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ScienceDirect

Transportation Research Procedia 41 (2019) 264–282

Transportation Research Procedia

www.elsevier.com/locate/procedia

International Scientific Conference on Mobility and Transport
Urban Mobility – Shaping the Future Together
mobil.TUM 2018, 13-14 June 2018, Munich, Germany

Exploring ways of measuring walkability

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Abstract

This article describes and evaluates a three-step methodology for measuring walkability at neighbourhood-scale, aimed at also being usable for planning practitioners. The methodology was developed as part of a larger study on whether densification in public transport nodes outside city centres in Norwegian cities is a good strategy for reducing traffic in cities, what can be done to increase the traffic-reducing effects, and how improved walkability can be part of this. We define walkability as to what extent the surroundings are nice to walk in, as well as pleasant and interesting, and inviting walking. Criteria for assessing walkability are divided into three categories: Infrastructure and traffic, Urbanity, and Surroundings and activities, with specified attributes attached. Data were collected from existing data sources, fieldwork, and interviews. We used the data to assess degree of walkability for each node on a scale from *highly walkable* to *not walkable* and found that walkability of the four investigated nodes varied from not walkable to walkable. The car-driver shares on travels related to the nodes were rather high, and we argue that they could be lowered by among others reducing car accessibility and improving walkability. We experienced that our methodology worked as intended at the neighbourhood-scale. If used at a larger scale, the approach could be supplemented by GIS tools. Interviews indicate that our perceptions as researchers are not necessarily in accordance of those of users of the streets. Use of Public Participation GIS tools could give a better understanding of these differences, and how this might be dealt with. Making cities more walkable is increasingly understood as a necessary part of sustainable urban development. By sharing experiences from using our methodology, we hope to contribute with relevant input to the ongoing discussions in cities across the world on how to measure walkability and how to develop cities and areas to become more walkable.

Keywords: walkability; methodology; nodes; walking shares

1. Introduction

Stopping traffic growth and reducing greenhouse gas emissions (GHG) from transport are long-held objectives in many countries and cities (European Environment Agency 2016, European Commission 2011, Owens and Cowell 2002, Norwegian Environment Agency 2015, UN Habitat 2013). In Norway, the Government has introduced a

10.1016/j.trpro.2019.09.047

national goal that increased transport-demand caused by the rapid population growth in Norwegian cities should not cause growth in road-traffic volumes, and this is often termed as the *zero-growth objective* (Ministry of Local Government and Modernisation, 2012, Ministry of Transport and Communications, 2013, 2017). Achieving the zero-growth objective, as the population in the city grows, requires that the average inhabitant reduces his or her average daily traffic volume by making fewer trips, shorter trips, and/or a lower share of trips as a car-driver. A main strategy for achieving this is to develop land-use and transport-systems in directions contributing to reduced transport-demand and to shifts in modal split towards less car-use (Ministry of Local Government and Modernisation, 2015). This strategy largely leans on theoretical and empirical knowledge concerning how and why the spatial structure (Newman and Kenworthy, 1989, 2015, Næss, 2012, Næss et al. 2017), as well as absolute and relative qualities of the transport-systems (Cairns et al. 2001, Downs 1962, 2004, Litman 2018, Noland and Lem 2002, Tennøy et al. 2014, Walker 2012), affect travel behaviour and traffic volumes.

Densification in public transport nodal points outside city centres is part of the strategy for achieving the zero-growth objective in many Norwegian cities (see for instance Municipality of Kristiansand 2011, Municipality of Bergen 2010, Municipality of Oslo 2015). We define such nodes as areas or neighbourhoods around strong public transport hubs that are denser and/or have a more mixed use than surrounding areas. By locating housing, work-places, and services in dense nodes with good public transport accessibility, conditions for walking, bicycling, and using public transport is improved, and hence a higher percentage of the journeys could be done on foot, by bicycle and public transport. There are, however, few studies concerning if and to what extent degree nodal point development in Norwegian cities contributes to lower traffic volumes than other ways of developing cities, and what affects the traffic-reducing effects. This article presents results from a study investigating these issues (Tennøy et al. 2017), focusing here on our investigations of *walkability in the nodes*. Walking is an important transport mode in urban areas, and a necessary part of public transport travel (Hilnhütter 2016). Our understanding was that the degree of walkability in the nodes would affect the competitiveness of the modes walking and public transport versus the private car, and hence should be included in the study.

We searched for suitable methods for measuring walkability on neighbourhood-level, but the methods we found were too resource-demanding or did not suit our needs in other ways. Several tools and methods are for instance developed for the North-American context and might not be transferable to the Norwegian context. We decided instead to develop and test a methodology of our own. We aimed at developing a methodology that can also be used by planners and in planning practice, since Norwegian planners has expressed such a need. This meant that the methodology should require easily accessible data, be usable without the need of expensive or specialist software, and without highly specialised skills.

In this article, we describe the methodology, our experiences with using it, as well as ways of improving it and adapting it to other types of areas and scales. We also present main results from our study of walkability in four nodes in three Norwegian cities, and our conclusions with respect to how walkability can be improved, and car-use reduced on journeys to, from and within nodes.

The article is organised as follows: Section 2 presents the theoretical understandings forming the basis for the empirical investigations, and Section 3 the research design, methods, data, and the main challenges experienced. Section 4 presents an example of how the method is used and the kinds of results it provided, as well as the findings on walkability in four investigated cases. In section 5 we reflect upon experiences, challenges and ways of improving the methodology, and on ways of improving walkability and reducing car-use on travels related to nodes outside city centres. The conclusions follow in section 6.

2. Theoretical framework for exploring walkability

Walkability is hard to define clearly. We understand it here as describing to what extent cities, neighbourhoods, routes or streets, are nice to walk in, as well as pleasant and interesting, and hence invite to walking. This is influenced by characteristics of the built environment, of activities and people, and of the context (Ewing and Handy 2009, Forsyth and Krizek 2010, Speck 2012, Newman and Kenworthy 2015, Hillnhütter 2016, Leslie et al. 2007, Lo 2009, Yin 2017). The understanding of how walkable an area is, varies with individual perceptions of a place (Ewing and Handy 2009), but for our purposes we focus on the built environment of, and activities in, defined areas on neighbourhood-level.

