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The changing city: risk and built heritage. The case of Lisbon downtown

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Abstract

After the devastating earthquake, tsunami and fires of 1755, the city of Lisbon was rebuilt as a modern disaster resilient city, implementing strict planning controls and earthquake resistant construction technologies. This is reflected in the regular grid layout of the historic city, namely the Baixa Pombalina, and its built fabric. But the city has changed considerably since 1755. Through GIS mapping of the city, this study identifies the exposure of the built heritage of Lisbon Downtown to natural hazards including earthquake, tsunami, flood and landslide. It then highlights some of the changes that have occurred within the city's landscape since 1755 and the potential impacts that these may have had on the ability of the city's fabric to perform as designed. In particular, it focuses on the historic urban precinct of Baixa Pombalina, the heart of the rebuilt city and part of the tentative UNESCO World Heritage property of Lisbon. Although many studies have been undertaken to examine the seismic performance of the Pombaline buildings, few have examined the greater context in which the buildings exist and its potential impact on their performance. Will the buildings be able to withstand a similar event now or have they been compromised by the changes that have occurred in and around them? This study considers the vulnerability of the city's historic structures and sites to various hazards and identifies areas of further research needed to enable the development of appropriate mitigation strategies to strengthen the resilience of the historic city.

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1. Introduction

Broadly, risk is calculated as a product of the exposure and vulnerability of places and people to potential hazards (damaging processes, natural or human, fast or slow onset, determined by probability, scale/intensity) and the losses (lives, livelihoods, physical, emotional and financial) that may be experienced as a result of their impact [1,2,3]. The concept of risk reflects the capacity of the people to resist, respond to and recover from such major events [4,5,6].

Emergency planning involves development of mitigation strategies to minimise losses from disaster. Emergency response and recovery strategies generally provide firstly for the physical well-being of the people (through provision of water, food, shelter and medical services), and secondly for the city's economic recovery (through provision of essential infrastructure, education and livelihoods). In most cases, comparatively little attention is given to the protection of the historic form and fabric of a city and its cultural inheritance, even though this is what gives the city its distinctive character, supports the emotional and spiritual well-being of its people, and contributes to a city's economy.

This study aims to bring awareness of the relationship between risk, urban dynamics and heritage, taking as a case study Lisbon Downtown, 'Baixa Pombalina', which was rebuilt following the disastrous earthquake, tsunami and fires of 1755.

2. Filling the gap: risk and cultural heritage

The area of Lisbon and the Tagus Valley, and specifically Lisbon Downtown, has been the subject of several approaches to risk assessment and management [7,8]. There have also been numerous studies regarding the values and conservation of cultural heritage assets of Lisbon Downtown [9,10,11]. However, there are no known studies involving the systematic assessment of the interrelationship between risk and heritage in Lisbon Downtown and the role of the changing urban environment in increasing or decreasing the risk to the urban heritage.

This research integrates cultural heritage into the hazard mapping of Lisbon Downtown. Geographic information system (GIS) tools have been used to cross reference the hazard maps provided in Lisbon's Municipal Master Plan (PDM) [12] with a non-exhaustive geo-referenced inventory of the built cultural heritage of the city (based on various documentary sources, but with particular reference to the project *Lojas da Baixa & Chiado* led by Gabinete de Estudos Olisiponenses). This information has subsequently been verified in the field and emblematic examples selected for GIS analysis.

This study enables analysis of the exposure of the built cultural heritage of Baixa to various natural hazards, to highlight potential vulnerabilities of the heritage to those hazards and to raise awareness of potential risks that arise from changes in the urban environment over time. In this study 'cultural built heritage' not only includes classified (legally protected) heritage, but also places with significant associations and meanings for the city's inhabitants and visitors, forming part of the collective imagination and identity of the city.

3. Lisbon Downtown: geomorphology and historical background

Lisbon Downtown is built over two creeks, the Arroios and Vale de Pereiro, which bifurcate upstream and are now channelled under Almirante Reis (east) and Liberdade Avenues (west) respectively. The built upon area of the city has expanded over time through successive reclamations of the northern margin of the Tagus estuary and the river valley, corresponding with a 6.2km² elongated terminal channel watershed. The area is founded on alluvium ("Esteiro da Baixa", a sedimentary feature formed in detritus and carbonate Miocene rock) but now stands mostly on anthropogenic deposits placed to raise and level the ground for construction [13]. The debris from old Roman and Medieval periods comprise the rubble used to fill the downtown area after the 1755 disaster [14,15].

