

## **PUBLIC SPACE AND MOBILITY IN HISTORIC CENTRES**

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### **RESUMO**

The recent ‘Alta de Coimbra e Rua da Sofia’ area, classified as World Heritage by UNESCO, is a unique opportunity that has triggered numerous support projects initiatives, encouraged by the University of Coimbra. One of the challenges that arises is the question of mobility, an issue less treated in the classification process (which is mainly focused on buildings). The quality of public space in general and the case of adequate infrastructure for mobility on one side, and the mobility management on the other side, are not areas set as criteria for classification by the UNESCO.

The main motivation of this work is the need to encourage classification that takes not only buildings but also specific characteristics of public spaces, that include not only infrastructure and also mobility management within smart approaches where inhabitants and visitors are locality guided and supported.

This study suits the thematic area ‘1 - Physical dimension / Real and virtual boundaries’, saying that the structure of the city should invite and encourage “public life”, through its public spaces and transport systems. This certainly applies to historic centers and the need to promote new approaches for the rehabilitation and for the use of these areas.

The quality of urban space can be measured by several urban indicators. The issue of mobility (in terms of infrastructure and management) is a key aspect for urban qualification, and can be measured by sustainable mobility indicators. Space Syntax techniques can provide some of these indicators, related with connectivity.

The geographical area compromise all routes serving this area. Several scenarios were tested that favor marriage between soft modes, public transportation and electric mobility. The results should provide guidelines for decision support in sustainable mobility policies or historic centres. The results include the identification and measurement of the most adequate indicators for classification of public spaces in areas applying for classification in terms of World Heritage. Based on this, a tool for creating several scenarios within multicriteria analysis, supporting decision was achieved. This was fully achieving combining a diagnosis for the ‘Alta de Coimbra e Rua da Sofia’ with the development of different scenarios for future improvements in the area.

### **1 INTRODUCTION**

The main motivation of this work is the fact that World Heritage Classification in historic urban centers does not have specific criteria for public spaces since it is centered in buildings.

The main objective of this work is the construction of a methodology that can help city councils to improve the quality of public spaces in candidate areas, using quality as an added ability of the urban structures, formed by its historic buildings and respective public space. This quality, when existing, can also help in the decision for choosing between two

very similar candidate areas or can be used as a guidance to decide which transformations are prior.

The methodology consists in selecting a set of indicators from literature that can be able to measure 'Public Space Quality for Mobility' and that are more adequate to the specific case of World Heritage Urban Areas. The application of a multi-attribute analysis to this set of indicators lead to the calculation of a total value - the mobility index - for each scenario and therefore, in the end, a comparison between scenarios or alternatives. The establishment of the relative weights of the factors that are composing the index can also be altered accordingly with the way they are valued from city to city. At this stage there are no costs associated with the different alternatives and just their value in terms of 'Public Space Quality for Mobility', as mentioned is considered. However the structure of the mobility index allows a valuation also related with cost, for further developments of this methodology.

This paper is structured as follows: first the background on mobility in urban historic centers and its importance (chapter 2), than the main actions that can be taken to improve that mobility at all levels from policies to infrastructure (chapter 3). After these two chapters, a more detailed explanation on the methodology (chapter 4) followed by the analysis procedures and results (chapter 5). Finally, a chapter on conclusions (chapter 6).

## **2 MOBILITY IN URBAN HISTORIC CENTERS**

François Asher (Asher, 2012) states that "the centre of the city was formerly defined geometrically, as the most accessible place for all, better protected and more valuable symbolically". However, with economic development, population growth and the consequent need to expand the cities associated with the construction of new and improved road infrastructure and the relocation of various urban activities, services and trade, "the most important place in an agglomeration is not the geometrical centre but its peripheral route" (Asher, 2012). The General Directorate of Planning and Urban Development (DGOTDU, 2005), in turn, sets the historical centre of the city as "the core of the original cluster, which radiate to other urban areas along with time" and it should be preserved and valued.

