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Resharing spaces, services and mobility: Developing a reshareability index for sustainable planning in Oslo

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Highlights

- Resharing dimensions in our cities and urban spaces require a further understanding, both theoretically and empirically
- Resharing is an interplay of spatio-functionality, social and digitalized/shared mobility in our built environment.
- Reshareability index supports the analysis of our neighborhoods for current and future sustainable developments
- Planners should focus on planning approaches to resharing practices by using the reshareability index

Abstract

Recent studies on sharing cities and sharing economies have focused on what can be (or is being) shared, such as public spaces, food, mobility, ideas, knowledge, governance strategies, as well as community facilities, such as places for working, education and welfare. Following this emerging trend of sharing, this paper explores the novel approach of *resharing,* that aims to support, amongst other things, the integration of *mobility sharing* and different forms of *space sharing* in residential, office and commercial buildings. Firstly, the study presents a novel theoretical and conceptual approach to (re)sharing, and secondly, it reports on an empirical analysis conducted in the urban district of Hovinbyen in Oslo, using the sub-districts of Løren and Økern as the two main cases. The study analyzes existing preconditions for *reshareability* and suggests an *index of reshareability* to guide future developments. Løren is, to some extent, better equipped than Økern to apply the resharing approach, and can thus become a place for further experimentation with local communities and stakeholders. The study contributes to understanding and assessing the *reshared qualities* and characteristics of city neighborhoods, which can provide a foundation for developing planning strategies to make local neighborhoods more 'sharing oriented' or 'reshareable'.

Keywords

Resharing dimensions; Shared spaces; Shared mobility; Reshareability index; Planning sustainable neighborhood

1. Introduction

The traditional concept of *sharing* has recently been vastly reconceptualized and discussed in several fields, such as food and urban studies, planning and architecture, mobility and transportation, and tourism, among others (Frenken and Schor, 2017). Scholars have explored, both theoretically and empirically, what can be (or is being) shared in the city, how sharing is beneficial to local communities, and the impacts that sharing may have on sustainable consumption and behaviors (Sanchez-Vergara et al., 2021). Within the sharing economy, different formats have emerged, based on, and supported by technology-driven platforms. As a result, people now often share common needs and interests which can be either rooted in, or free from geographic coordinates – such as various forms of co-living, co-riding and coworking, all of which contribute to more flexible, affordable and environmentally friendly lifestyles (Thompson, 2019). Similarly, within the mobility and transportation domain, shared mobility vehicles (e.g., cars, e-bikes, electric scooters) are being increasingly explored as alternatives to the use of private cars.

Recently, it has been recognized that the integration of shared mobility and spaces – as distributed practices – can affect not only a few urban blocks, but entire neighborhoods and urban spaces at large (Chan and Zhang, 2021). Despite this trend, shared facilities and activities have not yet been scaled up to become an integral part of service provision in various types of buildings and area designs. The topic remains much debated among scholars, including those who focus on residential buildings that cater to a broader group of users, such as elderly people or families with children (Lee et al., 2010). Though shared mobility and the sharing of services and resources has been studied (Frenken and Schor, 2017), the impacts of sharing on consumption and the spatial/place dimension of sharing remain largely unexplored. Cultural and demographic variations – that may condition the sharing activities and mobility practices in neighborhood spaces – remain unrecognized and understudied.

The integration of *mobility sharing* (e.g. electric vehicles, including emerging services and technology) and *space sharing* (e.g. shared workspaces, meeting rooms, indoor gyms, garages) in the same building and/or in neighborhood communities is a novel approach. The authors of this study refer to this phenomenon as *resharing* and have developed a reshareability index – that is, a tool which helps to identify the resharing features and conditions for resharing in a particular location/neighbordhood.

The following assumptions form the basis of our study (supplemented by Section 2). Future development should be based on sharing a combination of modules of mobility and spaces that may (or may not) be currently shared. 'Resharing' hereby refers to a pattern of development, where spaces and modes of mobility are repeatedly examined in the light of different usages and new ways of combining them, in order to react to emerging societal needs. These emerging needs should be exposed to disaggregated analyses based on age, income, education, spatial location etc. Currently, shared spaces and shared mobility are being both planned and analyzed separately, and no effort is being put into merging shared spaces and shared mobility as a cohesive package. Resharing refers to this unified bundle of shared spaces and shared mobility, which is not fixed in time or space, but is amenable to changing, given the context and scope of sharing. Shared spaces become multifunctional, multipurpose and ‘fluid’, and shared mobility modes are then linked to these fluid spaces. 'Fluid' spaces are those that can be converted for different uses in the light of different needs, temporality, scale etc (that is, they offer more functionality options, and by so doing, they optimize the number of hours that the space can be used). For example, a co-shared office could be transformed into a yoga centre in the evenings, and also used as a children's day-care facility on weekends. These shared spaces should be supplemented with shared mobility modes like e-scooters, shared bicycles, car sharing etc. Membership in these shared spaces will typically entail both physical and digital accessibility, which can be granted through residential or working status in a certain defined area. Membership, bookings etc. can be suitably linked with existing forms of access granted to residents, workers and visitors to the area. This form of resharing model can supplement the public sharing hubs that are already present in many cities.

To further clarify the concept of resharing, the authors of this study propose a conceptual framework which reflects how resharing interlinks the three dimensions of spatio-functionality, social and digitalization/shared mobility (see Fig. 1 in Section 2). The framework assists us in identifying features that can support conditions for resharing (and integrating these features with both existing and future shared mobility modes and spaces). The resultant reshareability index (see Section 4.1) is an indicator that assists in analyzing conditions for resharing. To the best of our knowledge, current studies on both shared spaces and shared mobility have not attempted to create such an integrated framework, nor an index to assess the conditions for developing integrated solutions to sharing.

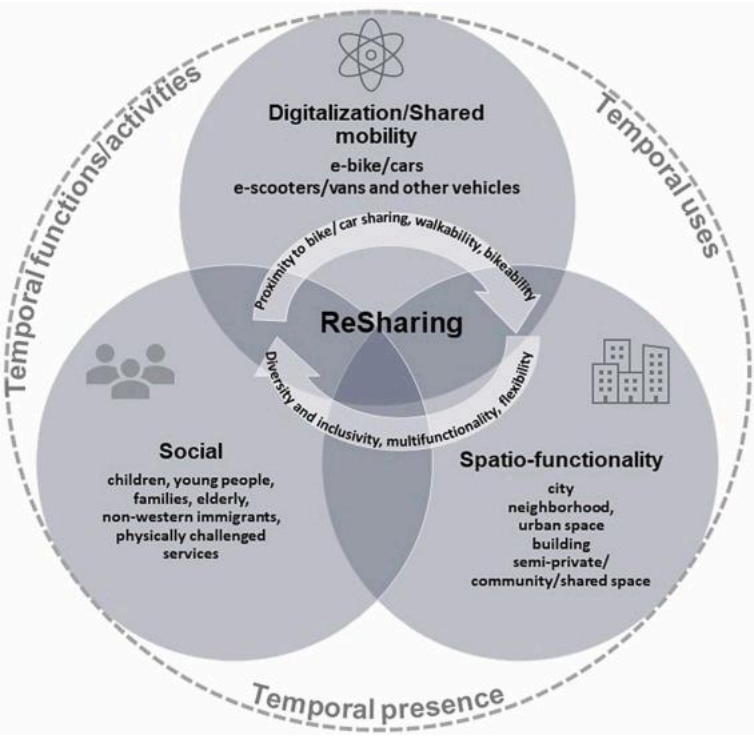

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Fig. 1. Conceptual model of resharing – integration of three dimensions: Spatio-functionality, Social and Digitalization/Shared mobility, including temporality.

Thus, the aim of this study is to explore the *resharing* approach, both theoretically and empirically, by conducting a case study in the district of Hovinbyen, in the north-eastern part of Oslo (with a major focus on the sub-districts of Løren and Økern). The study seeks to analyze the conditions which may support the development of shared mobility and multifunctional shared space solutions. It also investigates their integration into urban development and building projects and develops a reshareability index to quantify factors that support reshareability.

Section 2 reviews theoretical and empirical approaches that support the resharing conceptual framework. In particular, possible dimensions (spatio-functionality, social and digitalization/shared mobility) are first discussed theoretically and then their interlinking is explored within selected existing projects, together with insights into reshareability features that may increase opportunities and conditions for resharing. Section 3 introduces the planning context of Oslo and planning strategies in the district of Hovinbyen and sub-districts of Løren and Økern. Section 4 presents the research methods used in the study, which include spatial analyses using GIS, as well as the development of a reshareability index. This index was then applied to residential, commercial and office buildings in the districts, as well as public spaces in Løren, Økern and surrounding areas. The discussion of the main findings in Section 5 shows that factors such as the typological and functional diversity of buildings, street connectivity, accessibility to urban spaces (such as multifunctional buildings, places and green areas), access to public transport, and sharing car or bicycle hubs can support current and future conditions for reshareability. Section 5 also discusses the reshareability index at the building level (and 250 m at the grid level). In Section 6, the paper presents the main contribution of the study in understanding *reshared qualities* and characteristics of the built environment, as well as their limitations. Section 7 concludes by making suggestions for planning strategies in order to both further develop existing neighborhoods and plan new neighborhoods according to the resharing approach.

2. Conceptual model of resharing

The conceptual model of resharing aims to support, amongst other things, the integration of mobility sharing (e.g. bicycles, cars and electric scooters) and different forms of space sharing (e.g. training rooms, workspaces, meeting rooms, indoor sports facilities, storage for electric vehicles, postage facilities and pop-up libraries) in residential, office and commercial buildings. Such integration is relatively unknown in the scientific literature, since the discourses around resharing have not yet undergone any systematic formulation; for example, ‘shared mobility’ and ‘shared spaces’ still retain separate identities. Some examples of resharing are emerging in practice (see Table 2), which are place-based – that is, they generate sharing practices and activities in a defined physical space, and can thus be suitably targeted through planning interventions. This applies to both location-based shared mobility – such as sharing hubs to pick up a car and park your bicycle/electric scooter – and shared spaces which are defined for a certain building block or geographical area. Spatial proximity is one of the key conditions that can

generate sharing practices in buildings (Chan and Zhang, 2021, Widlok, 2016), including the provision of shared workspaces (Merkel, 2017). The idea of urban resharing needs to be broadened; it should be based on the principle that the practice of resharing is most effective when people's demands are pooled, and sharing opportunities are available in close proximity to where they live and work.

