Study on Urban Walkability in Almada: an Application of the IAAPE model

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Abstract: The IAAPE project - Indicators of Accessibility and Attractiveness of the Pedestrian Environment - provides a methodology capable of evaluating the built urban environment using GIS (Geographic Information Systems) and supported by the participation of local pedestrians. IAAPE produces indicators of walkability that deliver a diagnostic of the built environment walkability: the walkability index, called Walkability Score.

The main objective of this dissertation is to test the IAAPE model applied to an urban area different from the original study case located in Lisbon. Questions about the applicability of the model in the city of Almada are raised, when the weights of the indicators disclosed in the case study of Lisbon were used for Almada, and the validation process of the model was carried out through questionnaires to the population.

The IAAPE model showed to be adequate for the pedestrian context of the zone tested in Almada, globally, producing a useful and relevant diagnosis of the local walkability, as validated by the population surveys. However, the inadequacy of the model for some cases detected in the studied pedestrian zone is highlighted, such as the inconvenience caused to the resident population by conflicts in the crossings in a zone of coexistence between motor vehicles, light rail and pedestrians.

The opinions and concerns of local pedestrians, collected through a field survey, regarding their relationship with the built environment of the area, have proved essential to the proper implementation of the model, namely in the structuring phases of the model and in the consideration of the weights for the walkability indicators, as well as in a posteriori stage when validating the walkability scores obtained by the IAAPE model

Keywords: Walkability, Walkability validation, Pedestrian Accessibility, Built Environment, Active Modes of Transportation

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1. Introduction

The first question that arises is: "Why walk?". According to Saelens et al. (2003), walking is the most common form of physical activity among adults regardless of age, gender, ethnic group, education or economic status.

Pedestrian activity is prominently the most common form of the various forms of physical activity (Siegel et al., 1995), with its well documented and proven health benefits, such as reducing cardiovascular disease risk (Gregg, 2003). In addition to the particular benefits to the individual, a number of positive impacts can be numbered to represent the community, as well as the pressing topic of reducing current of human's ecological footprint, through the minimization of the use of motorized modes of transport and the reduction of energy consumption (Ewing et al., 2010). The great contribution of walking as a base of the sustainable city, trough benefits on social, economic, and environmental matters encouraged several fields of research in the study of walkability, starting with public health sciences, and ending with urban planning and transportation (Lee and Moundun, 2004).

The work developed in this dissertation aims to complement the research project called IAAPE - Indicators of Accessibility and Attractiveness of the Pedestrian Environment (Moura et al., 2017). The project is based on the development of a methodology capable of evaluating the walkability of the built environment with the help of programs based on GIS (Geographic Information Systems), and has the fundamental goal to providing a decision-making tool to municipal authorities by providing a walkability assessment tool for urban planning strategies and policies. The IAAPE model was originally conceptualized in the city of Lisbon. The main objective of the dissertation is to test its applicability in a different urban environment, namely in the city of Almada, land produce guidelines and recommendations regarding the issues of adaptability and transferability of the model, and to validate the model through questionnaires, hoping to make an important contribution to the IAAPE project.

2. Literature Review

Walking is capable of providing unattainable personal benefits, such as the sense of independence and freedom of choice, but also has expression in the social environment because it provides opportunities for interaction between people and increased sense of community (Sandt L. et al. 2008). It is documented from the classic Appleyard study (1969) that as motor traffic increases and walking opportunities decrease, there is a circumstantial decrease in levels of social interaction among residents.

In general, accessibility can be defined as an individual's ability to achieve activities, goods and opportunities, reflecting the ease of reaching potential destinations ("impedance factor") and the nature of the opportunities ("attractiveness") (Handy 2005). Litman (2009) defines walkability as being the quality of walking conditions, which include the attributes that relate to the existence of facilities for the purpose and the degree of pedestrian safety, comfort and convenience. Abley and Turner (2011) explain the walkability as the extent to which the built environment is favorable to accommodate in the activities of their daily lives. This definition has been established to allow a subjective or qualitative approach rather than an approach with specific and objective criteria. Cambra (2012) assumes this last definition in the primordial development of the tool of the IAAPE project, being that in the present work it will also be considered.