Already the author Mara Cavém describes the historic centre as housing and tourist attraction, focusing much of the economic and social potential of cities and that although it has been losing some appeal over the years, is maintained as a symbol and most striking feature of the history of a city. It also describes that the suburbanization phenomenon accompanied by the development of transport sector have fostered separation between workplace and residence, leading to an increase in the number of commuting, to a greater consumption of soil that has become unsustainable and to an increase of energy spending. This phenomenon activated the abandonment of historical centres, that turned to be degraded and aged (Cavém, 2007).

The excessive use of the car is also seen as a major contributor to the deterioration of historic centres, since these older urban areas of cities "were not prepared or were designed to take in a massive way this new element" (Freire Chico, 2008), leading to a saturation of traffic caused by excessive road traffic and therefore the loss of the space intended for pedestrian use, social activities and the trade itself. One of the main dilemmas of the historical core is therefore linked to its morphology and its urban layout. The continuing problems of accessibility of centres and mobility within it, are also linked to other problems such as population flight to the suburbs, abandonment and consequent deterioration of the housing stock, parking and under sizing the very loss of competitiveness of the central areas of conurbations to the emergence and establishment of

new services and the skilled trade in peripheral and semi-peripheral locations benefited by modern accessibility.

In the United Nations Conference held in Nairobi in 1976, it was agreed that governments, municipal authorities and the citizens themselves must take responsibility to safeguard and protect the historic core and its irreplaceable asset value by implementing measures and urban policies to preserve them and revitalize them, attracting potential residents and visitors. . Mobility is therefore one of the action plans that should be reviewed and on which sustainable strategic options should be studied to give back the importance of other times and the urban experience into historical centres.

### **3 ACTIONS FOR SUSTAINABLE MOBILITY IN HISTORIC CENTERS**

#### **3.1 Main actions**

Many authors identify overuse of individual transport, including private cars, as the main cause of congestion situations and swell of road traffic in urban areas, especially in historic centers, because they were designed as long before the appearance of this transport mode. Teresa Salgueiro (Salgueiro, 1999) states that the streets of the historic areas, marked by narrow profiles and often without tour - blocks the peaceful coexistence of motorized vehicles and pedestrians.

These problems should be solved by implementing a set of measures primarily aimed at creating an efficient system of public transport, the introduction of soft transport modes and the concept of intermodality, building physical elements or restrictions to private car, acting in accordance with the need to protect the public space and making it attractive and appealing to citizens.

The quality of historic centers should also be supported by a good network accessibility with a structured hierarchy that protects the most vulnerable users (pedestrians, cyclists, elder and children). Some decisions should be taken to improve the physical level of conservation and maintenance of the pavement. The functional level must be assured through good management that establish and regulate the traffic restrictions and permissions, promoting road quality at all levels of the road hierarchy, but promoting the quality of space for active modes, namely pedestrians.

With regard to parking in urban areas with historical significance, this should be the subject of "design and management that benefit the historical centers of the cities" (Sebastião, 2010). Solutions such as increasing the surface and underground parking capacity located in remote areas with affordable connections to historical centers and parking spaces, guarantee the attractiveness of these areas and promote the quality of life of its citizens. The implementation of paid parking to non-resident population should be viewed as a measure applied towards economic sustainability as a means of self-financing of these areas. Particularly in physical and functional maintenance actions, it is necessary to instill in citizens the idea that the use of public space in central cities is a rare commodity and therefore should be charged to motorists and promoted to pedestrians.

All of these measures to the mobility level are essential to restore and return the importance, status, value and quality of these spaces. This quality carries the symbolism and history of different communities over time, ensuring good levels of economic, social and environmental sustainability, by encouraging the use of public transport or the practice of intermodal behavior. The use of the individual motorized vehicle must be reduced, seeking also to restrict its accessibility by implementing effective parking management policies and acting at the design level of infrastructure and road access.

### **3.2 Identification of sustainable mobility indicators for historic centres**

As already mentioned, the promotion of sustainable mobility in urban areas is a complex process, because of the difficulty that the entities responsible for planning and management in urban areas have in the interconnection of all the actions effectively needed.

To combat this ambiguity, in 1992, the United Nations (UN, 2007) at the Earth Summit conference drew attention to the need to develop indicators and calculation methodologies related to the fields of sustainability, in order to facilitate the evaluation and decision process of the actions to be implemented.

