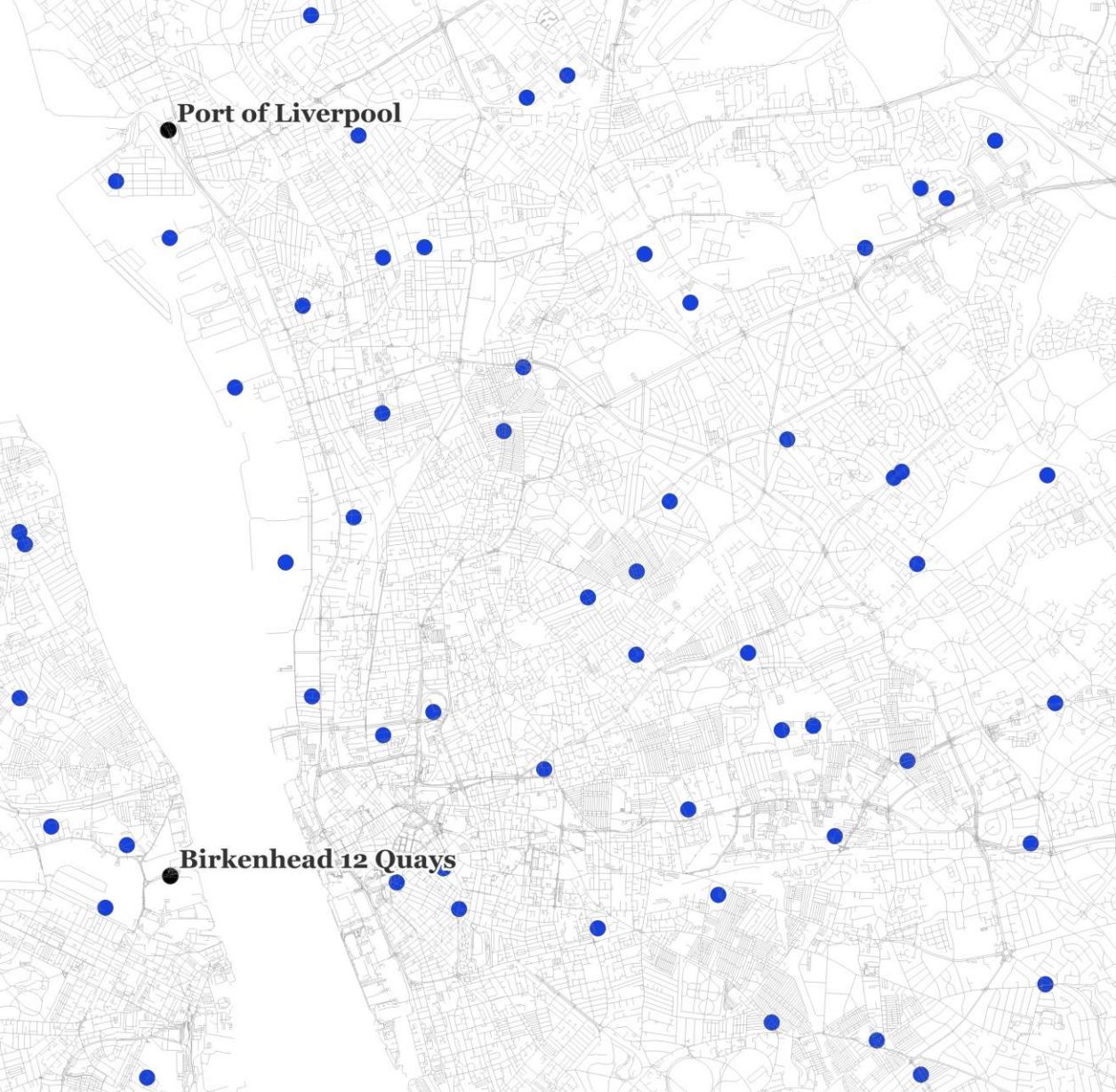


Likely destination estimation





Likely route estimation





Likely route estimation

Open Source Routing Machine

osrm-backend CI passing codecov 93% chat 8 online

High performance routing engine written in C++ designed to run on OpenStreetMap data.

