WALKABILITY AND USABILITY OF STREET AFTER RECONSTRUCTION – POTENTIALS FOR REVERSE LOGISTICS

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Abstract: *This paper considers the relationship between Walkability and Usability in order to understand the perceptions of residents' accessibility to community facilities provided after the street reconstruction. To address this goal the assessment framework that includes two corresponding measurement tools has been proposed. The results show that the certain level of walkability has been achieved by the street reconstruction. However, the relationship of usability score with some of the walkability dimensions shows that land mix accessibility is not at the satisfactory level indicating the necessity for the intervention within the examined City area, in terms of the street facilities service efficiency transformation to enhance overall sustainability.*

Keywords: *neighborhood walkability, system usability, street reconstruction, perception.*

1. INTRODUCTION

The road infrastructure of a country not only serves the basic need for safe transport of people and goods but is also considered vital for its growth and development. Urban freight transport, and particularly solid waste and recyclables collection systems are largely influenced by the distribution of land use and associated activity patterns. These, despite the advancement of technology or the provision of infrastructure create logistical challenges that will need both economically feasible and environmentally sustainable solutions.

As a peculiar form of mobility, walking rely on dedicated infrastructure but is also highly dependent on the built environment (Krizek et al. 2009). Lamíquiz and López-Domínguez (2015) showed that land use factors were more relevant than urban design in determining people's modal choice. Others found that what they call micro-design variables such as block size or intersection configuration exert an influence on walking (Cervero and Duncan, 2003; Frank et al. 2007; Lamíquiz and López-Domínguez, 2015). However, some studies (Hillier and Iida, 2005) show that there is a close relationship between the configuration and the residents' perception and movement through urban

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space. The imperative is to integrate this kind of locally perceived qualities in citywide models (Cervero and Duncan, 2003; Giuliano and Narayan, 2003).

2. METHODS

2.1 The walkability assessment framework

The objective of this paper is to understand the perceptions of residents' accessibility to community facilities provided after the street reconstruction, and therefore it can be used as a framework for determining effects on different logistics activities, particularly those related to solid waste and recyclables disposal. According to Abley (2005) walkability can be defined as the extent to which the built environment is friendly to the presence of people living, shopping, visiting, enjoying or spending time in an area. Frank et al. (2006) claims that walkability is also dependent on human behavior (of the residents) in the neighborhood area. Many different methodologies have emerged from various fields of study (public health, social sciences, transport engineering, urban planning and architecture) to measure the built environment quality and urban walkability. Moura et al. (2017) states that tools and methods have been put forward including audit tools, checklists, inventories, level-of-service scales, surveys, questionnaires and indices. All of them were developed and applied, with the objective of guiding user's audits for integration in general master and transportation plans.

The present study was undertaken to better understand the importance of perceived neighborhood walkability and possible environmental determinants of the street usability after reconstruction, as well as, to examine the shape and strength of the relationship of several built-environment attributes and street usability. Although the attributes used in study are not directly related to reverse logistics collection facilities, the idea itself can be used as kind of instruction to analysis the influence of distance on the motivation for recyclables disposal (González-Torre and Adenso-Díaz, 2005).

2.2 Street characteristics

Vojvode Stepe Street is one of the five most important roads in the territory of the city municipality of Voždovac. With a length of about 8 km it belongs to the longest city roads. This route, with 23 crossings, is slightly curved with correct visual perception possibilities in the most parts of the trace. Urban growth of the street surrounding demanded severe reconstruction of the street infrastructure and design in order to get fluent life of its users, and to establish good foundations for filling in empty spaces with new appropriate facilities. Concerning its high traffic frequency and concentration of various urban contents, and accordingly its functional complexity (Figure 1) specific design requirements/tasks were set. The aim of the project of street reconstruction was the adoption of the decision on the potential dislocation of tram tracks and realization of a certain street profile (Krstić and Žegarac, 2013). The street layout before and after reconstruction is presented in Figure 2.

Figure 1. Vojvode Stepe Street network and land use

Figure 2. The appearance of the road before and after reconstruction

2.3 Participants

A group of volunteers aged between 20 and 30 years was recruited from the students attending the Faculty of Transport and Traffic Engineering in Belgrade. All participants have inhabited at different locations along the street examined. The sample respondents were queried about their perceptions or awareness of environmental factors near their residence or in their neighborhood.