Whilst ancient Roman, Moorish and Medieval civilizations concentrated their political, social and religious centres behind a series of successive walls on the Hill of Castelo de São Jorge and its slopes, the riverfront was continuously occupied for at least over the last 2000 years. The archaeological remains show that a generalized pattern of small settlements gave way to a long evolving urban occupation around fishery and trade. The development in this area increased significantly through the fifteenth and sixteenth centuries, during the age of Discoveries and Expansion, to

include trade activities, royal services and defensive military constructions that frequently reused the materials of previous buildings [13].

Urban changes prior to the 1755 earthquake may have been influenced by events of flooding and/or landslides due to tectonic movements. Seismic engineering studies have proven many other episodes of earthquakes affecting Lisbon also present in the collective memory of the city: 1017 (not documented in written records), 1344, 1356, 1512, 1531, 1597, 1748 [13]. Tsunami events have also affected the region over the last 10,000 years and the geological record indicates intervals of recurrence in the order of 400 and 160 years, and particularly an interval of 220 years for abrupt events of marine introgression in the Tagus estuary contemporary to the seisms dated to the XIII-XVIII century. [14].

4. ‘Baixa Pombalina’: post 1755 rebuilding

The current layout, form, structure and character of Baixa Pombalina are the result of a deliberate reconstruction effort to build a modern commercial and disaster resilient city after the 1755 disaster. The project was undertaken by leading engineers and architects under the command of the Marquis of Pombal and the Crown’s Engineer Manuel da Maia. Maia’s design included respect for certain attributes of the destroyed city, including retention of the principal road axis, the location and size of the main squares and the use of the same hierarchical street naming scheme (‘rua-travessa’) [16]. Refer to Figure 1.

But significant changes were also made. A regular grid of wide straight streets replaced the previously irregular, narrow and winding streets providing an improved environment for the conduct of business [7; 17]. They gave the city a generous urban scale and a modern-day appearance, whilst enabling the efficient transfer of goods to and from the docks. The regularization of plots and the design of the buildings using, with little variations, the same building type; the employment of a standardized construction system, local materials and techniques, as well as a significant contingent of workers transferred from the constructing of the Mafra Convent (the biggest religious complex ever built in Portugal) enabled an efficient reconstruction. The renew of the city not only responded to the disaster as accommodate a much higher population density, whilst promoting an organized mix use, with commercial premises on the ground floor and residential units above. At the same time, the wide streets made the city more resilient to future earthquakes by providing a means of escape in the case of building collapse and better access for firefighting.

The design of the buildings was intentionally adapted from earlier building types that had survived the disaster. The ruins of the former city were raised and timber piles were driven into the soft alluvial soils to provide a stable base for rebuilding. These piles were maritime pine were immersed in water so that they could last indefinitely. The buildings were then constructed on massive vaulted masonry bases that were fire resistant. Above this the perimeter walls became thinner and lighter as they extended up the height of the building. In each building both external and the internal walls were braced through the use of a timber cage or ‘gaiola’ whose pieces were assembled in order to become seismically resistant [11]. The timber floor structures were tied into the walls using iron ‘hands’ so that they could act as diaphragms to absorb the shaking. The walls were filled with mixed masonry, using ceramic and stone elements, which embedded the timber frame. The buildings were arranged in blocks to buttress each other and solid masonry walls extended through the full height of the buildings, including the roofs, to provide fire separation between building units [8, 18].

The construction of drains under the main streets contributed to a healthy living environment by efficiently removing water and waste from the streets [19, 20, 21]. Land on the foreshore was reclaimed and raised to reduce the impacts of future tsunamis, but also to provide a large public space for conducting trade (Praça do Comércio). The grand ceremonial arch (Rua Augusta) at the entrance to the city, built as a memorial one hundred years after the event, stands to make the proud statement that Lisbon had not only survived the disaster, but thrived. This arch is the crowning piece in establishing the identity of the city.

The heritage value of Baixa Pombalina (Lisbon Downtown) is present in its urban planning and architecture, its historic and physical relationship with its environment (surrounding hills, Tagus River and Atlantic Ocean), its archaeological remains, its traditional commercial and residential occupation, its cultural centres and festivals. These attributes all contribute to the cultural identity of the city, its historic dynamic and interest as a tourist destination.

