

# The impact of the 1755 Lisbon Tsunami in Portugal: historical review

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**Abstract.** The original accounts reporting the 1755 Lisbon Tsunami were compiled, focusing on the descriptions related to damage and fatalities in Portugal. The accounts show that the most risk-prone areas are Peniche, the Lisbon Metropolitan Area and seven coastal areas in the south of Portugal (Lagos, Portimao, Armacao de Pera, Albufeira, Quarteira, Tavira and Castro Marim). The exact number of fatalities will probably never be known since 18<sup>th</sup> Century census were not as accurate as today, and did not consider children under seven years old. Nevertheless, the accounts show that Lisbon and Setubal suffered more due to the earthquake, fire and tsunami: about 10,000 dead (about 9%) and about 2,000 dead (about 17%), respectively. However, Castro Marim had the highest percentage of fatalities (about 55%), followed by Cascais (less than 29%), Lagos (17%) and Albufeira (more than 10%). The structural damaged on buildings in Lisbon were estimated at about 82%.

**Keywords.** 1755 Lisbon Tsunami, historical accounts, fatalities, damage

## 1 Introduction

On the November 1, 1755 an earthquake has occurred with epicenter offshore Portugal that triggered a tsunami. The disaster caused significant damage and many fatalities. Even on that time, there was the need to full understand the impact of the event. The most important original accounts were provided through a national inquiry [1] sent to all the civil parishes of Portugal. In addition, a field survey was conducted in Lisbon city [2] being the most reliable account because it was a first hand record, provided by a reliable person who surveyed the destroyed Lisbon streets. The 1758 Census also provide important data related to the disaster [3], however the data does not include the number of fatalities. The first compilation of the Portuguese original accounts was carried out focusing only on the southern district of Portugal [4]. Then, an author compiled all the original historical accounts in Portugal, including the 1758 Census and the Registered Dead [5], [6], [7], [8]. This work is the most complete compilation of this event because the author conducted a full transcription of all documents. However, due to the author's premature death, he could not finish his work and the accounts in the north part of Portugal have remained unknown.

More recently, a PhD Dissertation [9] was able to put together this event, being the first time that a complete comprehensive analysis of this historical tsunami has ever been conducted. The highlights of this work were published [10], by considering a re-interpretation of the tsunami parameters (initial response and travel times) reported by the witnesses, combined with tsunami numerical modeling and geological records found by other authors. In a study [11] the authors calculated the time of the earthquake as 10:15 - 10:16 (UTC) while another considered the duration of the earthquake [10] between 8 and 15 minutes. Still, much of the historical data have remained to be analyzed. Therefore, under the TsuRiMa Project

(<https://sites.google.com/a/campus.ul.pt/tsurima/>) which is active in the period 2012-2015, the historical accounts continue to be studied, being one of the Tasks of the Project. A more recent study focused on the interpretation on all the tsunami parameters in Portugal [12], considering the accounts on 21 places on the Portuguese coast. The major conclusions were: the initial tsunami response was uplift; the tsunami travel times vary between 16 minutes at Cape Saint Vincent and in less than an hour the tsunami reached all the Portuguese coastline; there were in general 3 major waves, although the tsunami was observed all day; and run-ups varying between 1.5 m in Oporto to more than 100 m at Sagres cliffs. However the account related to damage and fatalities have not been fully analyzed. Therefore, in this study these accounts will be translated to English discussed in order to understand the impact of the 1755 Lisbon Tsunami in Portugal.

## 2 Original accounts

The historical original accounts reporting damage and fatalities were translated into English. The locations of the 34 places describing the tsunami impact are presented in Figure 1.

1. Foz do Douro, Oporto: "This place did not suffer any ruin with the earthquake. This Civil Parish has 1334 adults, 186 minors, and 337 not present, giving a total of 1857 people" [3].

2. Mira: "In this civil parish there were no ruins because of the earthquake, and nobody died. (...) This Civil Parish has 2219 people" [1].