2.4 Data collection instruments

Neighborhood Environment Walkability Scale (NEWS)

The Neighborhood Environment Walkability Scale (NEWS) is one of several recently developed questionnaires designed to measure residents' perceptions of the environmental attributes of their local area. It aimed to capture constructs from transportation and urban planning literatures related to physical activity, mostly for transportation purposes (Saelens et al., 2003). NEWS is one of the most comprehensive and widely used self-report measures of the built environment, that assesses residents' perception of neighborhood design features including residential density, land use mix (covering both indices of proximity and accessibility), street connectivity, infrastructure for walking/cycling, neighborhood aesthetics, traffic and crime safety, and neighborhood satisfaction. Perceptions of neighborhood attributes were assessed among participants using slightly modified items from the NEWS scale in combination with items from the NEWS–A version of the NEWS (Cerin et al., 2006; Saelens et al., 2003). The Residential density subscale of the original NEWS and NEWS-A consists of six items rated on a 5-point scale (1 = none; 2 = a few; 3 = some; 4 = most; 5 = all). With the exception of the residential density and land use mix–diversity subscales, items from remaining NEWS sections scaled from 1 (strongly disagree) to 4 (strongly agree). Residential density items asked about the frequency of various types of neighborhood residences, from single-family detached homes to 13-story or higher apartments, and were weighted relative to the average density of single-family detached residences, so than weighted values were summed to create a residential density subscale score. The Land use mix – diversity subscale is assessed by the perceived walking proximity from home to 23 different types of destinations. Respondents were asked to provide their perception on how much time it would take to walk from home to reach these facilities. The amount of time was coded in 5min increments ranging from 1- to 5-minute walking distance (coded as 5) to ≥ 30-minute walking distance (coded as 1) indicative of low walkability. Higher scores on land use mix–diversity indicated closer average proximity. With the exception of the residential density subscale, all subscale scores were calculated as the mean across the subscale items (Cerin, et al., 2013). The final score on each dimension of the neighborhood environment was calculated based on the scoring method provided by (Saelens et al. 2003).

System Usability Scale (SUS)

System Usability Scale (SUS), developed by Brooke (1996) had a great success among usability practitioners since it is a quick and easy to use measure for collecting users' usability evaluation of a system. It consists of ten-item scale giving a global assessment of Usability, operatively defined as the subjective perception of interaction with a system (Brooke, 1996). To measure perceived street usability, SUS that provides a global view of usability based on subjective assessment was employed. The questionnaire is revised by experts with significant experiences in the related fields. SUS uses 5 point Likert scale to gather participant impressions of usability aspects. Respondents have to indicate the degree to which they agree or disagree with the statements. The selected statements actually cover a variety of aspects of system usability, such as the need for support, training, and complexity. Five out of ten statements were positive, while the other five statements were negative. In the aspect of system usability evaluation, the SUS is an efficient, time-conserving, and labor-saving way of subjective assessment. As a result, SUS will produce a single number representing a composite measure of the overall usability of the studied system. The overall SUS scores range from 0 to 100 in 2.5-point increments. The higher the score is, the more usable the system is and the more easily users can interact with it (Brooke, 1986; Isman & Isbulan, 2010).

2.5 Data analysis

Overall descriptive statistics (means, standard deviations, percentages, and distribution statistics) were computed for the sample on all measures. Bivariate correlation analysis was performed between the neighborhood-environment variables and overall SUS score. Data were coded, entered and checked using SPSS Version 21.

3. RESULTS AND DISSCUSSION

For each of the walkability components, mean scores were calculated for study participants. Residential density show high score values, which is not surprising taking into account that many new building are sprouting along the street. The highest mean scores were obtained for land use mix–diversity and land use mix–access subscales, indicating that residents perceive their neighborhood as high walkable. The lowest score of all received the aesthetics subscale. The mean score for crime was also very low which actually points to higher walkability. Respondents reported for poorer walking/cycling facilities which are the consequence of the lack of separate cycle lanes and inconsistent cycling infrastructure (Figure 3).

Neighborhood satisfaction mean score is 3.17. Students are most satisfied with the access to public transportation (M= 4.08) and commuting time to work/school (M= 3.95).

