Building a spatial participatory approach to locate urban logistics facilities, by eliciting experts' opinions

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Aim of the study

- Opinions of experts on the location of logistic facilities
- Participatory method to identify the most suitable locations
- Application to the case study of Dublin

Introduction

- Urban logistics is an increasingly important aspect of the urban planning and mobility sectors (Lagorio et al. 2016).
- To mitigate the impacts of city logistics, various measures can be implemented, including consolidating goods to reduce driving distances and using new technologies that can benefit the entire supply chain (Giuffrida et al. 2022).

75%

of the total EU population live in cities

70 b€

global cost of last mile deliveries

25%

urban freight is responsible for CO2 emissions

40%

road space taken up by delivery networks

Method and application

- Logistics facilities constitute an essential part of the supply chain

  - Loading bays: **physical bay** within the urban area and road network where freight vehicles can stop to **perform a delivery** to a nearby receiver and conduct any necessary cargo handling activities without disrupting traffic flow (Alho and de Abreu e Silva, 2014).
  - Parcel lockers: **automated boxes** that allows users for a **self-service** collection of parcels. They can be used as a delivery address or as an alternative delivery location, and also used as a service by logistics operators in a customer return strategy (Lagorio and Pinto, 2020).

Method and application

- Loading bays and parcel lockers permit an efficient and safe delivery of parcels in urban areas
- The correct location of such provisions can take advantage of different location-allocation methods that could be used to decide which area agrees with high technical standards.
- Literature addressed the topic for such facilities (e.g. Aiura & Taniguchi, 2006; Dezi et al., 2010; Dablanc et al., 2011; Comi et al., 2018; Lachapelle et al., 2018)
- Stakeholders' involvement is essential in urban logistics issues

Problem Statement

- The high technical standards can be used as a basis to determine the optimal location of such provisions through traditional **location-allocation methods**.
- However, such decisions cannot be based solely on quantitative data (sometimes absent or partially available), or on predictive models. They may require a **participatory approach** involving groups of experts (stakeholders, local authorities, governmental bodies, etc.).
- To ensure the effective functioning of logistic facilities, it is crucial to employ a participatory method that guarantees their location in a technically robust area widely accepted by **decision-makers**.

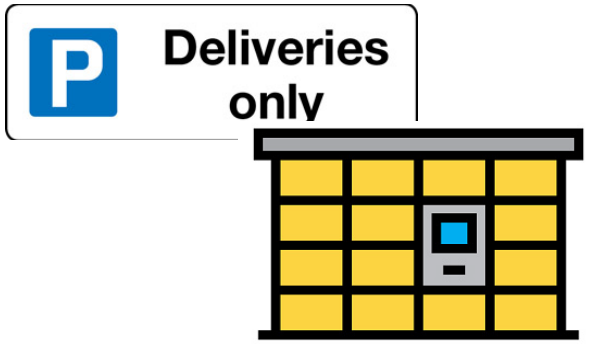
Method and application

TECHNICAL ANALYSIS | PARTICIPATORY APPROACH | SHARED DECISION

Criteria selection → Eliciting experts' opinions → Real-Time spatial Delphi → Robust decision on location

From literature review:

- Aiura & Taniguchi, 2006
- Comi et al., 2018
- Dezi et al., 2010
- Dablanc et al., 2011
- Delaître & Routhier, 2010
- Lachapelle et al., 2018
- …



Eliciting experts' opinions

Senator

Sustainable Urban Logistics Planning: locating Loading bays and Parcel Lockers in Dublin

Dear respondent,
We are a research group composed by members of the University College Dublin and of the Polytechnic University of Bari.

If you have received this form is because we believe that your participation is essential as you have valid expertise in our context of interest.

We are conducting a research whose aim is to identify suitable locations for automated parcel lockers and smart loading bays in urban areas and city centers. The study is part of the H2020 project SENATOR (Smart Network Operator Platform enabling Shared, Integrated and more Sustainable Urban Freight Logistics, https://www.senatorproject.eu/).

We thank you in advance for your time and cooperation!

For any information:

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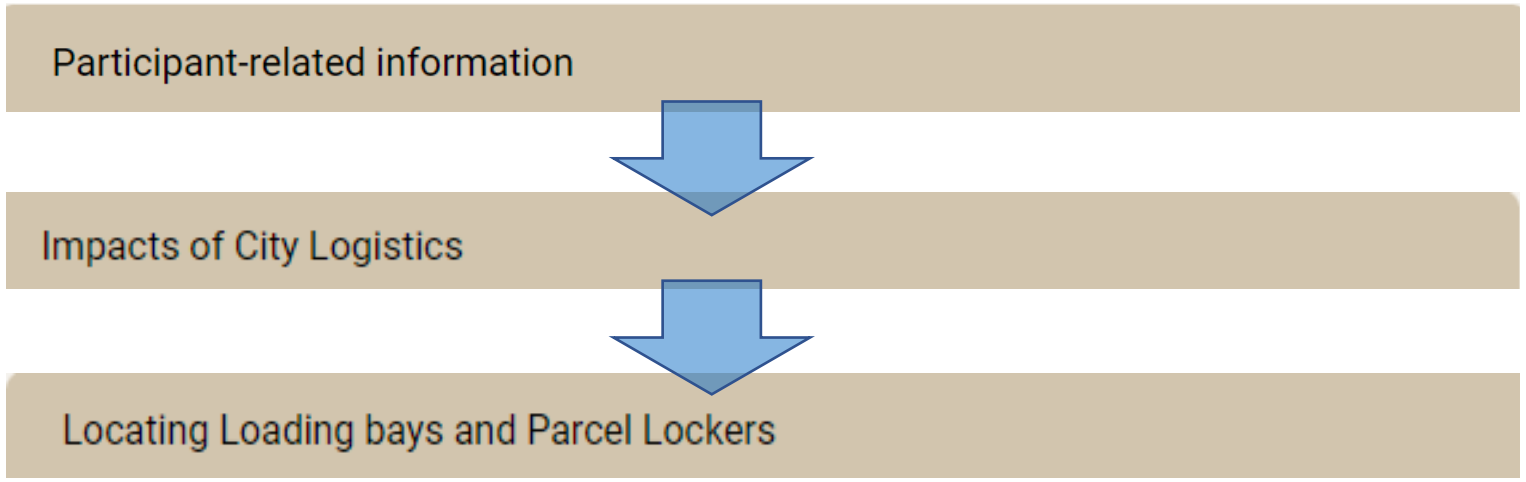
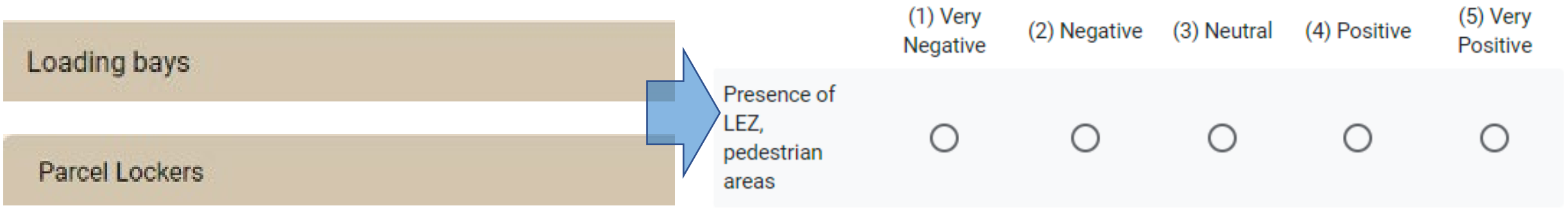
Have a look!