3. Figueira da Foz: "In this civil parish there were no ruins in the houses and buildings. Nobody died. (...) In this Civil Parish there are 900 people being about 500 of each sex." [1].

4. Lavos: "There were no ruins. (...) Nobody died. (...) In this Civil Parish there are 750 men older than 7 years old and 787 women older than 7 years old" [1].

5. Vieira: "There were no ruins. (...) Nobody died. (...) In this Civil Parish there are from 7 years old 622 people" [1], [8].

6. Peniche: "Peniche parished very little due to the earthquake and only 3 people died under the ruins. But the habitants saw the sea forming in an extremely high mountain, fearing being submerged on that square (that is almost an island) started to run through the salt marsh of land, where the sea reached many people, more than fifty people died" [2]. "There were parts of the rampart that the sea ruined till the foundation and there were ruins on the houses and vessels. (...) Number of people: 914 in S. Pedro Civil Parish, 2680 in S. Sebastiao Civil Parish, 990 adults and 89 minors in Ajuda Civil Parish [3]

7. A-dos-Cunhados: "Nobody died. (...) This Civil parish has 575 people" [7], [13]. "The Penafirme convent became uninhabitable. (...) There are 650 people [3], [7].

8. Ericeira: "the sea was so high that when it retired it moved some boats that were on the sidewalk"; "some boats were carried away from the beach. (...) Adults 1108, minors 147" [7].

9. Cascais: "(...) the sea getting out of its bed, throw the boats from the bay (...). More than 300 people perished in this cataclysm"; "(...) the sea entered through the town (...) and caused severe damage through the streets where it passed, and on the riverside smashed all the fishery vessels and boats there were more than 50"; "(...) many people perished overwhelmed under the ruins made by the earthquake, others drowned in the sea and others that were not found yet (...); " Number of people: 1709 in Nossa Senhora da Assunção Civil Parish, 883 in Ressuição de Cristo Civil Parish" [7]. "The sea destroyed the bridge, (...) on that day those who died and were identified were 514. However, there are many missing under the ruins. (...) There are many injured, some say 110, others 150. (...) This town has 2,484 – 2,505 adults" [14]

10. Carnaxide Civil Parish: "(...) in this Civil Parish there were no dead, and only one man, was washed away by the sea, disappeared. (...) The sea dragged the stones of the Cruz Quebrada bridge. (...) This civil parish has 1944 adults [7]

11. Bugio light house: "people and debris dragged away" [15]

12. Lisbon: "I asked the neighbors (...) and priests who was missing (...). I think that on the day of the earthquake, among those who parishes under the ruins, on the sea and due to the fire, there were about 5,000 people dead. Due to injuries another 5,000 more people died during the month of November" [2].

13. Benavente: "Nobody died (...) This Civil Parish has 1156 men, 1052 women (...)" [1], [6]

14. Seixal: "Many people died not only under the buildings but also drowned in the sea. (...) Seixal has 1,018 adults [7].

15. Almada: "Many people died not only under the buildings but also drowned in the sea. S. Tiago civil parish: there were 26 people on the registered dead, (...) 2,718 adults" [7].

16. Costa da Caparica: "By the registered deaths 19 people died, among them 5 drowned on the Costa"[7].

17. Sesimbra: "Considerable destruction to the vessels. (...) This civil Parish has 1534 people" [7]

18. Setúbal: "For sure more than 2,000 people died. The sea entered the town with such a fury that overthrow the thick and old wall, and many buildings. (...) many people died under the ruins of the buildings and drowned on the waves, there were also fires that caused big loss. (...) Anunciada Civil Parish has 3,223 adults and 283 minors. (...) Santa Maria da Graça Civil Parish, in 1754 there were 428 people, and after the earthquake, in 1755 there were 288. In 1758 the number of people between adults and minors were 718. (...) S. Julião Civil Parish: on the registered deaths, five people died washed away by the sea. This civil parish has 3,160 people. S. Sebastião Civil Parish: on the registered deaths, one person was washed away by the sea. This civil parish has 4,458 people." [7]

19. Mil Fontes: "Some houses that were near the beaches of the river, with the inundation were totally washed away by the waters and only there was sign where they were built up. It was not, however, considerable loss and they were only three basement houses. (...) This civil parish has 364 people" [5].