The concept referred to as "Walkability Index" is based on the construction of a general index capable of evaluating the walkability of a site and is considered a measure of accumulated opportunities (Vale et al., 2016). The term "Walkability Index" originated in the study developed by Frank (2005), in order to relate the built environment to physical activity in a study area. In this first approach to the walkability index, Frank (2005) introduced three dimensions that translate the walkability referred to as: Net residential density; Land use mix; and Connectivity of the street network. In a later study, a new dimension called Retail floor area ratio (Frank 2010) was added. The Walkability City Tool is a tool developed by SUMA-USC (2015) and presents a methodology based on GIS technology that integrates the participation of specialists, authorities and the population. The study returns a score called Walkability City Score, which integrates a set of factors that are divided into the following dimensions: Modal distribution, Urban mesh, Urban surrounding, Security and Environment (SUMA-USC, 2015). Almeida (2014) developed two tools for the systematic evaluation of public space characteristics called SeGAPe and VePe65 +. These instruments are based on the participation of the elderly age group in the classification of the streets, through questionnaires and the "observational audit" method, in order to systematically collect the aspects observed and perceived by the age group under analysis. Despite all the developments in the measurement of walkability, Cambra (2012) pointed out the following limitations that persist: the dispersion and diversity of measurement concepts and methodologies; the different scales of analysis; the urban context and the origin of the studies; the diversity of measurement indicators; and the scarcity of model validation.

Despite the dispersion of concepts when trying to structure the study of the walkability, solid contributions have been made in order to categorize the factors in the so-called walkability dimensions. Cervero and Kockelman (1997) propose the well-known set of 3D of the built environment: Density, Diversity and Design. More recently, based on a project for Transport for London on walkability, Pharoah (2005) proposes the 5C: Connected, Convivial, Conspicuous, Comfortable and Convenient. In the context of the following dissertation and within the work plan of the model developed by IAPPE, Cambra (2012), later developed in Moura et al. (2017), proposes to add two factors - Coexistence and Commitment - bring important qualities of the built environment to be considered in the walkability assessment, naming the new set of seven walkability dimensions, the 7C.

It is necessary to carry out verification of the validity of the results obtained that can provide a satisfying level of confidence of the measures used to quantify the walkability of the urban built environment. Several fields of the walkability research seek for the validation of the walkability assessment tools, which can be grouped generically in groups of research fields, regarding their respective validation questions and methods used. In the field of transport research, the work done by Ewing et al. (2012) which consisted in validating the dimensions of walkability through pedestrian counts in New York. The results indicated high levels of significance between the dimensions considered and the counts performed.

In Health Sciences, the study by Gebel et al. (2010) main objective was to observe the relations between the measures perceived by the participants and the attributes' results obtained objectively for the neighborhood walkability, and compared these with the values of physical activity and Body Mass Index of the participants living in those urban areas over a period of years. The groups of objective measures and the measures perceived allowed to build a correspondence matrix. The conclusion was that those with less correspondence between the scores of walkability had a higher Body Mass Index when compared to those with walkability perceptions consistent with the tool estimates. The validation carried out by Moura et al. (2017) of the IAAPE model for the two Lisbon's localities, Arroios and Gulbenkian, was based on the construction of the correspondence matrix of Gebel et al. (2010). The adult age groups (14-64 years) and the elderly group (+65 years) were considered, and the results obtained showed a satisfying agreement between the objective measures and the street's walkability perception of the respondents when compared to streets with higher values of Walkability Score, while Streets with smaller Walkability Scores values (below 40 over 100 scale) had little correspondence, revealing the presence of other factors not included in the analysis for this lower end of the walkability range.

Regarding the transferability of models to different locations other than the original case study, we highlight the work done in the IPEN project (Adams et al., 2014), whose general objective was to document the variation between characteristics of the built environment using GIS throughout studies carried out in 12 countries of five different continents. Results suggest that intra-regional studies are constrained by the limits of a region's specific urban environment characteristics and do not consider the true range and possible variation of these characteristics. Great differences were found between the issues related to physical activity among countries studied and the variables related to the urban environment, since cultural norms, approaches to urban development and transport investment vary considerably.

3. Methodology

The main goal of the IAAPE project is to innovate in methodologies that analyze and measure the walkability in an urban environment built by providing a structured model on GIS platform. This model aims to support analysis and decision-making of planning and transportation agencies, to provide walkability assessment of built environments that are potentially capable of changing a city-walking activity. The conceptual framework of IAAPE is shown in figure 1, and then briefly presented.

1. Case Study Characterization: The objectives of the analysis are defined, within the limits and geographical scales of the area to be studied. Available data and materials useful for the evaluation of the walkability (pedestrian networks, land uses, etc.) are collected here.