Sustainability indicators can be interpreted as various parameters that condense complex information in a simplified form and that can be used in different scientific analysis, political or everyday interactions, as well as in the decision making process.

Button (2002) states that for planning and more efficient and sustainable management of urban areas it is important to use tools that can identify and quantify the level of sustainability in their different bases: social, economic and environmental. It is in this context that the author defends the use of sustainability indicators, establishing some criteria for their design, such as clarity, objectivity, sensitivity easy to change and interpret. In addition to these requirements, the author insists on the premise that these indicators should preferably be numerically quantified, as it makes its interpretation easier by the decision-makers and enables their use in different urban areas, also making possible a variety of scenarios. These sustainability indicators are so meters that provide status information of a system or of changes in the system in the three segments of this concept: again environment, economy and social aspects (Häkkinen, 2007).

Thanks to the multiplicity of the sustainable development concept and experiences of diversity where the concept of sustainable mobility can be applied, there is a range of indicators that can be adapted and used in the evaluation and characterization of sustainability levels in different situations or scenarios.

Therefore, due to this plurality of applications, this study elaborates an analysis of the indicators used by different organizations, research groups, government agencies and entities, to realize what criteria and parameters are best suited to the construction a characterization index of sustainable mobility applied to the case of historic centers, having as main objective the evaluation of the space at the design level of road and pedestrian infrastructure.

One of the entities analyzed was the United Nations itself, that in 1992 built a first compendium of 134 representative indicators of the state of sustainable development in various areas and domains.

The indicators related to sustainable mobility include more targeted questions to the transport sector, such as the modal split of passenger and goods transport, and the intensity of energy, bleaching other aspects that are not so detailed but are equally important to assess urban areas in terms of mobility, such as the state of the road and pedestrian infrastructure or connectivity values between the different streets.

The European Commission also developed a methodology to assess the sustainable development of European countries in accordance with the objectives proposed in the European Strategy for Sustainable Development (ESD) to include a set of indicators which are based on economic assumptions, environmental, social and institutional strategic actions (Eurostat, 2011). On subjects close to the issue of sustainable mobility, twelve indicators linked to sustainable transport, energy consumed, modal split, pollutant emissions, road accidents and transport costs.

Following the European indications, the Portuguese Environment Agency (APA, 2007) as a way to monitor the state of the environment and sustainability, has developed a tool to support the management and evaluation of the country's sustainability. This tool was created to address the need to evaluate the evolution of the country in terms of sustainability and to help in making decisions that promote sustainable development. In a first publication, 2000, the "Proposal for Sustainable Development Indicator System" (APA, 2000) encompassed a platform with 132 indicators, of which 72 environmental, 29 economic, 22 social and 9 institutional. However, in 2007, after a process of literature review and based on the study of other countries and organizations systems, a new edition of "Sustainable Development Indicators System" was released, in which the following could be identified as indicators linked directly to the issue of mobility:

- Emission of greenhouse gases;
- Construction of roads and fragmentation of the territory;
- Average age of vehicles on the road;
- Occupation and land use;
- Population exposed to noise outside environment;
- Modal split and transport of passengers and goods;
- Road Accidents;
- Volume of transport of passengers and goods.

These and other indicators and definitions can be found in other authors such as Lautso et al. (2004), Melo (2004), Muñoz et al. (2007), (Litman, 2008), (Miranda e Silva, 2012), (Fitzgerald et al., 2012).

These studies were evaluated and compiled in order to identify the indicators that are common and/or more frequently used. Two more classes were added: mobility and transport systems. Those indicators are presented below, in table 1:

**Table 1 Indicators identified in several studies**

<b>Dimension</b>	<b>Indicators</b>
<b>Environmental</b>	Consumption of fossil fuels for transport Energy consumption in transport CO2 emissions Emissions of greenhouse gases Particulate emissions from transport Occupation, use and condition of land degradation Use of renewable and alternative energy in transport Environmental impact studies
<b>Economical</b>	Benefits / profits from the transport sector Expenses / costs relating to urban transport Investment in transport infrastructure Registered maximum values of parking
<b>Social</b>	Education for sustainable development Daily hours spent in traffic jams Information available to the public Number of accidents per year Number of accidents per hectare Number of parking spaces for people with special needs Number of dead / injured in accidents per year Number of dead / injured in accidents per hectare Exposure to noise Proportion of street intersections with pedestrian crossings Pedestrian crossings adapted for people with special needs User satisfaction Public transportation for people with special needs
<b>Mobility</b>	Accessibility to public spaces Accessibility to public transport (stops, services, equipment) Monthly distance bound for services / work / stations