20. Odemira: "The river, although it rose and altered a little bit did not cause any trouble. (...) The town has 1,140 people" [5].

21. Odeceixe: "On the earthquake the river grew up with such an impetus (...) inundating all the fields, leaving many fish of different qualities" [4]. "This civil parish has 320 people" [5].

22. Aljezur: "Nobody died. (...) The sea (...) razed the fortress leaving only the batteries" [4]. "The town has 1,044 people" [5].

23. Sagres: "(...) Nobody died. (...) Inside the square (of Sagres Fortress) there were 181 people. The sea (...) deposited many fish and big stones on the square. (...) (the sea) entered through a beach called Martinhal (...) tearing off the vineyards and leaving the land like a beach with several fishes, many big stones" [4]. "This civil parish has 170 adults and 28 minors" [5].

24. Budens: "The sea (...) carried inland 50 of the heaviest anchors" [4]. "This civil parish has 344 people" [5].

25. Lagos: "In my Civil Parish (São Sebastião) 95 people died under the ruins and washed away by the sea, by the list of confess, and from the Santa Maria Church 100 and many more died, not counting the outsiders that were in the city because it was a Holy Day and it can be judged the total being more than 300. (...) The damage made by the sea was to overthrow the rampart (...) and with violence that pieces of the rampart, with the size of buildings, moved through the city, destroying many houses, carrying away everything that was on the way, with boats and everything (...) and razed completely the São Roque chapel" [5]. "(...) more than 200 people died, and many more were injured, dying later as a consequence of injuries." [4], [5]. "Santa Maria civil parish has 1327 adults and 209 minores. S. Sebastiao civil parsh has 277 people" [5].

26. Alvor: "The sea (...) washed away the N. Senhora da Ajuda Chapel, that was at the beach, near the sandbar, and did not leave any trace of it, not even the foundations" [4]. "This civil parish has 757 adults and 135 minors" [5].

27. Portimao: "The quick inundation of the water (...) devastated the salt marshes of the town (...), houses, ruining all the market gardens (...) entering the water in the Misericórdia Church (...) destroying [...] 3 water-mills" [5]. "(...) on the backwash razed de São João Fortress and the Capuchos Convent at the margin of the river (...)" [4]. "On the registered dead, 38 people drowned, 15 adults and 19 minors, and 4 people are missing, washed away by the sea or buried under the ruins. (...) The town has 1,802 people" [5].

28. Ferragudo: "[...] the sea entered the houses and razed the 3rd part of them [...] there were no dead [4]. "This civil parish has 566 people" [5].

29. Armação de Pera: "The fortress was ruined with the sea, and with its impetus carried away the Santo António church leaving only a few stones; also collected 60 people, and then launched them dead" [5]. "The sea left just one house standing, (...) inundating everything (...) and drowning 84 people." [4], [5]. "This civil parish has 1,042 people" [5].

30. Albufeira: "The sea got out of its course and entered the suburbs of the town and washed away the Santa Ana neighborhood (...) left no signs where the houses were built, with the loss of many lives, broke apart three towers on the west and south of the rampart, parts of three towers to the north and many parts of the rampart, and the castle, and all the houses that were inside it. (...) It washed away the foundations of all the houses, except 27 that were very ruined. (...) Everyone that was in the church, when it collapsed, ran away to the street and there 227 people died. (...) The town has 2,189 people" [5].