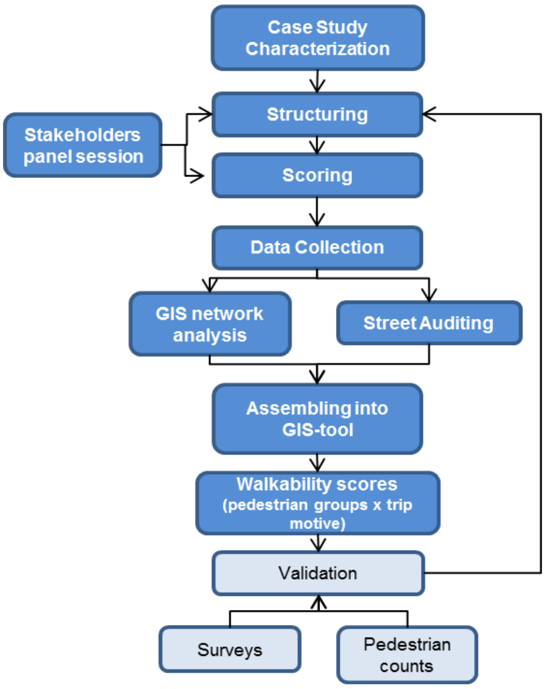

Figure 1 – IAAPE's conceptual framework

2. Structuring: A panel of experts in urban and transport planning selects a list of indicators taken from an extensive bibliographical review that best reproduces the 7C dimensions of walkability considered by the IAAPE model.

3. Selecting and scoring indicators: Subsequently, a stakeholders' session is held, including representatives of the four pedestrian groups (adults, seniors, children and people with mobility impairments) to obtain the main concerns and desires of their perception of walkability for the selection of indicators for each dimensions. In the same stakeholder session, the key-concerns of the participants are carried out through a Delphi type guided session with the help of the decision-making multicriteria application 1000minds (www.1000.minds.com). Table 1 shows the calibration of weights obtained by each group of pedestrians and for each travel motive for Lisbon. In the present research, these weights were considered, due to the impossibility of performing this stage of the IAAPE procedure. As such, this research is also a test for the transferability of these weights to the case study of Almada study case, performed through the validation procedures later describe.

4. Data Collection, GIS Network analysis and Street Auditing: Data is collected and stored on the GIS platform, combined with the visually supported digitized network using the Google Street platform.

Table 1 - Final selection of indicators and corresponding weights defined by each pedestrian group for each trip motive

Walkability Indicators by Dimension (7 C's)	Adults		Seniors		Impaired Mobility		Children	
	Utilitarian	Leisure	Utilitarian	Leisure	Utilitarian	Leisure	Utilitarian	Leisure
C1 - Connectivity								
C12: Pedestrian infrastructure	0.17	0.04	0.11	0.07	---	---	---	---
C13: Path directness	---	---	---	---	---	---	0.19	0.09
C14: Accessible pedestrian network	---	---	---	---	0.11	0.15	---	---
C2 - Convenience								
C21: Land use diversity	0.06	0.19	---	---	---	---	0.15	0.23
C22: Sidewalk effective width	---	---	---	---	0.16	0.1	---	---
C24:Daily commerce	---	---	0.16	0.27	---	---	---	---
C3 - Comfort								
C31: Vigilance effect	---	---	---	---	---	---	0.19	0.18
C32: Pavement quality	0.17	0.12	0.21	0.17	0.21	0.20	---	---
C4 - Conviviality								
C41: Meeting places	---	---	0.11	0.17	0.11	0.15	---	---
C42:Existence or visibility of anchor places	---	---	---	---	---	---	0.04	0.18
C43: Service hours	0.17	0.23	---	---	---	---	---	---
C5 - Conspicuousness								
C51: Existence or visibility of landmarks	0.11	0.19	0.05	0.03	---	---	0.12	0.14
C53: Street toponymical (street names, etc.)	---	---	---	---	0.05	0.05	---	---
C6 - Coexistence								
C61: Traffic safety at pedestrian crossing	0.22	0.15	0.21	0.17	0.21	0.15	---	---
C62: Pedestrian crossing location	---	---	---	---	---	---	0.23	0.14
C7 - Commitment								
C71: Enforcement of pedestrian regulation	0.11	0.08	0.16	0.13	0.16	0.20	---	---
C75: Existence of design standards	---	---	---	---	---	---	0.08	0.05

The digitization consists of the of the representation in the GIS format of the elements belonging to the pedestrian network (walk ways, crossings, walking paths in gardens, etc.) through a detailed topographic map of the area studied. The elements of the pedestrian network designated by segments are divided into arcs, which translate the walkways for pedestrians, and the crossings, when walkways intersect roads belonging to other modes of transport. The digitalized pedestrian network and the definition of areas according to the statistical subsections of INE would serve to obtain the network performance parameters calculated with The Network Analysis of ArcGis that relate to network connectivity, slopes, safety and location of crossings and compliance with legislation. After this stage, the audit of the streets is carried out to collect the audit parameters, which will be used to obtain the walkability indicators after normalization with value functions. This phase also serves to confirm the elements of the digitized pedestrian network map. The described phases are time consuming in the initial stages of execution, but tend to become efficient as the learning curve progresses.