The following services are available via HTTP API, C++ library interface and NodeJs wrapper:

- Nearest - Snaps coordinates to the street network and returns the nearest matches
- Route - Finds the fastest route between coordinates
- Table - Computes the duration or distances of the fastest route between all pairs of supplied coordinates
- Match - Snaps noisy GPS traces to the road network in the most plausible way
- Trip - Solves the Traveling Salesman Problem using a greedy heuristic
- Tile - Generates Mapbox Vector Tiles with internal routing metadata





Likely route estimation

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ropensci/stplanr

Sustainable transport planning with R



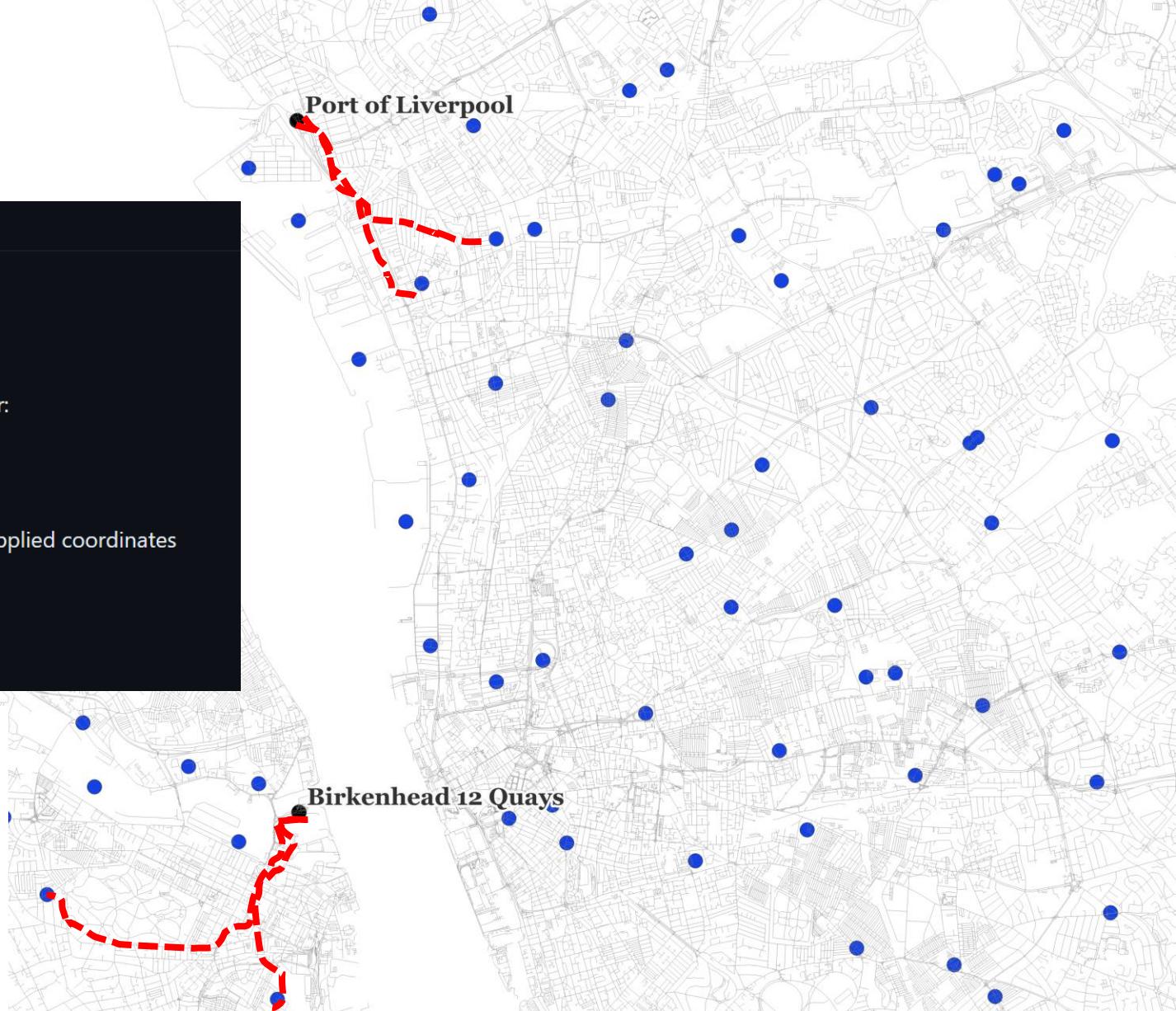
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Forks