	Average duration of trips Existence of bike paths Level of connectivity Pedestrian accessibility index Number of car parks Number of cyclists by area Number of parking spaces for loading / unloading Total number of parking spaces Mobility plans Urban mobility policies Average travel time by mode of transport Intermodal terminals Average speed of travel Average speed of movement
<b>Transport Systems</b>	Frequency of public urban transport Average age of vehicles on the road Number of cars per km Number of bus stops Number of motor vehicles per capita Number of travels of motor vehicles Number of travels of non-motorized vehicles Number of trips by mode of transport

Therefore and based on the objectives of this study and on the studies analyzed, a methodology was established for evaluating and promoting sustainable mobility in urban historic centers, presented in the next chapter. It considers this literature review but adds new indicators, within a multi-attribute approach to identify the best combination of indicators for urban historic centers.

## 4 METODOLOGY

### 4.1. Selected indicators and sustainable mobility index

The first step of this process consisted of a combination of several sets of mobility indicators from different literature sources that reflect the contents of the various dimensions of sustainability, resulting in a total of 273 indicators coming from thirteen different authors. Completed this survey (briefly presented in the previous chapter), we proceeded to filter out data, identifying the indicators that were common to the different authors. For the construction of Sustainable Mobility Index proposed in this work, it was decided to check some indicators presented in the previous chapter that were applicable to the case of historic centres and the creation of new parameters related to planning and urban management.

The indicators considered in the characterization and analysis of the Historical Centre were integrated in three dimensions (Infrastructure, Transport and Mobility) that address matters such as Management and Urban Planning, Traffic Engineering, Parking Sizing, Transport Planning, organized and distributed by the following themes: Urban Design; Parking; Traffic; Soft modes; Collective Public Transportation (Traffic) and Mobility Policies. Table 2 presents the indicators chosen to integrate Sustainable Mobility Index to historic centres, followed by the respective measurement units.

**Table 2 Indicators selected**

		<b>INDICATORS</b>	<b>UNIT</b>
<b>Road infra</b>	Urban	1. Share of public space	% total area
		2. Share of green spaces	% public space
		3. Share of space for the motor traffic	% public space

		4. Share of space devoted to parking	% public space	
		5. Share of area with traffic calming solutions	% public space	
		6. Density of conflict points per crossing??	Number conflict points/crossing	
		7. State of conservation of road pavements	Acceptable/Bad/Good	
		8. State of conservation of shared rides and spaces	Acceptable/Bad/Good	
		9. Connectivity car index	Arcs/nodes	
		10. Connectivity (Spatial Syntax)	Unit	
		11. Control Value (Spatial Syntax)	Unit	
		12. Global Choice (Spatial Syntax)	Unit	
		13 Health index (buildings versus open space)	Streets with/total streets	
		14. Share of sidewalks below the regulated minimum width	% of total	
		15. Share of one-way streets with width of less than 5.65 / 8.15 / 10.65 meters	%	
		Parking	16. Share of paid parking in CH	%paid/total
			17. Share of reserved parking spaces for people with reduced mobility	%reserved/total
			18. Share of reserved parking spaces for residents	%residents/total
	19. Share of reserved parking spaces for loans.		%residents/total	
	20. Share of reserved parking spaces for electric vehicles		%residents/total	
	21. Car parks in the surrounding area to CH		Number	
	Traffic	22. Road hierarchy	Acceptable/Bad/Good	
		23. Share of road intersections with pedestrian crossings	Pedestrian crossings/intersections	
	Sustainable Transport Systems	Soft Modes	24. Extension of bicycle routes	m
			25. Bicycle parking areas	Number
		Traffic	26. Frequency of bus pass	Buses/hour
27. Number of bus stops			Unit	
28. Mean distance between bus stops			m	
Mobility Policies		29. Sustainable mobility plans for CH	Yes/No	
		30. Intermodal terminals within 600	Yes/No	

## 4.2. Multicriteria analysis

Once settled the representative group of indicators that influence and determine the quality and value of an urban area of historical nature in the mobility level, a multi-criteria method is used for the index construction evaluating and comparing different scenarios proposed for the historic district in a study of the real situation.