For example, in residential buildings, it would be interesting to offer shared ride services when making a booking for a theatre, cinema or dining out in the city (Marsden et al., 2019). In such a context, digital platforms are increasingly necessary prerequisites in order to be mobile and benefit from shared services and mobility (Martinez and Keseru, 2023). This also implies that a neighborhood is an important planning unit for integrated residential, office and commercial shared solutions and revised forms of consumption. Considering these emerging trends, neighborhood communities are in a position to drive resharing practices.

The outcomes from literature review presented in Table 1, is intended to be integrative. This is a suggested approach for investigating emerging topics (Torraco, 2005). Existing discourses on the idea of resharing have not yet undergone a comprehensive or systematic review of the literature. Thus, in this study, the integrative literature review leads to an initial or preliminary conceptualization of the topic, rather than a reconceptualization of previous models (Torraco, 2005). Besides the lack of a systematic literature review on the concept of resharing, there is also a need for a conceptual model and comprehensive list of features for such practices. Table 2

Table 1. The dimensions of spatio-functionality, social and digitalization/shared mobility that are the foundations of resharing and related features.

Spatio-functional features	Some arguments and references
Multifunctionality/ Physical flexibility	Functional diversity of space use, including parking areas, building type and size are among the key conditions that can support the sharing of spaces and activities (Setti, 2013). Flexible layout and spaces are among the key conditions that can generate sharing spaces, practices, and activities (Lee et al., 2010, Carra and Dionisio, 2017).
Walkability and bikeability	Both indices refer to modes of urban mobility with potential health and environmental benefits. They include safety-relevant environmental factors, such as the presence of bicycle lanes and pedestrian networks/squares but viewed through the lens of comfort or perceived safety (Osama et al., 2020).
Characteristics of streets/ ground floors	Physical, environmental and social characteristics are important. The notion of 'mixed-use' is one of the characteristics of streets that can support a variety of functions, activities, and ambience that people who live or work there might desire (Mehta, 2007), including the presence of the trees. Ground floor functions and facades provide an important link between the city, buildings, and people. Suggestions are to: i) formulate a general policy for active ground floor frontages on important streets; ii) avoid long stretches of larger units, by using narrow units with many doors; iii) ensure that the building scale carefully observes the human scale (overview given by Gehl, 2011).
Accessibility to green areas	Access to public and semi-public green areas, as well as shared gardens in dwelling places are important features, considering possible interactions distance to green areas (Nielsen and Hansen, 2007).
Openness and closeness of street profiles	The openness and closeness of the street profile is linked to the façades and layout of buildings. The quality of building frontages facing the footway is an extremely important factor for the quality of an urban area and its perception by people (Gehl, 2011).
Social features	
Diversity and inclusivity of a place	Diversity and inclusivity are linked to community facilities for young and elderly people (Lee et al., 2010), as well as all social groups in various places and buildings (Kristiansen et al., 2019). Several forms of shared mobility (e.g., bicycle sharing) help to overcome mobility issues and open up a wider range of opportunities for people who do not own a bicycle or car (Interreg North Sea Region – SHARE-North, 2021).
Collaboration and variety of tasks	Collaboration is evident among people who work together to co-produce something within sharing activities/practices/economy. Collaboration also implies that a larger number of tasks can be achieved when the group of potential workers is bigger and more varied in terms of skills (Richardson, 2015).
Formal/informal social interactions	Social interactions within neighborhoods or buildings provide residents living in the community with knowledge about other residents and social structure (Williams, 2005). Formal interactions occur mainly in indoor communal spaces, while brief informal interactions happen in outdoor communal spaces and some indoor community spaces such as laundries, car parks and workshops (Williams, 2005).
Provision of community facilities	This refers to facilities that are publicly used and shared by local residents. These spaces help to build neighborhood relationships (Lee et al., 2010). Community facilities can also embed a mixture of shared spaces and/or welfare facility (Lee et al., 2010).
Shared workspaces	New ways of sharing workspaces are emerging within the growth and development of knowledge economies. The shared workspace can be an active centre in the neighborhood (Babb et al., 2018).

Spatio-functional features	Some arguments and references
Digitalization/Shared mobility features	
Digital platforms and modes of transport	Digital platforms facilitate the use of shared vehicles. Applications include transport on-demand, as well as van ride sharing or pooling. Transport-on-demand tools also have the potential to reduce single-occupant vehicle trips, as well as to encourage different transport options for commuters (Liyanage et al., 2019). Shared mobility hubs can be managed by both private providers and by cities, or by cooperation among all actors (Interreg North Sea Region – SHARE-North, 2021).
Flexible car/bicycle-sharing membership and pass for public transport	Membership in flexible car/bicycle-sharing schemes can encourage people to start car sharing or using any mode of shared mobility. However, a trigger is necessary, such as "temporary provision of free car-sharing membership or a travel budget for shared mobility and public transport" (Interreg North Sea Region – SHARE-North, 2021, p. 141).
Active sharing campaigns	Campaigns about sharing and public awareness of shared mobility are key elements. Branding sharing hubs through social media, as well as car-sharing campaigns on postcards, in movie theaters and other public events can encourage people to share (Interreg North Sea Region – SHARE-North, 2021).
Bicycle repair shops	Users can sign up online or at a bicycle repair point, to repair their own bicycles. Maintenance can be also offered for free in a bicycle repair shop managed by the municipality (See the case of *A Library for Children's Bikes*, in Belgium) (Interreg North Sea Region – SHARE-North, 2021).
Accessibility to sharing mobility hubs	Accessibility is one the key conditions for shared mobility (Barr et al. 2021). Shared mobility hubs (stations to access cars, bicycles and cargo bicycles) are managed by both private providers and by cities, or by cooperation among all actors (Interreg North Sea Region – SHARE-North, 2021). Digital platforms are a prerequisite for accessing such hubs (Martinez and Keseru, 2023).

Table 2. International projects and their resharing dimensions and insights for reshareability index.

Country /City	General description	Resharing dimensions and insights for reshareability index
Germany Bremen	New housing developments have integrated features of shared mobility, with the aim of addressing growing mobility needs, the scarcity of public spaces, and the need for affordable housing. Incorporating carsharing into transport strategies makes it easier to remove parking spaces or forego building new ones (Interreg North Sea Region – SHARE-North, 2021).	**Spatio-functional features***Walkability and bikeability* • Broader sidewalks • Cycling lanes • Pedestrian plazas *Characteristics of streets* • Presence of trees *Accessibility to green areas* • Presence of playgrounds**Social dimensions** *Diversity and inclusivity* • Opportunities for those who do not own a bicycle or car *Formal/informal social interactions***Digitalization and shared mobility features** *Accessibility to sharing mobility hubs* • On-site car sharing stations • Shared bicycles • Shared cargo bicycles *Flexible car-sharing membership* • Car sharing memberships

Country /City	General description	Resharing dimensions and insights for reshareability index
		Bicycle repair shops
Netherlands Haarlem	The Haarlem project is based on the principles of the sharing economy, including energy transitions, the use of smartphones, and new mobility patterns. In this project, new houses will be developed, and shared vehicles will be provided and available for all residents (Interreg North Sea Region – SHARE-North, 2021).	**Spatio-functional features***Multifunctionality/flexibility* • Parking areas must be developed in a way that they can be converted into other functions when there is no longer a demand for them *Accessibility to green areas***Social dimensions** *Diversity and inclusivity* • Opportunities for all residents *Provision of community facilities* *Formal/informal social interactions***Digitalization and shared mobility features** *Accessibility to sharing mobility hubs* • Access to public transport • On-site car sharing stations • Shared bicycles • Shared cargo bicycles *Flexible car/bicycle-sharing membership and pass for public transport* *Bicycle repair shops*
Netherlands Utrecht	The Merwede project aims to create a sustainable and healthy environment that can provide affordable homes and numerous facilities, such as a market hall and mobility hubs for shared transport, as well as expansive green spaces (Marc Koehler Architects, 2023). Twelve thousand people are expected to live in the area, specifically including older adults, and special provision has been made for residential care (Marc Koehler Architects, 2023).	**Spatio-functional features***Multifunctionality/flexibility* *Accessibility to green areas***Social dimensions** *Diversity and inclusivity* *Provision of community facilities* • Community facilities for elderly people *Formal/informal social interactions***Digitalization and shared mobility features** *Accessibility to sharing mobility hubs* • Access to public transport • On-site car sharing stations • Shared bicycles • Shared cargo bicycles • Shared scooters *Flexible car/bicycle-sharing membership and pass for public transport*

Country /City	General description	Resharing dimensions and insights for reshareability index
Japan **Kioto**	Machiya is based on the transformation of traditional wooden townhouses into new residential and industrial installations which provide shared workspaces, cafes, and shops, allowing for sharing of spaces and resources, while preserving the cultural heritage of the city (Intaraksa and Ongsavangchai, 2022).	**Spatio-functional features***Multifunctionality/flexibility* • Functional diversity of space and building types like residential complexes and public schools *Walkability and bikeability***Social dimensions** *Diversity and inclusivity* • Opportunities for all residents, including students *Provision of community facilities* *Shared workspace* • Family-based, small-scale industrial installations, in which the workplace is integrated in the everyday life of the community *Collaboration and variety of tasks* *Formal/informal social interactions***Digitalizisation and shared mobility features** • *Accessibility to sharing mobility hubs* • Access to public transport • On-site car sharing stations • Shared bicycles

Taking cues from discussions in the literature to date, the conceptual model presented in this section is drawn from the features that make a place, building or neighborhood *reshareable.* By 'reshareable', we mean combining shared mobility and shared spaces as an integrative part of developing residential, office and commercial spaces, with a view to including all social groups and initiating new social interactions. We use a combination of an integrative literature review, together with an overview of new, developing and existing projects (see 2.1 International examples on resharing and insights for reshareability index, 2.2 Norwegian context of resharing and insights for reshareability index). This enables us to propose an initial or preliminary conceptualization of different forms of resharing (that is, a large variety of shared mobility modes and shared spaces, and related combinations thereof) (Fig. 1). The model is based on three main dimensions: spatio-functionality, social and digitalization/shared mobility features that can enable the (re)shareability of buildings, spaces and neighborhoods (Fig. 1). The model could be further developed by researchers in terms of additional features and their interrelations in any given context.