31. Quarteira: “124 people died; 28 at the Quarteira beach, drowned by the sea and 96 inside the church. (...) the sea entered (...) and killed 52 people. (...) This civil parish has 1,641 adults and 200 minors”[5].

32. Faro: “The sea got out of its limits just a little bit (...). The city has 6951 people” [5].

33. Tavira: “The biggest destruction was near the sea, there were 250 dead. S. Tiago Civil parish has 1,907 adults and 327 minors; Santa Maria civil parish has 4,260 people”[5].

34. Castro Marim: “In Castro Marim everything was razed; (...) the entrance of the sea made notable damage; (...) more than 180 people died. This civil parish has 291 adults and 35 minors” [5].

Porto Santo, Madeira: “The sea (...) got out of its limits, [...] came to the land by the space of Ilheu de Cima, introducing its waters through the brook of the town [...]and it seems that only one house was overthrown by the sea” [5].

Funchal, Madeira: “(...) It arose full fifteen feet perpendicular above high water mark, although the tide, which ebbs and flows here seven feet, was then at half ebb. The water immediately receded again, and, after having fluctuated four or five times between high water and low water mark, the undulations continually decreasing (not unlike the vibrations of a pendulum) it subsided, and the sea remained calm as before this phenomenon had appeared” [16]. “At Funchal the sea rose 5 meters above high tide and on the north of the island (...) the sea retreated about 100 m, leaving on dry land a large quantity of fish.” [5]

Angra do Heroismo, Azores: “The sea made some refluxes so violent that in Terceira many ships were in danger of wreck. (...) suddenly at about ten hours in the morning, in three continuous waves, that were elevated to more than three meter above mean [sea] level, demolishing many houses, following an ebb so extraordinary that at Angra some anchors of the vessels were uncovered, and the ships almost touch the keel at the bottom of the sea.” [5]

### 3 Interpretation of the historical accounts

The original accounts in Portugal are very complete, showing the tsunami hit the entire Portuguese coastline, not only in the mainland but also in the Madeira and Azores Islands (Figure 1). Table 1 summarizes the damages and fatalities in the country. Furthermore, the 1758 Census allows to calculate an approximate percentage of fatalities (Table 1 and Figure 2). Still, the data is not very accurate because the 18<sup>th</sup> Century Census does not include children under seven years old.

The accounts show the most complete assessment was carried out in Lisbon [7], where an effort was conducted to estimate the damages on the houses as well as fatalities, by classifying the data of the civil parishes between burned, ruined and no damage (Table 2). Even the houses that did not suffer any damage due to earthquake and fire had to be demolished because of the city’s reconstruction plan. In spite of the efforts, the 18<sup>th</sup> century census were not as accurate as today, as therefore some discrepancies were found: an author [7] compiled several historical records of the city showing the total population before the earthquake was 157,192, overestimating the data presented in Table 1 for 47,438 people. The author noticed the difference, and commented about the discrepancy. On the other hand, the difference in the population data before and after the earthquake varies between 58,946 and 106,384. These discrepancies have led to a debate among scholars pointing out the unknown fatalities in Lisbon. However the same author [7] pointed out the field survey conducted immediately after the earthquake [2] that showed the number of fatalities in Lisbon due to the earthquake, fire and tsunami were about 5,000 on the day of the earthquake, and about 5,000 more during the month of November due to injuries and winter harsh conditions. The significant decrease in the number of Lisbon’s population after the earthquake (Table 1) is because most left the city to the suburbs, and not because they have died. Therefore, the fatalities in Lisbon considered in this study area about 10,000. The damaged houses in Lisbon were estimated at about 82%.

