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Traffic-restriction in Ramallah (Palestine): Participatory sustainability assessment of pedestrian scenarios using a simplified transport model

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ABSTRACT

Assigning specific infrastructure per transport mode addresses discrepancies between mobility and land-use developments. This paper elaborates on pedestrian scenarios for central Ramallah, a major urban developing area in Palestine. The sustainability of the four alternative pedestrian scenarios is assessed according to the participatory multi-actor multi-criteria analysis, which integrates stakeholder objectives in the evaluation of the alternative scenarios. To determine the impact of each pedestrian scenario on the traffic flow, an origin–destination matrix is estimated by means of traffic counts, according the Furness distribution algorithm and the maximising-entropy approach. Results forward the medium Al-Zhara scenario as compromising alternative between the objectives of the governmental, transport operator and local business stakeholder groups, as it instigates less congestion, pollutant gas and greenhouse gas emissions. Detour routes subjected to parking constraints are proposed to optimise the reduced traffic flow.

Introduction

Half of the world population dwells currently in urban areas, making sustainable urban land-use a common key challenge in preserving the planet's viability. The social, economic and ecologic impact of global urbanised land-use developments is especially severe in developing countries, due to the lack of organised structure and regulations (Reidsma et al., 2011; Nesheim et al., 2014). Still, elaborating on sustainable urban land-use in an occupied state like Palestine, involves particularly unstructured interaction between socio-economic, political-demographic and environmental concerns, which are principally subjected to open evolutionary processes of unpredictable external and internal change (Rammel et al., 2007; Orenstein et al., 2011).

Access control and the restriction of human mobility, used as a crucial strategy in the Palestinian occupation, is such an unpredictable open evolutionary process which affects sustainable urban land-use and sustainable mobility in particular. Next to the Israeli settlements and the Israeli settler roads, the checkpoints, the boarder passes and the segregation wall impede the mobility of the Palestinians physically. In the last decades, the Hejaz railway, the Gaza seaport, the Arafat airport and the Qalandia airport have been abolished. Hence, motorised road transport (private cars, taxis, mini-busses and busses) and active modes (walking and cycling) are the only available mobility modes for the Palestinian citizens.

Next, the Oslo Peace Agreement (1994) divides the Palestinian territory in three categories. Area A is entirely subjected to the Palestinian Authority, in comparison to Area B where the Palestinians are only responsible for planning and development. Israel maintains control over political and security issues in Area B, while regulating the absolute jurisdiction in Area C (Abdelhamid, 2006). As the conflict includes a high degree of uncertainty in spatial developments in Palestine (see QCEA, 2012), continuity in sustainable urban land-use is best warranted in Area A.

Ramallah is the main Palestinian service-providing city in Area A of the West Bank. Whereas the Second Intifada (intensified Israeli-Palestinian violence during 2000–2005) perpetuated the Israeli

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access control strategies in Area B and C, motorised and active mobility progressed rather permissive in Ramallah. Rising commercial activities amplified short-distance trips in a central area characterised by a radial road network in favour of vehicles, in contrast to insufficient infrastructure for active road users. Establishing sustainable urban mobility systems in developing countries requires integrated land-use and transport policies, ascribing each specific infrastructure to different transport modes, in order to improve the quality and convenience of short displacement journeys (Santos et al., 2010; Wulfhorst and Priester, 2013). This manuscript elaborates traffic-restricted scenarios for Ramallah to enhance pedestrian mobility[1] in the city's central area. As such, the manuscript bridges discrepancies between spatial and transport planning by promoting active mobility (see Rodrigues da Silva et al., 2008). Moreover, a simplified transport model, based on real data collected from traffic counts, estimates the impact of the traffic-restrictions on motorised traffic flow. Finally, the sustainability of four alternative traffic pedestrian alternatives is assessed by means of the participatory multi-actor multi-criteria approach.

Materials and methods

The public net benefit of transport infrastructure investments is generally determined by social cost–benefit analyses (SCBA), which provide a quantified overview of the merits and drawbacks of the feasible infrastructural scenarios, listed as high as possible in monetary terms on a cost and benefit scale (Wesemann, 2002). Assessing the sustainability of transport infrastructure extends the purely economic evaluation to the social and ecological domain, impeding the quantification and monetisation of particular assessment criteria (Damart and Roy, 2009). Multi-criteria analyses (MCA) are in comparison more appropriate for the interdisciplinary evaluation of infrastructural projects (Munda, 2009). Still, there is a deficit in transport related assessment instruments which examine the influence of the infrastructural interventions on the actual motorised vehicle flow. The present paper contributes to this deficit by modelling motorised road traffic in Ramallah, in order to estimate the traffic volumes on the road sections which will be subjected to traffic-restrictions. Subsequently, the impact of the detouring vehicle flow is examined and considered in the sustainability assessment of the alternative pedestrian scenarios.