This conceptual model can be used for analyzing conditions in neighborhoods, developing new design proposals, assessing new proposals, and prototyping solutions and layouts. It can also support the implementation of GIS methods, observational studies and focus groups. The three main dimensions: spatio-functionality, social, and digitalization/shared mobility constitute our summary of what makes a place reshareable.

The shared activities and practices reflect also a temporality which has a duration with a beginning and an end, although these time points may fade away (Neuhaus, 2015). The temporal use and appropriation of spaces (in terms of uses, functions, activities, and presence) by both routine users and/or more transient neighborhood residents, can directly and indirectly affect resharing practices. The temporal dimensions should be explored by means of empirical analyses (through for example, interviews, surveys, focus groups and spatial observation) in future studies.

The three main dimensions in the conceptual model are expanded by the list of features in Table 1, together with relevant references to existing studies, both international and in Norway (see Table 3). Emerging urban projects and future scientific studies will help to expand the features identified in Table 1. Moreover, the outcomes from Table 1 support the development of the input factors shown in Table 4 (see Section 4) that form the basis for developing the reshareability index (see 4 Research materials and methods, 5 Results).

Table 3. Examples of resharing projects in Norway and insights for reshareability index.

Norway	General description and concept	Resharing dimensions and insights for reshareability index
Bærum ***(north-western part of the Oslo region, a neighboring municipality)***	The project is called the 'Good neighborhood' project (*det gode nabolag*) (Bærum Kommune, 2023). The idea is to introduce the option to choose between owning and renting a care home among several new co-located properties. The main goal is to create an inclusive community between people, regardless of age and functional level (Bærum Kommune, 2023).	**Spatio-functional features***Multifunctionality/flexibility* *Accessibility to green areas* *Walkability and bikeability***Social dimension** *Diversity and inclusivity* *Provision of community facilities* • Community facilities for elderly people *Formal/informal social interactions***Digitalization and shared mobility features** *Accessibility to sharing mobility hubs* • Access to public transport
Tomter ***(south-eastern part of the Oslo region, 43 km from Oslo)***	A 'Green neighborly community' (*grønt nabofellesskap*) is based on the co-housing model (https://www.nabofellesskap.no/↗). In a modern housing association, the residents help develop their own living environment within private homes and shared houses.	**Spatio-functional features***Multifunctionality/flexibility* *Accessibility to green areas* *Walkability and bikeability***Social dimension** *Diversity and inclusivity* *Provision of community facilities*Community facilities for elderly people *Formal/informal social interactions* *Shared workspaces***Digitalization and shared mobility features** *Accessibility to sharing mobility hubs* • Access to public transport
Stavanger ***(south-western part of Norway, 550 km from Oslo)***	'Gaining by sharing' is a project based on sharing and community activities. This is an innovative, sustainable and inclusive form of living. It differs from other housing models since the residents would own less and share more, and benefit from social, environmental and economic value. (https://gainingbysharing.no/↗)	**Spatio-functional features***Multifunctionality/flexibility* *Accessibility to green areas* *Walkability and bikeability***Social dimension** *Diversity and inclusivity* *Provision of community facilities* • Community facilities for all with different backgrounds *Formal/informal social interactions*
Oslo Friis' Gate 6	This housing community is based on the principles that neighbors have dinner together, share spaces such as large living rooms and a gym, children enjoy themselves in the playroom, and young people play billiards in the basement. (https://magasin.oslo.kommune.no/byplan/ikke-som-alle-andre-borettslag#gref↗)	**Spatio-functional features***Multifunctionality/flexibility* *Accessibility to green areas* *Walkability and bikeability***Social dimensio** n *Diversity and inclusivity* *Provision of community facilities* • Community facilities for all, including elderly people *Formal/informal social interactions***Digitalization and shared mobility features**

Norway	General description and concept	Resharing dimensions and insights for reshareability index
		Accessibility to sharing mobility hubs • Access to public transport • Shared bicycles
Oslo Borettslaget Kollektivet ***Hovseterveien 96, 98, 100A, 100B, 102A, 102B*** ***0768 Oslo***	The housing association Kollektivet is the result of a unique collaboration between three women's organizations and the local housing association, Boligbyggelaget (USBL). In addition to ordinary apartments, the housing association should have a collective areas. Conditions were put in place so that joint activities, contact between people, equality and well-being would characterize the neighborhood. (https://www.brlkollektivet.no/?page_id=11↗)	**Spatio-functional features***Multifunctionality/flexibility* *Accessibility to green areas* *Walkability and bikeability***Social dimension** *Diversity and inclusivity* *Provision of community facilities*Community facilities for all, including elderly people *Formal/informal social interactions***Digitalization and shared mobility features** *Accessibility to sharing mobility hubs* • Access to public transport • Shared bicycles
Oslo Living Lab ***Vollebekkveien 4, 0598 Oslo***	This project is based on the sharing concept which has been identified as a relevant measure for the homes of the future, in order to meet the ambitions for social, economic and environmental sustainability. In the lab, the project team tests different sharing concepts to understand the residents' needs and how they experience proposed solutions. (https://nye.obos.no/living-lab/beboe↗)	**Spatio-functional features***Multifunctionality/flexibility* *Accessibility to green areas* *Walkability and bikeability***Social dimension** *Diversity and inclusivity* *Provision of community facilities* • Community facilities for all, including elderly people *Formal/informal social interactions* *Shared workspace***Digitalization and shared mobility features** *Accessibility to sharing mobility hubs* • Public transport • Transport services offered to seniors • Shared bicycles

Table 4. Factors to identify in developing a reshareability index (the factors analyzed in this study are in bold text).

Resharing features	Input factors to calculate the reshareability index
Multifunctionality/flexibility **Multifunctional spaces have the potential to reduce the need for additional space, as a single space can accommodate multiple functions, which can be a cost-effective and efficient use of resources. Public and semi-public spaces, such as libraries, community centers and public squares, may be more shareable than private spaces. A building and its size can impact the reshareability of an area. Additionally, larger buildings with more retail units and multifunctional spaces may be more shareable than smaller, single-use buildings.**	• **Number and diversity of mixed-use buildings** • **Availability, accessibility and diversity of public amenities, services, shared workspaces**

Resharing features	Input factors to calculate the reshareability index
	• **Access to cultural and recreational activities** • Accessibility and inclusivity for people with disabilities • Degree of flexibility and adaptability for different uses and functions • **Degree of mixed-use development (e.g., residential, commercial, cultural)** • Proportion of public and semi-public buildings • Quality and **diversity of public amenities (e.g., community centers, libraries)** • **Building type and size**
Walkability and bikeability **The level of walkability and bikeability in an area can influence its shareability. Areas with well-designed pedestrian and bicycle friendly infrastructure may be more shareable than areas that are not as accessible.**	• **Proximity to bicycle sharing and car sharing stations** • Presence of way-finding signage and maps • Quality and **quantity of sidewalks and bicycle lanes** • Accessibility for people with mobility impairments • **Availability of bicycle parking** and storage facilities
Street characteristics and ground floors **The dimensions and widths of streets can impact their level of reshareability. Wider streets with more space for pedestrians, cyclists, and public transportation can be more shareable than narrow streets with limited space.**	• Number and type of street-facing businesses • Street furniture and amenities (e.g., benches, waste bins) • Quality of street lighting • Availability of public art and other cultural amenities • Safety measures (e.g., cameras, emergency call boxes) • **Presence of trees** • Ground floor functions

Resharing features	Input factors to calculate the reshareability index
	• Analysis of floor frontages and large/narrow building units
Street openness and closeness **The degree of openness or closeness of a street network can affect the ease of movement and access to different parts of an urban or rural area. A highly connected street network may be more shareable than a sparse one, as it enables people to move around easily.**	• **Number of intersection points in the street network** • Proportion of pedestrian-only streets and public spaces • Traffic calming measures (e.g., speed bumps, roundabouts) • **Degree of street connectivity** • **Openness of the façades of buildings** • **Quality of the building frontages facing the footway**
Access to green areas **The presence of green spaces, parks and other natural areas can contribute to the shareability of an urban or rural area. Access to these spaces can encourage social interaction, recreation and relaxation, which are key components of a shareable community.**	• **Proximity to parks, natural areas and park trails** • **Availability of recreational amenities (e.g., playgrounds, sports fields)** • Quality and **quantity of parks and green spaces** • Degree of natural and ecological diversity • Degree of accessibility for people with disabilities
Access to sharing hubs **The availability of sharing public transportation, such as e-scooters and car-sharing services, can increase the shareability of an area by providing more affordable and accessible transportation options.**	• **Availability of public transportation options (e.g., bus, train, ferry)** • Frequency and reliability of public transportation services • Cost and affordability of public transportation options • **Access/proximity to alternative transportation options (e.g., car-sharing, bicycle sharing)** • Integration with other modes of transportation
Population diversity **Demographic and socio-economic factors can influence the shareability of an area. Different age groups, genders and socio-economic groups may have different needs and preferences in terms of shareable spaces.**	• **Proportion of residents from diverse backgrounds** • **Median household income**

Resharing features	Input factors to calculate the reshareability index
	• Age distribution and proportion of families with children • Educational attainment and job opportunities • Degree of inclusivity and accessibility for marginalized communities

To conclude this section, we note that the resharing paradigm moves beyond current knowledge on sharing in general. The conceptual model and Table 1 suggest that the various uses of shared spaces and shared mobility are evolving, and that new modalities of sharing need to be better understood. Such understandings need to be further framed in the light of the design of current neighborhoods and people's behaviors, since neighborhood layout, street design and architecture can play a positive role in suppressing the need to use private vehicles (Cao et al., 2007). In this context, little is known about the social dimension, that is, people's needs, and the ways in which they experience the combinations of different hierarchies of shared spaces. These hierarchies include public spaces (related, for example, to leisure activities), semi-public spaces and private spaces (housing), together with shared mobility opportunities (see findings described in Table 1).