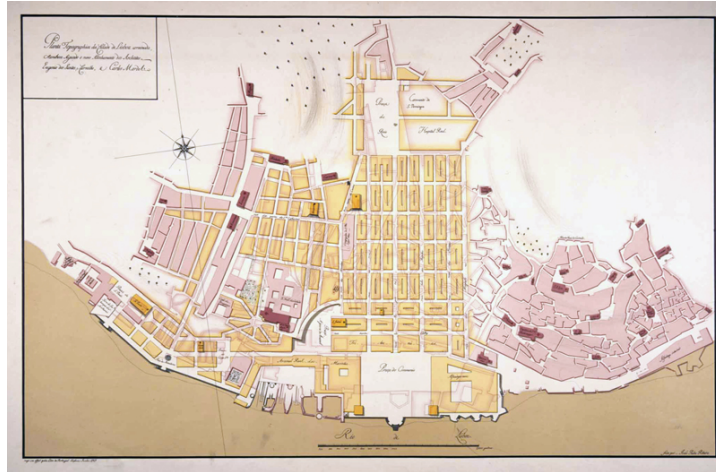


Figure 1 – Map of Lisbon showing the new street layout designed by the architects Eugenio Carvalho dos Santos and Carlos Mardel, dated 12 June 1758 (yellow) laid over that of the ruined city (pink). Overlay prepared by architects Eugénio dos Santos Carvalho and Carlos Mardel, 1947 (Source: *Museu da Cidade*, City Museum).

5. Susceptibility of ‘Baixa Pombalina’ and its heritage to natural hazards

The sectorial diagnosis of "Risks and Civil Protection" included in the Regional Plan of Lisbon Metropolitan Area (*Plano Regional de Ordenamento do Território da Área Metropolitana de Lisboa – PROT AML*) indicates that Lisbon Downtown is located in an area of very high seismic susceptibility (Mercalli intensity modified X to VIII) [6]. This is due not only to its proximity to active underwater structures bordering the Portuguese mainland, but also to a fault zone in the lower Tagus valley [22]. It is also built on soils of high seismic susceptibility (unconsolidated alluvium), both along the waterfront and over the ancient streams [14]. Figure 2 indicates the exposure of the built heritage of Baixa to seismic hazard.

Lisbon has been hit by strong tsunamis five times in the last 2000 years: two in the Roman period, two in the sixteenth century, and one following the great earthquake of 1755. The probability of a significant tsunami event has been assessed in seismic susceptibility studies, and is based primarily on historical records and the influence of the direct tidal effect. The risk assessment conducted for PROT-AML indicates that a tsunami could encompass the riverside area of Baixa to a height of 5 meters [22]. Refer to Figure 3.

Historical records correlated with other variables such as slope, degree of ground permeability, ground water flow lines, direct tidal effect, and constraints of the urban sewerage and drainage network, show that the low-lying areas around Rossio and Praça do Comércio are the areas with the highest exposure to flood risk. However, other areas of Baixa are also shown as being at high to moderate flood risk, the exposure often coinciding with a concentration of drainage points, both natural and artificial. Figure 4 shows the exposure of Baixa’s heritage to flooding.

Landslide or mass movement is relatively common in Lisbon following high cumulative rainfall or heavy concentrated rains and is associated with the slopes around the hill of Castelo de São Jorge. The risk mapping for landslides in the Lisbon PDM is based in the analysis of geotechnical behavior of soils and rock, completed within the scope of the seismic risk assessment and correlated with known records of slope instability [12].

6. Vulnerability of the built heritage in the context of the changing urban landscape

The assessment of risk to cultural heritage, not only requires an understanding of the hazards that may impact a place and its people, but also a good understanding of the vulnerability of the city fabric to those hazards, and the potential loss of heritage values (both tangible and intangible) that may be experienced. This type of assessment involves a more detailed or intimate knowledge of the building fabric (its strengths and weaknesses), building condition, local site

conditions within which the buildings exist (foundations and surrounding urban context), occupation, contents and use. All of these can increase or decrease the risk to the fabric of the city and its cultural heritage values.

