Špela Verovšek:

VREDNOTENJE TRAJNOSTNE UČINKOVITOSTI SOSESK Z VIDIKA MOBILNOSTI IN POVEZLJIVOSTI

NEIGHBOURHOOD SUSTAINABILITY ASSESSMENT – THE ASPECT OF MOBILITY AND CONNECTIVITY

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POVZETEK

Namen tega prispevka je vpogled v raziskavo tekočega nacionalnega projekta (financiran s strani Agencije za raziskovanje RS), ki naslavlja izzive podatkovno podprtega odločanja v trajnostnem urbanizmu ter razvoj novih metodologij za integracijo, optimizacijo in analizo prostorskih podatkov, ki so pomembni kot podpora odločanju pri trajnostni prenovi in optimizacijskih ukrepih v slovenskih soseskah in naseljih. Trenutno se posvečamo predvsem možnostim uporabe lokacijskih podatkov, ki jih zagotavljajo mobilne naprave in pripadajoča infrastruktura. Napredek na tem področju je omogočil hiter razvoj v industriji lokacijskih podatkov in raziskavam omogočili razumevanje uporabnikov in njihovega vedenja v realnem času na številnih področjih. Predvsem so tovrstni podatki uporabni na področju indikatorjev, povezanih z mobilnostjo in dostopnostjo, kot pomembnima faktorjema kakovosti bivanja v lokalnem okolju.

KLJUČNE BESEDE

trajnostno vrednotenje, soseska, mobilnost, povezljivost

ABSTRACT

The aim of this contribution is to reveal an insight into the ongoing national research project (funded by Slovene Research Agency), examining the data-driven support for sustainable and quality urban renewal on the neighbourhood level. Special concern is dedicated to the assessment methodologies and integration of data in the instruments used for assessment purposes. In our previous research projects, we encountered numerous obstacles related to data accessibility, data resolution and data integration accompanied by a critical lack of metrics for addressing less quantifiable aspects of urban quality, sustainability and well-being in neighbourhoods. Our current concern is focused to the indicators of mobility and connectivity as metrics important for quality and liveability of neighbourhoods.

KEY-WORDS

sustainability assessment, neighbourhood, mobility, connectivity

1. INTRODUCTION

This article provides a brief insight into recent research conducted by the Faculty of Architecture (University of Ljubljana), in liaison with the Faculty of Computer and Information Science and the Faculty of Arts (Department of Psychology), dealing with the data-driven support for sustainable and quality urban renewal on the neighbourhood level, along with the integration of data into instruments used for assessment purposes.
In our previous research projects, we encountered numerous obstacles related to data accessibility, data resolution and data integration accompanied by a critical lack of metrics for addressing less quantifiable aspects of urban quality, sustainability and well-being in neighbourhoods.

Our present research efforts aim to reveal the potential of the location-based data provided by mobile devices and associated infrastructures. The latter have enabled the location-data industry and research to understand how audiences move and behave in real time. While such data are widely recognised as a beneficial source of information in various fields and solid advances have been made in both analytics and modelling, little progresses has been seen in exploiting that potential as regards sustainability assessment tools.

Two main reasons make targeting the objectives of this research important: (i) to offer urban decision-makers a supporting instrument able to inform and substantiate spatial interventions in the renovation process of different neighbourhoods through a consistent and standardised framework of key indicators/criteria; (ii) to give spatial users and residents a clear insight into the state of the neighbourhood, its sustainability and quality, while also encouraging them to increase their commitment to improvements (through various ways like changing non-sustainable habits, their own monitoring, their own contribution of data etc.)

2. BACKGROUND

The question of the quality and sustainability optimisation of today's neighbourhoods has proven to be particularly relevant in combination with data-driven decision-making (Bibri, 2019) and related methodologies. Rerecord-keeping and monitoring the progress of neighbourhoods with respect to various aspects of sustainable development as well as the short- and long-term comparability of successful revitalisations is an emerging need.