Furthermore, the combination and interlinking of different dimensions can be anchored in the notion of the post-functionalist city, "where the boundaries between urban functions have become blurred, where different functions co-exist in the same space, and where new and unprecedented functions emerge through citizens' appropriation of places" (Di Marino and Lapintie, 2017, p. 2). Within the post-functionalist planning approach, the provision of more multifunctional spaces and flexible arrangements would be able to address contemporary social and environmental challenges.

To this end, the framing of resharing needs to be expanded. For example, the ground floors functions in a building could integrate a larger variety of shared spaces and facilities across several buildings, as ground floor functions and facades provide an important link between the city, buildings and people (see Gehl, 2011, in Table 1). In some contexts, shared or community facilities refer to a mix of shared spaces and welfare facilities, including both physical and functional dimensions (Lee et al., 2010). At a micro level, the physical dimension refers to the range of facilities that users can find in the same building, or site that provides services. The spatio-functional dimension is about linking the services that are required by users; that is, the effective provision of services at a single site (see Lee et al., 2010, in Table 1).

Regarding the domain of transportation and mobility, the conceptual model presented in this section can support further theoretical and empirical analyses on interlinking and combining shared mobility (use of electric scooters, cars and bicycles), and shared spaces in various types of infrastructure (walkways, roads, parking lots and garage spaces, as some of the latter would remain free at various times) (Kaparias and Wang, 2020, Priya Uteng et al., 2019). In addition, we need to consider semi-private and private courtyards, community spaces and garages, as these can be used for parking shared cars and bicycles, as well as for bicycle repair shops and other shared spaces/activities).

2.1. International examples on resharing and insights for reshareability index

New projects across Europe and beyond are showcasing initial attempts at resharing (in the form of integrating residential shared mobility and shared spaces – both outdoor and indoor). Traditionally, parking spaces were mandatory in new residential buildings and if not provided, the developers had to pay a fee to the city (Interreg North Sea Region – SHARE-North, 2021). Today, it has been found that the majority of residents would be willing to switch to more sustainable modes of transport, which in turn, would reduce the extent of private car ownership and the demand for parking spaces in the city, as well as increasing the use of digitalization (Interreg North Sea Region – SHARE-North, 2021). Such changes would create extra semi-private and public shared spaces for several purposes. Through these alterations, urban streets and spaces would become more liveable.

Four pioneering projects have been recorded in Germany, the Netherlands, and Japan, as presented in Table 2. The integration and combination of spatio-functionality, digitalization/shared mobility and social dimensions, (see the conceptual model of resharing, Fig. 1), have been identified and summarized in each project, as well as the insights for reshareability (the column named "*resharing dimensions and insights for reshareability index*" in Table 2).

The examples summarized in Table 2 demonstrate the real integration of the resharing dimensions in different contexts, showcasing how urban areas can be designed and managed to promote shared resources, collaboration and sustainable living. Such initiatives can ultimately foster a pattern of reduced consumption at the urban level. These examples also provide several insights in compiling reshareability index.

2.2. Norwegian context of resharing and insights for reshareability index

The concept of sharing has historically had its presence in the Nordic countries including Norway, but it became diluted in the proliferation of structural developments which were both based on and encouraged private patterns of consumption. As early as the 1930 s, the first communal kitchens appeared in Oslo (Jonsrud, 2021). But after the second World War, the priorities were to build schools, kindergartens and community centers, instead of residential areas (Jonsrud, 2021). In the 1970 s, housing associations and collectives started to emerge again in Norway, with some of them still functioning as housing associations to this day (see the examples of Kollektivet Hovseter in Friis' Gate 6, in Oslo, and Villa Holmboe in Tromsø, as well as Bofellesskapet in Trondheim which was established in the late 1980 s) (Jonsrud, 2021).

In Oslo, compared to the past, garages and parking areas have now been reduced or become more flexible for the use of residents, guests and workers in the area (for example, Parqio, https://www.parqio.com/en↗). But these emerging trends are still in nascent stages and the innovative use of space in shared garages is mostly ad-hoc, without being guided by any vision on sharing. Although there are several shared workspaces in the city, both public and private (Di Marino et al., 2022a, Di Marino et al., 2022b), Norway does not yet have examples of shared workspaces which are integrated into residential developments.

Further, there is another layer to current housing and demographic developments in urban Norway which necessitates that the framing of 'resharing' is taken up urgently. Statistics reveal that compared to 15% of people who lived alone after the second World War, approximately 48% live alone today, thus generating extra pressure on the number of required homes (see the overview given by Jonsrud, 2021). This also implies that many people live in cramped quarters, especially in urban areas; for example, close to 13.4% of Oslo residents live in cramped conditions (Jonsrud, 2021). Of these, couples with children constitute the highest proportion of cramped households (Jonsrud, 2021). The ageing population and the impending 'elderly wave' is also an extremely important phenomenon to consider. It is projected that by 2038, 57% of the Norwegian population will need care homes (Bærum Kommune, 2017). In this context, community projects currently being developed are targeting families with children, and other needs such as care homes for older adults and those who are physically challenged (Bærum Kommune, 2017). More recently, as shown by the desk research conducted by the authors, new projects are being initiated in Norway, based on shared residential spaces and services, in response to current and projected demographic trends. Examples of these projects are presented in Table 3.

Table 3 shows that some aspects of shared mobility and transportation are integrated with the other features in the projects analyzed. However, compared to the international projects (see Table 2), several features of the digitalization and shared mobility dimension – for example, on-site car sharing stations, shared cargo bicycles, shared scooters, car sharing memberships, and bicycle repair shops – are not yet present in the residential Norwegian projects. In most of the Norwegian cases analyzed (Table 3), there is close proximity to the train station and other hubs, but the remaining features of digitalization and shared mobility (as in Table 1 and Table 2) are still not part of emerging sharing designs for residential buildings.

The Stavanger project is rather different, since it emphasizes only the two dimensions of spatio-functionality and social features. Despite the project being based on sharing concepts, no digitalization and shared mobility features are being planned at the moment. It seems that the residents will be dependent on private cars and their own bicycles, since the area is not close to any public transport hubs.

Nonetheless, this analysis is a good basis on which to further integrate the third dimension (i.e. digitalization and shared mobility features) in projects analyzed and its future transformations. In particular, the limited features of shared mobility in these projects and other urban transformations should be further discussed with the city of Oslo, private developers and transportation agencies, as well as public and private organizations that are interested in shared mobility.

We can assume that the limited features of digitalized/shared mobility in the majority of the projects listed in Table 3, (as well as the absence of digitalization/share mobility features in Stavanger project), is linked with the current emergence of sharing mobility practices in Norway, and in Oslo in particular. The uptake of all forms of shared vehicles – cars, bicycles and e-scooters – has recently been rising in Norwegian urban centers, especially in Oslo. Car sharing emerged in the mid-1990 s and since then, the sector has grown to include multiple service providers that represent a broad range of business models and growth strategies. The vast majority of sharing organizations are either located in, or focused on the Oslo metropolitan area, making it the center of mobility sharing activities in the country.

But despite this centrality, studies have highlighted that even in Oslo, shared mobility practices remain skewed, favoring a certain category of the population – the young, educated, high-income group. Further, when locational decisions for shared services are not made wisely, then these services also tend to cater primarily to young, educated, high-income men (Priya Uteng, 2021, Priya Uteng et al., 2020, Priya Uteng et al., 2019). Shared mobility – such as car and bicycle sharing – has been shown to offer access to families and other households who might not be able to afford a private vehicle (Kębłowski et al., 2020), and it has the potential to cut across age, gender and life stages (Obersteg et al., 2019). Therefore, what is needed, is careful integration of these services into both spatial and structural systems which are accessible to the different and varied groups of people that co-exist in a city at any given point of time.

3. The case of Hovinbyen: the planning context

Two key tenets and challenges identified by planners and policymakers, for creating a sustainable and compact Oslo, is to keep the central city districts alive after working hours, and to intervene in the most monofunctional districts in semi-peripheral and peripheral areas of the city. The new district of Hovinbyen is attempting to address similar issues, which we present as a case study to further discuss and shape the idea of reshareability.

The city of Oslo is still rather monocentric with few suburban districts (Tiitu et al., 2021). This is the result of compact city strategies developed in the 1990 s, which resulted in a high concentration of activities and multiple functions in the most central areas (Næss et al., 2011). It is also very evident that mixed-use development (e.g., combination of grocery stores, offices, public libraries and schools) occurs around the main transportation hubs of the metro and trains, which is also the case in Hovinbyen. There have recently been concentrated efforts to increase current accessibility levels in the city, in the form of good public transport connections, varied walking routes and cycling paths (City of Oslo, 2019, p. 48). The new car-free program (City of Oslo, 2019) aims to expand "the pedestrianized network in the Oslo city center and move the focus of urban development away from vehicle accessibility and towards pedestrians, cyclists, public transport, good public spaces and meeting places" (p. 18, translated by the authors).

Besides sustainable mobility strategies, Oslo has also implemented several initiatives in recent years to promote more affordable housing options, such as co-living and co-housing. The focus on sustainable living, public transportation, and social and affordable housing makes Oslo a prime location for implementing reshareability concepts. In particular, Hovinbyen is the city's largest urban development project (11 km^2). The aim is to transform this new and upcoming area into a more sustainable, livable, walkable, bikeable and vibrant urban district.