Eliciting experts' opinions





Eliciting experts' opinions

Impacts of City Logistics

City Logistics is a phenomenon steadily increasing in recent years due to the ongoing urbanization and changes in consumer behaviour, such as e-groceries, e-commerce and same-day-delivery orders. While urban logistics vehicles account for up to 15% of traffic only, they contribute significantly to urban air polluting emissions, and they are responsible for climate change. Different logistics companies operating in the same city often perform their services to broadly the same locations with an overlapping delivery network and by taking up to almost half of road space; moreover, logistics vehicles are disproportionally involved in fatal collisions, undermining the social sustainability of cities.

If you want to get more information on the impacts of city logistics, please have a look at the two documents:

- Iclei (2021). Ecologistics, Low carbon freight for sustainable cities.

- Interreg Europe, 2020. Sustainable Urban Logistics. A Policy Brief from the Policy Learning Platform on Low-carbon economy

Based on these premises and your experties, which sustainability dimension is most affected by City Logistics? *

	First	Second	Third
Economic	○	◉	○
Social	◉	○	○
Environmental	○	○	◉

Comments

La tua risposta

Eliciting experts' opinions

- The spatial features are divided according to three categories:
- Topology and geometry of the location, e.g.: characteristics related to the geometric features of the streets where the facility might be located; presence of Points of Interest
- Demand and Accessibility, e.g.: presence of users, socio-economic characteristics of the area
- Traffic and Operation, e.g.: motorized traffic, presence of similar facilities

Eliciting experts' opinions

Loading bays

Factors related to the topology and geometry of location:

- One-way street or a road with one lane in each direction (Aiura & Taniguchi, 2006; Delaître & Routhier, 2010)
- Presence of off-street parking facility (Aiura & Taniguchi, 2006)
- High Slope (Aiura & Taniguchi, 2006)
- On street parallel parking (Aiura & Taniguchi, 2006; Delaître & Routhier, 2010)

Eliciting experts' opinions

Loading bays

Factors related to Demand and Accessibility:

- Presence of goods receivers (e.g. retailers) (Comi et al., 2018)
- Presence of end consumers (e.g. citizens) (Comi et al., 2018)
- Presence of transport and logistics operators offices (Comi et al., 2018)
- Long distance from the loading bay to the customer (Aiura & Taniguchi, 2006)
- Presence of Public Transport stops and terminals (Cochrane et al., 2017)

Eliciting experts' opinions

Loading bays

Factors related to Traffic & Operation

- Presence of LEZ, pedestrian areas (Dezi et al., 2010; Dablanc et al., 2011)
- Low motorized traffic volume (Alho et al., 2018)
- Presence of traffic lights (Alho et al., 2018)
- High freight traffic volume (Dezi et al., 2010)
- Presence of other loading bays (Dezi et al., 2010)

Eliciting experts' opinions

Parcel Lockers

Factors related to the topology and geometry of location:

- Presence of car parking (Lachapelle et al., 2018)
- Presence of bike rack or station (Lachapelle et al., 2018)
- On arterial road (Lachapelle et al., 2018)
- On public property (Lachapelle et al., 2018)
- Outdoors (Lachapelle et al., 2018)
- Presence of transit stop (Keeling et al., 2021; Rohmer & Gendron, 2020; Iannaccone et al., 2021)
- Short distance from Post Office (Lachapelle et al., 2018)

Eliciting experts' opinions

Parcel Lockers

Factors related to Demand and Accessibility

- Proximity: university, commercial activities (Lachapelle et al., 2018; Mitrea et al., 2020; Iannaccone et al., 2021)
- Area with high population density (Lachapelle et al., 2018; Schaefer et al., 2021)
- Socio-demographic factors: income, unemployment, age, access to internet, education (Lachapelle et al., 2018; Schaefer et al., 2021; Mitrea et al., 2020)
- Accessibility: public transport and private vehicle (Faugere, L., Montreuil , 2017; Lemke et al., 2016; Iwan et al., 2015; Lachapelle et al., 2018; Mitrea et al., 2020; Iannaccone et al., 2021)

Eliciting experts' opinions

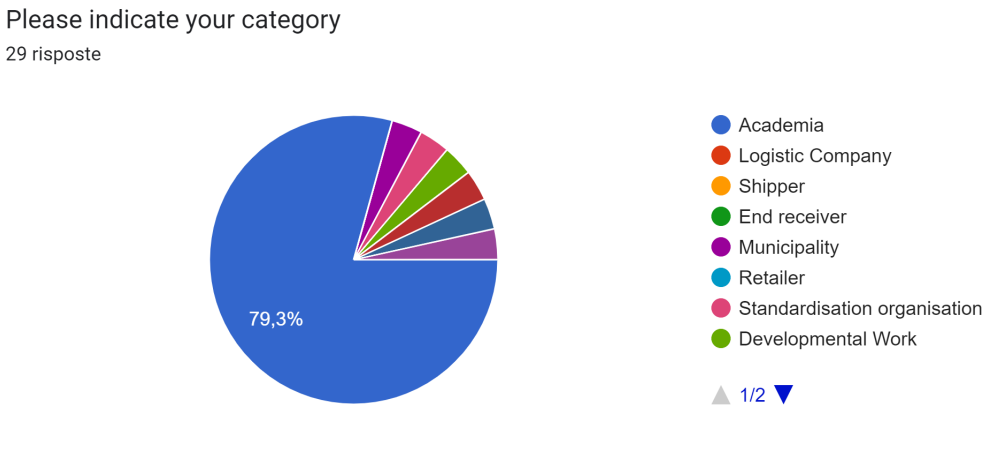
Parcel Lockers

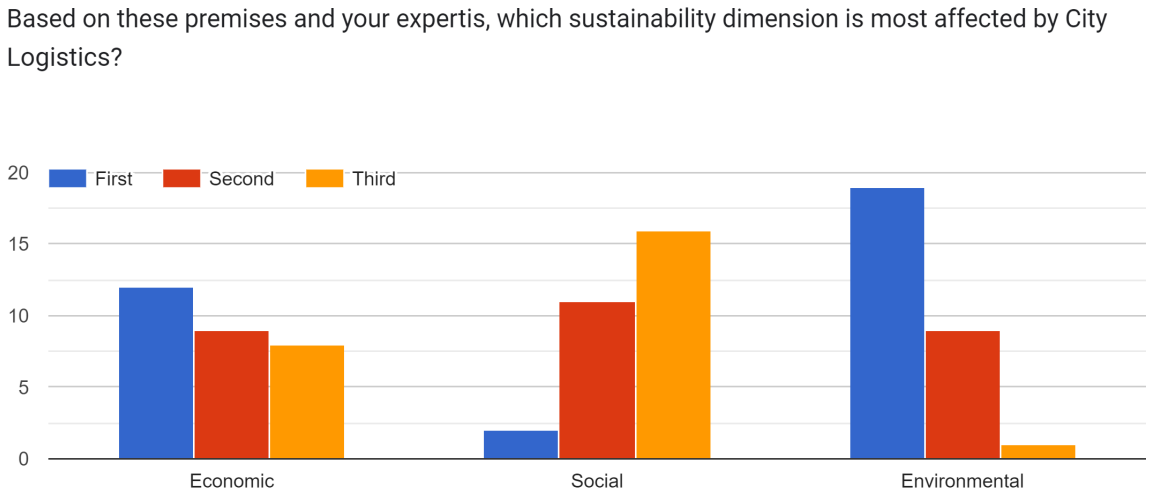
Factors related to Demand and Accessibility

- Presence of another parcel locker (Lachapelle et al., 2018)
- High freight traffic volume (Dezi et al., 2010;)
- Low motorized traffic volume (Alho et al., 2018)
- Presence of LEZ, pedestrian areas (Dezi et al., 2010; Dablanc et al., 2011)