Although Downtown Lisbon was designed as an earthquake and fire-resistant city, it was built on unstable ground (over river flats and the remains of earlier settlements). Archaeological investigations indicate that the foundations of the city vary. In many parts of the city a timber platform and piles were used to provide a stable base for construction and some protection from liquefaction in a seismic event. However, these elements must stay wet to remain in good condition. The impermeability of modern ground surfaces, changes to drainage systems, excavation for basements and the underground railway, and the pumping of underground water, have the potential to lower the water table and put the piles, and thus the stability of the city, at risk. Although most of the piles uncovered to date appear to be sound, some decayed piles have also been unearthed (Bank of Portugal and Millennium Bank archaeological sites).

Since the eighteenth century, ground levels in the city have risen through successive road upgrades and the introduction of modern infrastructure, including the introduction of trams [23]. The current road surface, which cambers to shallow gutters on the outside edges of the streets, sits well above the eighteenth-century road with its large central drain. Thus, the capacity of the streets to hold excessive amounts of water has been reduced. In some places, the footpaths are now higher than the floors inside the buildings and in high rainfall events, the retail businesses and historic shop interiors located at street level are at high risk of damage. The old haberdashery shops located along the Rua da Conceição are situated at the downhill end of the main axial streets of Baixa and are at particularly high risk.

Constantly damp conditions within the buildings compromise not only their interior finishes and contents, but also their long-term structural stability [20]. Rising damp due to high ground levels around the buildings, the use of impermeable surfaces and poor drainage are exacerbated by the use of non-breathable wall finishes such as cement render, causing decay not only of the brickwork and decorative tile finishes for which the city is renowned, but also of the structural timbers and iron hands that provide the seismic resistance of the upper walls. Similarly leaking roofs and windows in abandoned or poorly maintained buildings cause decay from the top down.

Many buildings in Lisbon Downtown have been altered to accommodate the changing needs of the people that occupy them. This includes provision of modern plumbing and electrical services, lifts and more open living spaces. A considerable number have had their internal frames replaced in reinforced concrete or steel. The impact of these changes on the overall stability of the closely packed buildings, which were designed to buttress each other during a seismic event, and on their historic facades, has been explored to some extent, but needs further detailed investigation: [24, 8].

In order to analyse the degree of exposure of cultural heritage to potentially damaging phenomena, it is necessary to assess the probability of occurrence and the characteristics of natural disasters, which is known as the susceptibility dimension of risk equation. The susceptibility maps concerning seismicity, tsunami and flooding were provided by Lisbon Municipal Master Plan and by the sectoral diagnosis "Risks and Civil Protection", of the Regional Plan of Territorial Planning of the Lisbon Metropolitan Area - PROT AML [25].

It is also important to evaluate the severity of the impact on the assets resulting from the exposure, i.e. the level of damage or loss of values, which depends on multiple factors of physical, socioeconomic and institutional vulnerability.

To achieve that purpose, the GIS built to assess the cultural heritage exposure to natural disasters included not only the protected sites and buildings, but also places which, due to their connection with the traditions and customs, have a cultural value, given their contribution to the unique character of "Baixa Pombalina". The municipal survey of stores with history, for example, was determinant to the inclusion in the GIS database of this kind of places that shapes the identity of Lisbon downtown.

By mapping the heritage sites of "Baixa Pombalina" and overlapping this cartography with the susceptibility maps, it is possible to identify the exposure of these sites to large scale risks, such as earthquakes, tsunamis, mass movements and floods.



Figure 2 – Map showing exposure of the heritage of ‘Baixa Pombalina’ to seismic hazard (Source: Adapted from Lisbon Municipality, Municipal Master Plan of Lisbon, 2012, and based on field work).



Figure 3 – Map showing exposure of the heritage of ‘Baixa Pombalina’ to direct tidal effect / 5m high tsunami (Source: Adapted from Lisbon Municipality, Municipal Master Plan of Lisbon, 2012, and based on field work).



Figure 4 – Map showing exposure of the heritage of ‘Baixa Pombalina’ to flooding (Source: Adapted from Lisbon Municipality, Municipal Master Plan of Lisbon, 2012, and based on field work of the authors).