In order to contextualise the sustainability and sustainable development of the built environment, many assessment tools have been developed in past decades. This has occurred at different spatial scales, from the single building scale to the neighbourhood and city scale so as to facilitate decision-making and improve the sustainable performance and organisation of various spatial entities (Zheng et al., 2017). Neighbourhood sustainability assessment (NSA) tools are instruments that evaluate the sustainability performance of a given mesoscale entity such as a neighbourhood or district against a set of criteria and corresponding indicators (Sharifi and Murayama, 2015). The composed indicators help to disaggregate the complex phenomena and impact chains in built environments and offer a practical framework for detecting situations and understanding the relationship with more abstract criteria and goals like environmental compatibility, economic efficiency and quality of dwelling. Compact sustainability assessment procedures were initially developed for impact assessment at the level of individual buildings and gradually developed to the neighbourhood or district scale. The last decade has witnessed the release of several urban sustainability certification standards, especially ones focused on the spatial mesoscale. More than a few reviews (e.g. Sharifi & Murayama, 2015; Reith & Orova, 2015; Kaur & Garg 2019) note the most widely recognised systems, such as LEED ND (Leadership in Energy and Environment Design – Neighbourhood Development; United States), BREEAM Communities (Building Research Establishment's Environmental Assessment Method – Communities; UK), DGNB District (German Sustainable Building Council for District; Germany) CASBEE UD (Comprehensive Assessment System for Building Environment Efficiency – Urban Development; Japan), HOE2R (HQE High Quality Environmental and Economy in Regeneration standard, European Union), SCR (Sustainable Community Rating, Australia) etc. Most of these tools are similarly structured: the instruments follow a system of multidimensional criteria and indicators, wrapping up the scores by hierarchically arranging the goals to facilitate evaluation, monitoring and benchmarking. The indicators are commonly clustered according to an initial three-silo approach – gathered around economic, social and environmental dimensions/pillars on the highest hierarchical level, which impairs one's ability to understand the interdependence of these three domains and related impacts (Cohen, 2017). Similarly, four-part or five-part (daisy) concepts are introduced in some cases, comprising additional dimensions of technical/operational and institutional. In the next hierarchical step, NSA tools typically follow categories, often denoted as themes[1], which further label the concerns of sustainability and liveability[2]. Each theme is further divided into sets of criteria, indicators and sub-indicators. NSA frameworks are often strongly linked to their original regional contexts and thus not necessarily transferable to other environments (Sharifi and Murayama, 2015). In order to open up their use and make them more universal, some tools provide two types of indicators: prerequisite/mandatory indicators and optional indicators. In addition, mandatory indicators can have different reference values (benchmarks) and the weighting scheme can be dissimilar in order to keep the evaluation relative to the regional context and to be able to distinguish between different cultural or local backgrounds. However, to make assessments reliable, comparable over time or transferable as regards the location the biggest challenge is to clearly identify the generic and specific indicators to be used and embedded in the frameworks or to define interchangeable indicators or suitable weights. The literature provides little by way of solid answers to these issues, instead pointing out specific scopes and indicators that seem to be more important than others in certain thematic areas.

Another crucial problem that is often identified is data availability. One can establish and propose a perfectly suitable indicator system for the assessment, but that is of little use if data are not accessible or available for certain scales, localities or time frames to perform the analyses. In reviews of assessment tools and their operability (e.g. Zheng, 2017; Boyle et al., 2018; Chao et al. 2020),

1 A review (Verovsek et al., 2016) reveals the most frequently associated categories: natural resources and energy (also environmental resources, ecological concern, environmental efficiency etc.), built environment and organisation (also denoted as land use, urban pattern and building typology etc.), transport and mobility (also denoted as connectivity, mobility and accessibility, transportation and infrastructure etc.), identity and cultural heritage (historical continuity, sense of attachment), health and safety (safety of open spaces), quality of public spaces (also denoted as the liveability of urban places), economic value and marketing (denoted also as economic viability), community engagement (social cohesion and participation, social networking and interaction) and similar.