5. Assembling walkability scores: The walkability indicators shown in Table 1 are calculated using value functions based on the audit and GIS-based parameters, capable of converting the qualitative and quantitative scales on a scale of 0-100%. These functions can be obtained through the application of several construction methods, and in this model was used the 1000minds method (www.1000minds.com). It is through the weights of the walkability indicators taken from the stakeholder session, presented in Table 1, that the Walkability Scores calculation formulas are constructed for each age group and trip motive. For example, the two formulas used to obtain Walkability Score in the group of adults for utility (1) and recreational (2) travels are presented:

$$WS_{adults\_utilitarian} = 0.17\times C12 + 0.06\times C21 + 0.17\times C32 + 0.17\times C43 + 0.11\times C51 + 0.22\times C61 \quad (1)$$

$$WS_{adults\_leisure} = 0.04\times C12 + 0.19\times C21 + 0.12\times C32 + 0.23\times C43 + 0.19\times C51 + 0.15\times C61 \quad (2)$$

Cutoff factors were used for the Impaired Mobility pedestrian group, since it is the only group in which the degree of mobility limitation makes it impossible to overcome the presence of certain obstacles, unlike the other groups of pedestrians. Therefore, it was assumed that when C14 (Accessible pedestrian network) equals zero, the WS value is automatically zero as well. This happens every time the path link width is less than 1.2 meters; when there are steps up to 15 cm or when the slopes are greater than 10%.

6. Validation: In the present work, questionnaires are carried out with the objective of validating the results obtained through the IAAPE model, by comparing these with the pedestrians' perceived walkability of the segments. It is intended, therefore, to know if the judgment of pedestrian matches Walkability Scores obtained, and if there are unexplored points of view in the measurement of the walkability. The online Google Forms-based questionnaire was built according to the following structure:

Group I - It is asked which is the best and worst street from the perspective of the respondent to walk in their neighborhood, and the reasons that lead to making these two decisions through the selection of three attributes from two dropdown lists.

Group II - Two streets belonging to the study zone are presented to respondent, which are rated 5 (Very good pedestrian quality) and 1 (Very poor pedestrian quality), based on the Walkability Scores obtained with the IAAPE model. After this benchmarking respondents are asked to rate a third street from 1 to 5 according to his perception. This question makes it possible to verify whether the street respondents' classification will match to the Walkability Scores obtained. Respondents are requested to rate three streets with classification.

Group III – A set of 5 street pictures of the study zone are presented to respondents that correspond to 5 Walkability Score classes (1 to 5), without showing them the rates of each picture. Then, the respondent is asked to sort the streets according to pedestrian quality from very good to very bad. This test aims to verify the correlation degree between the raking obtained by the IAAPE model WS and the ordering made by the respondents.

4. Application of the IAAPE Model in the Case of Study of Almada

The study area is located the central district of Almada, and was delimited using a buffer of 350 meters around the Primary School Dom António Costa, located in Professor Egas Moniz Str. The study area belongs to the old parishes of Almada and Cova da Piedade. When comparing this area with the study area of Arroios, in Lisbon, there are similarities regarding the demographic distribution of the population (Census 2011, INE), land use distribution, where predominantly residential use is verified, and because they are two urban areas with a compact and fluid urbanization mesh. As such, we believe were grounds for accepting structuring and scoring stages' results of the IAAPE model, obtained in Lisbon's stakeholders' session.

The digitization of the pedestrian network was performed based on OpenStreetMap in ArcGis, summing up 231 arcs and 124 crossings. The digitization of Almada's coexistence was new to the existing digitization methodology, and the zone includes part of Av. Nuno Álvares Pereira and Luís de Queiroz Str., and the entire plaza of Movimento das Forças Armadas. The streets audit of the parameters that allow to obtain the indicators of walkability, involves a solid work of previous preparation, namely to identify of the segments in the field and evaluate the descriptors of the parameters accordingly. This phase is decisive for the confirmation of the digitized pedestrian network, where new pedestrian network features emerged.