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Likely route estimation

Thicker lines = More trucks





Likely route estimation

Thicker lines = More **emissions**

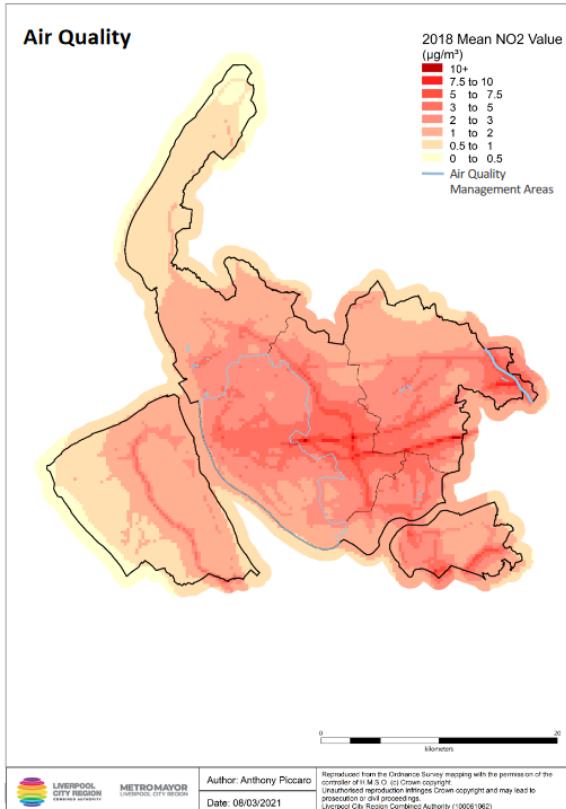




Discussion: next steps



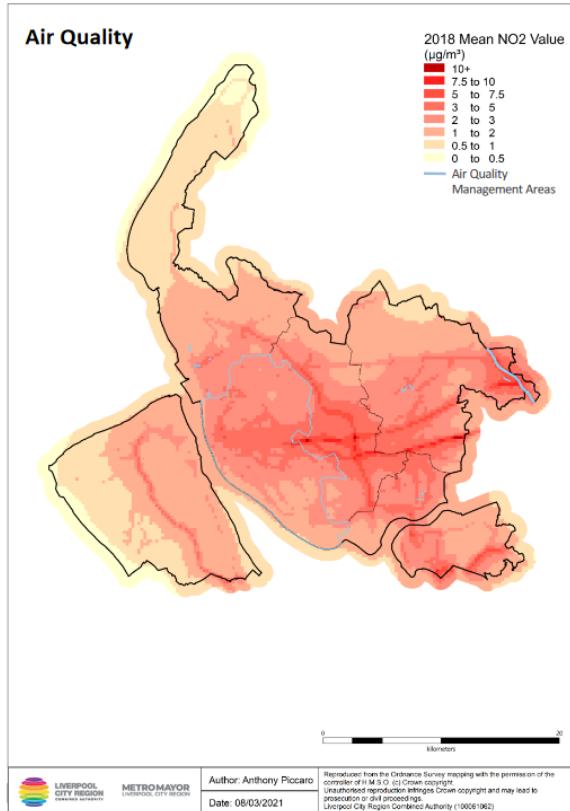
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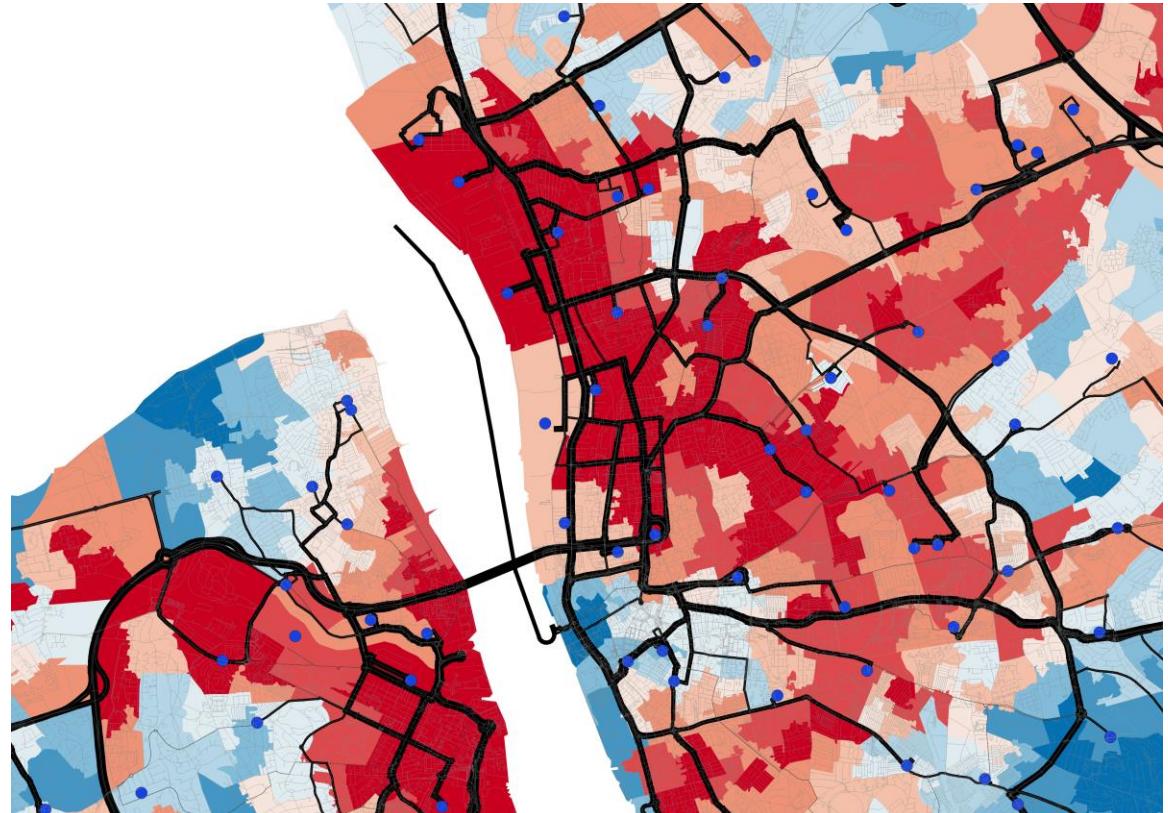
Quantifying GHG emissions and exposure from HGVs in LCR CA