Fire is a common hazard in all cities. The 1988 fire in the historic Chiado district (immediately adjacent to Baixa) was reported as the city's worst disaster since the 1755 earthquake, destroying 18 commercial buildings and 40 businesses and left 300 people homeless and 2000 more jobless [26]. Fire fighters were hindered in their response to the fire by newly introduced street furniture and café structures. Fire risk to the buildings of Baixa Pombalina will be determined not only by the vulnerability of their timber-framed construction, but also their use, contents, age and the condition of their electrical wiring, as well as the capacity of their occupants to respond to a fire. Many of the residents of Baixa are now elderly and highly vulnerable, both physically and economically, and would find recovery from such an event extremely difficult.

7. Conclusions and Final Remarks

Lisbon Downtown is much more than a remarkable historic urban centre and pioneer example of European anti-seismic construction. It is a place where heritage ranges from the monumental to the everyday, a place of vitality with a rich socio-economic diversity and cultural activity. This study shows the importance of linking risk, heritage and urban dynamics, to better understand the risks to the heritage of the city in general and the Lisbon downtown, in particular; not only the Pombaline structures but also the early shop interiors and traditional commercial activities. With the aging and highly vulnerable local population, a disaster on the scale of the 1755 earthquake could cause irreversible abandonment of the place and an incalculable loss of heritage, through the destruction of the fabric, the collective memory and the cultural identity of Baixa.

Although numerous risk and heritage studies have been undertaken in relation to Baixa Pombalina, these studies are poorly linked and few consider the interrelationship between risk, the dynamic urban context and the heritage of the city. The use of GIS to map the heritage attributes of the city and overlay them with the hazard susceptibility and infrastructure maps enables the development of more detailed analysis of risks to the urban fabric of Lisbon and the potential loss of its heritage values. The GIS data management system also provides the opportunity to link and share data across sites, enabling the prediction of potential risks at neighbouring sites where relevant data is missing.

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References

- [1] R. Jigyasu, Towards developing methodology for integrated risk management of cultural heritage sites and their settings, 15th ICOMOS General Assembly and International Symposium: 'Monuments and sites in their setting - conserving cultural heritage in changing townscapes and landscapes', China, 2005. <http://www.icomos.org/xian2005/papers/2-16.pdf>
- [2] N. Okada, Urban Diagnosis and Integrated Disaster Risk Management, *Journal of Natural Disaster Science*, vol.26, No.2, 2004, pp.49-54. http://ci.nii.ac.jp/els/110002703813.pdf?id=ART0002983744&type=pdf&lang=en&host=cinii&order_no=&ppv_type=0&lang_sw=&no=1454344827&cp=
- [3] M. Pelling, *The Vulnerability of Cities: Natural Disasters and Social Resilience*. Earthscan, New York, 2003.
- [4] J. Adams, *Risk*. UCL Press, London, U.K, 1995.
- [5] Smith, Keith (2013). *Environmental Hazards: Assessing Risk and Reducing Disaster*, Routledge, 6th edition, p.504
- [6] Wisner, B. et al. *At risk: natural hazards, people's vulnerability and disasters*, 2nd edition, Routledge, London, 2004.
- [7] D. Brand, H. Nicholson, *Learning from Lisbon: Contemporary Cities in the Aftermath of Natural Disasters*, in J. Tiefenbacher (Ed.), *Approaches to Disaster Management - Examining the Implications of Hazards, Emergencies and Disasters*, 2013, CC BY 3.0 license.
- [8] L.F Ramos, P.B. Lourenço, Modeling and vulnerability of historical city centers in seismic areas: a case study in Lisbon, *Engineering Structures*, No.26, 2004, pp.1295–1310.
- [9] J. França, A. Augusto, *Lisboa pombalina e o iluminismo*, Bertrand, Lisboa, 1987. http://www.ceg.ul.pt/download/Publicacoes_Download/CRamos/AvaliacaosusceptibilidadeperigosnaturaisRegi%C3%A3oLisboaValeTejo.pdf
- [10] W. Rossa, *Lisboa Iluminada — século XVIII*, in Jorge Carvalho Mourão (org.), *Lisboa e o Rio, paradigmas de cidades atlânticas*, catálogo da exposição. Lisboa, Câmara Municipal de Lisboa, 2008, pp. 62-77