This is to say, there should not be consider the same index everywhere, but it should be adapted to local characteristics through the evaluation of different scenarios, eventually changing the set of indicators or/and the importance of each one of them within the index.

The multi-criteria methods are methods easy and simple use whose problems are expressed in the decision matrix. This matrix comprised a set of 'm' alternatives (or scenarios) each with 'n' criteria (or indicators) and each of its elements represents the performance of each alternative or scenario according to each criterion or indicator. It is also fundamental to assign weights to the indicators according to the usual methods.

### 4.3. Case study

This work is then based on the application of a multi-criteria analysis method for the creation of a Sustainable Mobility Index, assessing different scenarios proposed for the historic centre study in terms of sustainable mobility.

The case study is part of the Coimbra World Heritage Area 'University of Coimbra Alta and Sofia'. Since there was a need for test the methodology in an area with homogeneous characteristics, the area of the Alta, inside historical center was used indicated in figure 1.



**Figure 1 Coimbra University World Heritage area called 'Alta'**

This area was classified recently as part of World Heritage of UNESCO, based on three main criteria's:

- Witness an exchange of considerable influences over a span of time or within a cultural area, on the development of architecture or technology monumental arts, the planning of cities and landscapes of creation;
- Offer an exceptional example of a type of building or architectural or technological ensemble or landscape illustrating one or more significant periods of human history;
- Be directly or tangibly associated with events or living traditions, with ideas, beliefs or artistic and literary works with an exceptional universal significance.

The strong historic nature and exceptional cultural heritage of this space turns it into one of the most visited places in Portugal, besides having a significant and consistent student population. The public space in this area has very specific characteristics, similar to other historic urban centres, due to the urban structure formed by the buildings. Mobility is one of the most important quality of urbanity to be sustained in this type of place, both because of residents and students but also because of visitors.

The urban mobility policies have not been implemented as it would be desirable by the local city council, namely by limiting the circulation of motorized cars or implementing measures to motivate the use of soft modes or even small changes in pavement that could improve this overall situation thorough simple changes - adequate to this kind of urban structure - like traffic calming measures.



Therefore, this study identifies the quality of public space in this area, through the methodology adopted and the criteria's choose and then establish some scenarios showing how small changes can change deeply this classification.

## 5 ANALYSIS

Using the multi-criteria approach, the present situation was compared with two different scenarios, showing how apparently small changes in the infrastructure can do a lot for the quality of the urban space in terms of sustainable mobility in the historic centre of the Alta of Coimbra. The thirty indicators on table 2 were considered and measured for the Alta using a set of software and drawing tools including AutoCAD, ArcGis and Space Syntax, and also through information provided by local authorities or through field research.

For **scenario 1**, it was intended to provide a solution to the Coimbra Historical Center - Alta that can be implemented in the short term and which carries a limited financial burden for the municipality - since the proposed changes result mainly from implementation simple measures in terms of management and parking design, introducing new solutions for traffic calming and increasing areas of green space. This first alternative is also intended to demonstrate that it is possible to improve the mobility indices of the Historic City of Coimbra - Alta by improving just some of the 30 indicators proposed in this paper. The indicators changed were:

- Improving of the area of green spaces which corresponds to an increase of the percentage of area for green space of approximately 0.7% regarding the current situation.
- Implementation of traffic calming which provided an increase of 0.2% the percentage of areas with traffic calming solutions regarding the situation current.
- The conversion of 40 parking spaces, of which 34 have become pay parking, 3 have become parking reserved for people with reduced mobility and the remaining 3 reserved parking for the loading and unloading. This represents an increase of approximately 4%, 0.33% and 0.34% of the indicator values for these parameters. It was also proposed the construction of an underground car park in the surrounding area of Coimbra Historical Center - Alta within an accessibility radius equal to or less than 600 meters and 4 bicycle parking areas inside, notably at the university facilities.
- Increase of approximately 10% of the average number of times buses run in the Historic Center.

