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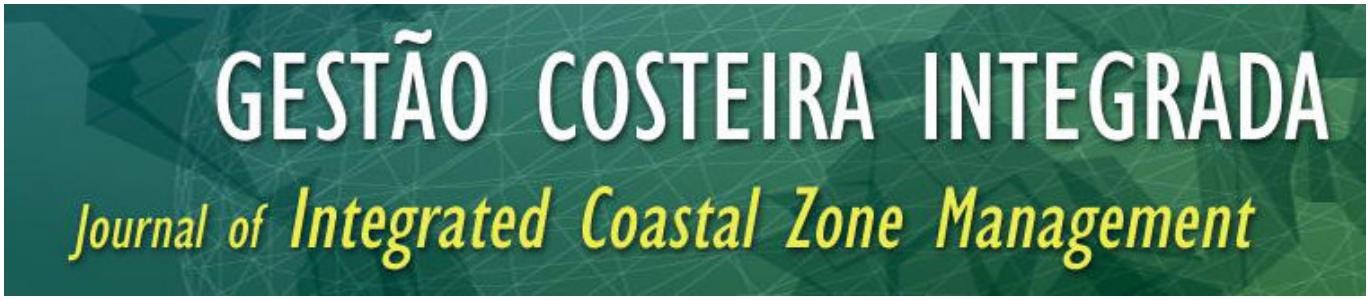

Beliefs on the local effects of climate change: Causal attribution of flooding and shoreline retreat

Perceção e crenças sobre os efeitos locais das alterações climáticas: Atribuição causal de inundações e recuo de linha de costa

Silvia Luís[@, 1], Fabiana E.P. Freitas[2], Nuno Rodrigues[2], António J.A. Nogueira[2], Catarina Roseta-Palma[3], Maria Luísa Lima[4], Luísa Pinho[2], Filomena Cardoso Martins[5], António Betâmio de Almeida[6], Góneri Le Cozannet[7], Vincent Jolivet[8], Ana I. Lillebø[2]

[@] Autor correspondente: silvia_luis@iscte.pt
[1] ISCTE - Instituto Universitário de Lisboa
[2] Universidade de Aveiro (UAVR), Departamento de Biologia & Centro de Estudos do Ambiente e do Mar
[3] Instituto Universitário de Lisboa (ISCTE-IUL), Business Research Unit
[4] Instituto Universitário de Lisboa (ISCTE-IUL), Centro de Investigação e de Intervenção em Psicologia Social
[5] Universidade de Aveiro (UAVR), Departamento de Ambiente e Ordenamento & Centro de Estudos do Ambiente e do Mar
[6] Universidade de Lisboa (ULISBOA), Instituto Superior Técnico, Lisboa, Portugal
[7] Bureau de Recherches Géologiques et Minières (BRGM)
[8] ACTeon – Environment, Research & Consultancy

ABSTRACT: Adaptation to climate change is a process that should engage different participants, including not only researchers and technicians but also other stakeholders and local individuals and, therefore, it is important to understand their beliefs on the local effects of climate change. Recent studies illustrate a linear relation between coastal distance and scepticism, which is lower in coastal zones than in inland. A possible explanation is that people living inland do not experience (or do not perceive) particular natural hazards as being caused by climate change, or attribute the natural hazards to other causes, apart from climate change. This might influence the relative importance of dealing with direct anthropogenic effects and planning adaptation to climate change. Therefore, the goal of this work was to explore this effect by comparing beliefs on the local effects of climate change in Aveiro region (Portugal), specifically in Baixo Vouga Lagunar (BVL, located in the inner side of Ria de Aveiro Coastal Lagoon, 10 km distance from the coast) with the nearby coastal zone between Esmoriz and Vagueira settlements. Stakeholders were interviewed and local individuals were surveyed in order to explore causal attributions towards relevant local

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environmental problems and compare with data available from the coastal zone. Natural hazards concerned flooding in BVL and shoreline retreat in the coastal zone. Results suggest that in BVL both stakeholders and local residents did not attribute local natural hazards to climate change. However, in the coastal zone, local natural hazards were indeed mostly attributed to climate change. This attribution to climate change was further correlated to a higher risk perception of natural hazards in the coastal zone but not in BVL. Thereby, it is important to consider distance from the shoreline in order to promote local processes of adaptation to climate change.