Hovinbyen's central location in Oslo – with direct connections to the region in general – is considered to be an advantage and impetus for attracting knowledge-based businesses. The targets in the plans for Hovinbyen include 27,000 new homes and more than 100,000 people by 2030. But despite Oslo's ambitions to promote attractive, compact living, and sustainable mobility in this upcoming area, the existing urban form – large roads and transverse connections, with a low degree of walkability and bikeability – confront the ideal for a sustainable living environment (City of Oslo 2018). To further unpack the reshareability issues at hand, the sub-districts of Løren and Økern were selected for this study (Fig. 2), due to having the highest concentration of residential units, and modest levels of walkability and accessibility. Oslo has 15 administrative units (so-called *bydeler*). Since Hovinbyen is not an administrative unit, the two sub-districts of Løren and Økern belong to the administrative units of Grunnerløkka and Bjerke, respectively.

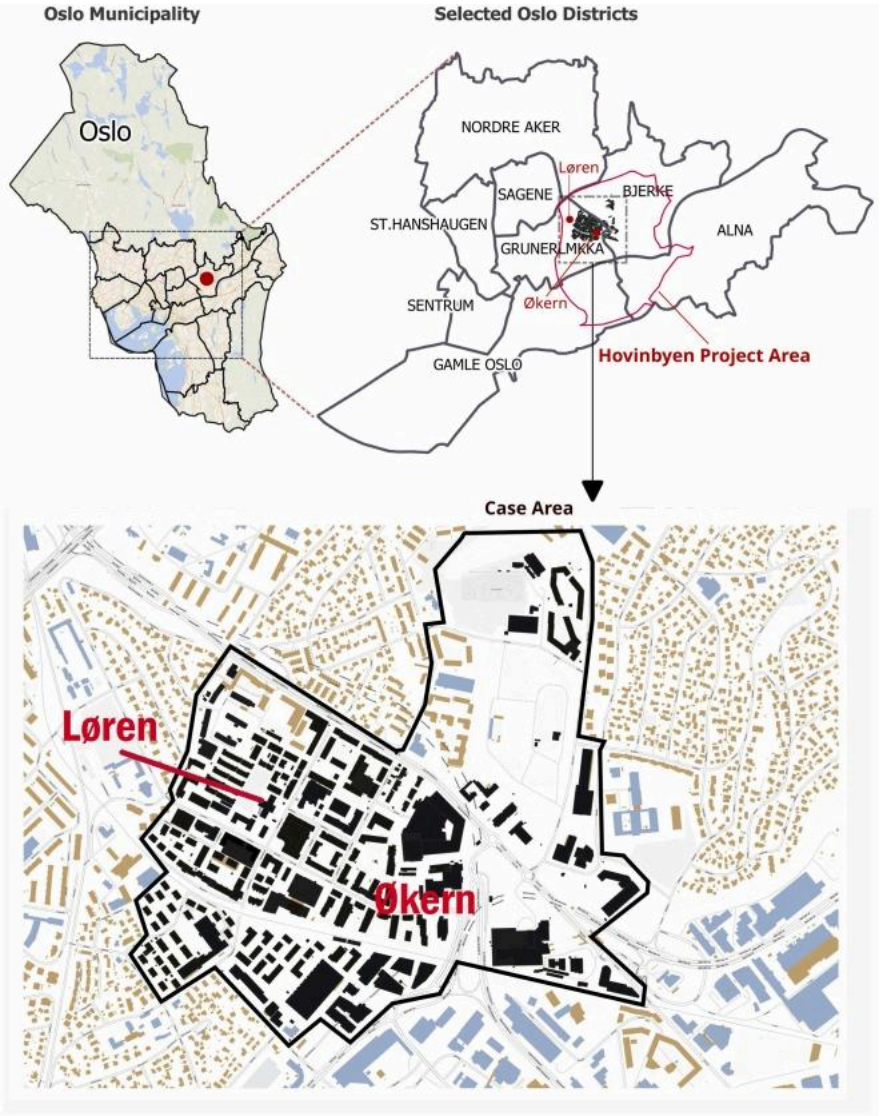

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Fig. 2. Oslo and the district of Hovinbyen, zooming in on the areas of Løren and Økern.

The case study covers a large area of around 800 ha (Fig. 2). Løren has been recently transformed, with industrial functions having been replaced by residential projects. The objective of the municipal planning initiatives has been to develop multifunctional urban and residential areas, reachable on foot or by bicycle (City of Oslo, 2018). According to the plan, this area has huge potential to link to the densest and most central areas of the city, but a major challenge is connecting to the surrounding areas by means of sustainable transportation modes (City of Oslo, 2018).

In Økern, several arrangements are planned for safe and attractive bicycle parking spaces, within the immediate proximity of important destination points, for a high proportion of users. A green ring of 5.5 km, linking the most important parks and recreational areas around Økern, has been earmarked to create new and coherent connections for walking and cycling (City of Oslo 2018). Økern has been identified as one of three areas (with Bryn-Helsfyr and Breivoll) that can become a regional hub with a high density of employment centers. It is envisaged that these three sub-districts should complement each other in providing a high degree of mixed functionality to attract new residents (City of Oslo, 2018).

Against this backdrop, we aimed to assess the extent to which reshareability concepts are present in the current spatial configuration of the selected case districts. There are certainly both political will and planning efforts in place to make Hovinbyen a compact urban district which can operate according to sustainability principles. However, further probing is needed to judge the current levels of shareability and sustainability that are present in Hovinbyen.

4. Research materials and methods

The study has identified some key factors which help to define a reshareability index (see Table 4 in Section 4.1). This section describes the development of the index. Spatial analyses were conducted to examine the various factors that affect the reshareability of a neighborhood and its spaces and buildings. The proposed index was applied in the two sub-districts of Løren and Økern in Hovinbyen (see Section 5). It is also a method that may be applied in other contexts and places.

4.1. Reshareability index

Defining a reshareability index for an urban area, based on a Geographic Information System (GIS), requires a multidimensional approach that can account for the various factors that affect the reshareability of a space. Table 3 illustrates some key factors that should be considered when developing a reshareability index. The factors included in Table 4 were carefully selected based on their relevance to the resharing concept. The rationale for each factor's inclusion was driven by a balance between available data, literature review findings, and the practical importance of factors in reshareability, such as mixed-use development, accessibility to amenities and street connectivity.

Once these factors had been identified, a reshareability index was developed that assigns weight to each factor based on its level of importance. The methodology for assigning weights to factors in the reshareability index was driven by an equal-weight approach, but this can be varied in future depending on how a community decides to assign weights to the different factors. The reshareability index can be used to evaluate the extent of reshareability in different areas in a city or region, and identify opportunities for improvement.

In Table 4, the factors in bold text are those taken into account in the analyses presented in this study. The other factors were not considered due to unavailability of data in the districts, as well as limited GIS and statistical data in national database. Thus, there is a need to collect new data for future studies.

By assigning weights to each of the selected factors, a comprehensive and nuanced reshareability index can be calculated for a particular location or district. This index can be used to evaluate and compare the reshareability levels in different areas of a city or region, and to identify opportunities for improvement. The weights should ideally reflect a balance between the various factors that contribute to reshareability, while also considering the specific needs and preferences of different communities and user groups.

It's important to note that the weights described below are not fixed, and may need to be adjusted depending on the specific context and goals of the particular reshareability index. For example, to create a weighted index for 'Walkability and bikeability', we can assign a weight to each item that contributes to this factor, such as:

- Sidewalk width and condition – Weight: 30%
- Diversity of public amenities (e.g., community centers, libraries and shared workspaces) – Weight: 30%
- Proximity to shared bicycle and car-sharing stations – Weight: 20%
- Proximity to parks, natural areas, and park trails – Weight: 20%.

The proposed function for calculating the overall reshareability index would incorporate the weighted indices of all the selected main factors, and can be expressed mathematically as follows (an example using four selected main factors):

Reshareability Score = (w1 * (Street openness + Walkability/Bikeability) + w2 * (Access to Green Areas) + w3 * (Access to Sharing Hubs) + w4 * (Availability of Shared Workspaces and Community Facilities) / (w1 + w2 + w3 + w4). In this study, the reshareability index for Hovinbyen was calculated for the factors highlighted in Table 4.

The rationale for assigning weights is rooted in the relative significance of each factor to the concept of reshareability. While certain factors may hold more importance than others, for the purpose of this paper, a conservative, equal weighting approach was adopted due to data constraints and in order to maintain simplicity. Future iterations may delve into a broader spectrum of factors, and the proposed dashboard will provide a more flexible and customizable approach for users seeking a comprehensive reshareability analysis. In short, the following steps were undertaken: i) collect the necessary data for each factor in the index; ii) create a Python script to import the necessary GIS libraries, such as ArcPy or PyQGIS; iii) create a function that adopts an additive index and calculates the score for all selected factors, with equal importance, i.e. weight 1 to each factor iv) use the resulting score to rank different areas in Løren, Økern and the surrounding areas, in terms of their level of reshareability.

5. Results

5.1. Outcomes from the spatial analyses in Hovynbyen

Fig. 3 shows that the degree of street connectivity is higher in Løren compared to Økern, due to the urban structure (its morphology and building typologies). The higher density of mixed-use buildings and structured networks of roads are more visible in Løren, while Økern is

characterized by large size and monofunctional typologies (commercial/industrial).