2 As a concept, liveability is not an independent variable; to some extent, it depends on the 'triple-bottom' sustainability model. As such, liveability is a specific, nuanced and qualitative component of the broader concept of sustainability (Szibbo, 2016).

the lack of data for quantitative evaluation was most commonly fixed by performing qualitative assessments based on a surveying methodology[3] or trained expert estimation. Another solution often used is simple interpolations where a wider area (or time lap) is relied on to proxy for performance against an indicator or more indicators. Both can critically decrease the geospatial resolution and eloquence of the data, resulting in an assessment of weak informative strength.

Paradoxically, on one hand we are facing an increasing amount of captured and gathered urban spatial data from various sources while, on the other, we encounter significant data scarcity, especially of small-scale, micro-urban and fine-grained records that allow us to theoretically define and track the NSA tool parameters. For this reason, we aim to further develop or modify the existing NSA indicators so that they reflect information relevant to specific aspects of sustainability and quality of dwelling, while also constituting solid pillars for data acquisition and analysis.

3. SUSTAINABLE MOBILITY INDICATORS

Due to the wide thematic coverage of assessment frameworks and accompanying extensive range of possibly important indicators, databases and data types, our work programme is set as a series of testbeds in initially separate theoretical and applied assemblies. This workflow allows us to study in detail selected data assemblies and actual IT-supported solutions. Our current interest concerns traffic and mobility indicators as a very important component of sustainability assessments. The second reason for delving into this thematic scope is the well-articulated prospect of data support in this thematic field, also feasible on the level of neighbourhood scales.

The addition of mobility as a concern in the context of sustainability assessment tools gave rise to a new discursive practice devised by academic research, government agencies, and transportation agencies and institutions. The World Business Council for Sustainable Development (WBCSD) formulates the process of developing urban sustainable mobility as follows: "The ultimate goal is to accelerate and extend access to safe, reliable and comfortable mobility for all whilst having, zero traffic accidents, low environmental impacts, affordability, and reduced demands on energy and time/…/" (WBCSD, 2018).

The Directorate for the Mobility and Transport of the European Commission in liaison with the WBCSD has developed a comprehensive set of practical and reliable indicators (SUMI[4]) that support cities in performing a standardised evaluation of their mobility system, practices and travel patterns, which has to some extent also proven to be a good starting point for neighbourhood sustainability assessments. The indicator set specifically adapted for European cities (SMP2.0 Sustainable Mobility Indicators) comprises the following core indicators: affordability of public transport for the poorest group indicator, accessibility of public transport for mobility-impaired groups indicator, air pollutant emissions indicator, noise hindrance indicator, road deaths indicator, access to mobility services indicator, greenhouse gas emissions indicator, congestion and delays indicator, energy efficiency indicator, opportunity for active mobility indicator, multimodal integration indicator, satisfaction with public transport indicator, traffic safety modes. These are further followed by 'non-core indicators': quality of public spaces indicator, urban functional diversity indicator, commuting travel time indicator, mobility space usage indicator, and security indicator (reported perception of crime-related security in the city transport system (including freight and public transport, public domain, bike lanes and roads for car traffic and other facilities like car or bike parking). Other tools for assessing sustainable mobility that have been developed cover similar thematic scopes (Gillis, et al. 2015) by which decision-makers can better understand the sustainability values, or the lack thereof, and further monitor or compare them with regard to the geolocation or time cross-sections.

Unfortunately, many indicators mentioned above or identified in other sources (e.g. Daniels et al., 2018) are not well suited to neighbourhood-like or even city-like scales. While promoting quantitative metrics with well-quantifiable and compact data use, the great majority[5] of indicators is still forced to rely on the less efficient surveying methodology, indirect use (Verovsek et al., 2016) or imply an adaptation of the simple spatial or time-based linear interpolation methods, which considerably decreases the eloquence of the data. On top of extensive data requirements, such metrics are costly to obtain. For example, audits and surveys require a massive deployment of resources, and are only standardised at a country level (Kraemer et al., 2019), hindering the correct quantification of mobility indicators on a local scale.