Based on existing literature, we have organised the attributes we understood to be most relevant in our context under the headings of three partly overlapping main factors: Infrastructure and traffic, Urbanity, and Surroundings and activities, see Table 1.

Table 1: Factors and attributes relevant for assessing walkability in the case-areas.

Factors	***Attributes***	***Highly walkable***	***Walkable***	***Somewhat walkable***	***Not walkable***
		◄			►
Infrastructure and traffic	Street or road character	Streets			Roads
	Pedestrian infrastructure	Sidewalks			No sidewalks
	Crossings	Defined crossings at same level			Barriers and detours for pedestrians
	Traffic volumes	Low			High
	Speed levels	Low			High
	Pollution and noise	Low			High
	Traffic safety	High			Low
	Universal design	High accessibility			Low accessibility
	Public transport connectedness	Walking routes connected to public transport stops			Walking routes not connected to public transport stops
Descriptive conclusion					
Urbanity	Density	High			Low
	Proximity	Short distances			Long distances
	Connectedness	Connected to the city structure			Its own structure
	Scale	Pedestrian			Vehicle-oriented
	Orientation of buildings	Buildings oriented along the street			Buildings receded from the street/road
		Building head-to-head to the sidewalk			Parking in front of buildings
	Block sizes	Small blocks			Long/large blocks
	Permeability	High Permeability			Non-permeable
	Pedestrian network	Coherent pedestrian network, short cuts			Infrastructure as barriers for pedestrians
	Urban structure	Grid			Cul de sacs
	Parking lots	Few			Many, making barriers
	Urban spaces and parks	Many			Few/none
	Green	Street trees, parks etc			No greenery
	Street furniture	Many			Few
Descriptive conclusion					
Surroundings and activities	Destinations	Multiple			Few or no one
	Activities	Multiple			Few or no one
	People walking or staying	Many			Few or no one
	Facades	Active			Closed
	Mix of functions	High			Low
	Vibrancy	High			Low
	Maintenance	High			Low
	Experienced safety	Feels safe			Feels non-safe
	Wayfinding	Easy			Not easy
Descriptive conclusion					

Infrastructure and traffic concerns mainly if there are safe spaces for pedestrians to walk (sidewalks, defined crossings), whether there are detours increasing travel time for pedestrians (number of crossings, crossings at same level, absence of planned detours), and if traffic volumes and speeds causes noise and pollution, and negatively affect traffic safety and how pleasant a street is. To what extent the infrastructure is universally designed, affects who the route or area is walkable for. How walking routes lead to public transport stops influences connectedness to public transport. The degree of walkability can be summed up to if the organising structure of an area has the characters of street or roads, and to what extent the priority is on the private car or not (Newman and Kenworthy 2015, Arup 2016). Streets are narrower, has tighter curves, fewer lanes and can be more easily crossed than roads. Streets do not have the same type of markings, signage, fences as roads have. Streets, relatively speaking, have larger sidewalks, less car traffic and lower speeds. They are built more on the premise of the pedestrian than the roads and can be multifunctional places for social and economic exchange, as well as movement (Kahn 1973, Carmona et al. 2017).

Urbanity, as we use the term here, concerns other attributes of the built environment than the transport infrastructure, that stimulates how efficient and pleasant it is to walk. This includes for instance density, affecting proximity and walking distance, which strongly influence if walking is a relevant mode of transport (Hjorthol et al. 2014, Newman and Kenworthy 2016). It also includes connectedness and if the urban structure is at a pedestrian scale (see for example Gehl 2013, Speck 2012, Newman and Kenworthy 2015, Melia 2015, Ewing and Handy 2009, Forsyth and Krizek 2010), for example, if functions are close to each other, and if buildings are oriented along the street and built head-to-head to the sidewalk rather than receded from the street. Another relevant attribute is block-size, affecting degree of permeability, and if pedestrians can choose between routes and take short cuts. Further, if the area has a coherent pedestrian network as opposed to large, empty spaces or parking lots or other infrastructure that creates barriers, if there are urban spaces and parks where pedestrians can stay, socialise, play and spend time, and if there are street trees and street furniture inviting to such activities, an area or street is understood as more walkable than if having opposite characteristics.

The last group of factors, *Surroundings and activities,* includes attributes like the amount, types and variation of destinations and activities in an area, influencing how pleasant and worthwhile the area is to walk in. An area or street characterised by many destinations, activities and people, active facades, a mix of functions, and a vibrant street life, good maintenance, experienced safety and easy wayfinding is understood as more walkable than streets and areas with opposite characteristics (see for example Gehl 2013, Gehl Architects 2014, Krogstad et al. 2015, Speck 2012, Jacobs 1961, Montgomery 2013, Hass-Klau 2015).

3. Research design, methodology and data

When developing a methodology for measuring walkability, we searched for ways of collecting data describing the factors and attributes listed in Table 1 and described in section 2. We read up on previous studies aimed at measuring walkability on different levels. Various methods for data-collection were used in these studies, including GIS and softGIS (Sthåle 2012, Kyttä 2011, Kyttä et al. 2013), video analysis (Hilnhütter 2016), shadowing (Krogstad et al. 2015) and walking as urban observation with qualitative measures (Pierce and Lawhon 2015, Macpherson 2016). Also, different design- or community-led project have addressed different ways of mapping neighbourhoods, including surveys and participation. Some of these have led to toolkits and guides for mapping and design based on experiences and reference projects (NPRA 2012, CABE 2007, UCL 2017, ITDP 2018). As mentioned, we found that none of these suited our needs perfectly, because they were developed for other scales than the neighbourhood-level, the contexts were too different from ours, they were to resource-demanding or required specialised skills. These approaches and methods served, however, as important inspiration for the methodological approach we designed for our study.