After collecting the parameters in the street audits, we calculated the walkability indicators. The spreadsheet was set up using the value functions of the indicators, with the information gathered by the audit and the SIG parameters values. With the estimated WS for each segment, the corresponding distance-weighted means were calculated. The results obtained for the means of the walkability indicators are shown in figure 2. The three indicators with lower values are C24 - Density of daily use (11.3% of total network length), C42 - Existence of meeting places (16.2%) and C53 - Signaling and management boards in Streets (15.4%); while the higher indicators are C13 - most direct path condition (63.4%), C31 - Facade transparency (70.2%) and C32 - Pavement surface quality (75.8 %).

Based on these indicators, calculated the Walkability Scores of each segment, for the groups of pedestrians and for each trip motive (utilitarian and recreational). Results were then integrated into the ArcGIS pedestrian network, and Walkability Score maps were built (figures 3 and 4), and the representativeness of the extension of arcs (%) in Table 2.

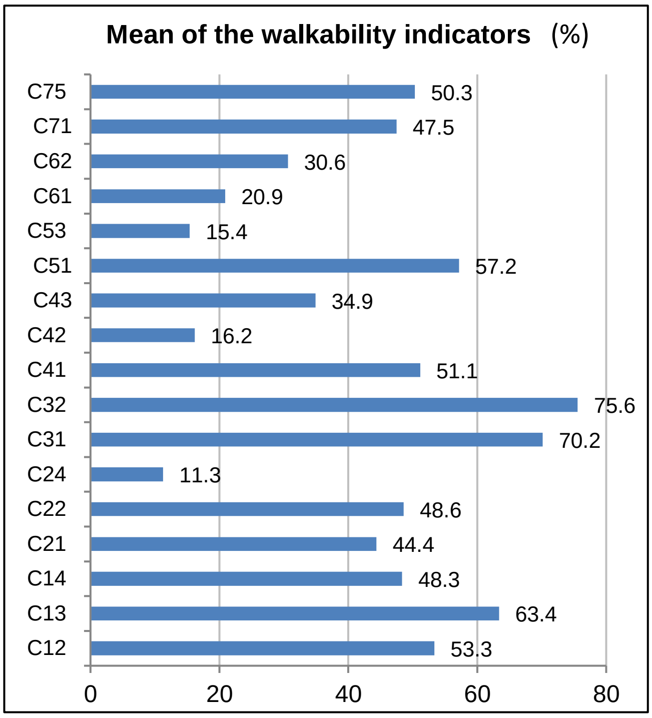

Figure 2 - Mean of the walkability indicators in Almada

Table 2 – Percentage (%) extension of arcs per W.S. rank

W.S. Rank	**Adults**		**Seniors**		**Impaired Mobility**		**Children**	
	Utilit	Leis	Utili	Leis	Utili	Leis	Util	Leis
0 -<20	3	9	4	10	**52**	**52**	2	3
20 -< 40	26	30	37	**44**	2	2	23	35
40 -< 60	**50**	**40**	**48**	38	18	16	**47**	**44**
60 -< 80	18	16	11	7	23	23	23	15
80 - 100	4	5	1	1	6	8	5	4

The validation questionnaire of the model was carried out online and through on-street interviews. A total of 287 respondents were collected (aging 15 to 64 years) including local residents and non-residents, in order to enlarge the sample. Among the 287 responses, 181 were women and 106 were men; 134 residents of Almada. In group I of the questionnaire, it was not possible to perform the correspondence matrix similarly to the study of Moura et al. (2017), due to non-responses by residents in Almada. The responses related to the most valued and less satisfactory attributes in the street were then addressed. Table 3 presents the results and the most valued attributes relate to the physical characteristics of the sidewalk. It should be noted that there is a undervaluation of the attribute flow and speed of the cars by respondents when asked from a negative perspective when compared to the more positive perspective.

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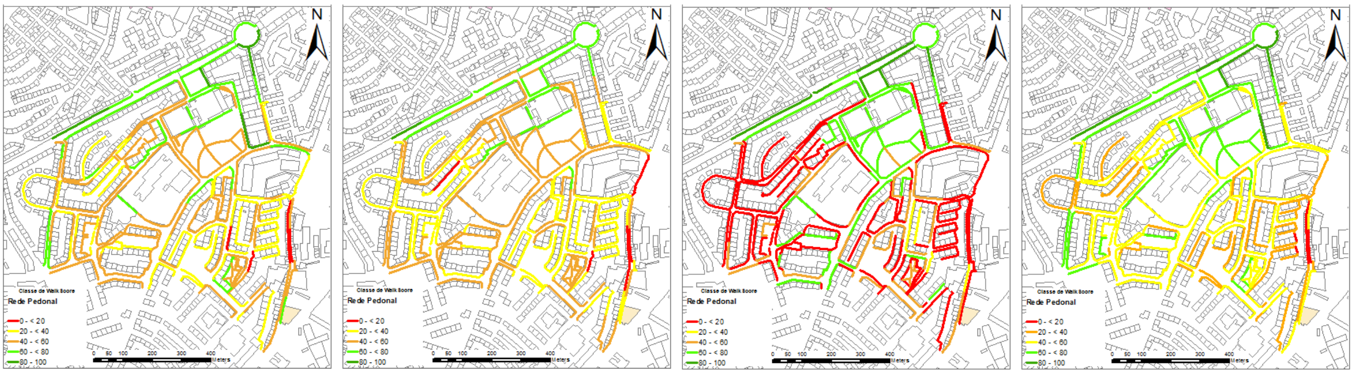