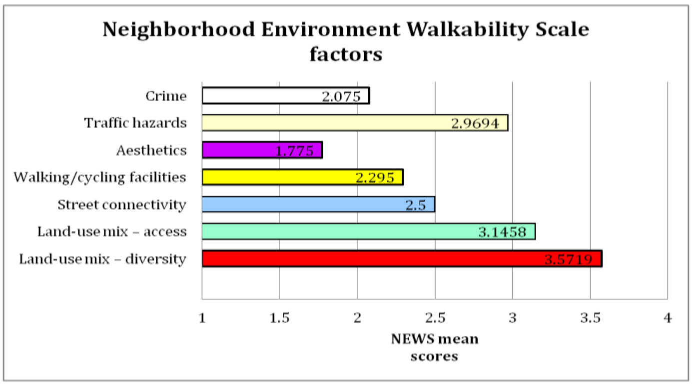

Figure 3. Subscale Scores from the Neighborhood Environment Walkability Scale

This can be explained by the fact that the majority of them live in the student dormitory located in the immediate vicinity of the public transport stop, or at a very short distance from the faculty so they can easily walk to a bus or tram station. The access to shopping opportunities and pleasantness of walking in the neighborhood were highly rated too (3.58 and 3.53, respectively). Their satisfaction with cycling facilities is very low (M= 2.25) which is in accordance with the low mean scores on walking/cycling subscale. Respondents are also annoyed by road-traffic noise as a characteristic of their residential milieu, since the dormitory, the faculty building or their residences are also located in proximity to tram tracks. The same participants evaluated the new street design using the System Usability Scale (SUS). The overall mean score of the SUS was found to be 54.125. The best way to interpret the SUS score is to convert it to a percentile rank. As SUS also enables a comparison of different systems, the interpretation should take into account that in studies that use the SUS to determine the usability of a system, an average score of 70 is generally awarded (Bangor et al. 2008). This means that a score of 66, for example, is considered more usable than 44% of the products in the (Sauro, 2011) database (and less usable than 56%). Anything with a percentile below 50% is, by definition, below average, and anything above 50% is above average. Low SUS scores indicate to the researchers and designers that they need to review the system and identify problems encountered with the design. Bivariate correlation analysis was performed between the neighborhood-environment variables and the overall street usability score (Table 1).

Table 1. Significant correlations between the NEWS factors and SUS overall score

		1	4	5	6	7	8	9
1	SUS overall score				-.328*	.460**	.318*	.613**
2	Residential density						.738**	
3	Land-use mix – access				.466**			
4	Walking/cycling facilities							.491**
5	Aesthetics	.499**	.459**		-.413**	.358*	.405**	.653**
6	Traffic hazards							
7	Crime							.376*
8	Land-use mix – diversity							.400*
9	overall satisfaction							

*. Correlation is significant at the 0.01 level (2-tailed).
**. Correlation is significant at the 0.001 level (2-tailed).

Overall satisfaction show statistically significant correlation to all other scales, excluding land use mix accessibility and traffic hazards. The largest correlations were found with aesthetics and overall SUS scores. Similarly, aesthetics subscale exhibited significant correlations to all other subscales, with the exception of residential density and land use mix accessibility. The strongest positive correlation was discovered between residential density and land use mix-diversity. Conversely, there were significant weak to moderate negative correlations between perceived traffic hazards and overall SUS score, as well as between perceived traffic hazards and aesthetics. The magnitude of our results is in line with previous studies (Leslie et al., 2005; Sallis et al., 1990). Nonetheless, if the street is perceived as less usable, there is a growing threat of traffic hazards. It may be that walkers in the present study may just be more aware of threats to safety, pay more attention and attach greater importance to traffic hazards due to their professional orientation. It is possible that traffic safety is a construct consisting of several dimensions, such as traffic volume, speed, and facilities for protecting and separating pedestrians and cyclists from traffic. Research needs to examine more specific aspects of traffic safety.

In assessment the influence of environmental factors, it is important to examine objectively observable domains such as distance to facilities (Sallis et al., 1990; Troped et al., 2001) and the location of participant's homes (Bauman et al., 1999). The findings may be, to a certain extent, attributed to a long-standing problem in the field, ''self-selection'' i.e., it is not the built environment that changes travel behavior, but values and attitudes of the people living in them. Namely, respondents in this study have chosen the place of residence with the intention to be as close as possible to the faculty. The perceived distance can be influenced by the type of land use and design characteristics. It was found that design element such as continuous walking systems that connect door fronts with transit stops or other destinations can create good connections (Rahman et al., 2018). The proximity of public transport and shopping spots make this street highly accessible for pedestrians. The importance of neighborhood buffer is relatively understudied and there is no consensus on what defines a 'neighborhood' (shape or size). Distances of 200m-1600m around participants' homes are typically used to represent the size of the neighborhood because these typically point at 'walkable' distances to local destinations (Jeffrey et al., 2019). All the aforementioned show how values, preferences and motivations mediate amongst the object and subject characteristics and provide powerful arguments to understand how individuals take modal choices. In the same time mentioned distances of 200m-1600m, which represent the size of neighborhood are also ideal for conducting analysis of motivation for recyclables disposal which need widening attribute sets.