As mentioned, the investigation of walkability was part of a larger study concerning, if and to what extent, development of areas close to public transport nodes contributes to lower traffic volumes than other ways of developing cities, and what affects the traffic-reducing effects of nodal point development (Tennøy et al. 2017). Selection of cases for this study was made in cooperation with the relevant municipalities. Criteria for case selection were that: i) The case areas are located outside the city centre, ii) Several public transport lines meet, and the public transport service is relatively good compared to other parts of the city, and iii) The areas have a mixed use, with dwellings, workplaces, services, and more. Four nodes in three different Norwegian cities were selected as cases: Vågsbygd in Kristiansand, Danmarks plass in Bergen and Nydalen-Storo and Bryn-Helsfyr in Oslo (see Figure 1). The area defining the nodes were given by ten minutes walking distance from the main public transport stops, adjusted to the basic statistical unit in the Norwegian system ("grunnkrets").

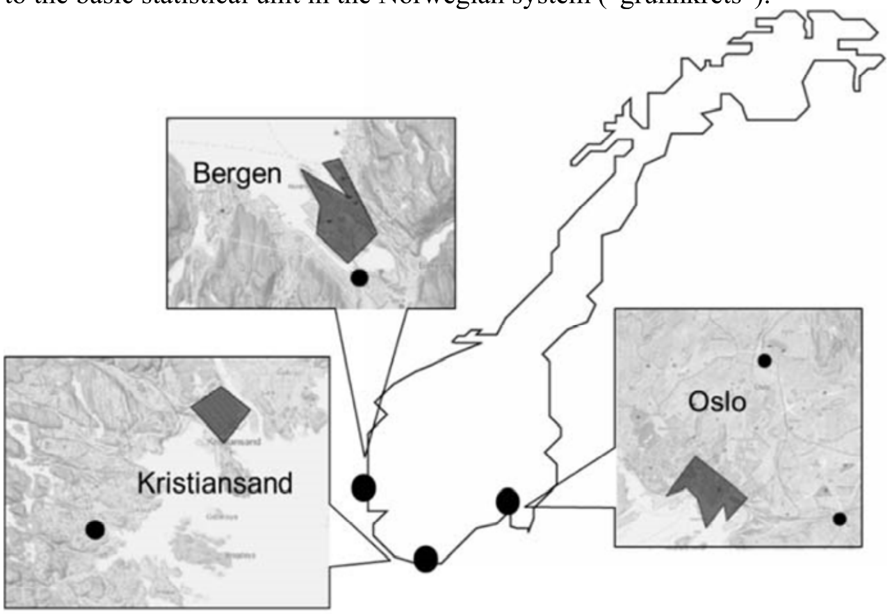

Figure 1: The three case cities and the location of four nodes in each city. The city centres in each city are also marked (The background maps for the cities are from the Norwegian Mapping Authority at norgeskart.no).

Our methodological approach can be described as a context specific case-based evaluation (Carmona et al. 2017), using complementary strengths of both quantitative and qualitative data to address complexities. The methodology consists of gradually establishing a detailed picture of an area by using data from document analysis, register data, maps, and spatial registrations, and combing these data with new data from fieldwork and interviews. Our approach is described in a three-step methodology for assessing walkability (see Figure 2 and the appendix), covering the factors and attributes we understood as being relevant for walkability, as listed in Table 1.

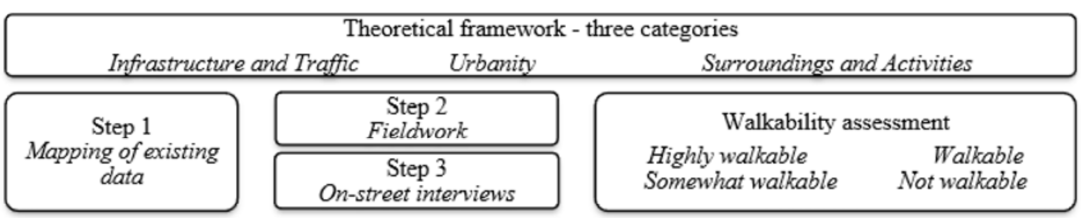

Figure 2: Methodology with combined methods for investigating walkability.

In step one, *mapping of existing data*, we collected data from easily accessible sources, such as register data from existing data bases, open map tools, documents, and interviews. The documents studied were mainly municipal master plans (Municipality of Kristiansand 2011, Municipality of Bergen 2010, Municipality of Oslo 2015), and these were supplemented with interviews with municipality planners in Kristiansand and Bergen. For Oslo, we got written material about the cases from the municipal project manager. National travel survey data, comprising reports from about 60 000 persons nationwide, were used in analyses of travel behaviour (Hjorthol et al. 2014). Geo-coded data from the Central register of enterprises (Statistics Norway 2016a), including all units in Norway with economic activity, were used when analysing number of workplaces in different areas, and population statistics (Statistics Norway 2016b) when analysing population development. Data from Open Street Map, online maps from the

Norwegian Mapping Authority (norgeskart.no) and the municipal open GIS viewing platforms were used to gather information about the nodes (for example bike accessibility, functions and use of buildings).

For several of the attributes listed in Table 1, data could not be collected from existing sources, and were collected through *fieldwork,* in Step two in our methodology. For defined routes in each case area, selected in Step one due to being important walking routes in the case-areas, assigned researchers registered qualities of the areas with the help of a registration form (see form in appendix). Two researchers filled out each form and then sat down comparing notes, discussing findings, and arriving at common understandings.

To add the user-perspective to the assessment, *on-street interviews* were conducted in Step three, by asking people in the area (employees, dwellers, and visitors) questions regarding their travel habits, the use of public spaces, the qualities of the area, and other important destinations (see interview guide in appendix).

The walkability assessment was made for each node by the researchers who had also done the data collection. Data collected throughout the three steps where used to assess attributes within each category along a scale from highly walkable to not walkable. These assessments were aggregated for each category, and then for each area. Two researchers did individually assess each area, and then sat down and compared notes. They arrived at common understandings and created a case report for each area. When choosing to use a scale from highly walkable to not walkable, instead of an index or score for each feature or category investigated, we kept the approach qualitative. We believe this is more transparent than defining an index (or the like) for how walkable the area is assessed to be. Our experience from planning practice is that defining such a number may take focus away from the broad qualitative appraisal conducted when doing these kind of assessments, and that a written description is more useful. We present our assessment of Danmarks plass as an example on how we have used our methodology in section 4.1. Section 4.2 focus on the results from the assessment of walkability of all four nodes, and section 4.3 on the findings concerning what affects the traffic-reducing effects of node development.