Figure 3 - Illustrative Walkability Score maps for utility travel for the Adult, Elderly, Impaired Mobility, and Children groups (left to right)

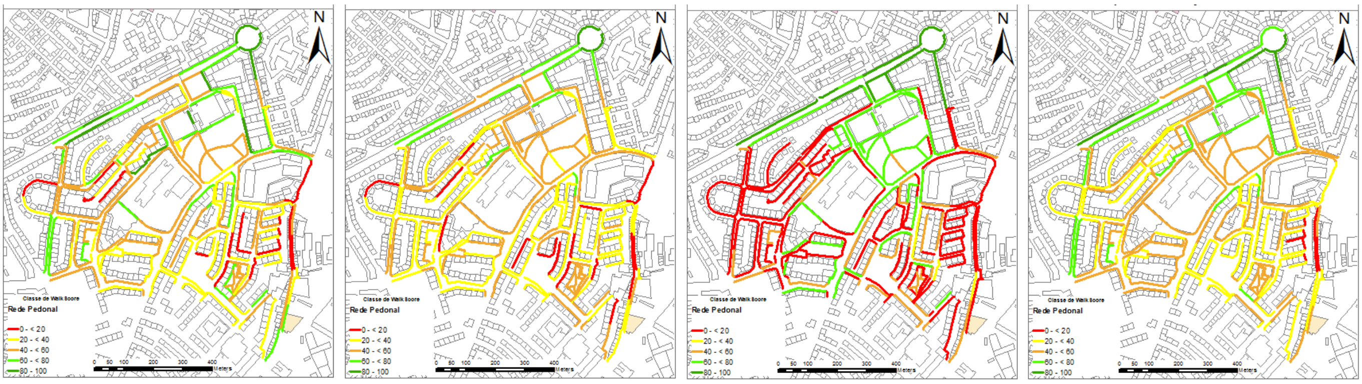

Figure 4 - Illustrative Walkability Score maps for leisure travel for the Adult, Elderly, Impaired Mobility, and Children groups (left to right)

Table 3 - Results group I responses - most valued attributes and less satisfactory

Most value Attributes	Non-resident	Resident
Clean sidewalks	41%	36%
Sidewalks with pavement in good condition	55%	58%
Link to other destinations, public transport interface	13%	29%
Sidewalk width	45%	38%
Absence of obstacles	29%	31%
Offer of commercial establishments and / or services	14%	20%
Places of stay and/or leisure	15%	26%
Reduced flow of cars driving at low speed	21%	15%
Quiet, low noise and low pollution environment	41%	31%
Other	11%	3%

Less satisfactory Attributes	Non-resident	Resident
Dirty sidewalks	43%	47%
Sidewalks with pavement in bad condition	62%	50%
Lack of links to other destinations, public transport interface	7%	12%
Narrow sidewalks and existence of obstacles	69%	69%
Lack of commercial establishments and / or services	3%	8%
Lack of Places of stay and/or leisure	11%	14%
High flow of cars driving at high speed	39%	43%
Noisy environment with poor air quality	41%	28%
Other	6%	4%

In the second group of questions answers were collected for the classification of three streets, for three different versions. Results indicate that the answers by interviewees and the IAAPE scoring do match in 1st version (Alexandre Herculano Str.), where 50% of the total responses match the IAAPE Walkability Score between 20-<40. For the remaining streets there was no such correspondence. In 2st street exercise (Mouzinho de Albuquerque Str.) most answers (46%) were within the class 40-<60, whereas IAAPE's model scored that street within 60-<80. Padre Antonio Vieira Str. (3st street) was overvalued by the respondents when compared with IAAPE's Walkability Score, where 55% of the respondents classified the street 60-<80, while the model rated 40-<60. The results obtained for this question are presented in Table 5, where it can be verified that the majority of respondents (44%) got the total matching of the sequence of the streets from the applied model.