Keywords: causal attribution, risk perception, local individuals, stakeholders, Aveiro Lagoon, anthropogenic activities.

RESUMO: A adaptação às alterações climáticas é um processo que deverá envolver vários atores, incluindo não só académicos e técnicos, mas também atores-chave e residentes, importando compreender as suas perceções quanto às alterações climáticas. Estudos recentes mostram que existe uma relação linear entre a distância a que as pessoas vivem da costa e o quanto acreditam nas alterações climáticas, sendo o ceticismo menor nas zonas costeiras do que no interior. Uma das razões poderá ser o facto de as pessoas que vivem afastadas da costa não estarem expostas diretamente (ou explicitamente) a determinados problemas ambientais como resultado das alterações climáticas, ou atribuam os problemas ambientais a outras causas que não as alterações climáticas. As diferenças na perceção dos indivíduos quanto às causas dos perigos ambientais naturais podem traduzir-se no estabelecimento de diferentes prioridades para lidar com os efeitos diretos de impactes antropogénicos, bem como condicionar a motivação para a adaptação às alterações climáticas. O estudo pretendeu explorar este efeito da dimensão espacial comparando crenças ambientais na região de Aveiro (Portugal), especificamente no Baixo Vouga Lagunar (BVL, localizado na margem interior do sistema lagunar, Ria de Aveiro, a 10 km da costa), com a zona costeira próxima entre as povoações de Esmoriz e Vagueira. Consistiu na realização de entrevistas a atores-chave e de questionários a residentes, com vista a explorar as atribuições causais dos principais perigos ambientais naturais no BVL, comparando com dados de investigação disponíveis da zona costeira. Focou-se em inundações no BVL, e no recuo da linha de costa, na zona costeira. Os resultados sugerem que tanto os atores-chave como os residentes não tendem a considerar as alterações climáticas como causa dos perigos ambientais no BVL. Contudo, junto à costa, os perigos ambientais são maioritariamente atribuídos às alterações climáticas. A atribuição às alterações climáticas está ainda associada a uma maior perceção de risco dos perigos ambientais no caso da zona costeira, mas não do BVL. Assim, importará considerar a distância à linha de costa para facilitar os processos locais de adaptação às alterações climáticas.

Palavras-chave: atribuição causal, perceção de risco, residentes, atores-chave, Ria de Aveiro, atividades antropogénicas.

1. INTRODUCTION

Climate change is now recognized as a significant problem, validated by the Intergovernmental Panel on Climate Change (IPCC). Climate trends have undergone changes in the long term, and these are expected to continue or increase (IPCC, 2013). Coastal and estuarine zones are particularly sensitive, because they are exposed to extreme natural events and are subjected to pressures from human activities (Kennish, 2002; Lotze et al., 2006; IPCC, 2014). It is expected that changes in climatic parameters will influence the risks associated with weather, with an impact on society and the environment. For the Mediterranean climate region, which includes most of the Portuguese territory, the expected impacts are droughts, an increase in heat waves (in terms of duration and intensity), scarcity of fresh water, and sea level rise (IPCC, 2013; ADAPT-MED, 2015). Other expected impacts in coastal areas correspond to the effects associated with extreme weather events, such as the increased frequency of intense precipitation events, and consequently the increased frequency and intensity of river flooding, severe storms, coastal erosion (shoreline retreat), and the expansion of saline intrusion in estuaries and adjacent land, with a subsequent loss of habitat (IPCC, 2014).

Adaptation to climate change is a process that should engage different types of participants, including not only researchers and technicians, but also stakeholders and residents. This need has been highlighted in recent years, with the objective of improving the quality of decision-making, promoting greater acceptance of policies and a better understanding of natural hazards, and ensuring the democratic legitimacy of decision-making, not just as mere bureaucratic burden (e.g., Lee et al., 2013). It might also be significant in order to promote protective behaviours and diminish individuals' specific vulnerabilities to climate change (see Garai, 2016).

It is therefore important to understand the different environmental perceptions that these key players have on climate change. Environmental perceptions, such as risk perception, result of how individuals receive and process information from the everyday world and are embedded in a sociocultural and historical web (see Gifford, 2007).