Further, counter-intuitive associations were also found, e.g. lack of associations of street connectivity with other factors. The different direction for the neighborhood-based differences in aesthetics (residents of the low-walkable neighborhood had higher ratings of aesthetics) is likely to be attributable to the low-walkable area having topography with more trees, shrubs and open green spaces as well as scenic views, than did the high walkable area (Leslie et al., 2005). Cul-de-sacs may be an indicator of aesthetically pleasing environments, while areas with a grid street pattern may have more non-residential destinations that make walking more interesting. Well-connected street networks may facilitate residents' walking for transportation by providing direct and short routes to destinations (Berrigan et al. 2010). Perhaps, there are moderators of the aesthetics-walking association. Thus perceptions of aesthetics and safety could reflect real differences across objectively measured neighborhood types or differences in the way the perceived and objective built environment measures are operationalized (Jack and McCormack, 2014). Evidence show that configuration statistically determines how pedestrian flows are distributed within street networks, even without considering land uses (Lamíquiz and López-Domínguez, 2015).

McCormack and Shiell (2011) acknowledge that some environmental attributes could be located under multiple categories that may not be mutually exclusive. For example, connectivity, land use mix, and traffic-related factors are associated with walking for transport but not recreational walking, and population density is associated with walking but not cycling for any purpose. Perceived land use mix–access is significantly and positively associated with perceived street connectivity, whereas in the present study related to traffic hazards. Studies that have reported on intersection density (an objective measure of perceived street connectivity) indicated that intersection density was associated with walking for transport (Kerr et al., 2015). The high walkability neighborhood had a mixture of single- and multiple-family residences (which is consistent with higher residential density), a concentration of nonresidential land uses (restaurants, grocery or convenience stores, and other small retail stores) along the main corridor of the neighborhood, having a mostly grid like street pattern, with short block lengths and few cul-de-sacs (Saelens et al. 2003). Researchers in planning and transportation have identified land-use mix, residential density and street connectivity as the key aspects for creating walkability indices (Frank and Pivo, 1994). The lack of street connectivity associations with other walkability dimensions in the present study may be due to low perceived street usability (Čičević et al., 2017).

3.1 Limitations and further research

It should be recognized that the current study suffers from several limitations. Conceived as a pilot investigation, restricted to small sample in one neighborhood in one city means that comparisons should be considered preliminary. Neighborhood from which participants were recruited, may have limited variability of some of the environmental attributes and therefore increase the chance of finding atypical profiles of environmental indices. Further studies that involve comparisons across different contexts be necessary to understand the factors that influence the effect size of walkability. Further research using longitudinal data would be required to follow the impact of changes in neighborhood layout or design (improvements, reconstruction).

4. CONCLUSION

Neighborhood environmental quality is an important factor that affects human wellbeing, which, fortunately, can be improved through proper urban management. Many cities around the world are now developing integrated solutions to major environmental challenges and are transforming themselves into more sustainable and self-sufficient communities (Dizdaroglu et al., 2009). It has been clear that the pedestrian friendliness of urban environment is better described using no single but composite indices. Most of them aim to be operative tools to evaluate and design walkable communities (Southworth, 2005). They may be helpful to decision makers in where to focus transportation investments and where to guide future growth.

The project of street reconstruction is being delivered within the context of a highly urbanized setting where the optimum solution is derived from a balance of competing technical and stakeholder constraints. However, as Hildebrand (2003) claims, developing transport infrastructure only provides alternatives but does not necessarily change one's travel behavior. This implies that a people-centered approach is essential to understand how people actually behave in making (sustainable) travel choices. Within neighborhood walkability, besides *hard* factors (that can be quantified and measured - residential density and land use) contribution of household waste management parameters in the context of Reverse Logistics (RL) (Jalil et al. 2016; Purkayastha et al., 2015; Senawi and Sheau-Ting, 2016; Trabold and Babbitt, 2018) should be co-examined (accessibility, availability, convenience of waste bins, collection schedules, accessibility and route planning for waste collection vehicles, etc.). Thus, the recommendation is that NEWS scale should be extended by adding items (waste bins presence awareness, preferred and acceptable walking distances to bins, recycling knowledge and attitudes, etc.), which affect RL processes in certain urban area.

With better understanding and more consistent and frequent measurement of the walkability and usability of urban environments, by means of inexpensive, time-conserving and labor-saving instruments decision-makers will be empowered to enact policies that create more sustainable urban areas. The study results indicate a need for more definitive research regarding the relationship between the two very important constructs, neighborhood walkability and usability to prioritize neighborhood changes. Thus, these changes impose the necessity for the waste disposal facilities distance attributes assessment, in order to be improved by the RL practice.

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