4. Findings

4.1. Measuring walkability - the case of Danmarks plass in Bergen Norway

Danmarks plass is located around two kilometres from the city centre of Bergen, Norway's second largest city. After implementing a light rail system, the city has encouraged urban development around important light rail stops. The case area includes two light rail stops and contains both housing, businesses, local and regional services, and some retail around these two hubs. Parts of the node have been transformed from former industry to housing and offices and some retail. The area is also a node in the bus system and both regional and local bus routes meet here. There are also two main road systems (E39 and County road 255) that runs through the area, with several lanes, large ramps, and intersections, as well as toll collection stations. Some characteristics of Danmarks plass, based on quantitative register data collected through step one, are presented in Table 2.

Table 2: Characteristics of Danmarks plass, based on data collected in Step one.

Theme	**Characteristics of Danmarks plass**
Urban structure	Housing areas with different characters, with a denser core with service and businesses. A motorway crosses through the middle of the area. Urban regeneration from industry to housing and offices along the fjord.
Centrality (distance to city centre)	2 km
Density	
Density – inhabitants	5207 inhabitants per km^2
Density – employees	5189 employees per km^2
Density – in total	10395 inhabitants and employees per km^2
Mixed use	
Degree of mixed use (inhabitants/employees)	1,0

Mix of uses – per cent and type of function:	
- Retail and service	24 %
- Offices	27 %
- Other workplaces	49 %
Accessibility by public transport	Very good
Accessibility by car	
- Road accessibility	Good
- Parking accessibility	Good
Accessibility by bicycle	
- within the neighbourhood, node	Poor
- towards the city centre	Good
Physical access for pedestrians	Good

Data characterising attributes listed in Table 1, that could not be retrieved through existing data sources, were collected through fieldwork and interviews (as described in section 3). The researchers used the registration form for Step 2 (see appendix) when mapping relevant attributes of each of three pre-selected routes in this case area, systemizing impressions, and findings from the inspection, and later used to create a case report for each area. The on-street interviews were done during the fieldwork. A total of 20 persons living, working, studying, or visiting Danmarks plass were interviewed. For nine of these, public transport was the main means of transport on the trip, for five walking was the main means of travel. While 12 of the interviewees had access to car, only three used car as main means of transport this day. Most of them did find the offer of services in the area adequate to cover daily needs. They also found the area well facilitated for biking and walking, and most of the interviewees consider the traffic situation in the area less dominating than we as researchers experienced it. The interviews were mainly used to adjust the researchers' impressions.

Based on the data collected in the three steps, we could assess the walkability of Danmarks plass, as summed up in Table 3. A written description follows the table.

Table 3: Properties of the node Danmarks plass case summed up.

Factors	Attributes		Highly walkable	Walkable	Somewhat walkable	Not walkable	
Infrastructure and traffic	Street or road character	Streets			X		Roads
	Pedestrian infrastructure	Sidewalks	X				No sidewalks
	Crossings	Defined crossings at same level				X	Barriers and detours for pedestrians
	Traffic volumes	Low				X	High
	Speed levels	Low				X	High
	Pollution and noise	Low				X	High
	Traffic safety	High			X		Low
	Universal design	High accessibility		X			Low accessibility
	Public transport connectedness	Walking routes connected to public transport stops	X				Walking routes not connected to public transport stops
Descriptive conclusion		*Car domination (several motorways and major roads) but also areas with street character*					

Factors	Attributes		Highly walkable	Walkable	Somewhat walkable	Not walkable	
Urbanity	Density	High		X			Low
	Proximity	Short distances		X			Long distances
	Connectedness	Connected to the city structure		X			Its own structure
	Scale	Pedestrian		X			Vehicle-oriented
	Orientation of buildings	Buildings oriented along the street		X			Buildings receded from the street/road
		Building head-to-head to the sidewalk			X		Parking in front of buildings
	Block sizes	Small blocks			X		Long/large blocks
	Permeability	High Permeability		X			Non-permeable
	Pedestrian network	Coherent pedestrian network, short cuts			X		Infrastructure as barriers for pedestrians
	Urban structure	Grid		X			Cul de sacs
	Parking lots	Few			X		Many, making barriers
	Urban spaces and parks	Many			X		Few/none
	Green	Street trees, parks etc			X		No greenery
	Street furniture	Many			X		Few
Descriptive conclusion			*Partially a continuation of the dense urban structure (inner city), pedestrian scale*				
Factors	**Attributes**		**Highly walkable**	**Walkable**	**Somewhat walkable**	**Not walkable**	
Surroundings and activities	Destinations	Multiple		X			Few or no one
	Activities	Multiple			X		Few or no one
	People walking or staying	Many		X			Few or no one
	Facades	Active		X			Closed
	Mix of functions	High		X			Low
	Vibrancy	High		X			Low
	Maintenance	High		X			Low
	Experienced safety	Feels safe			X		Feels non-safe
	Wayfinding	Easy			X		Not easy
Descriptive conclusion			*Some public spaces that also contains green elements, several meeting places, many that bicycle and walk, active facades in the central part*				

With regards to infrastructure and traffic, the car dominates the overall picture in the neighbourhood of Danmarks plass. The motorway E39 has six lanes, high traffic volumes and speed levels, and puts restrictions on what happens along the road, also due to pollution and noise. The other roads in the area have a more mixed appearance, from road characteristics to stretches that have more the appearance of a street. The stretch between the two light rail stops is the most urban in character but has narrow sidewalks and fences to stop pedestrians from entering the street, prioritising the light rail. E39, dividing the area, can only be crossed by pedestrians in specific underpasses. The ramps to the underpasses are narrow and steep, though the rest of the area seems to have quite good accessibility concerning universal design. Walking routes are well connected to public transport stops.