- [11] V. Santos, O sistema Construtivo Pombalino em Lisboa em Edifícios Urbanos Agrupados de Habitação Colectiva – Estudo de um Legado Humanista da Segunda Metade do Séc. XVIII, Tese de doutoramento, Universidade de Lisboa, 1995.
- [12] Município de Lisboa, Plano Diretor Municipal de Lisboa – Planta de Ordenamento. Elementos constituintes disponibilizados em formato vectorial em: <http://www.cm-lisboa.pt/viver/urbanismo/planeamento-urbano/plano-diretor-municipal>, 2012. And: Relatório de caracterização síntese. Primeira Revisão Aprovada em Assembleia Municipal de 24 de julho de 2012 e publicada em Diário da República de 30 de Agosto de 2012, 2012.
- [13] V. Durão, Reclaimed Land: an Urban Analysis The landfills in Lisbon's downtown and riverfront, Portugal, *Journal of Integrated Coast Management*, Volume 12, N. 1, 2012, pp. 17-30.
- [14] I. Almeida, C. Andrade, M.C. Freitas, J. Moreno, M.C. Cabral, S.C. Craveiro, F.M. Marques, Holocene Paleoenvironmental Evolution of the Lisbon Downtown Area as Recorded in the Esteiro da Baixa Sediments – First Results, *Journal of Coastal Research*, SI 56 (Proceedings of the 10th International Coastal Symposium), Lisbon, 2008, pp. 574 - 578.
- [15] P. Teves-Costa, I. M. Almeida, I. Rodrigues, R. Matildes, C. Pinto, Geotechnical characterization and seismic response of shallow geological formations in downtown Lisbon. *Annals of Geophysics*, 57(4), 2014. <http://www.annalsofgeophysics.eu/index.php/annals/article/view/6390>
- [16] C. Sepúlveda, C. Aires, A. Magalhães, Manuel da Maia e os engenheiros militares portugueses no terremoto de 1755, Lisboa, Imprensa Nacional, 1910.
- [17] J.R. Mullin, The reconstruction of Lisbon following the earthquake of 1755: a study in despotic planning. University of Massachusetts–Amherst, ScholarWorks@UMass Amherst, 1992.
- [18] E. Poletti, G. Vasconcelos, P.B. Lourenço, Timber Frames as an earthquake resisting system in Portugal, in Correia, Lourenço e Varum (Eds.). *Seismic Retrofitting: learning from Vernacular Architecture*, Taylor & Francis Group, London, 2015.
- [19] L. Trindade, A.M.D. Diogo, Intervenção arqueológica de emergência na Rua dos Correios em Lisboa. *As Sondagens no's 2, 6, 7, 9 e 1, Orevista Portuguesa De Arqueologia*, Vol.7, No.2, 2004 pp.27-47
- [20] J. Bugalhão, A. Teixeira, The sewers of downtown Lisbon in the 16th century: an archaeological approach, *Cadernos do Arquivo Municipal*, ISSN 2183-3176. 2ª Série Nº 4 (julho - dezembro 2015), pp. 89-122
- [21] F.A.S. de Miranda, Caracterização dos Edifícios Pombalinos da Baixa de Lisboa, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, June 2011
- [22] D. Conde, M. Telhado, C. Antunes, R. Ferreira, A Tsunami in Lisbon-Assessment of Critical Areas. 3rd IAHR Europe Congress, Book of Proceedings, 2014, Porto, Portugal. https://www.researchgate.net/profile/Daniel_Conde/publication/272681653_A_Tsunami_In_Lisbon_-_Assessment_of_Critical_Areas/links/54ec8dbb0cf28f3e65343b78.pdf
- [23] J. F. Carvalho, J. Dias, C. Pinto, T. Cunha, J. Leote, S. Vilanova, J. Narciso Earthquake Mitigation in the Lisbon and Lower Tagus Valley area, Portugal. 13th International Congress of the Brazilian Geophysical Society held in Rio de Janeiro, Brazil, 2013, pp. 26-29. <https://dspace.uevora.pt/rdpc/handle/10174/9169>
- [24] C. Ramos, J.L. Zêzere, E. Reis, Avaliação da susceptibilidade aos perigos naturais da região de Lisboa e Vale do Tejo. *Perspetiva e Planeamento*, no. 17, 2010 pp.57-73.
- [25] Zêzere, J.L., Ramos, C e Reis, E Riscos e Protecção Civil – Diagnóstico Estratégico Final, CCDR-LVT, PROTAML, Lisboa, 2010.
- [26] P. Delany, *Lisbon Journal: A City's Heart in Ruins: Now to Put It Together*, New York Times, 1988.