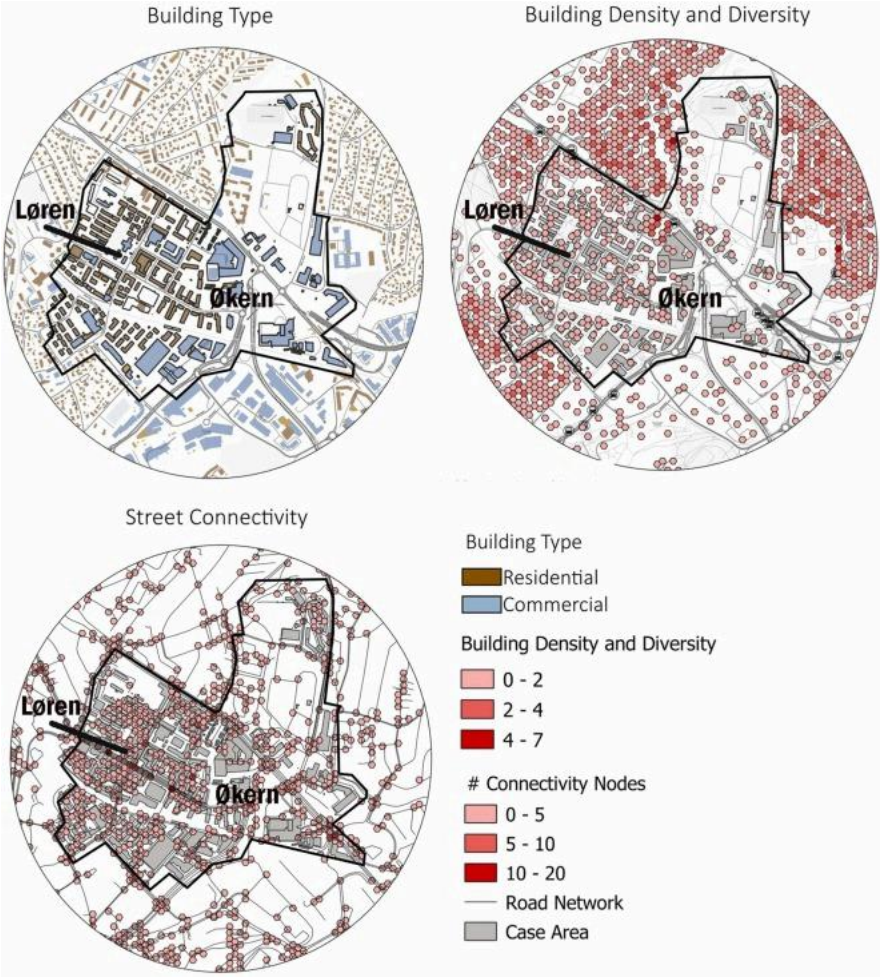

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Fig. 3. Building type, building density and diversity, and street connectivity in Løren, Økern and surrounding areas.

For example, in Økern, there is a shopping center and several office buildings (some comprising 18 floors), but movement and accessibility around these buildings is rather low.

A higher level of accessibility to multifunctional services (such as restaurants, arts and culture, as well as nature and sport) is observed in Løren, and less in Økern (Fig. 4).

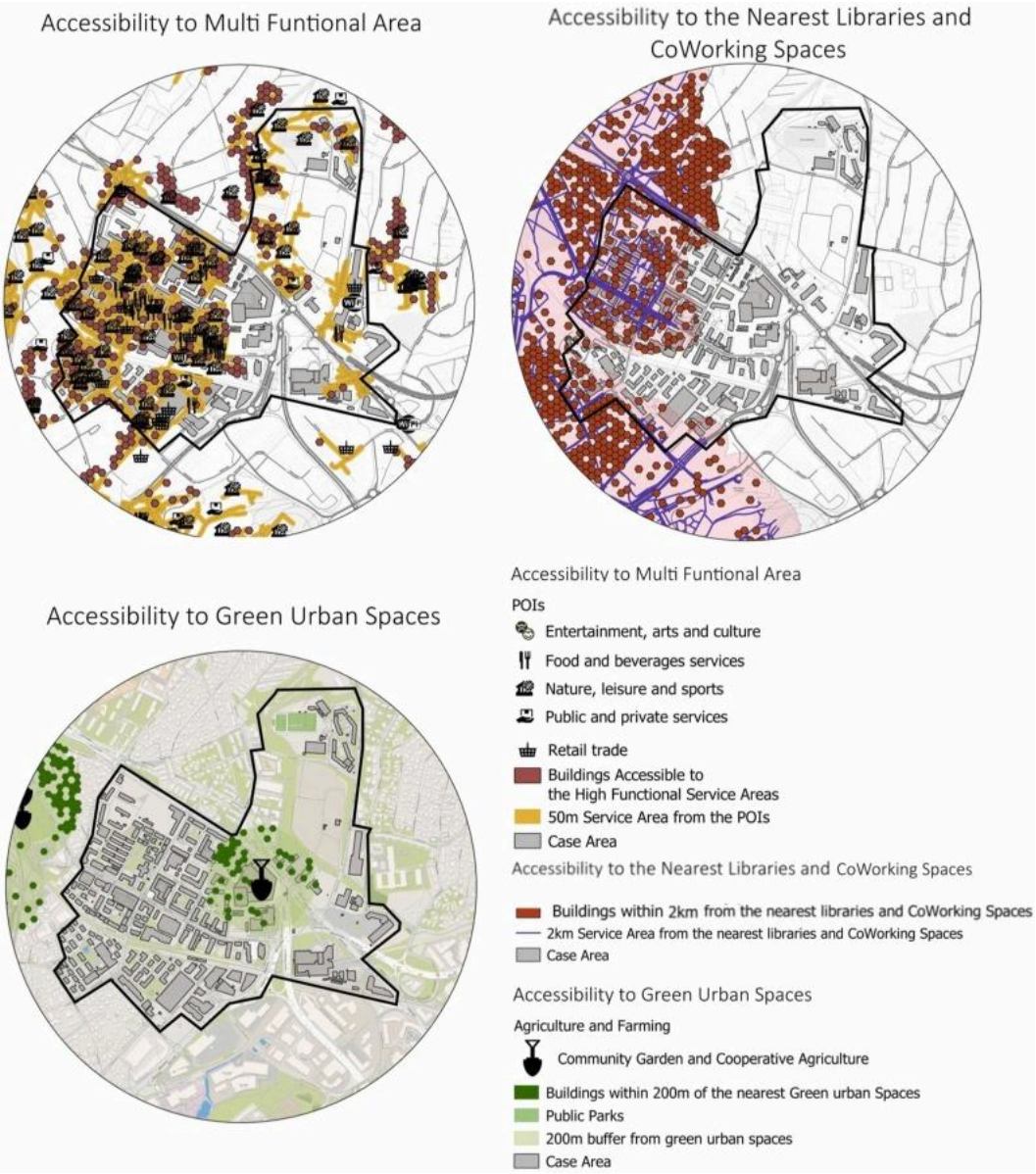

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Fig. 4. Accessibility of multifunctional areas, nearest public libraries and coworking spaces, and green urban spaces in Løren, Økern and surrounding areas.

Along the two main roads (Lørenveien and Økerveien) which cross from west to east between the two districts, such access is possible within a radius of 50 m. In other parts of the two districts, however, the spatial distribution of amenities and services is rather low. There is a lack of shared workspaces, such as coworking spaces and public libraries, in the entire district of Økern, while people living in some parts of the two districts are up to 2 km away from the nearest libraries and new workplaces. This shows a rather low presence of, and access to knowledge resources, community spaces and collaborative workspaces for several purposes, such as learning, working and playing.

In addition, the provision of green areas is rather low in both sub-districts (Fig. 4). There are two public parks (Sisen Park and Løren Park) in the central part of Løren. The Løren Park was developed along with the residential area of Lørenbyen and opened in 2015. The other residual green areas in Løren are those surrounding Lørenbanen and Løren hallen). The biggest park (Torshovdalen) is along the western border of Løren and is accessible by pedestrians. Økerparken is the biggest green area in Økern, located 400 m from a metro stop.

Access to public transport consists mainly of bus stops along the main road Dag Hammarskjølds vei (which becomes Økerveien), that crosses the two districts Løren and Økern from west to east. The metro line runs parallel to the main road (250 m away) (Fig. 5).

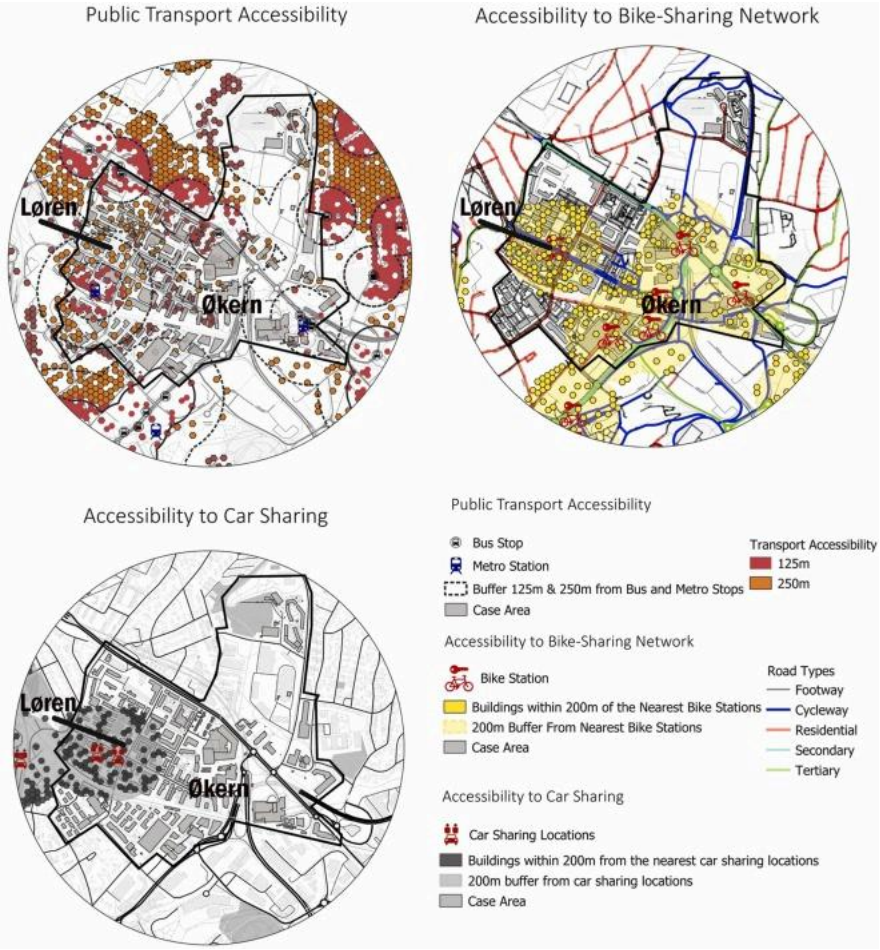

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Fig. 5. Accessibility to public transport, bicycle sharing, and car sharing in Løren, Økern and surrounding areas.