Results from the survey

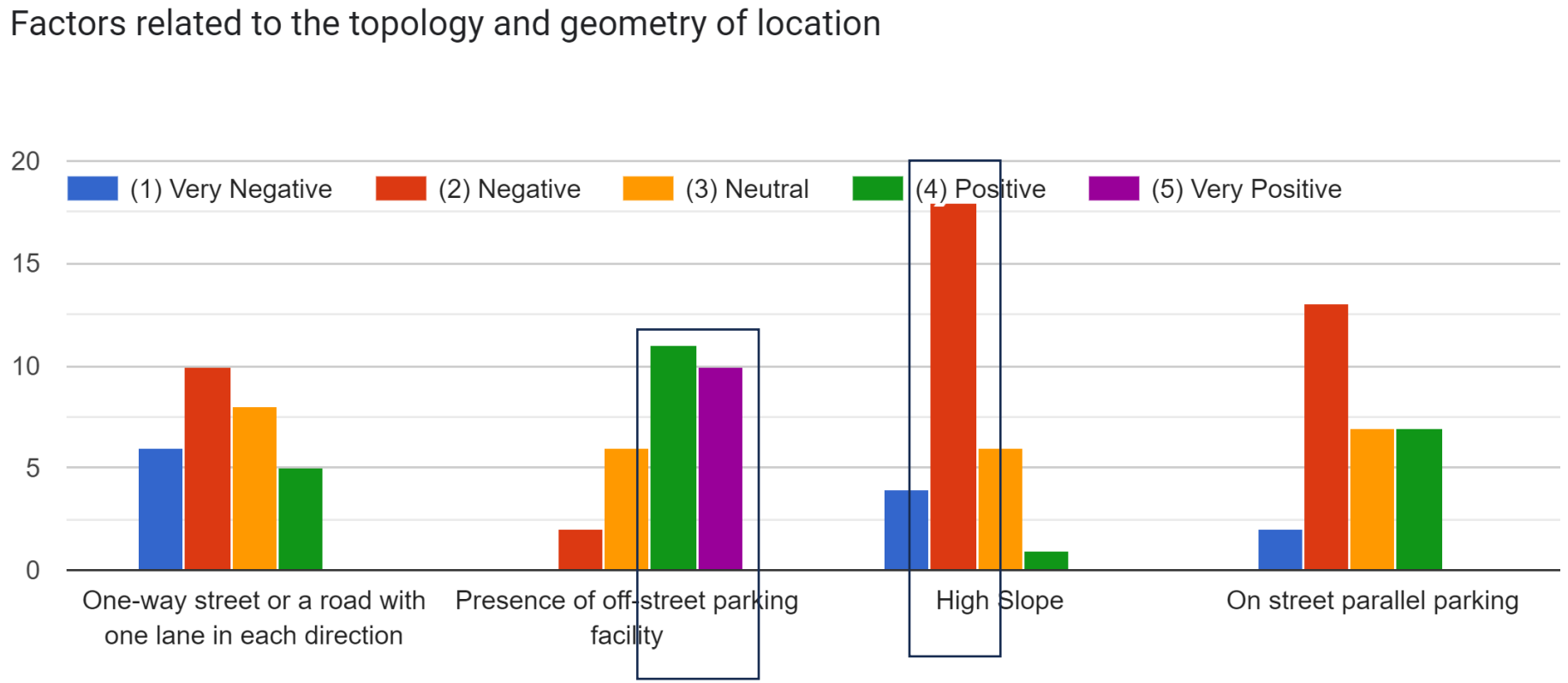
- The questionnaire has been filled by N = 29 experts, in a time span of 1 month.