Furthermore, there is evidence that scepticism about climate change tends to increase with distance from the coast, possibly because the better-known effects of climate change, such as shoreline retreat, are not experienced first-hand by inland population (Milfont et al., 2014). Climate change beliefs appear to be closely related to individuals' personal experiences (Whitmarsh, 2008). As research typically takes place in coastal zones (for instance, regarding this study area: Pinho, 2012; Schmidt et al., 2014; Luís et al., 2016), it is important to also investigate adjacent areas that are exposed to climate change. Thus, this study compares whether natural hazards are equally attributed to climate change in a coastal area facing the Atlantic Ocean and in a nearby area facing the inner area of a coastal lagoon.

1.1 Case studies

The coastal zone of Aveiro is vulnerable to the impacts of sea level rise. Recent studies have shown a mean rise of 1.15 (+/- 0.68) mm per year, between 1976 and 2003 (Lopes et al., 2011). The case studies, presented below and described in more detail in supporting information (SI-I_Case study description), correspond to Baixo Vouga Lagunar (BVL), the inland zone where the Ria de Aveiro lagoon joins the Vouga River, at a 10 km distance from the coast (ADAPT-MED, 2015), and to the coastal zone between Esmoriz and Vagueira settlements (Pinho, 2012) (Figure 1). These two areas where chosen for