We assessed Danmarks plass to be an urban extension of the inner city, even if the fjord and the road systems partly divide the neighbourhood from the surroundings. Compared with Bergen city centre, Danmarks plass has half the density (counted as employees and inhabitants per square km), but twice the density compared to the rest of the city. The buildings are mostly at a pedestrian scale, even if there are some larger buildings that mainly relate to themselves rather than to their surroundings. The area is permeable, but less permeable than the city centre, especially due to the E39 dividing the area. There are many different pedestrian routes to choose from in the area, and there are several pedestrian short cuts or openings to cross through. The distances between functions and destination points are short, and the node offer specialised services in addition to daily services. There is a mix of street parking and larger parking lots. There are different types of urban spaces in the area, from areas for ball games and small playgrounds, to new public spaces in the regenerated areas. Some squares in front of the buildings in the older parts of the neighbourhood are used to park cars. The quality of the spaces varies. Few of the streets have trees, except the new streets in the regenerated areas towards the fjord. The greenery comes mostly in the shape of front gardens, and as part of public squares. The newer squares are furnished, but in general the use of street furniture is somewhat limited.

Figure 3: Large scale infrastructure makes the node very accessible by both car and public transport but also creates barriers and detours for pedestrians. Squares in front of buildings are used for parking. Photo: Oddrun Helen Hagen.

When focusing on surroundings and activities we found that Danmarks plass has destinations and activities that cover mainly local needs. Regardless of this there are many pedestrians and several parts of the neighbourhood feel vibrant. Most people seem, however, to walk through the area or straight to their destinations and are not staying in the area. Several buildings have active ground floors, even if some of them did not have tenants at the time of the fieldwork. The distances to the fjord and the mountains surrounding the city are short, and there are signs for pedestrian routes and access. On the negative side, the crossings under the motorway are hard to find and can feel unsafe, especially at night. The ramps to the underpasses have an overall worn look, the rest of the area seems well maintained.

The evaluation of walkability of Danmarks plass is summed up in Table 3. We assess Danmarks plass to be somewhat walkable. Over all, the area is urban, it has infrastructure for pedestrians, and varied surroundings and encounters/activities, but the walkability is reduced by the barrier that the motorway makes and that the crossings underneath it can feel unsafe and as a detour. There is potential to strengthen the walkability in Danmarks plass by creating more pedestrian friendly crossings of the motorway, restricting parking on squares and refurbish the squares with street furniture and trees, and to fill empty ground floors with activities and amenities, that will contribute to more activity.

4.2. Walkability in four Norwegian nodes

We assessed a total of four nodes in the same manner as Danmarks plass, see summary in Table 4. According to our assessments, walkability in the investigated nodes varies from not walkable to walkable. Only one of the nodes, and only parts of this node, was assessed to be walkable. The character within the nodes in Oslo were so different that each node was divided in two when assessing walkability. A main finding is that the pedestrian infrastructure often is in place in the nodes, but that the walkability of the nodes in general are low, especially due to car-dominated planning.

Table 4: Walkability in the nodes summed up.

	Vågsbygd	**Danmarks plass**	**Nydalen-Storo**	**Bryn-Helsfyr**
Walkability	*Not walkable*	*Somewhat walkable*	*Nydalen: walkable* *Storo: not walkable*	*Bryn: not walkable* *Helsfyr: somewhat walkable*
Urbanity	Not urban, suburban housing and villas, receded facades	Somewhat urban, partially a continuation of the dense urban structure, pedestrian scale	Nydalen: Somewhat urban, partially a continuation of the dense urban structure, pedestrian scale Storo: Not urban, large scale buildings, receded facades	Bryn: Not urban, large scale buildings, retracted facades Helsfyr: Not urban, large scale buildings, receded facades
Infrastructure and traffic	Large roads but low amount of traffic Dominating parking lots and free parking for shopping and park and ride	Car domination (several motorways and major roads) but also areas with street character Parking fee, but large amount of surface parking and on street parking in the area as whole	Nydalen: Streets with street trees Storo: road domination, low permeability Parking fee, but large amount of surface parking and on street parking in the area as whole	Bryn; road domination, low permeability Helsfyr: road domination, but higher permeability Parking fee, but large amount of surface parking and on street parking in the area as whole
Surroundings and activities	Few active facades, few public space formations Many pedestrians, especially around the shopping centre	Some public spaces that also contains green elements, several meeting places, many that bicycle and walk, active facades in the central part	Nydalen: Active facades and space in front of buildings, proximity of retail and services and destination points Storo: Inactive facades and few public spaces, a couple of large destination points but with large distances in between	Bryn: Inactive facades and few public spaces, few destination points and few pedestrians Helsfyr: more functions than Bryn, more active facades and few public spaces, a couple of large destination points and many pedestrians

5. Discussion

5.1. The experiences made with the case-based evaluation methodology

The aim in this project was to develop a methodology for measuring walkability that require easily accessible data, is usable without the need of expensive or specialist software, and without highly specialized skills. The methodology should also be useable for planning practitioners. Based on our experience using the methodology, we believe we have achieved this. We experienced that the data required by the methodology was easily available (we used mostly open data), they were mostly suitable and easy to use, and they gave a sufficient understanding of the degree of walkability in the case-areas. With a relatively small sample of cases, and investigations on neighbourhood-level, walkability could be investigated and assessed without GIS analyses or use of another specialist software. The use of predefined registration forms enabled quite effective and robust working procedures. Lastly, the type and amount of data needed fitted well for assessing street and neighbourhood level. Based on this, we believe our approach meet the criteria set when we started developing it.

We also faced some challenges. One was that some data sets are geocoded on address or coordinate level and meet the requirements to be used to assess areas at lower scales like neighbourhoods, while other relevant data sets should mainly be used on city or district scale. There are moreover shortcomings concerning what kind of data sets exists.

While information about traffic volumes were easy available and more or less up to date (at least on main roads), none of the case-areas had registrations (current nor going back in time) on volumes of bicyclists and pedestrians. Assessment of people activity was therefore based on impressions of such activity during the relatively short period when we were doing the fieldwork. Better recording and documentation, by counting the number of people walking or staying in public places (Gehl 2013 and 2014), would be an interesting contribution to the assessment. In the described methodology, we supplemented the researchers´ registrations with the user perspective from visitors, dwellers, and employees by doing on-street interviews. It was interesting to notice that the interviewees considered the neighbourhood more positive than the researchers, especially coming to the traffic situation. But this also raises interesting challenges that should be considered in further use and development of the methodology; like how to consider different perspectives when doing such assessments. Various pedestrian groups, as well as different planning practitioners and researchers, might perceive and evaluate an area differently when it comes to walkability, sometimes making it difficult to make a final evaluation.