Results from the survey

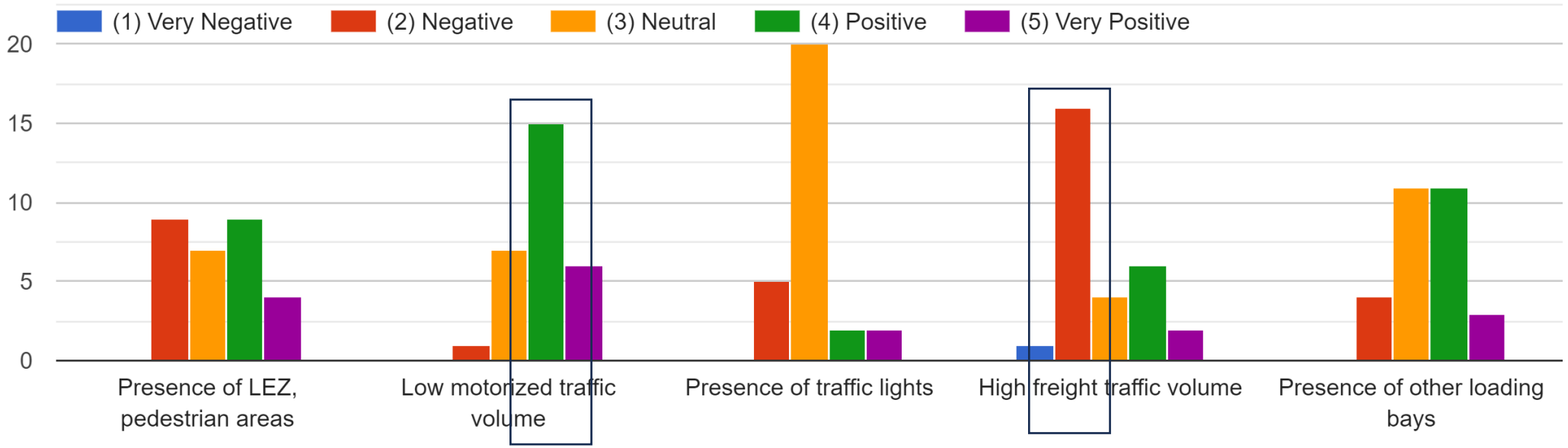
Loading bays



Results from the survey

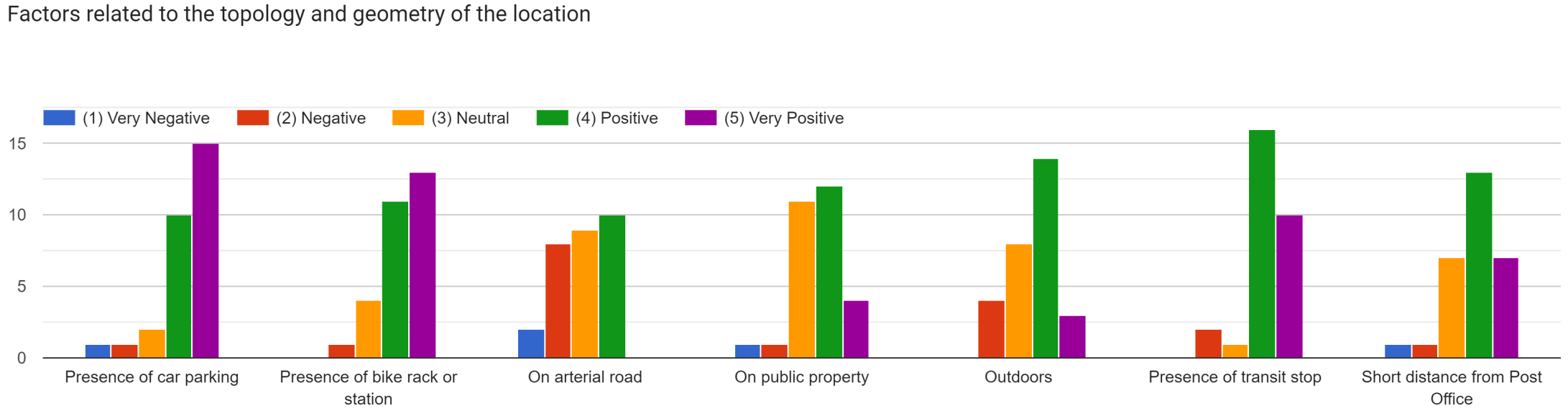
Loading bays

Factors related to traffic and operation



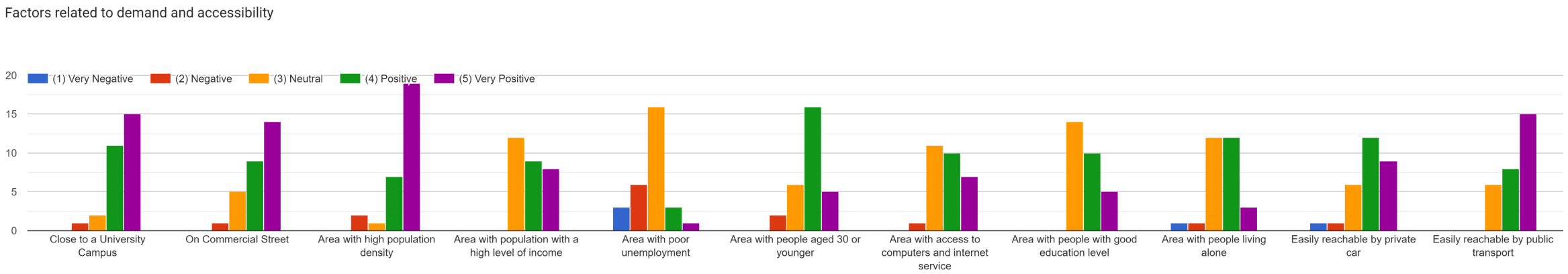
Results from the survey

Parcel Lockers



Results from the survey

Parcel Lockers



Results from the survey

Open Comments

- *You want some concentration of loading bays so deliveries from the loading bays to the ultimate recipient may be consolidated. Too much concentration causes congestion/peak demand for delivery to the loading bays.*
- *I think that these areas need to be out of the city or in the perimeter to put the heavy vehicles out of the urban centre*
- *Parcel lockers will always attract some motorized traffic, so easy parking is needed*
- *We need to think in these areas because of the proximity of people to them. If a person needs to use a car or a motorcycle to get there we are failing. People may to walk or cycle to them in less than 15 minutes.*

GIS-based compatibility index

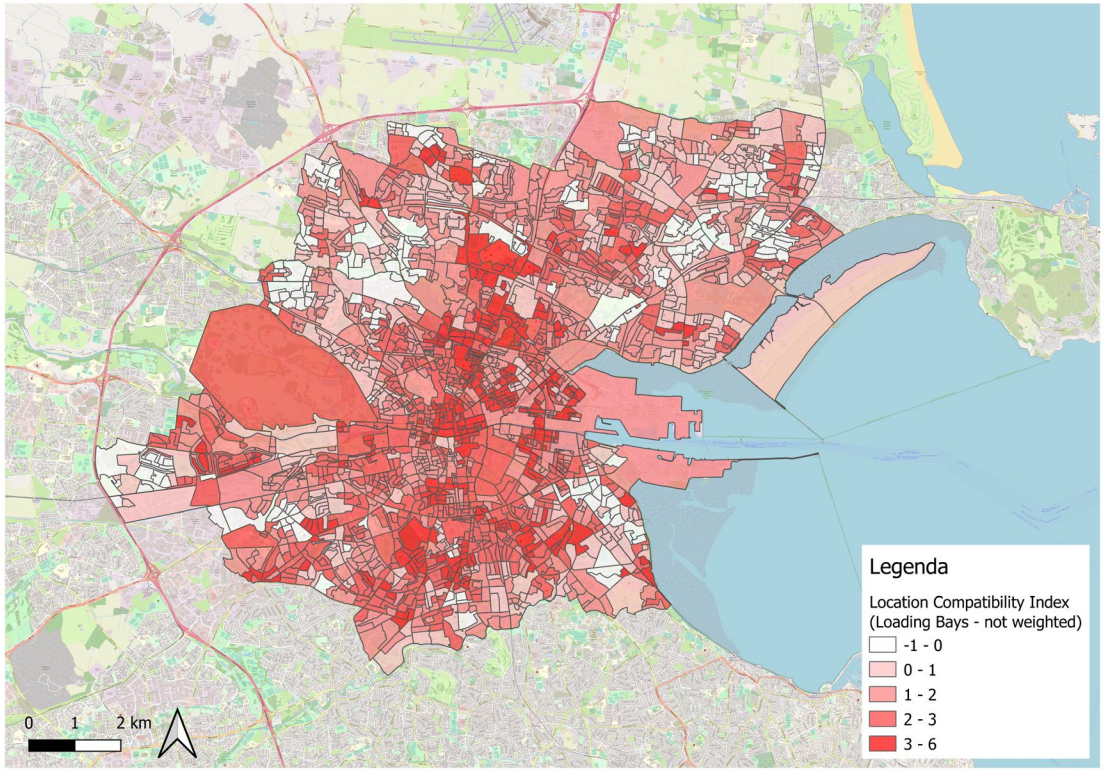
$$LCI_{LB} = \left(\sum_{1.i}^{4} w_{1.i} C_{1.in} + \sum_{2.i}^{5} w_{2.i} C_{2.in} + \sum_{3.i}^{5} w_{3.i} C_{3.in}\right)_{LB} \quad (1)$$

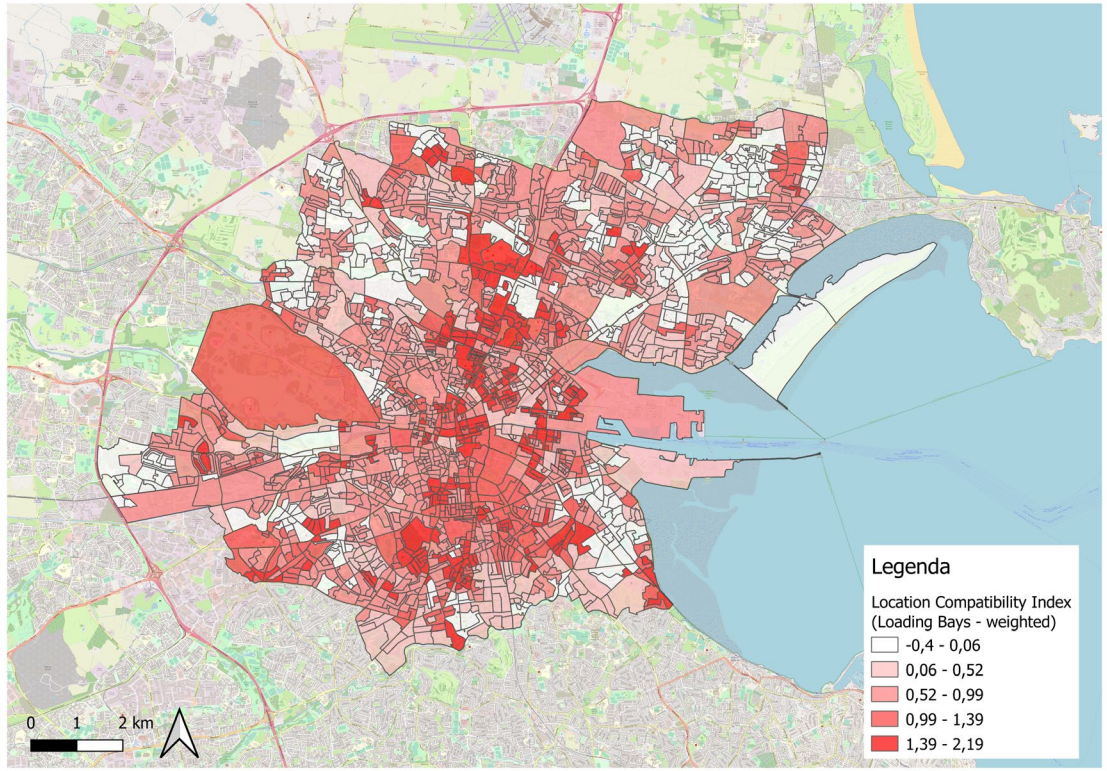
$$LCI_{PL} = \left(\sum_{1.i}^{7} w_{1.i} C_{1.in} + \sum_{2.i}^{5} w_{2.i} C_{2.in} + \sum_{3.i}^{5} w_{3.i} C_{3.in}\right)_{PL} \quad (2)$$

where $w_{1,i}$, $w_{2,i}$, $w_{3,i}$ are the average weights set according to experts' opinions for each criterion and Ci are the criteria

