Transportation Research Part A 91 (2016) 330–345

Contents lists available at ScienceDirect

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra

Integrating land use and transport practice through spatial metrics

Julio A. Soria-Lara [a,*], Francisco Aguilera-Benavente [b], Aldo Arranz-López [c]

[a] Transport Studies Unit (TSU), School of Geography and the Environment (SoGE), University of Oxford (U.K.), South Parks Road, Oxford OX1 3QY, United Kingdom
[b] Department of Geology, Geography and Environmental Sciences, University of Alcala, C/Colegios n°2, Cp 28801 Alcalá de Henares, Spain
[c] Department of Geography and Spatial Planning, University of Zaragoza, C/Pedro Cerbuna 12, 50009 Zaragoza, Spain

ARTICLE INFO

Article history:
Received 7 May 2015
Received in revised form 18 June 2016
Accepted 29 June 2016

Keywords:
Corridor
Sustainability
Light Rail
Landscape
FRAGSTATS

ABSTRACT

Despite the growing development of tools that can integrate land use and transport, the desired integration is still illusive in daily practice. To address this gap, the current study uses spatial metrics, a set of methods traditionally used for studying changes in the spatial structure of landscapes, which are translated into the domain of transport planning. It examines how spatial metrics can be integrated into "Land Use Transport" strategy-making, and how useful they are according to the practitioners' perceptions. A Light Rail Transit corridor in Granada (Spain) provides the empirical focus of this research. Land use characteristics such as: land use mixing, land use diversity and green areas connectivity were successfully studied using spatial metrics, and they were used to map three "Land Use Transport" strategies: (i) proximity dynamics and non-motorised modes; (ii) modal shift from cars to Light Rail Transit system; (iii) shared spaces between motorised and non-motorised modes. Practitioners perceived that spatial metrics could improve the "Land Use Transport" strategy-making process in comparison with traditional methods used in practice. However, certain shortcomings related to the usability of spatial metrics are also highlighted and discussed. This study concludes with a reflection on research challenges for adapting spatial metrics to transport practice.

1. Introduction

In the field of transport research there is a growing interest in unravelling the complex relationships between land use and transport (e.g. Bertolini and Dijst, 2003; Cervero and Kockelman, 1997; Hrelja, 2015; Van Acker et al., 2007). This is supported by the idea that if the land use and transport sector are reciprocally supportive, important benefits of mobility can be increased (e.g. access to amenities, jobs, etc.), while negative impacts could be reduced (e.g. pollution, congestion, noise, etc.). In particular, Banister (2005, p. 97) discusses six groups of land use factors that are interconnected with transport: settlement size (Hickman and Banister, 2007); urban density (Oakes et al., 2007), land use diversity (Pitombo et al., 2011), urban design (Jones et al., 2007), local accessibility to public transport (Cervero et al., 2009); and the provision of parking (Albert and Mahalel, 2006). While academia eagerly explores how the abovementioned factors affect travel behaviour and the use of different transport modes, the translation of those findings into daily practice is still lagging behind, and shared "Land Use

* Corresponding author.
E-mail addresses: julio.soria-lara@ouce.ox.ac.uk (J.A. Soria-Lara), f.aguilera@uah.es (F. Aguilera-Benavente), arranz@unizar.es (A. Arranz-López).

http://dx.doi.org/10.1016/j.tra.2016.06.023
0965-8564/

Transport" (LUT) visions and concepts are often absent in practice (e.g. Ewing and Cervero, 2012; Su et al., 2014; Waddell et al., 2007; Te Brömmelstroet and Bertolini, 2008).

Regarding LUT, the lack of spatial perspective during the planning process is seen as one of the crucial barriers. This addresses the need to translate abstract land use characteristics that impact travel behaviour, such as: land use mixing or land use diversity into a more intuitive language for the professional groups in practice (Silva and Pinho, 2010; Soria-Lara et al., 2015; Straatemeier, 2008). If this barrier persists, the desired LUT integration will be very difficult to achieve in practice, especially in the context of emergent communicative planning approaches that demand support decision tools to facilitate the interaction and debate of professional domains (Bertolini et al., 2008; Curtis, 2011; Habermas, 2007). In contrast, if the lack of a LUT spatial perspective is overcome, this can help to reinforce transport practice as a collective process, where different actors and professional groups can more easily deliberate and exchange views in order to effectively design LUT strategies (Te Brömmelstroet and Bertolini, 2010). An important consideration here is to find methods and tools that can provide new insights into the described knowledge–practice gap.