Our experiences with developing and testing an approach to measure walkability in nodes give us the opportunity for discussions on improvements of the methodology and on what scales it can be applied. We used the approach to assess walkability of neighbourhoods. On a district, city, or regional level, there is a larger need for automatization of the data gathering and use of quantitative data. Using the approach would be too complex and time consuming in larger studies with more cases or larger study areas. In such cases, the use of GIS software would be helpful to both gather and structure larger data sets, as well as to measure and analyse features like density, connectivity, land use attributes and others (Leslie et al. 2007). Using GIS could also allow for other types of analyses of the data, like overlay methods to identify relationships between datasets. For the described case studies, suitable data sets for use in GIS are available, either as free accessible data sets or as data sets that can be acquired from governmental agencies. Still, the use of GIS tools demands skills and specialist software, making it only suited for those with these skills and access to software.

In our experience, the fieldwork was an important supplement to the use of register data and other existing data. Much of the data collected through fieldwork cannot be retrieved from existing data sets or maps. In our understanding, these data were necessary to arrive at a sufficient understanding of the area to allow for assessment of the walkability. But like mapping, scale affects the fieldwork. Fieldwork is a doable task on neighbourhood or street level, but if moving up in scale to a district, city, or region it is not possible to carry out the same extent of fieldwork. For further use of the methodology on neighbourhood or street level, we believe that the fieldwork could be further strengthened. We experienced that conducting the fieldwork by two researchers together gave benefits both for effective registrations and for later discussions and contributed to more robust assessments. Walking with other professionals and/or with practitioners who are going to use the results of the research is an option that could be added to the approach, both to improve the transfer of knowledge and verify or supplement the assessments made by the researchers.

As mentioned, we found the perceptions of users both interesting and important when assessing walkability at this scale. The chosen approach, on-street-interviews, was however time consuming, and we experienced it difficult to get people answer. Another restriction was that we only got in contact with the limited number of people we chose to stop (in this case pedestrians at the selected time of the fieldwork) and that agreed to answer. A methodological improvement could be the use of a Public Participation (PP) GIS tool, where web and location-based surveys are applied through user-friendly applications. This allows gathering of more knowledge, as well as reaching more and different users than the one you meet in the neighbourhood at certain times of the day. Another benefit with PP GIS tools like softGIS is that the experiential, geo-coded "soft" knowledge can be analysed together with the "hard" GIS information, enabling to analyse connections between two levels of information (Kyttä 2011, Kyttä et al. 2013). The use of PP GIS tools, or smart-apps recording travel behaviour, could also be suited to gather information about where most of the users of an area, or even different users, choose to walk and where they believe improvements are needed to improve or ensure walkability. For future use we see that our questionnaire could be slightly altered to fit into a softGIS approach. Another improvement could be combining fieldwork registrations with shadowing selected users. This has for example been done among elderly citizens in one city in Norway (Krogstad et al. 2015). Shadowing (Czarniawska 2007) would give the researcher the opportunity to follow users when walking in or through the neighbourhood, thus studying the actual behaviour of the person walking and with an interview in the end it would also be possible to ask how the person perceive the surroundings while walking. Both the use of PP GIS tools and shadowing would be more labour intensive than on-street-interviews. These approaches would as well add better knowledge to understandings on how walkable an area is based on individual perceptions on place (Ewing and Handy 2009), which we did not include in this study.

We find that some of the challenges faced when measuring and assessing walkability in nodes with different qualities and sizes, and in different cities, can be adjusted through improvements and adaptions of the methodology. To ensure further use, especially among planners and in planning practice, we find it important that approaches for measuring and assessing walkability do not become too complicated or too labour intensive. This is a contradiction to some of the suggested improvements and implies maybe the need of making different approaches for practice and research.

5.2. Improving walkability and reducing car-accessibility to enhance traffic-reducing effects of the nodal point development strategy

Our exploration of walkability, and ways of measuring it, was part of a larger project, where the main purpose was to investigate if, and to what extent, the densification in nodes outside the city centre is a good strategy for achieving the goal of zero growth in traffic volumes. We found that the nodes generate less traffic per workplace and per resident than more sprawled areas of the cities, and far more traffic than city centres and inner-city areas, see Figure 4.