For this reason, our effort was to delve into the opportunities given by location data. Location data is a term associated with geographical information about a specific mobile device's position related to a time identifier (Ewen, 2019). Location data can be aggregated and analysed to provide significant scale insights into behaviour and movement. One such opportunity is represented by the use of 'Floating Car Data' – records resulting from timestamped geo-localisation and speed data directly collected by moving vehicles and their users[6], as a basis for estimating various parameters like actual vehicle travel times on selected routes. Such data are provided, for example, by services such as Google Maps, Waze, and similar, usually after paying a fee. Compared to classic data queries, as Kraemer (2019) puts is, such data sources – being constructed from mobility information alone – are significantly less expensive to compile (involving only computer-processing cycles) and are available in real time.

4. THE USE AND DEVELOPMENT OF TRAVEL TIME RELIABILITY INDICATORS

As regards our objectives to primarily address sustainable mobility with respect to quality of dwelling and liveability, we decided to consider measures of travel time reliability on road motorised trips. The importance of travel time reliability in traffic management, monitoring, benchmarking and network design has received considerable attention in the past decade (Fangfang Zheng, 2017). It refers to indicators assessing

3 Conducting a city-wide household travel survey requires extensive resources. Therefore, even developed cities and countries perform travel surveys only every 5 or 10 years. As a result, travel survey approaches usually lack instantaneity and continuity (Yin et al., 2020).

4 SUMI is a service contract for the European Commission's Directorate-General for Mobility and Transport providing technical support related to sustainable urban mobility indicators (MOVE/B4/2017-358). The project helps urban areas using the "SMP2.0 Sustainable Mobility Indicators" developed by the World Business Council for Sustainable Development (WBCSD).

5 The study conducted by Bongardt et al. (2011) proved by comparing and analysing 16 sustainable mobility assessment tools that more than 70% of revised indicators struggle with a significant or large lack of available solid data on the global level. The most serious challenge, they claim, relates to the efforts for collecting and processing data in terms of the less efficient surveying methodology.

6 Records rarely directly relate to cars/vehicles (e.g. GPS-equipped cars), but to the mobile devices of the car users – adopting the cellular network data, every switched-on mobile phone works as a traffic sensor and is thereby an anonymous source of information.

consistency or dependability in travel times, as measured day to day or across different times of the day (Federal Highway Administration, 2006) and essentially applied to any travel mode. Vandervalk et al. (2014) define it as the variability in travel times that occurs for a specific trip or route over the course of time and the number of times (trips) that either 'fail' or 'succeed' according to a predetermined performance standard or schedule. While being a highly valued characteristic among travellers and commuters, travel time reliability affects their participation in activities and plays a decisive role in perceptions of choice and well-being. Although the value of travel time has for many decades been considered the main factor in travellers' perceptions and hence drivers' route choice decisions, researchers have more recently postulated that these travel time models may have been leaving out reliability and certainty considerations (Chepuri et al. 2019) of importance for time management (individual trip planning) and modern travel patterns. In fact, Lyman et al. (2008) state the consistency of travel times along a given corridor may be of much more important than the actual travel times.

By considering on-road travel time reliability, we look at the question of the predictability of planned or executed trips associated with the neighbourhood/s under consideration. These metrics are important for providing a realistic assessment of how consistent and predictable the traffic situations are on certain routes – in our case, routes related to selected neighbourhoods and targeted destinations within the city. While travel times along a certain route on a working day often vary by the departure time during the day (differences in morning and afternoon peak hours), most travel time variability indicators seek rather than capture changes and deviations from the 'normal' or 'expected' at a certain time of the day. In relation to these targets, different kinds of solid measures have in recent years been proposed and applied to assess traffic performances and reliability (Chepuri et al., 2019) such as standard deviation, planning time index, buffer index, frequency of congestion, coefficient of variation, skew and width of travel time distribution, and others.

In order to observe and reflect on such reliability indicators in terms of NSA assessments, we established a testbed based on three neighbourhoods in the city of Ljubljana (Fužine, Savsko naselje, Soseska Zeleni Gaj) and six independent routes. Each neighbourhood was set as a route origin for two travel trips – one heading to the destination point in the city centre and one heading to the commercial service/shopping centre on the outskirts of the city.