Spatial metrics, operationalised by the moving-window approach, are shown here as a promising solution. They provide a set of spatial indicators that are traditionally used for studying landscape processes and patterns (Turner, 2005). Over the past years, spatial metrics have been used more frequently in urban studies to characterise urban growth patterns (e.g. Barreira González et al., 2015; Aguilera et al., 2014; Herold et al., 2005; Li et al., 2008). However, their effectiveness at the transport practice level is largely unexplored (Soria-Lara et al., 2014).

Accordingly, this paper will explore the following research questions: *How could spatial metrics be integrated into LUT strategy-making, and how do practitioners consider their usability and outcome for spatial planning practice*? We answered this by applying three spatial metrics (*interspersion and juxtaposition index; shannon diversity index*; and *aggregation index for green areas*) on the Light Rail Transit (LRT) corridor in the metropolitan area of Granada (Spain). The aforementioned spatial metrics were used to analyse and study three specific land use characteristics that are strongly related to transport systems, but are not always taken into consideration in transport practice: land use mixing, land use diversity and green areas connectivity. First, the results from spatial metrics were combined to identify and locate three LUT strategies: (i) proximity dynamics and non-motorised modes; (ii) modal shift from cars to LRT; (iii) shared spaces between motorised and non-motorised modes, on the LRT corridor. Second, a set of practitioners were asked to indicate their views on both the usability and outcomes of spatial metrics for LUT strategy-making.

In the next section, recent academic insights on the use and limitations of spatial metrics in urban studies are discussed. In Section 3, the research method is described, while Section 4 presents both the application of the three spatial metrics to the context of Granada and the perceptions of practitioners on their usability and outcomes. This paper closes with several concluding remarks and recommendations for further enquiries.

2. Spatial metrics: Definition and limitations in the urban context

The concept of spatial metrics comes from the application of "landscape metrics" to the context of urban areas. These widely-known landscape analysis tools gained importance during the last decades for analysing spatial characteristics and patterns of urban growth (e.g. Wu et al., 2011; Kaza, 2013), triggering the use of the so-called spatial metrics (Herold et al., 2003; Seto and Fragkias, 2005). According to Herold et al. (2003), spatial metrics can be defined as "measurements derived from the digital analysis of thematic-categorical maps exhibiting spatial heterogeneity at a specific scale and resolution". Consequently, spatial metrics have become a popular tool in urban studies (e.g. Aguilera et al., 2014; Dietzel et al., 2005; Wu et al., 2011).

A literature review of more than 50 publications from ISI web of Knowledge[1] shows a frequent use of spatial metrics in the following fields:

(i) Analysing and describing urban growth patterns at city level (e.g. Xu et al., 2007; Shrestha et al., 2012; Aguilera et al., 2014). The consulted studies in this field offer abundant insights into aspects related to urban growth, such as: urban sprawl, fragmentation of natural areas, and conurbation.
(ii) Comparing and classifying different cities across the world (e.g. Taubenböck et al., 2009; Schwarz, 2010). These studies aim at comparing urban growth patterns in different cities according to several spatial characteristics of urban land uses that are measured by spatial metrics.
(iii) Simulating urban growth patterns (e.g. Petrov et al., 2009; Aguilera et al., 2011; García et al., 2011; Kong et al., 2012). These studies mainly aim at using spatial metrics to calibrate urban growth simulations, comparing spatial metrics results from simulation models with real urban growth patterns.

Despite the growing application of spatial metrics from "landscape analysis" to the study of urban phenomena, certain shortcomings, negatively affecting the applicability of spatial metrics in urban contexts, can be seen.

[1] Relevant journals are e.g. Landscape and Urban Planning; Applied Geography; Computers, Environment and Urban Systems; Landscape Ecology; Ecological Indicators.