For **scenario 2** a greater financial effort by the City Council was considered, to be implemented in the medium term. This solution is characterized by the modifications considered in the scenario 1 at the level of road structure, morphology, urban layout and appearance of the historic center and also interventions at the parking management level. The changes implemented have caused changings in the parameter values associated with 19 indicators.

-First it was decided to redesign some parts of the Historical Center, in particular by destroying the private parking lot located next to the School of Architecture converting it to an area of green space: This represents a raise in the percentage of green spaces in the historic area under consideration about 63.45%.

-The roads of the historic center were also changed cutting some of them to traffic, and making it only accessible to pedestrians. These changes coupled with changes in parking, implying a decrease of approximately 2.5% in the percentage of area dedicated to motor traffic (decreased from 15.2% to 12.7%).

With regard to parking areas, adding to the elimination of parking spaces these changes caused a decrease of almost 50% from the parking area of this historic area, which

corresponds to a decrease of approximately 5% in the percentage of parking area compared to the current situation (decreased from 10.6% to 5.4%).

- The redevelopment of other spaces making them enable for sharing and free movement of pedestrians and authorized motor vehicles such as the collective urban transport buses, was also promoted, increasing the percentage of area with traffic calming solutions, from 14.5% to approximately 34%.The restructuring of the road network and the consequent elimination of some traffic flows and crossings has reduced the average number of conflict points to two in this new scenario, and the connectivity index automobile to 1:14 and increase the percentage of intersections road with tickets to pawns to 62% approximately; In addition to amendments already mentioned to the urban design level, there was a concern to resize some aspects of the pathways of the historic centre, verifying a decrease in the percentage of tours with widths lower to 1.20 (increased from 17% to 13% approximately) and a decrease in the percentage of one-way streets with widths below the standard values assumed (decreased from 41% to 38% approximately); In order to improve the average rates of connectivity, control value and global choice, four alternatives for pedestrian paths were created, including by building a staircase that enables direct access between two important spaces;

-With the elimination of some parking areas, the overall number of parking places (including places of private parks reserved to University Coimbra) reduced 1253 seats to 835 seats, and the total number of parking available at the Old Town visitors reduced 898 645 locations. Apart from these changes, we proceeded to a redistribution of the number of parking spaces in the different types identified. Increased to 10 the number of parking spaces for people with reduced mobility by converting some places.

-For this scenario it is also proposed a translation and relocation of four places reserved for electric vehicles that already existed.

All these changes have forced a reduction in the number of free parking spaces. However, in order to avoid the drastic of reduction in the supply of parking and meet demand, it was suggested the construction of two underground car parks located in the area surrounding the historical center within a radius less than or equal to 600 meters, Increasing to four the number of parks parking serving the historic district. Finally, and as already mentioned, it was presented this proposal creating a bike path along the sidewalk of one if the main streets. Although the slope of the street layout (4.93%) is higher than the 4% threshold that has been stipulated, a query to RMUE of Coimbra, paragraph 4 of Annex I referring to Public Space Design of Rules, admitt that bike lanes route with slopes up to 5 % can be allowed. It was also suggested the construction of six bicycle parking areas located close to the university facilities.

## 6 CONCLUSIONS

The resulting score for the three alternatives was as reported in Table 3, after a process of analysis through TOPSIS and after a conversion for the scale 1-10. These values represent the relative proximity between the alternatives and the ideal, maximizing all the benefits and minimizing all the costs.

**Table 3 Score of the 2 alternatives**

A0	A1	A2
0,1	2,1	9,8

The changes made in Alternatives A1 and A2, improved significantly the final score. Although not considering the cost of each intervention and therefore each alternative, the results show that just with some changes, the quality can improve drastically and therefore high score for the A2 alternative is the result of all the changes proposed.

However there is still a need to measure more accurately the intensity between changes in each one of the indicators, how these changes impact in the final score for each alternative and also how to include costs. Moreover the methodology developed in this paper can be easily adapted to these new developments, which is the focus of the research being developed in the next stage.

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