GIS-based compatibility index

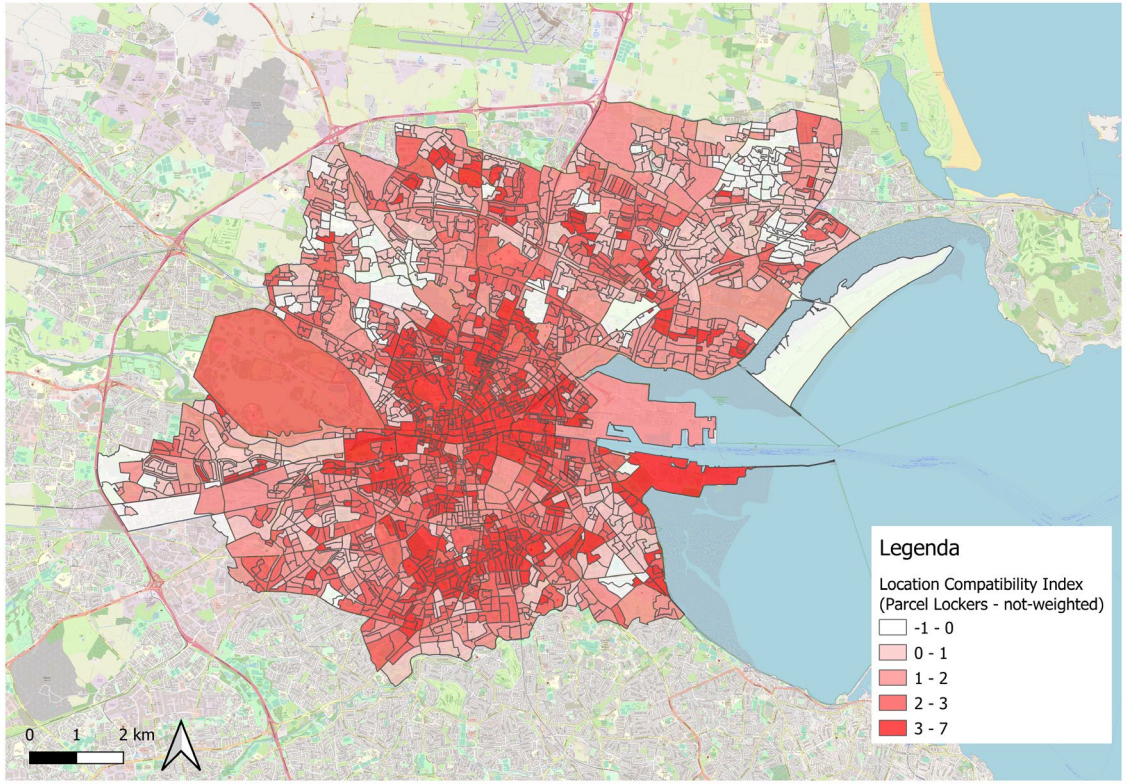
Loading bays

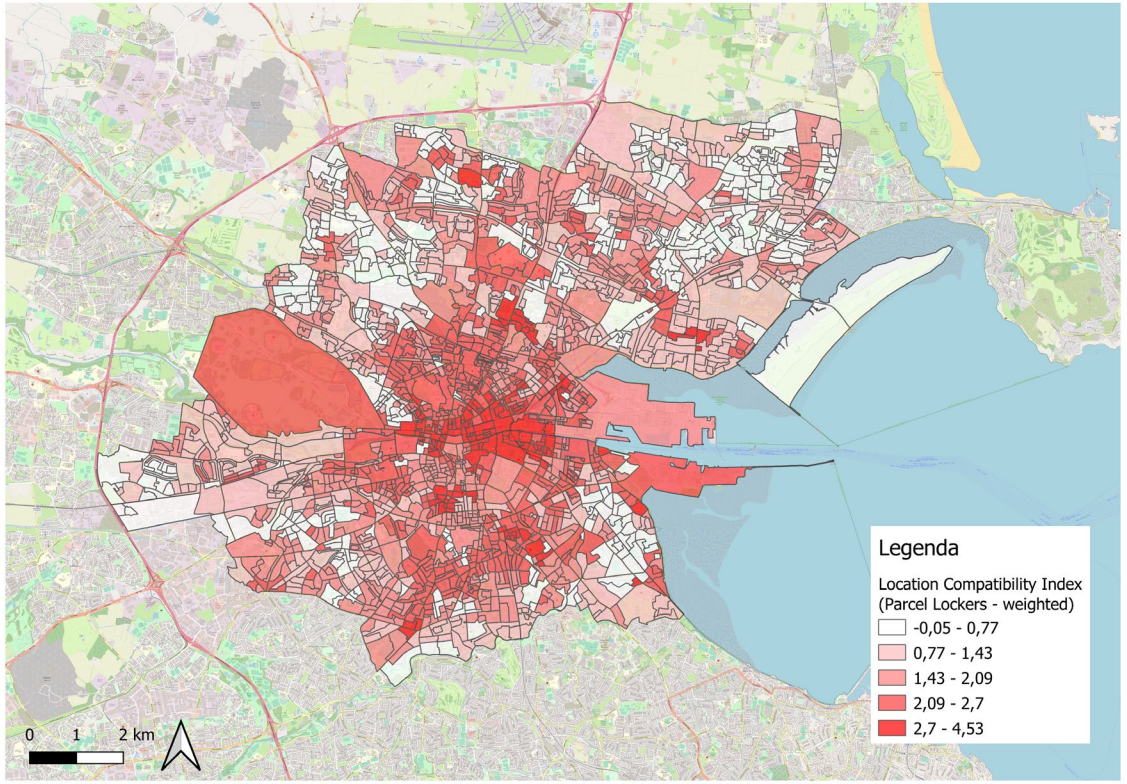




GIS-based compatibility index

Parcel Lockers





Real-Time Geo-Spatial Consensus System

www.rtgscs.com

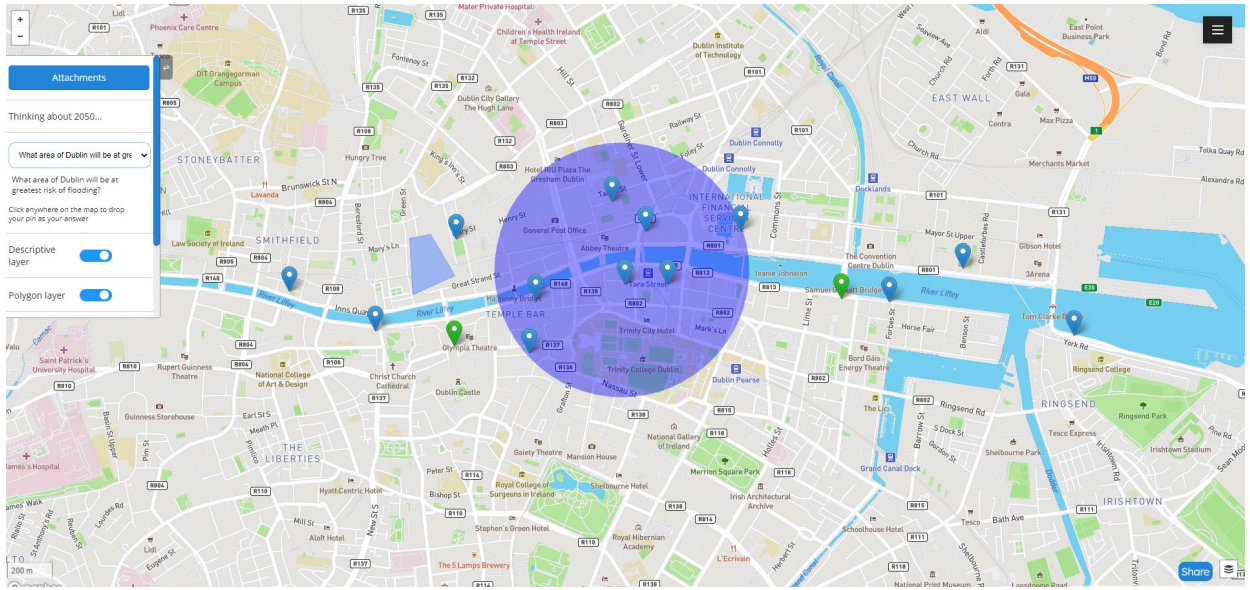


Fig. 1. RT-GSCS Interface

Fig. 2. RT-GSCS Logo

Developed by Calleo Y., Di Zio S. and Pilla F.

Real-Time Geo-Spatial Consensus System

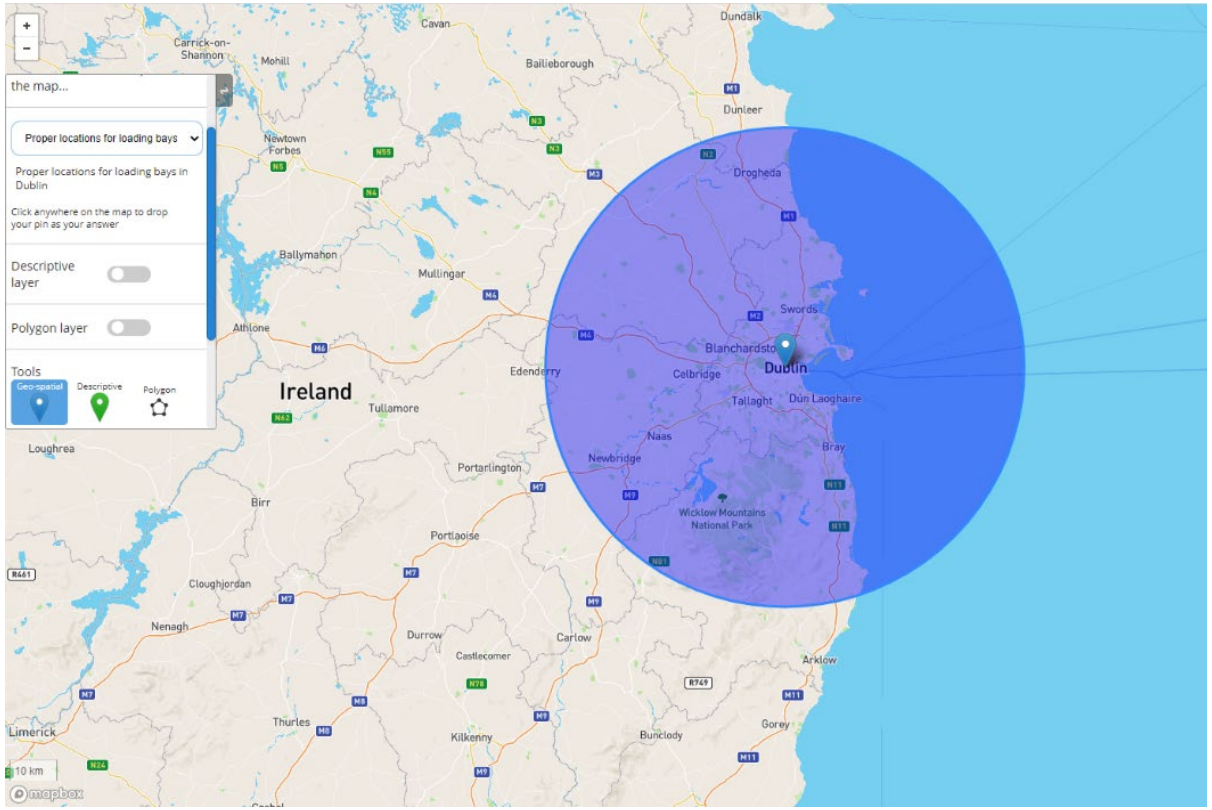


Table 13. Panellists involved

	Contacted panellists	Participating panellists
Internal	13	4
External	32	26
Total	45	30

Two Delphi questions related to the spatial locations of the facilities:

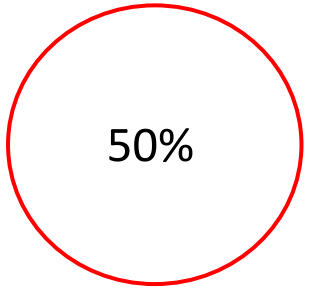
"Please, indicate with a point on the map...

- RQ1: Proper locations for loading bays in Dublin
- RQ2: Proper locations for parcel lockers in Dublin"

Platform click on the map and insert a pin on the preferred location; the platform automatically registers the response and its geographic coordinates.

They were provided with GIS-based compatibility index maps

Statistical Algorithm



Spatial convergence

a circle containing at least 50% of the opinions

- **Geometric element** (C) including 50% of N judgments
- $N = n_1, n_2, n_3, \ldots, n_j$ is the number of the experts' judgments on a question (points on the map).
- We want to find a **minimum area** A_i of a circle C_i covering half of those points: $A_i \supseteq T_{N/2}$ where $T_{N/2}$

denotes a set containing 50% of the points.

- Since there are infinite circles, we impose the constraint that C_i must have its centre in one of the

N points .

- For each question we find an ordered vector $A = A_1, A_2, A_3, \ldots, A_N$ where A_i is the area of a circle containing 50% of the N points and centered in point n_i . Then, $\min(A)$ corresponds to the geo-consensus radius.