The data shows that several parts of the two districts are more than 250 m away from both bus and metro stops. This low degree of accessibility to public transport is partially supplemented by the bicycle sharing hubs that are provided around the metro stops. These are also placed along Økerveien that changes direction and crosses the district from north to south. Considering the lack of public transportation options, this road is more equipped than others with bicycle sharing facilities.

Car sharing locations with a medium degree of accessibility from residential buildings are observed only in some parts of Løren (Fig. 5). Although all car sharing hubs are in public spaces and along the streets, only a few residents are able to reach one within a radius which could be labelled as 'easily accessible'. It is important to highlight that digital tools play a crucial role in facilitating the seamless integration of shared mobility options into the daily lives of residents, making it easier for them to engage in sustainable and collaborative transportation practices. This intersection of digital technology and reshareability holds the potential to enhance the overall accessibility and convenience of shared mobility solutions in the area; however, it is contingent upon having the digital skillset to operate these shared mobility tools, which might not be equally available among all demographic and age groups.Interestingly, there is a clear intersection between the areas which present most optimum conditions for reshareability and those where population density is higher (Fig. 6). Nonetheless, access to transport, multifunctional areas and green spaces remains rather low and needs to be incorporated into future plans and projects.

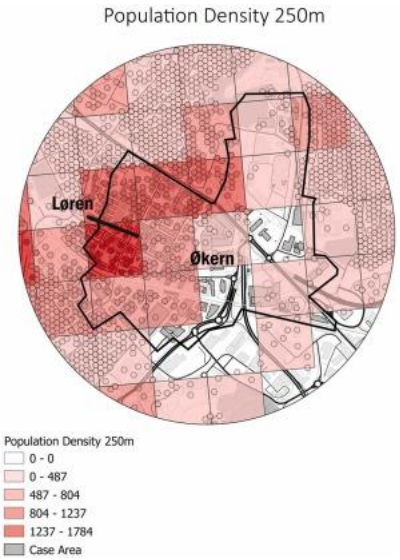

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Fig. 6. Population density in Løren, Økern and surrounding areas.

Higher population density clearly fosters a greater potential for shared resources and collaborative initiatives. Further, a higher level of education promotes a culture of innovation, creativity and participation in sharing-based activities, thus contributing to the overall reshareability and sustainability of a community.

According to statistics, the level of higher education attainment on average in the two districts of Løren and Økern is relatively close to the total average for the entire Oslo (see Table 5, Statistics Norway, 2023). The higher educational attainment levels of the residents in Løren and Økern can support their ability to engage in reshareable activities, that require higher levels of expertise or specialized knowledge.

Table 5. Educational attainment in the two administrative districts Grunerløkka and Bjerke to which Løren and Økern (the two districts of Hovinbyen) belong, respectively (Statistics Norway, 2023).

	2022				
	Numbers	Percent			
Educational attainment	Total	Below upper secondary education	Upper secondary education	Teritary vocational education	Higher education
Oslo total (all districts)	583616	18.6	24.1	2.2	55.1
Grünerløkka	55575	15.6	20.2	2.1	62
Bjerke	28517	23.9	27.2	2.1	46.7

5.2. Reshareability indices: guides for a sustainable planning in Oslo

By combining the various data sources used in this study, it is possible to develop a comprehensive map of existing shareable spaces in Oslo that can be used to guide urban planning and development decisions. Calculating the reshareability index at the 250 m grid level (Fig. 7) provides a spatial assessment of areas that are conducive to implementing the resharing concept, considering factors such as street connectivity, access to green spaces, walkability, bikeability and the availability of shared transportation options. It offers a means to identify and prioritize locations that facilitate reshareability, as well as the efficient utilization of resources within a neighborhood or urban context.

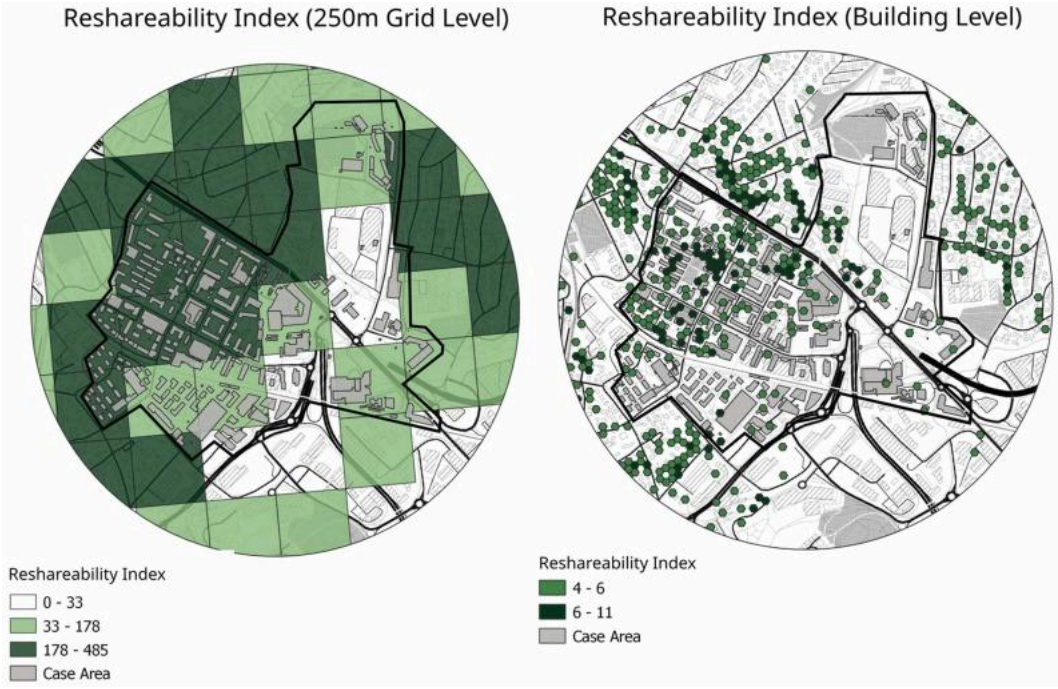

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Fig. 7. The reshareability index at the grid and building levels, in Løren, Økern and surrounding areas.

For example, the index could be used to identify areas that need new public spaces, bicycle lanes or shared public transportation services. The reshareability index at the building level (Fig. 7) provides a quantitative measure of how well a building supports the reshareability concept, taking into account the selected factors. It serves as a tool to assess and prioritize buildings that promote the reshareability concept. The grid-based reshareability index was derived from the building-level analysis, but with a coarser resolution of 250 m.

As shown in Fig. 7, certain buildings within the grid exhibit the desired features we have considered.

It is important to note that the reshareability index presented here is not limited to this specific study area but can be adapted and applied in any location. The credibility of the reshareability index is illustrated with some tangible examples in Fig. 8, Fig. 9. Here, we aim to illustrate the practical applicability of the index in aligning with existing practices of mobility and space sharing.

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Fig. 8. Aligning the reshareability index with empirical evidence: high reshareability index (building level), Løren distric.

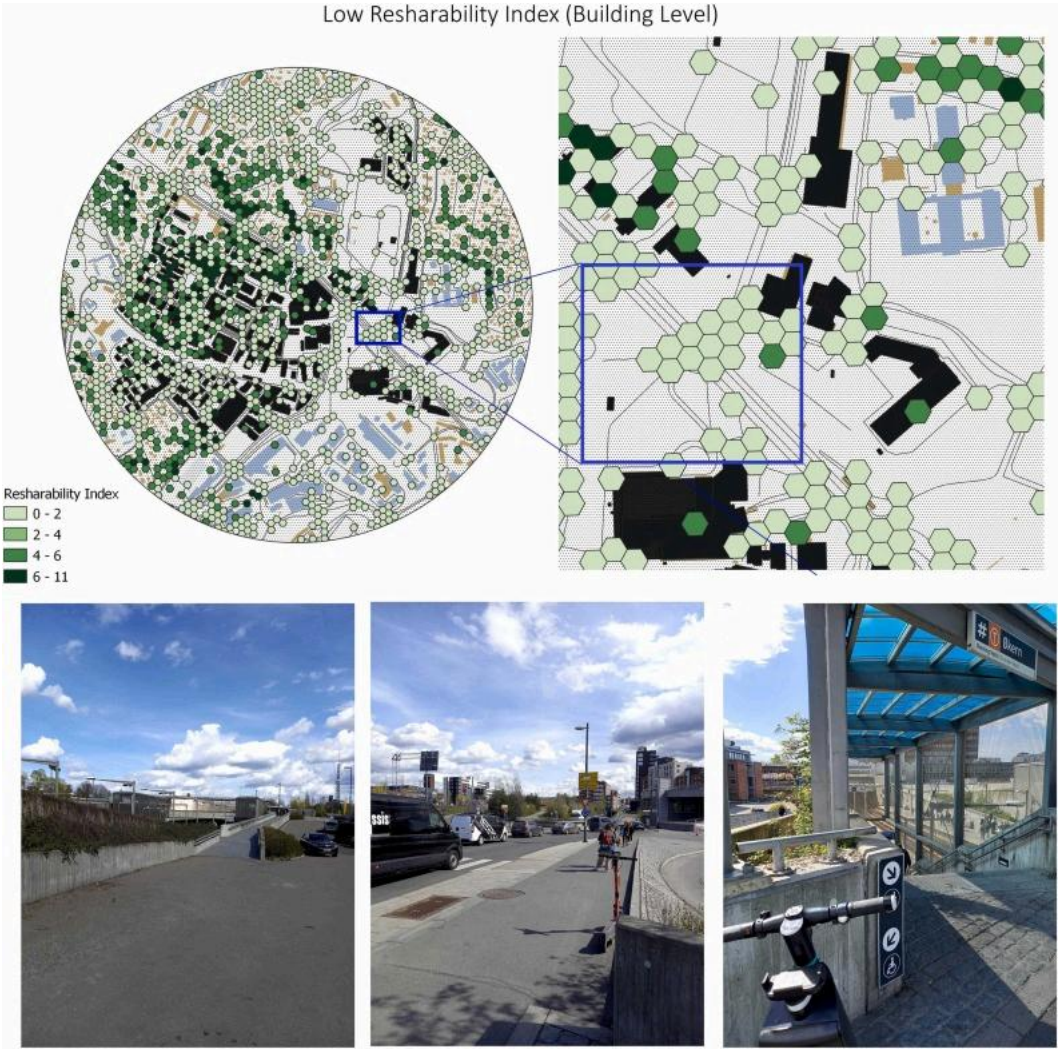

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Fig. 9. Aligning the reshareability index with empirical evidence: low reshareability index (building level), Økern district.