The analysis of the accounts also shows that the north part of the country, from Oporto (1) to Vieira (6), did not suffer any damages or fatalities. By contrast, the most risk prone areas, where damage and fatalities were reported, are Peniche, the Lisbon Metropolitan Area and seven coastal areas in the south of the country (Lagos, Portimao, Armacao de Pera, Albufeira, Quarteira, Tavira and Castro Marim). Nevertheless, the accounts show that Lisbon and Setubal suffered more due to the earthquake, fire and tsunami: about 10,000 people died (about 9%) and about 2,000 people died (about 17%), respectively. However, Castro Marim had the highest percentage of fatalities (about 55%), followed by Cascais (less than 29%), Lagos (17%) and Albufeira (more than 10%). The damaged houses in Lisbon were estimated at about 82%.

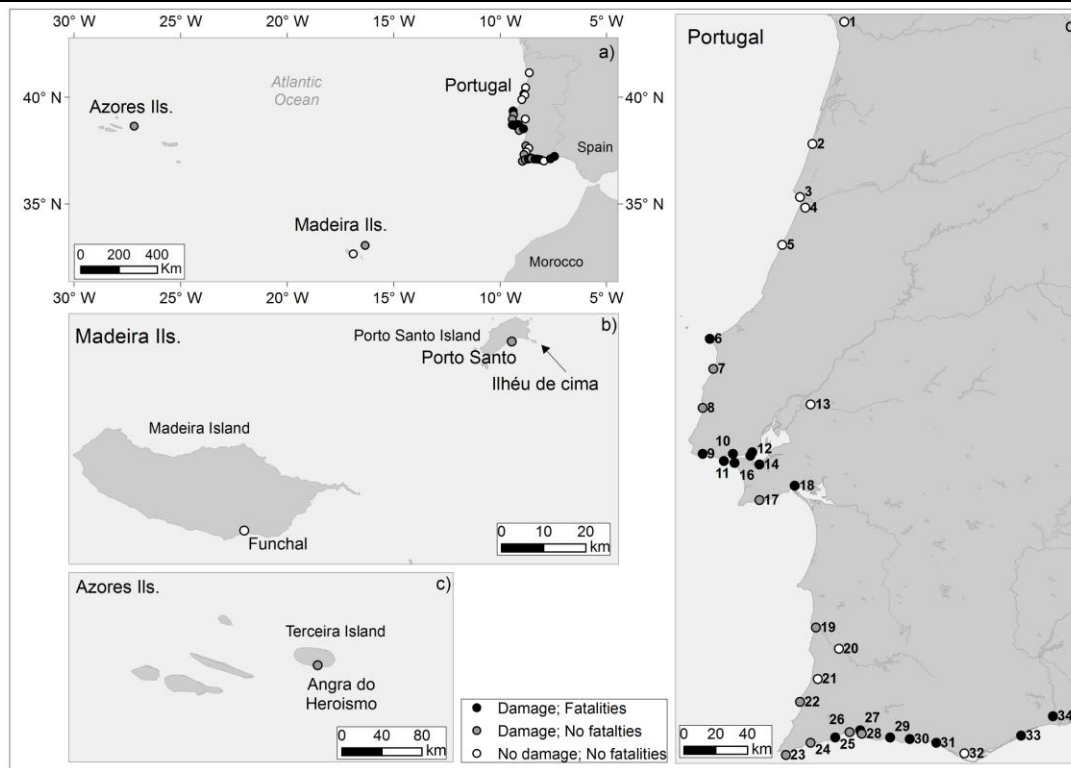


Figure 1: Summary of the tsunami effects reported by the eyewitnesses: a) Framework; b) Madeira Islands, c) Azores Islands; d) Portugal mainland

Table 1: Summary of damage, fatalities and population data. (u-unknown; 1- Damage/fatalities due to earthquake and tsunami; 2- Damage/fatalities due to earthquake, fire and tsunami; 3-includes fatalities during the month of November).