Transport demand model

Abstract transport models make use of theoretically sustained mathematical equations to represent real world mobility behaviour in a simplified form. To construct a mathematical model, reasonable socio-economic data is required to estimate the amount of displacements between each origin and destination zone (Van Mierlo and Macharis, 2005). Still, since socio-economic data on donum level (lowest administrative level in Palestine) is difficult to find and sensitive to retrieve, the paper elaborates on simplified mathematical transport modelling. A particular body of research specifies simplified transport models, which rely on a minimum amount of information to estimate a trip matrix (Abrahamsson, 1998). As the amount of traffic on a particular road can be seen as a combination of a trip matrix and a route choice problem, traffic counts provide direct information about the sum of all origin–destination (OD) pairs that use the specific counted road section (Ortuzar and Willumsen, 2011).

[1] Considering the hilly altitude of Ramallah (+900 m) and the hot and primarily dry climate, active mobility is narrowed to pedestrian mobility. Cycling activities are currently nearly inexistent in Ramallah, in contrast to the plain drylands of Jericho in the Jordan Valley.

To find the reasonable OD matrix T for the traffic estimation problem, the study area is divided into N zones, which are interconnected by a network of links and interchanging nodes. The essential stage of the estimation problem from the traffic counts is the determination of the paths (combination of links) followed by the trips from each origin to each destination. The variable P_{ij}^{a} signifies the proportion of traffic travelling from zone i to zone j using link a. The traffic volume V_a on a specific link a is consequently the summation of all the traffic T_{ij} between the N zones multiplied by their relative proportion:

$$V_a = \sum_{ij} T_{ij} P_{ij}^{a}, \quad 0 \le P_{ij}^{a} \le 1 \tag{1}$$

In order to solve the route choice problem, which estimates the proportion of traffic on a given link P_{ij}^{a} following a particular path, different assignment methods can be used. Robillard (1975) distinguishes between two main methods: proportional and non-proportional assignment. Non-proportional techniques detach the proportion of trips over a particular link from the traffic flow on the same link, in contrast to proportional assignment where the costs of all links are treated similarly. The present paper considers the different costs of each credible path between zone i and j, based on constraints of travel time, fuel costs and congestion. Paths with an eligible cost structure obtain a percentage of the total amount of traffic between two zones, in contrast to expensive paths containing an unrealistic amount of links. As a result, the allocated percentages per path (containing a set of links) are aggregated per link, determining the P_{ij}^{a}'s.

Next, the OD matrix between the N zones is estimated based on the Furness distribution algorithm. This simple algorithm, also referred to as the growth-factor method or multi-proportional method, updates a prior OD matrix relying on the counted traffic links $\hat{V}_a$ (Gupta and Shah, 2012). As such, function (1) specifies all the T_{ij}'s by balancing them iteratively towards their corresponding V_a values on the counted links, until the counted and modelled values converge under an acceptable maximum error. Once the OD matrix with all the traffic (T_{ij}) between the N zones is known, the V_a's per link can be computed by means of function (1), which summates the product of the total traffic (T_{ij}) and the traffic proportions (P_{ij}^{a}) per link.

Maximising the entropy of the Furness distribution OD matrix substantiates the results of the initial OD matrix. The entropy-maximising approach (Wilson, 1974) enables the aggregation of micro states (individual travellers, origin, destination, mode, journey time, etc.) in macro states (total number of trips on a particular link) if specified information on the micro states is unavailable. In this case meso states (trip numbers between OD zones) are used to estimate the macro state. Entropy-maximising approaches have been used in transport modelling for many years and provide a least-biased OD matrix, by minimising the difference between the uniform target and the estimated matrix (Ortuzar and Willumsen, 2011). Willumsen (1978) wrote the problem to estimate trip matrices from traffic counts as:

$$\text{Maximise } S_1 \frac{T_{ij}}{t_{ij}} = -\sum_{a} \left(T_{ij} \ \ln \frac{T_{ij}}{t_{ij}} - T_{ij} + t_{ij} \right) \tag{2}$$

subjected to the constraints:

$$\hat{V}_a - \sum_{ij} T_{ij} P_{ij}^{a} = 0, \quad T_{ij} \ge 0 \tag{3}$$

The right-hand side of the function is commonly referred to as the entropy function S_1 with his variable (T_{ij}/t_{ij}), which should be maximised to generate the most likely OD matrix (Ortuzar and Willumsen, 2011). The variable of the entropy function consists of