As we delve into specific areas and showcase the resonance of our index with actual urban dynamics, we contribute not only to the academic discourse, but also offer practical insights for urban planners, policymakers and stakeholders involved in reshaping and optimizing urban spaces for shared mobility and collaborative living.

6. Discussion

This study contributes towards building a theoretical and empirical understanding of the reshareable characteristics and qualities of cities and districts (both resharing dimensions and reshareabiltiy index). The paper has presented a conceptual model (Fig. 1) for resharing supported by an integrative literature review that explores the resharing dimensions of spatio-functionality, social, and digitalization/shared mobility (see Table 1). Both the conceptual model and the resharing dimensions (Table 1) were built on a review of current urban residential developments, both internationally and in Norway. The aim of the study was to explore possible interlinking between the resharing dimensions and insights for reshareability indices (see Table 2, Table 3). The Hovyinben district in Oslo, in particular two of its sub-districts, Løren and Økern, was analyzed. The study demonstrates how to calculate a reshareability index that can support reshareability priorities in urban development (including in development plans for future districts).

The first part of the paper presents a review of international residential projects (see Section 2.1 and Table 2), showing evidence of emerging interactions among the three conceptual dimensions, including pioneering examples in which the digitalization/shared mobility dimension replaces the focus on private needs and more shared spaces are created for residents and their social activities. In several Norwegian residential developments, despite the long tradition of sharing, the integration occurs mainly between the spatio-functional and social dimensions, while limited features of the digitalization/shared mobility dimension have been integrated with spatio-functional and social features.

Secondly, by considering several preconditions for reshareability – that include factors such as access to public transport, green spaces, multifunctional areas, shared spaces and buildings – the study reveals that in Hovinbyen, the sub-district Løren presents more reshareable features than exist in Økern that can render a district suitable for implementing the resharing approach (noting that the Økern area is still under development) (see Fig. 3, Fig. 4, Fig. 5, Fig. 6, Fig. 7). The additional Fig. 8, Fig. 9 show further empirical evidence of high and low levels of reshareability, respectively in Løren and Økern. Thus, this study recommends that existing reshareable features should be expanded and integrated into the overall design and development of both areas, given the current levels of shared spaces, and the lack of shared mobility networks and services (as revealed in both Løren and Økern) (for further details, see the Hovinbyen Strategic Plan (City of Oslo 2018).

It is evident that further research should be undertaken, in Norway and beyond, to understand the full implications of the resharing dimensions (including temporal use/presence, functions/activities), as well as to consider a complete range of reshareability services needed at both the area and building levels. The ways in which these services should be prioritized and weighted, in order to develop a comprehensive reshareability index, will inevitably vary, according to who is involved in the selection and weighting decision-making process. It is therefore suggested that a series of workshops should be organized, in which different demographic groups, stakeholders, planners and decision makers undertake independent weighting of the different factors which should be included and assessed. This would help to create a context-specific reshareability index to guide future developments in a specific context.

Extending this line of thought, future research projects could entail gathering expert opinions and feedback from the local community to assign more accurate weights to each factor, and thereby generate a more refined and context-sensitive reshareability index. This would enable to identify and promote the development of reshareable areas to enhance sustainable living and improve the quality of life for residents. The reshareability index and associated features could be used to guide future new developments, as well as to improve existing ones.

We have so far worked with and presented area-level indicators which provide a partial picture of the reshareability potential of a particular district or city. Further studies should provide additional layers to extend this study. For example, data on building facades from GIS analyses, corroborated by spatial observations of the facades focusing on the footways and openness/closeness of the building profiles (see Table 1, Table 4), should be incorporated into a future index. Other factors that are not included in the proposed index (refer to Table 4) – such as air quality, noise pollution and access to healthcare and other public services – may also play a significant role in determining the reshareability of different areas. The various inputs need to be carefully constructed in a local context, with local actors and residents. This new approach should be developed and shared with stakeholders, planners and policy makers.

To assess the effectiveness and impact of reshareability initiatives, it is crucial to establish long-term monitoring and evaluation mechanisms. This will allow for ongoing evaluation of the reshareability index, identification of areas for improvement, and tracking of the outcomes and benefits of reshareable urban development, over time. Regular evaluation can inform evidence-based decision-making and support continuous refinement and enhancement of the proposed reshareability tools.

Reshareability indices are sensitive to the cultural, social and contextual aspects of different regions and cities. Factors such as cultural norms, community values and local preferences should also be considered when designing reshareable environments. This will ensure that the concept is tailored to the specific needs and characteristics of each area and its community, thus fostering a sense of belonging and inclusivity.

The integration of smart technologies, such as the Internet of Things (IoT) devices and data analytics, can enhance both implementation and monitoring of the reshareability index. Incorporating smart technologies can further optimize the functionality and sustainability of reshareable environments, since they can enable efficient resource management, real-time monitoring of shared spaces and services, and personalized user experiences. But it is crucial to study and monitor the design, deployment and adoption of these technologies, so that different demographic groups and people at various life-stages are included in the process.

7. Conclusion

The aim of this study was to provide a theoretical and empirical understanding of the resharing concept, including a preliminary assessment of the preconditions for reshareability in Hovinbyen (a north-eastern district in Oslo, Norway). This was done by providing a conceptual model of resharing and exploring its dimensions, namely spatio-functionality, social, and digitalization/shared mobility, as well as by reviewing existing urban projects (their resharing dimensions provide insights for developing reshareability indices).

The study further reveals the need to identify input factors that enable the calculation of reshareability indices. Examples are provided to demonstrate how such a reshareability index may be calculated to support and evaluate existing developments in the two sub-districts of Hovinbyen (Løren and Økern), as well as for future developments and in other locations. To the best of our knowledge, the type of analyses presented in this study – attempting to analyze several resharing dimensions which support the combination of shared spaces and shared mobility – have not been previously conducted in today's cities, nor have there been analyses of factors that make districts and buildings more reshareable.

The study suggests that the (disaggregated) tools currently used to analyze shareability factors can be better implemented to analyze the synergies among the different dimensions of space and mobility (spatio-functional, social and digitalization/shared mobility), following the proposed approach to reshareability. The reshareability factors – such as those mapped in this study – can be expanded and applied to examine existing urban districts, and/or to guide official planners and policy makers in enhancing the level of reshareability in future projects in districts and cities.

While this study has focused on the specific case of one district in Oslo, the findings and reshareability index developed can serve as a foundation for guiding urban development not only within Oslo, but also in other cities and regions. The concept of resharing and reshareability index can be adapted and applied to different contexts, thus enabling the creation of more sustainable and liveable communities worldwide.

Finally, the resharing approaches and reshareability index presented in this paper are not merely about the provision of physical infrastructure. The ideas involve a cultural shift in the way people (including residents, politicians, policy makers, planners, real-estate developers, innovators etc.) perceive, engage and plan the urban environment. Building a culture of sharing, collaboration and community requires time and effort in order to foster trust, change behavior and encourage participation. This process entails engaging with a range of stakeholders, with particular attention being paid to the residents, promoting awareness and education, and creating platforms for community interaction and cooperation.

CRediT authorship contribution statement

Tanu Priya Uteng: Conceptualization, Funding acquisition, Investigation, Project administration, Resources, Writing – original draft. **Mina Di Marino:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Validation, Visualization, Writing – original draft. **Seyed Hossein Chavoshi:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Validation, Visualization, Writing – original draft.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix 1. Data Sources

Appendix 1 provides an overview of the data sources utilized in the development of the reshareability index in this study. The primary sources include OpenStreetMap (OSM) of Norway, Geonorge, and additional data obtained from third-party providers. Each factor considered in the reshareability index is associated with its respective data source.

Appendix 1: Input factors for the reshareability index – data source and references

Input factors for the reshareability index	Data Source	Reference
Building type	Arealressurs-AR5, Geonorge	fkb4 WMS
Number and diversity of mixed-use buildings	N50 Buildings and Facilities area, OpenStreetMap (OSM), Norway	OSM Norway
Availability and diversity of public amenities/services, shared workspaces	Points of Interests (POIs), OpenStreetMap (OSM), Norway	OSM Norway
Access to cultural and recreational activities including parks, natural areas, and park trails and green spaces	Park facilities, sports and culture, Geonorge	Anlegg park, idrett og kultur
Availability of car sharing stations	bilkollektivet	bilkollektivet
Availability of bicycle parking and storage facilities	POIs, OpenStreetMap (OSM), Norway	OSM Norway
Access to public transportation stops or hubs	Public Transport, OpenStreetMap (OSM), Norway	OSM Norway
Degree of street connectivity	Road Network, OpenStreetMap (OSM), Norway	OSM Norway

Openness of the façades of the buildings / Quality of the building frontages facing the footway	Fieldwork survey	-
Population density on grid 250 m	Befolkning, Geonorge	Population, Geonorge
Educational attainment in Oslo, Grunerløkka and Bjerke	Statistics Norway	Statistisk sentralbyrå

Data Availability

Data will be made available on request.

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