Place	Damage	Fatalities		Population data (older than 7 years old)		
		Number	%	1755	1756	1758
1. Opo.	---	0	0	---	---	1857
2. Mir.	---	0	0	---	2219	---
3. Fig.	---	0	0	---	900	---
4. Lav	---	0	0	---	1,537	---
5. Vie.	---	0	0	---	622	---
6. Pen.	Destroyed the rampart, houses and vessels	> 50	> 1.1	---	---	4,673
7. Cun.	Destroyed the Penafirme convent	0	0	---	575	650
8. Eri.	Boats were washed away	0	0	---	---	1,255
9. Cas.	More than 50 fishery vessels and boats were destroyed. Almost all buildings collapsed (1)	> 624-664 (1)	> 24.9-26.7	---	2484-2505	2,592
10. Car.	Destruction of Cruz Quebrada bridge	1	0.05	---	---	1,944

Table 1: Summary of damage, fatalities and population data. (u-unknown; 1- Damage/fatalities due to earthquake and tsunami; 2- Damage/fatalities due to earthquake, fire and tsunami; 3-includes fatalities during the month of November) (cont).

Place	Damage	Fatalities		Population data (older than 7 years old)		
		Number	%	1755	1756	1758
11. Bug.	Debris washed away	People dragged away	u	---	---	---
12. Lisb.	Destruction of many buildings (2)	10,000 (2,3)	6.4 – 9.1	109,754 – 157,192	50,808	156,254
13. Ben.	---	0	0	---	2,208	---
14. Seix.	---	Many (1)	u	---	---	1,018
15. Alma.	---	> 26 (1)	> 1.0	---	---	3,867
16. Capa.	---	5	0.3	---	---	1,484
17. Sesi.	Destroyed the vessels	0	0	---	---	1,534
18. Setu.	Destruction of the rampart, many vessels and buildings (2)	> 2,000 (2)	> 16.9	---	---	11,842
19. MFon.	Destroyed 3 beach houses	0	0	---	---	364
20. Odem.	---	0	0	---	---	1,140
21. Odec.	---	0	0	---	---	320
22. Alj.	Destroyed the fortress	0	0	---	---	1,044
23. SAGR.	Destroyed the vineyards	0	0	---	---	198
24. Bud.	Destroyed the Almadena fishing net, with 50 heavy anchors	0	0	---	---	344
25. Lag.	Destruction of the rampart, many vessels and buildings (2)	> 300 (1,3)	> 17.4	---	---	1,723
26. Alv.	Razed the chapel	0	0	---	---	892
27. Por.	Destroyed the salt marshes, market gardens, houses, and 3 water-mills. On the backwash razed de São João Fortress and the Capuchos Convent	38	2.1	---	---	1,802
28. Fer.	Destroyed 1/3 of houses	0	0	---	---	566
29. APera	Destroyed the fortress and many houses	60 - 84	5.8 - 8.1	---	---	1,042
30. Alb.	Destroyed a neighborhood and the rampart	> 227	> 10.4	---	---	2,189
31. Quar.	---	28 - 52	1.5 – 2.8	---	---	1,841
32. Faro	---	0	0	---	---	6,951
33. Tav.	Significant damage (1)	250 (1)	2.6	---	---	9,494
34. CM.	Everything was razed (1)	> 180 (1)	> 55.2	---	---	326
P. Santo	Inundated the town, and only one house was overthrown by the sea	0	0	---	---	---
Funchal	On the north of the island the sea retreated leaving on dry land a large quantity of fish	0	0	---	---	---
A. Hero.	demolishing many houses	0	0	---	---	---

Table 2: Population and houses data in Lisbon, before and after the earthquake [7].