Geographical results

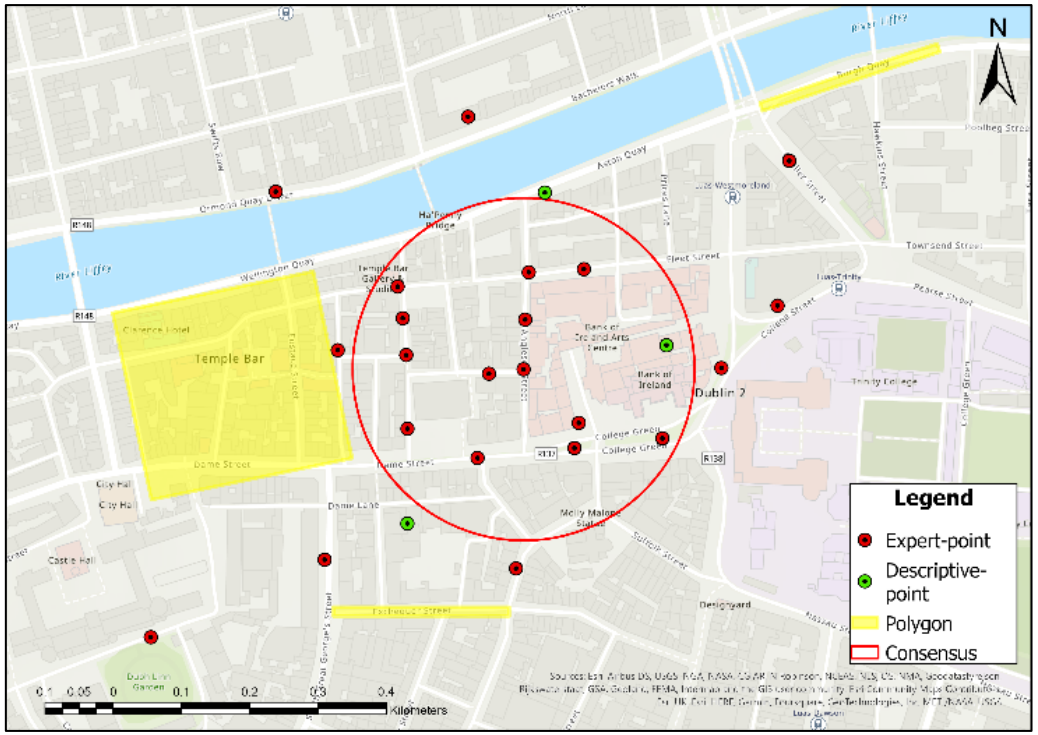


Fig. 3. Loading Bays

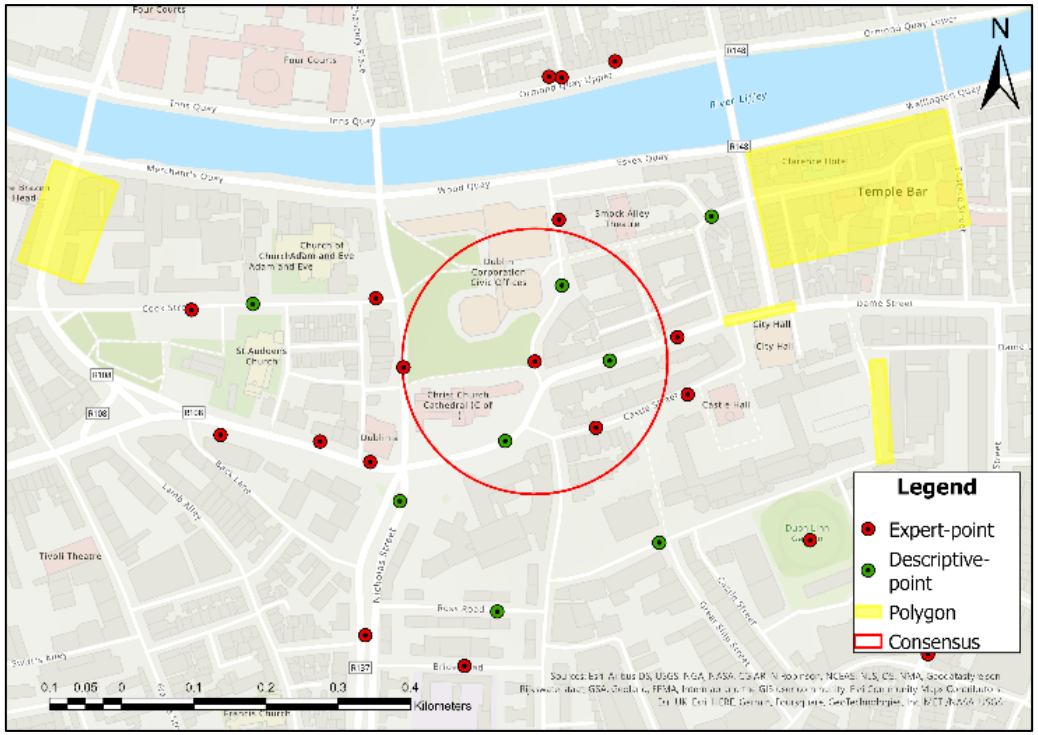


Fig. 4. Parcel Lockers

Geographical results: *heatmaps*

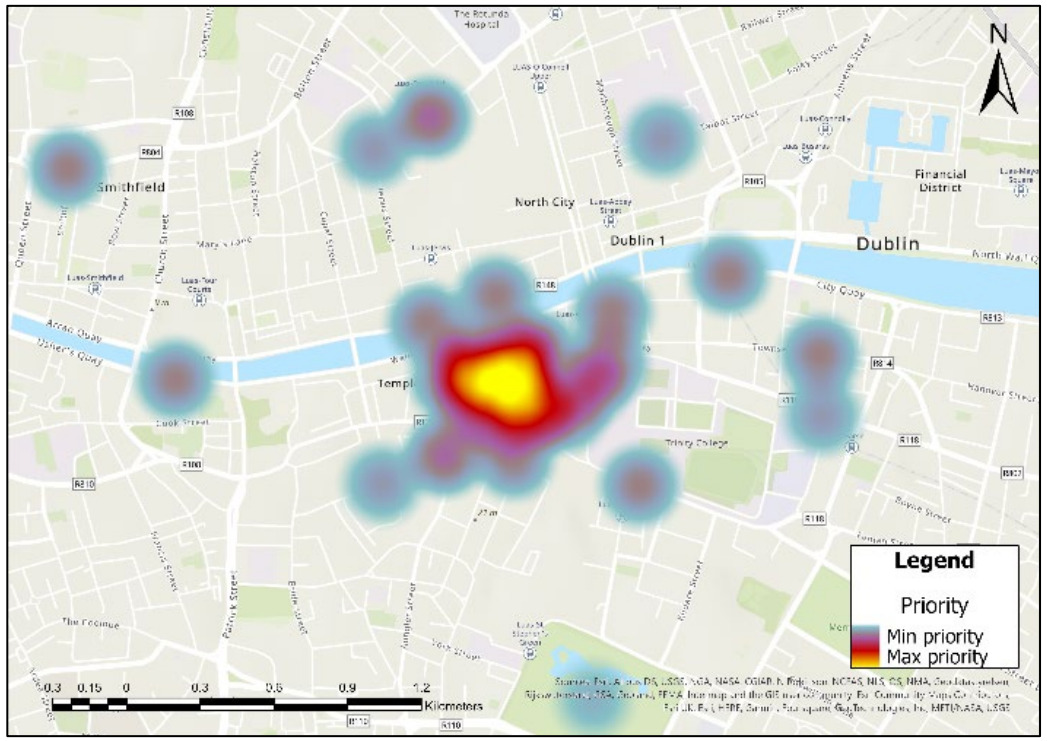


Fig. 5. Loading Bays: heatmap

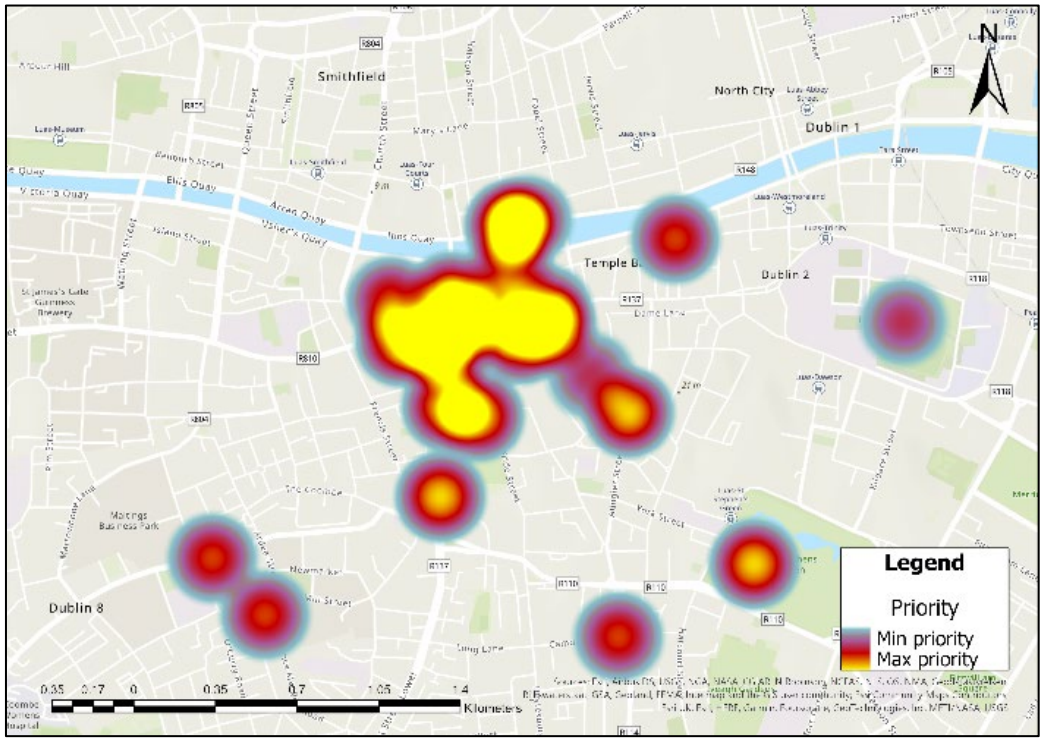


Fig. 6. Parcel lockers: heatmap

Results: Spatial consensus

- M_1. This indicator shows the final circle area in km^2.
- $M_2 = 1 - \frac{FC}{S}$. This indicator shows the degree of geo-consensus where the more the measure is close to 1, the more the circle is small compared to the surface of the study area.
- $M_3 = \frac{FC}{IC} \cdot 100$. This indicator shows the metric of consensus among participants, and the higher the value (close to 100%), the more we have a lower convergence of opinions among the panellists. The more the percentage is close to zero, the higher the spatial consensus.

Id	Study Area (S) ($\boldsymbol{km^2}$)	Initial circle (ic) ($\boldsymbol{km^2}$)	Final circle (FC) ($\boldsymbol{km^2}$) $\boldsymbol{M_1}$	$\boldsymbol{M_2}$	$\boldsymbol{M_3}$	Pins	Comments
LB (Q1)	117.8	1.36	**0.15**	**0.998**	**11.02%**	35	7
PL (Q2)	117.8	1.44	**0.11**	**0.999**	**7.63%**	30	10
Total						65	17

Results: Time Series

- **Time series:** We consider the stability achieved when the last few points (typically around 5% of N) do not significantly change the circle size (Von Der Gracht, 2012).

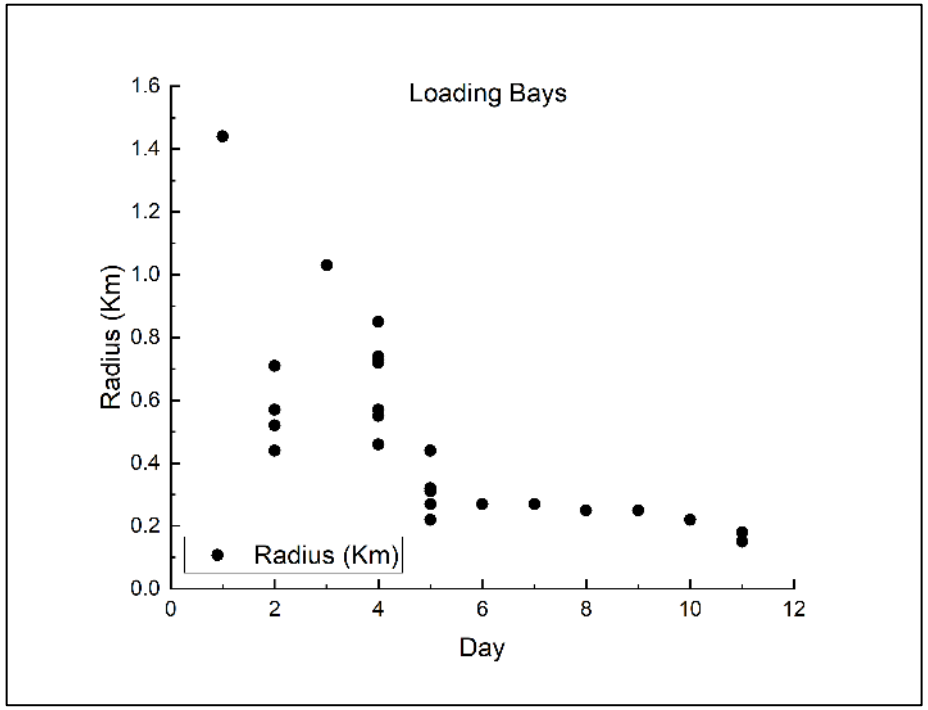