The anonymous mobility patterns, more specifically the on-road travel times, were aggregated by Google's Directions API[7] combined with the Real-time weather API, to capture the travel times for selected routes during 3-week periods. Although much attention was paid to the selection of data-capturing periods, to ensure representative situations on roads we faced certain unexpected impacts of Covid-19 regulations. The sample of days included in the examination period will be extended during the next few months after the regulation ceases to avoid declinations in data sets caused by the traffic situations thus imposed.

According to the data captured, we first proceed with descriptive analysis of the traffic flows to estimate the components required (such as free-flow curves, the impact of weather conditions, day of the week etc.), which further allow for normalised values or other indicators of interest (e.g. buffer index) to be calculated. Current partial results revealed that travel times reliability fluctuates significantly both temporally (intra and inter days) and spatially (among the routes with regard to the origins in the neighbourhoods and among routes with respect to the destination). Traveling on certain routes in certain intervals would make one experience relatively high levels of time loss and uncertainty due to the increased travel time variability. By conducting additional analyses, we will further strive to find or modify the most narrative/descriptive indicators for NSA assessment purposes – in relation to location-data availability and prospects – to allow us to best classify the neighbourhoods, while also establishing a connection between mobility-related parameters on one hand and key quality/sustainability indicators on the other.

7 Google's Directions API provides anonymous trip times crowdsourced by users who have opted-in to Location History (Bassolas et al., 2020). More information about the aggregation procedures and data capturing can be found at https://policies.google.com/technologies/location-data#how-find

5. CONCLUSION

Given the ongoing debate on the optimal structure of NSA tools, their thematic coverage and indicators assortment in the assessment scheme, perhaps the most important question recurring in our research is: are the metrics proposed a true reflection of the issues and challenges that concern neighbourhoods and associated communities and people. The endorsed relevance of the particular observed variable/indicator is therefore an important step in ranking it among others in the NSA framework, thereby increasing the assessment instrument/tool's efficiency, feasibility and slickness.

Recognition of the different conceptual perspective in relation to the data requirements and opportunities compared to existing procedures obviously sheds light on the potential held by mobile location data. This has come about both from the user perspective in the manifestation of how the variability of travel time is experienced and from the perspective of urban planning/renewal and management in the expression of how the variability of travel times impacts the environment, local economies and travel patterns.

POVZETEK

Raziskovalni projekt predlaga razvoj novih metodologij za integracijo, optimizacijo in analizo prostorskih podatkov, ki so pomembni kot podpora odločanju pri trajnostni prenovi in optimizacijskih ukrepih v slovenskih soseskah in naseljih. Predlagani projekt gradi na izsledkih in delu predhodnega raziskovalnega dela, v katerem smo zasnovali sistem vrednotenja trajnostne učinkovitosti sosesk na osnovi modularnega sistema kazalcev in kriterijev ter povezane metode interpretacije vrednosti. Namen naših sedanjih raziskovalnih prizadevanj je razkriti potencial lokacijskih podatkov, ki jih zagotavljajo mobilne naprave in pripadajoča infrastruktura. Napredek na tem področju je omogočil hiter razvoj v industriji lokacijskih podatkov in raziskavam omogočili razumevanje uporabnikov in njihovega vedenja v realnem času na številnih področjih. Medtem ko se eksploatacija tovrstnih podatkov razmeroma hitro razvija in predstavlja enega najbolj koristnih virov v smislu analitike, ponovne rabe podatkov in modeliranja, pa se na področju ocenjevanja trajnosti sosesk ta potencial še ni udejanjil. V pričujoči raziskavi se zato selektivno osredotočamo na parametre trajnosti/kakovosti, ki jih lahko merimo in spremljamo s pomočjo omenjenih podatkovnih setov. Pri tem vzdržujemo kontinuiteto zasledovanja poglavitnega cilja, to je, izboljšanje pogojev za podatkovno-podprto odločanje pri ukrepih in intervencijah ob prenovi sosesk.

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