In the third group of the questionnaire, the ordering of 5 streets was requested, from best to worst, to compare with the ranking based on IAAPE model results. The results obtained for this question are presented in Table 4, where it can be verified most respondents (44%) matched fully the sequence of the streets obtained from IAAPE model results.

Table 4 Results of group III of the questionnaire

Matching streets	**0**	**1**	**2**	**3**	**5**
N.º sets	44	45	20	10	1
N.º total answers	4	19	46	87	120
%	1%	7%	16%	30%	42%

5. Discussion

The vectorization and audit phases were carried out without some setbacks. Doubts have arisen as to the ambiguity of concepts within the established pedestrian network typology, and it is reinforced that a satisfactory degree of knowledge of the study area is required for these phases in order to capture the dynamics and habits of pedestrians at the site. The street auditing phase proved to be challenging due to the fact that the definition of the parameter descriptors was not clear enough at times or because it did not fit the reality at all. This difficulty was more prominent in parameters whose definition of the descriptors was not sufficiently discriminated, thus increasing the subjectivity of the measurement by the auditor.

In relation to the results obtained from the Walkability Scores, it can be seen that in general the study area scored medium values on a scale of 0 to 100. For the pedestrian groups Adults and Children most of the segments of the network are classified between 40 and 60 on both motives of travel. Regarding Elderlies utilitarian trips, most segments score 40-60, while for recreational trips they scored less, i.e., 20-40. Finally impaired pedestrians are the most penalized as the network scores This group was highly penalized as the required accessibility conditions were not satisfied, namely the minimum walking width (1.2m), and / or the absence of steps greater than 15 cm, and / or slopes of the road less than 10%.

The places with the highest Walkability Scores were Nuno Álvares Pereira Av., the Plaza of the Movement of the Armed Forces and Luís de Queiroz Str. The highest score of the area in the Plaza of the Movimento das Forças Armadas concentrates many attraction sites, commerce and services, while offering physical attributes of the sidewalk quite satisfying. Residential streets with low mixed uses, attraction sites, wayfinding elements, absence of formal crossings in the desire lines and safe crossings, and the failure to comply with interventions at the level of urban design, were the factors that led to lower than average walkability scores. The Manuel Febrero Str. obtained street the lowest Walkability Score, as besides not meeting standards of residential streets, it provides low quality pedestrian infrastructure, available walking width and opportunities for meeting and socializing.

The results obtained with the questionnaire for validation suggest that the formulation of the IAAPE model is adequate for the evaluation of the study area, generically speaking. The group of questions with the best model validation results was the ordering of five streets, with about 42% of the total responses ordering totally coincident with the results of the model. Carrying out the questionnaires on the street was an important input for this work, since it allowed to detect opinions and problems of the residents in the study area. The most problematic situation raised by the respondents was the conflict between modes of transportation in the pedestrian zone, and that the model was not able to portray in a reliable way the impact that these conflicts have on the population that uses the space. It is concluded that there is a possible mismatch in the attribution of weights to the indicators, suggesting that the stakeholder session would be fundamental to capture all these issues prior to model execution.

6. Conclusion

Overall, the application of the model to the city of Almada was successful as the walkability scores obtained portray correctly the perceived walkability by pedestrians, as demonstrated by the validation exercise. Still, there were some issues regarding the limitation of the model to properly describe certain walkability situations, and that need further development with the aim of enabling the Walkability Score of all elements of the pedestrian network. In relation to the specific case study, the IAAPE model does not cope correctly the coexistence zone, mainly regarding safety issues of simultaneous crossing of two road carriageways and the light railway, in a place built and named as a pedestrian zone by everyone. For these reasons, the initial stakeholders' session would have enriched and specified better the structuring and selection of proper walkability indicators of the case study, thus getting closer to the concerns and desires of those who walk there. Thus, there is some evidence that the Walkability Scores would have been different if this session had taken place. In spite of this, the adjustments that would be made would not be totally opposite of the applied model, since in addition to the specific cases mentioned, we are facing an urban location with similarities to Lisbon's original case, and the results obtained through validation do not reject the our assumptions.

The possibility of making a positive contribution to the whole community, with a view to improving living within cities and collaborating to create more sustainable societies, has been one of the main purposes of this project since the inception of the IAAPE model. To this end, it is essential that everyone participates towards reaching this goal, from the urban planning and transport planners to the common citizen. In order to reach this goal, the continuous enrichment of the model with the study of sites with particular characteristics and their integration in the model, the improvement of the process of adjustment and calibration of the formulas of obtaining indicators and Walkability Scores and the standardization of the methods of validation of the model in order to allow comparison between case studies.