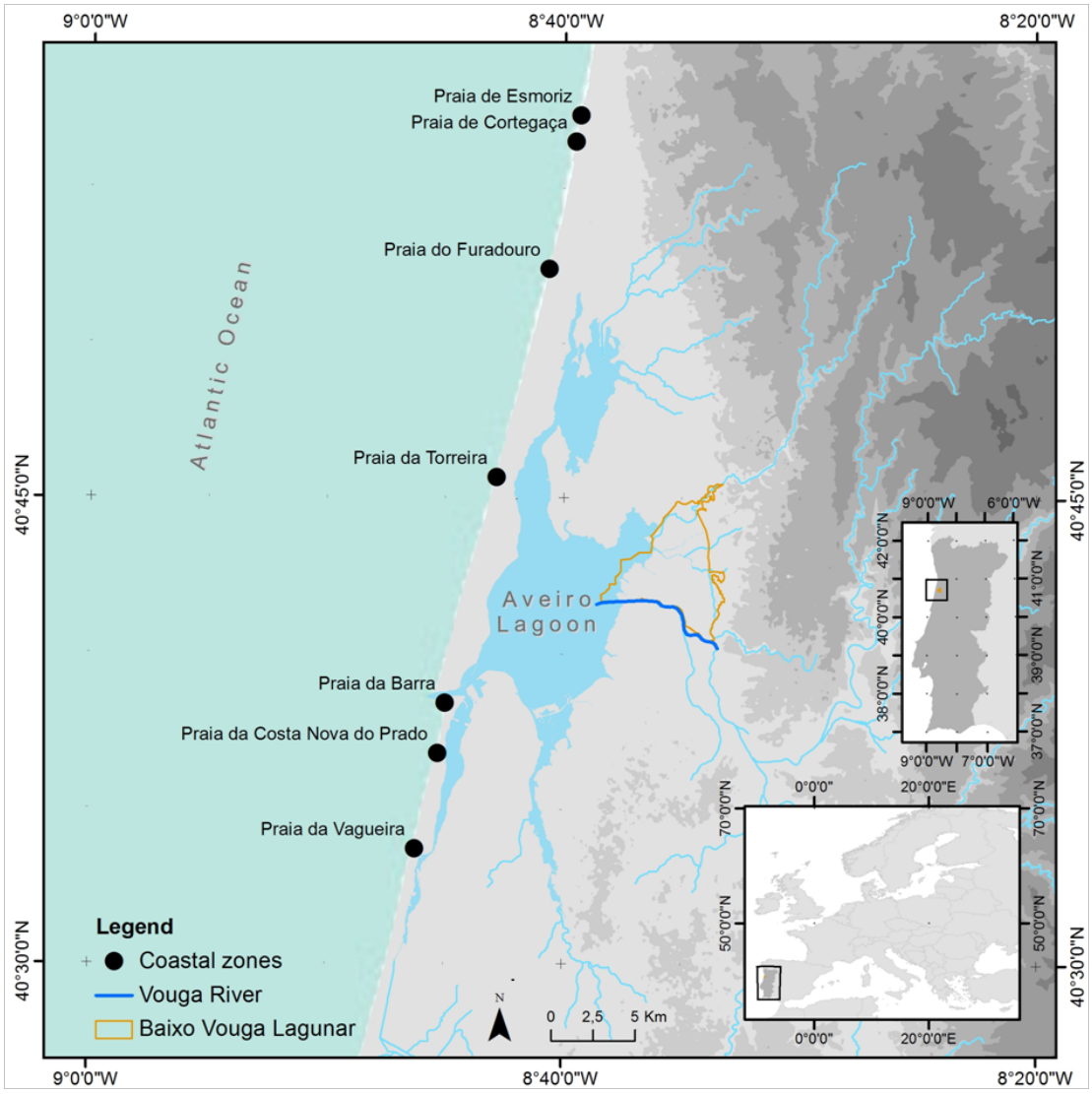

Figure 1 – Study area locations. BVL: inland study area at the coastal lagoon shore at 10 km from the shoreline (BVL - orange limit polygon). Coastal zone: coastal study area represented by settlements located at the shoreline (coastal settlements - black dots).

comparison because populations experiences the same local climatic change, namely, changes in air temperature and precipitation patterns and sea level rise will affect both areas. However, local populations may have distinct perceptions regarding the impacts of climate change, as they experience different natural hazards (e.g. shoreline retreat and floods), and may also experience other present causes that might be overlapping with the climate change impacts, making those less perceptive.

1.1.1 Baixo Vouga Lagunar

BVL is located in the centre of Portugal (40º 43' N, 8º 36' W), comprising the municipalities of Aveiro, Estarreja, and Albergaria-a-Velha, with an area of 3000 ha. BVL is a part of Ria de Aveiro Coastal Lagoon, which is classified as a Special Protected Area, under the Natura 2000 network. It has unique characteristics regarding the landscape units that form the territory ('bocage'- small-holdings with living edges, open fields and wetlands), which result from a strong relation between local individuals, the territory, and water. Human activities, in particular agriculture, have shaped its landscape to make crops and economic sustainability viable. The confluence of the Vouga River with the Ria de Aveiro lagoon takes place in the southeast part of BVL where the equilibrium between the influences of fresh water (of fluvial origin) and brackish water (from the lagoon) is in constant demand. The wetlands areas in BVL include shallow-depth water courses that are influenced by tides (transitional waters from the lagoon), and other fresh water courses (ditches) (ADAPT-MED, 2015), meaning that there is a connectivity between the aquatic habitats from freshwater wetlands to marine/coastal wetlands. This connectivity is particularly relevant during flood events, due to extreme precipitation, as well as during Ocean storm events, due to surface saltwater intrusion. Sea level rise also contributes to surface saltwater intrusion, however direct anthropogenic driven changes in the system hydrology and tidal prism are already causing surface saltwater intrusion, namely in the inner areas of the lagoon. A more detailed description of the BVL in the environmental, socio-economic and climate change context is included as Supporting Information (SI –I_Case study description).

1.1.2 Coastal zone

The nearby coastal zone is in Esmoriz, Cortegaça, Furadouro, Torreira, Barra, Costa Nova do Prado, and Vagueira beaches, in the municipalities of Ovar, Murtosa, Ílhavo, and Vagos. This zone is characterized by a dune system that borders the wetlands of Esmoriz and Ria de Aveiro lagoon. It is an area with a significant presence of natural and forest areas, where the effects of erosion and dune degradation can generally be observed. Dune degradation has been mostly caused by the occupation and urbanization of public domain land (Pinho, 2012).