Civil Parishes affected by the disaster	Population data (older than 7 years old)		Houses	
	Before	After	Before	After
Burned	61,978	18,961	14,779	2,022
Ruined	21,671	16,492	10,012	3,946
No damage	26,105	15,355	8,544	6,063
Total	109,754	50,808	33,335	12,031

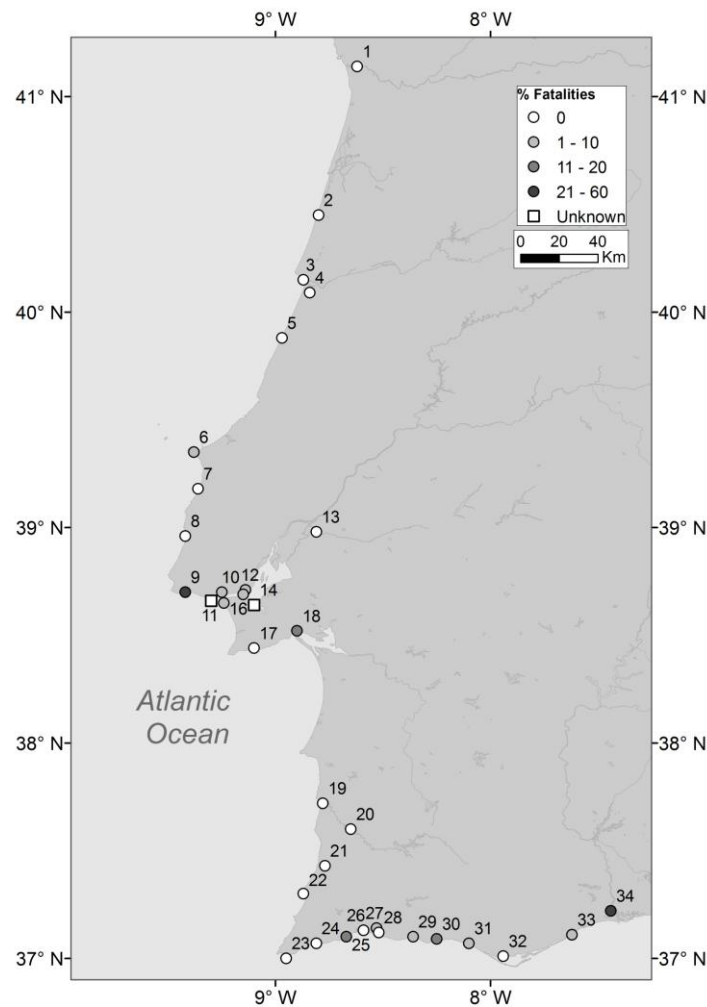


Figure 2: Percentage of fatalities in Portugal due to the 1755 Lisbon Tsunami

## 4 Discussion

The original historic accounts reporting damage and fatalities in Portugal due to 1755 Lisbon Tsunami were complied. The historical accounts show that places where damage and fatalities were reported are the most tsunami risk-prone coastal areas. These are Peniche, the Lisbon Metropolitan Area and 7 coastal areas in the south of Portugal (Lagos, Portimao, Armacao de Pera, Albufeira, Quarteira, Tavira and Castro Marim). The exact number of affected people will probably never be known since 18<sup>th</sup> Century census were not as accurate as today, and did not consider children under 7 years old. Nevertheless, the accounts show that Lisbon and



Setubal suffered more due to the earthquake, fire and tsunami: about 10,000 people died (about 9%) and about 2,000 people died (about 17%), respectively. However, Castro Marim had the highest percentage of fatalities (about 55%), followed by Cascais (less than 29%), Lagos (17%) and Albufeira (more than 10%). The damaged houses in Lisbon were estimated at about 82%.

These results are important for spatial planning agents and stakeholders in order to mitigate future tsunamis because it is possible to point out which coastal areas are at risk, particularly the low topography areas. Furthermore, the Portuguese coastal areas have been suffering significant development since the 18<sup>th</sup> Century such as the construction of marinas and ports, as well as the increase of coastal populations. On January 5-7, 2014 a winter storm was classified as a meteotsunami [17], [18], causing more than 16 million in damages in Portugal. Although nobody died, there were more than six people injured and about 20 needed assistance because they were too close to the shoreline, to watch the waves, mainly to take photos and videos. These facts increase even more the Portuguese coastline to a future tsunami.

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