7. References

Abley, S., & Turner, S., 2011, Predicting walkability. NZ Transport Agency, Research Report 452

Adams MA1, Frank LD, Schipperijn J, Smith G, Chapman J, Christiansen LB, Coffee N, Salvo D, du Toit L, Dygrýn J, Hino AA, Lai PC, Mavoa S, Pinzón JD, Van de Weghe N, Cerin E, Davey R, Macfarlane D, Owen N, & Sallis JF., 2014. International variation in neighborhood walkability, transit, and recreation environments using geographic information systems: the IPEN adult study. International Journal of Health Geographics, vol. 13:43

Appleyard, D., 1969. The Environmental Quality of City Streets: The Residents Viewpoint. Journal of the American Planning Association, vol. 35, pp. 84-101.

Almeida, M. F. 2015. VePe65+: Um Instrumento de Observação das Condições de Pedonalidade em Meio Urbano, Instituto de Ciências Sociais 3.

Cambra, P. J. M. 2012. Pedestrian accessibility and attractiveness indicators for walkability assessment (Thesis for the Master Degree (MSc) in Urban Studies and Territorial Management IST-UTL).

Cervero, R., & Kockelman, K. 1997. Travel demand and the 3Ds: density, diversity, and design.

Transportation Research Part D: Transport and Environment, 2(3), 199-219.

Ewing, R., & Cervero, R., 2010. Travel and the Built Environment. Journal of the American Planning Association, vol. 76(3), pp. 265–294.

Ewing, R., Connors, M. B., Goates, J. P., Hajrasouliha, A., Neckerman, K., Nelson, A. C., & Greene, W., 2012. Validating urban design measures. Transportation research board 92nd annual meeting, No. 13-1662

Frank, L.D., T.L. Schmid, J.F. Sallis, J. Chapman, & B.E. Saelens. 2005. Linking Objectively Measured Physical Activity with Objectively Measured Urban Form: Findings from SMARTRAQ. American Journal of Preventive Medicine, vol. 28 (2), pp. 117–125.

Frank, L. D., 2010. Neighbourhood Design, Travel, and Health in Metro Vancouver: Using a Walkability Index - Executive Summary. UBC Active Transportation Collaboratory.

Gebel, K., Bauman, A. E., Sugiyama, T., & Owen, N., 2011. Mismatch between perceived and objectively assessed neighborhood walkability attributes: prospective relationships with walking and weight gain. Health & Place, vol. 17(2), pp. 519–524.

Gregg, E. W., Gerzoff, R. B., Caspersen, C. J., Williamson, D. F., & Narayan, K. V., 2003. Relationship of walking to mortality among US adults with diabetes. Archives of internal medicine, vol. 163(12), pp. 1440-1447.

Handy, S., 2005. Critical assessment of the literature on the relationships among transportation, land use, and physical activity. Transportation Research Board and the Institute of Medicine Committee on Physical Activity, Health, Transportation, and Land Use. Resource paper for TRB Special Report, 282.

Lee, C., & Moudon A. V.. 2004. Physical activity and environment research in the health field: Implications for urban and transportation planning practice and research. Journal of Planning Literature, vol. 19, pp. 147–181.

Litman, T. 2009. Transportation cost and benefit analysis. Victoria Transport Policy Institute, vol. 31

Moura, F., Cambra, P., & Gonçalves, A. B. 2017. Measuring walkability for distinct pedestrian groups with a participatory assessment method: A case study in Lisbon. Landscape and Urban Planning, 157, 282-296.

Pharoah, T., 2005. Watching out for walking: Using new developments to secure better walking conditions. 6th International Conference on Walking in the 21st Century.

Saelens, B.E., Sallis, J.F., & Frank, L.D., 2003. Environmental correlates of walking and cycling: findings from the transportation, urban design, and planning literatures. Annals of behavioral medicine, vol. 25(2), pp. 80-91.

Sandt, L. S., Schneider, R. J., Nabors, D., Thomas, L., Mitchell, C., & Eldridge, R. J., 2008. A Resident's Guide for Creating Safe and Walkable Communities. U.S. Department of Transportion.

SUMA-USC, 2015. Walkability City Tool – Herramienta de Analisis de la Caminhabilidad. Retrieved from: https://issuu.com/walkabilitycitytool

Vale, D., Saraiva, M. & Pereira, M., 2016. Active accessibility: A review of operational measures of walking and cycling accessibility. Journal of Transport and Land Use., vol.9 No. 1, pp. 209–235