Fig. 6. Loading Bays: time series

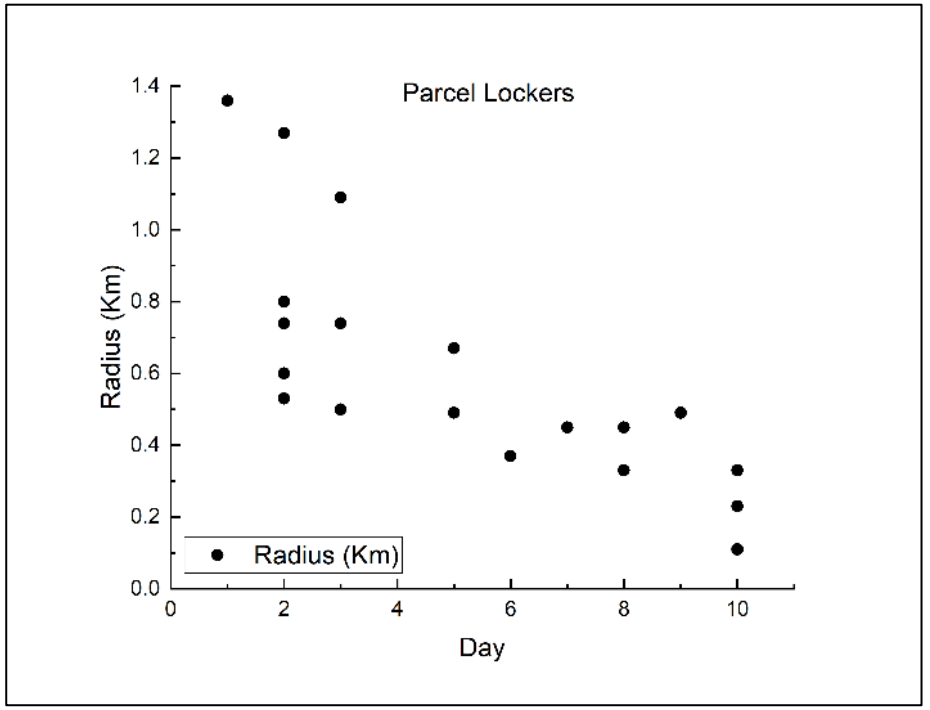


Fig. 6. Parcel lockers: time series

Conclusions and Future Works

- Novel **spatial participatory approach** useful to identify suitable locations for loading bays and parcel lockers
- Logistics experts identified as relevant almost all the location criteria present in the literature analysis
- The **use of weights** in the computation of the localization compatibility index **reduces the number of compatible zones** and allows an improvement of the selection process

Conclusions and Future Works

- The study shows that **Real-Time Spatial Delphi** could be a useful tool to ensure that logistic facilities are located in a technically robust area.
- RTSP revealed a **high degree of consensus among the participants**, as indicated by the convergence measures M_2 and M_3.
- At the moment, RTSD applies to the **search for a single point** for each question and since there are several suitable points for both PL and LB in a city, it is evident that there are many suitable locations for this purpose
- Possibility to have different algorithm working on the same map and the same question to avoid limitations regarding **multiple clusters of points**.

Conclusions and Future Works

- We are working to integrate AI in RTSD and show a visualization of the potential scenarios

Thanks for your attention!

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