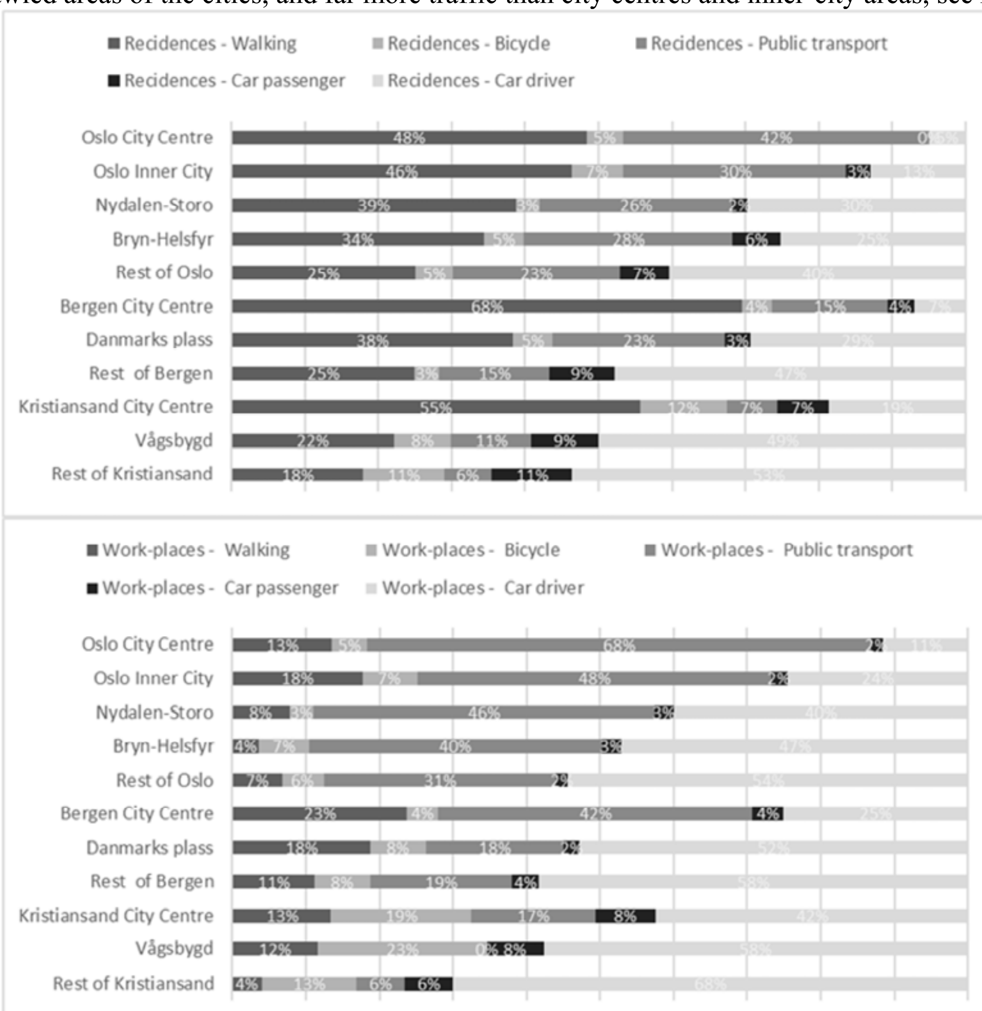

Figure 4: The first diagram in the figure shows modal splits for trips that starts or ends in the zone the respondent lives in, aggregated to neighbourhood. Data from the Norwegian Travel Survey from 2009 and 2013/14 (N (trips) Oslo=12808, N Bergen=8849 and N Kristiansand=5093). The second diagram shows modal splits for trips that to and from work-places in the zone, aggregated to neighbourhood. Data from the Norwegian Travel Survey from 2009 and 2013/14 (N (trips) Oslo=3784, N Bergen=1342 and N Kristiansand=743). Facsimile from Tennøy et al. 2017.

The shares of trips of car-drivers on trips to and from the case-area are somewhat higher than we had expected. They vary from 25 to 48 percent on trips to and from residences in the case areas and from 40 to 58 percent on trips to and from workplaces located in the areas. Shares of trips done by public transport vary from 11 to 29 percent on trips to and from residences in the case areas and from 0 (Vågsbygd) to 46 percent on trips to and from work-places. Bicycling shares vary from 4 to 29 percent on trips to and from residences and from 4 to 23 percent on trips to and from work-places. Finally, the shares of trips done on foot (walking as the main mode of transport on the trips) vary from 22 to 34 percent on trips to and from residences in the case areas and from 12 to 18 percent on trips to and from work-places located in the areas. A conclusion is thus that directing new developments to public transport nodes outside city centers contributes more to achieving the Norwegian zero-growth objective than allowing low density sprawl, and that steering new developments towards areas in and close to city centers is significantly more efficient with respect to achieving this goal.

A logical question following from this is, what can be done to reduce car-usage on trips related to nodes. One solution could be to change the relative quality by different modes of transport in ways strengthening the competitiveness of other modes than the private car. As part of the study, we assessed accessibility by different modes to, from and in the nodes (Tennøy et al. 2017). A finding across the cases is that accessibility by car is good or very good. The areas are located with direct access to main road systems, and the availability of parking is ample. All who want a parking space can find one, with or without a parking fee. We also found that accessibility by public transport to all nodes was good or very good. Accessibility by bicycle varied from bad to good. Walkability was, as described in section 4.2, assessed as varying from not walkable to walkable (only parts of one of the nodes).

Ways of reducing the competitiveness of the private car include, among others, to reduce parking accessibility through removal of parking spaces and introduction of more or higher parking fees, and to reduce road accessibility, for instance by reducing number of lanes or increasing road-tolls. Bicycling-shares vary significantly, and are very low in some nodes, indicating that improving bicycling infrastructure could make some people shift from car to bicycle. Significantly improving public transport services is probably not an option in our cases, since public transport accessibility already is good or very good. We found that the walkability in the nodes could be improved, indicating a potential for increasing walking-shares by further facilitating walkability.

In existing nodes, this can for instance be done by establishing more and better crossings of roads and streets, by refurbishing urban spaces in ways making them more inviting as spaces to stay, play or socialise, by introducing activities that attracts more and other types of users, or by introducing street furniture and trees in streets and urban spaces. In the nodal point areas assessed in our study, transforming areas used for surface-parking could be a key issue for making the areas more walkable and reduce car-use. By replacing large parking lots with buildings with active ground floors, parks, urban spaces, or other activities, both the actual and the perceived distances between activities would be reduced, and the areas could become more inviting for walking. Removing parking from smaller urban spaces in front of buildings would free up areas that could be refurbished in ways inviting users to stay in the area for a while. Removing on-street parking would free up space for planting trees and widening sidewalks. Improving walkability in such ways could also strengthen public transport competitiveness, by making the first and last mile of the public transport trip more pleasant and attractive. Removing parking would also give room for improving infrastructure and accessibility by bicycle and public transport and reduce accessibility by private car. Together, this could be important contributions to reducing car-usage on trips related to nodal point areas.

When developing new nodes, or significantly transforming or enlarging existing ones, planning should take the pedestrian perspective first, and ensure that the area is developed in ways inviting walking, for instance by designing streets instead of roads (as discussed in section 2). This would represent a significant shift from the current car-based planning and development of Norwegian nodes outside city centres, towards planning and development strengthening the competitiveness of more sustainable modes of transport, which would contribute to make the node development a successful strategy for achieving the Norwegian zero-growth objective.

6. Conclusions

In this article we have examined how to measure and assess walkability on neighbourhood level by developing and testing a methodology including different methods. Our focus was to develop an easy to use approach based on academic literature and empirical studies. We believe we have achieved this by using data that are easily accessible and usable without the need of expensive or specialist software, though we see that improvements can be made. The researchers who conducted both the three steps and the final walkability assessment of the nodes all have experience from practice, and since the fieldwork and mapping can be done quite effectively, we think that the methodology is suitable for use on street and neighbourhood levels by both researchers and practitioners. On a district, city, or regional level there is a larger need for automatization of the data gathering and use of quantitative data. In further developing of methodology for investigating walkability we find it important that the approaches do not become too complicated or too work intensive. This to ensure further use. Yet we believe, that the users´ point of view on walkability should play an even more important part in further development.