Discussion: next steps



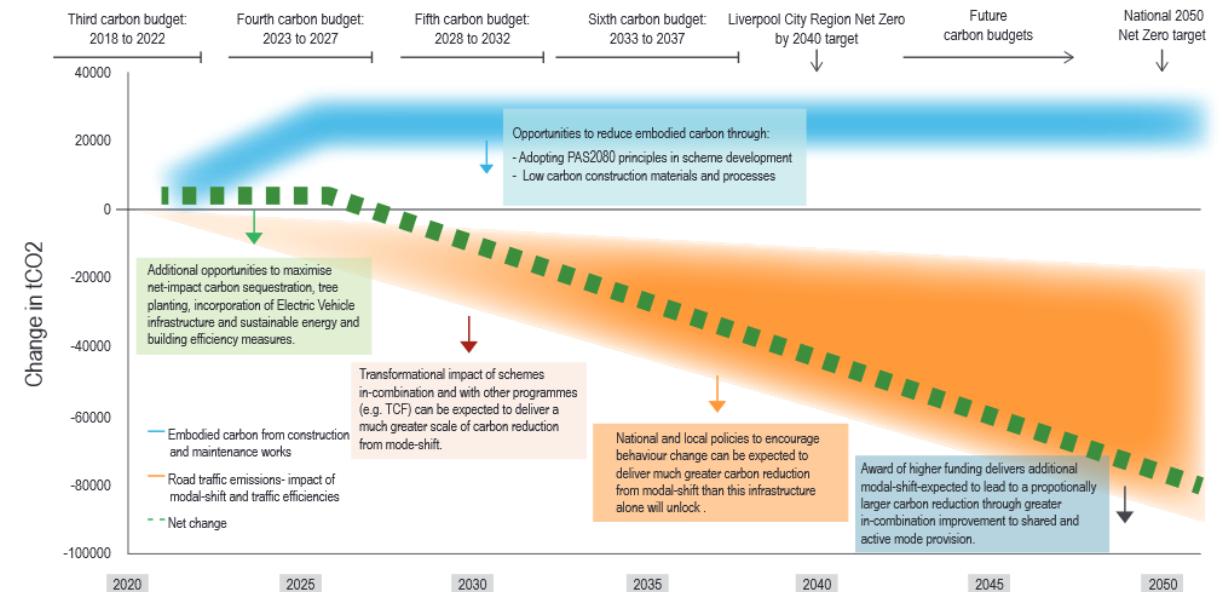
Quantifying GHG emissions and exposure from HGVs in LCR CA



Understanding the socio-economic characteristics of population exposure



Discussion: next steps



Evaluating the impacts of potential decarbonisation strategies*

*LCR CA have made a commitment to reach net zero carbon by 2040



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