To be useful for further use in planning practice, the results of the walkability assessment must be understandable and accountable. However, different approaches, both regarding methods and scales, make it challenging to compare and verify results from different studies of walkability (Forsyth and Krizek 2010). This should be addressed as well. As the Institute for Transportation and Development policy (ITDP 2018) points out: *"With a better global understanding of walkability, and more consistent and frequent measurement of the walkability of urban environments, decisionmakers will be empowered to enact policies that create more walkable urban areas (ITDP 2018:4)".* Challenges related to steering land-use and transport developments towards achieving a more sustainable travel pattern, are relevant both in small towns and big cities, and are not exclusive to Norway. Improving walkability is an important part of this. We therefore believe our effort to improve both the methodological and empirical foundations for measuring and assessing walkability can contribute ongoing discussions in many countries on how land-use and transport planning can be organised to facilitate more sustainable mobility patterns.

Acknowledgements

This article is based on the findings from a project entitled: ‘‘Effects on traffic and emissions of densification in nodes in Bergen, Kristiansand, and Oslo’’, Project No. 1575/2017, funded by the Municipality of Kristiansand, the Municipality of Bergen, the Municipality of Oslo and The Norwegian Association of Local and Regional Authorities (KS).

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Appendix A. Evaluation guide for walkability at neighbourhood level

Step 1: Description and mapping of the neighbourhood

1. Delineation of study area (and hinterland) (show on map)

- Describe (in short) the key features of the area: status in the urban structure, distance to city centre, important characteristics
- Statistical register data on densities of employees and inhabitants as well as demographic characteristics
- Earlier mappings and local knowledge, information from plans

2. Mapping (from aerial photographs):

- Describe the road access with public transport lines and stops
- Describe the situation for parking and public spaces (main parks and public spaces)
- Describe how the businesses (including services and retail) and dwellings are placed, and the distances between them
- Define main destination points and important pedestrian links

3. Choose a core area for further mapping and evaluation based on an evaluation of the whole study area.
Describe and show on map

4. Further delineation of the routes to be mapped in the field (step 2).
The areas should be important thoroughfares that runs through the areas.

Step 2: Mapping of important routes with registration form

The registration form should be filled out based on mapping and systematic field studies (there should be one form for each route). The field work should be documented in the form and with photos to illustrate the findings documented in the form.

Theme	Registration
Stretch/ route (name and/or short description)	
Time (of day) and date	
Urban structure	
- functions (mix and type) and how they are placed in relation to each other	
- could the area be described as its own unit/node/ centre	
- destination points	
- other	
Greenery	
- street trees	
- front gardens	
- parks	
- other	
Transportation situation	
- type of roads	
- car traffic	
- public transport presence	
- number of bicycles (experienced not counted)	
- amount of people walking (experienced not counted)	
- presence of exchange points between modes	
- noise and visible pollution	
- other	
Infrastructure for walking	
- presence of sidewalks, width of side walk, crowding	

- separation from bicycles
- crossings, roundabouts (and how easy is it to cross)
- distance between crossings
- curbs and design
- incline
- lights
- benches
- floor, evenness
- other

Street/road

- width, separation of modes
- design (curvature, crossings, roundabouts, signs)
- streets, urban space (formations)
- other

Buildings/structure of the built environment/ street grid

- city blocks, freestanding structures, villas
- height of buildings
- distance between building and sidewalk
- length of the facades
- amount of parking space (not only the marked places)
- vacant lots
- grid, cul de sac
- permeability
- short cuts, possibilities to walk between buildings
- other

Connections between buildings and the street/road

- places in front of buildings (and qualities)
- active facades
- receded facades
- fences, walls
- other

Barriers

- infrastructure, parking lots
- traffic
- nature/rivers
- long facades (with or without gates or doors)
- other

Maintenance

- standard
- if the areas are perceived as dusty or dirty
- variations due to seasons
- lighting
- safety

- other **Urban spaces** - use of squares, spaces and benches - orientability - sun and shade - number of pedestrians (many/few) - activities, play grounds, outside seating (restaurants and cafés) - closed or open facades - if the place can be described as "vibrant" - other **Summing up** - what is the positive traits along the thoroughfare/stretch when it comes to walkability - what is the negative traits along the thoroughfare/stretch when it comes to walkability (- implications for different groups)	

Step 3: Interviews

Interview guide for semi-structured interviews of inhabitants, employees and visitors:

1. Place of interview
2. inhabitant/employee/visitor a. If visitor, how often do you visit?
3. Age
4. How to do you normally travel to get here (or from here if you live here)
5. Do you sometimes use public transport (if the answer to 4 is not public transport)?
6. Do you have to change if you use public transport?
7. What do you think about the public transport offered?
8. Is it easy to find the stop, the time tables etc?
9. Has the opportunity to use public transport or the proximity to services influenced the choice to visit/live/work here?
10. How would you describe the service and retail in the neighbourhood?
11. Which functions do you use?
12. Is there places that you consider as important, also for others as well as meeting places?
13. How is the neighbourhood facilitated for different modes?
14. How will you describe the current situation for traffic in and around the node (use name of node)?
15. Is there some critical issues when it comes to the traffic management (Ques, delays on specific roads, critical times)?
16. to what extent does the car traffic and infrastructure connected to it (roads, parking lots) influence the (urban) environment?
17. Is it easy to walk in the neighbourhood?
18. Is it safe and pleasant to walk at all times?
19. How is the general maintenance (winter, seasonal, night time)?
20. Do you bicycle in the neighbourhood?
22. If yes, which purpose has usually the trip?
23. If yes, is it easy to bicycle here?
24. If yes, how is the maintenance (season, night)?
25. If yes, is there enough parking?

26. Do you have a car?
27. If yes, what do you use the car for?
28. If yes, do have a parking places at home and/or at work?
29. Do you go often to the city centre?
30. How do you use the city centre; do you use it differently that here?
31. With what mode of transport do you travel there?
32. Is there other places that you travel to on a regular basis?
33. With what mode of transport do you travel there?