In this zone, Esmoriz, Cortegaça, Furadouro, and Costa Nova are the most critical situations in terms of coastal risks: densely built areas have led to the implementation of massive coastal defence structures. The erosion is very high, and involves the loss of territory: shoreline retreat has reached in some locations a rate of 12 m per year (CEHIDRO, 2010, cited in Pinho, 2012). It should also be noted that, also in this case, there are causes other than climate change that enhance shoreline retreat. Indeed, even for the worst sea level rise scenarios, shoreline retreat would constitute at most about 10% of the retreat that was actually identified (Silva et al., 2007, cited in Pinho, 2012). A more detailed description of the Coastal zone between Esmoriz and Vagueira settlements, in the environmental, socio-economic and climate change context is included as Supporting Information (SI – Case study description).

1.2 Objective

This study aims to explore whether there are differences in the causal attribution of natural hazards to climate change considering BVL, located 10 km from the coastline, and the coastal zone between Esmoriz and Vagueira settlements. To achieve this goal, stakeholders were interviewed and local individuals answered to a questionnaire. This allowed analysing the perceptions of these two types of key players who might play different roles in the process of adaptation to climate change. Furthermore, because there was data of coastal populations available from Pinho (2012), the BVL questionnaire results were further compared with those of coastal populations. We focused on the most relevant natural hazards: flooding and salt water intrusion in BVL, and shoreline retreat in the coastal zone. Our working hypotheses were that a) stakeholders and residents would not frequently attribute the causes of natural hazards in BVL to climate change, and that b) individuals in BVL would be relatively less prone to attribute natural hazards to climate change, when compared to those in the coastal zone.

2 METHOD

2.1 Baixo Vouga Lagunar Zone

2.1.1 Interview to stakeholders

Twenty-one entities were successfully contacted from the list of parishes, municipalities, public authorities

for water, territory and agriculture, non-governmental entities and private companies that had stakes at the BVL. Following these contacts, 16 local and regional stakeholders provided their informed consent and agreed to be interviewed in 2014. In Table 1, there is a description of the type of stakeholder being interviewed (policy-maker, administration, end-user; either local or regional). Most stakeholders were local and worked in administration. The majority were males (87.5%).

The interview was semi-structured and focused on the effects of climate change in BVL, among other issues. Interviews were held face to face, transcribed, sent to the stakeholders for content validation, and corrected when pointed out. The interview guideline is available as supporting information (SI – II_Interview and questionnaires).

Table 1 – Type of stakeholders interviewed.

Type	Zone	
	Local	Regional
Policy-maker	2	2
Administration	5	2
End-user	2	3

2.1.2 Survey by questionnaire to local individuals

A convenience sample of 37 students from the University of Aveiro, residing in municipalities that comprise the BVL, gave their informed consent to answer the questionnaire, and were paid EUR 5 for their participation. The study was advertised at classrooms and using flyers and posters. The questionnaire was completed online during 2015. Most participants were female (75.70%), with a mean age 21.08 years (*SD* = 2.61), and resided in the parish of Glória-Vera Cruz (43.24%). The questionnaire was adapted from Pinho (2012), so that we could compare between the perceptions in BVL and those in the coastal zone using the same methodology. Participants were asked about their risk perception of extensive flooding, in particular its probability of occurrence, using a response scale that ranged between *impossible*, *1*, and *most likely*, *4*, and were also inquired about the past evolution of extensive flooding in BVL, using a 5-point response scale that ranged from *has decreased a lot*, *1*, to *has increased greatly*, *5*. They were also asked to choose three causes to explain this evolution, based on the results of the interviews with stakeholders and on prior work by Pinho (2012). The questionnaire is available as supporting information (SI –II_Interview and questionnaires).

2.2 Coastal zone

2.2.1 Survey by questionnaire to local individuals

We extracted a sample from Pinho's database (2012) of medium and high education individuals, among age groups that ranged between 15-24 and 25-34 years old. This was done in order to control the possible differences in the causal attribution of natural hazards to climate change due to the level of education and age. It was not of interest to have representative samples but to compare differences among relatively similar samples. It resulted in a sample of 30 participants that lived in areas with high risk of shoreline retreat, mostly female (66.70%), aged between 25-34 years old (90%), and residing mostly in Furadouro (43.30%).

Participants were asked about their risk perception of shoreline retreat, in particular its probability of occurrence, using a response scale that ranged between *impossible*, *1*, and *most likely*, *4*, and were also inquired about the past evolution of the shoreline, using a 5-point response scale that ranged from *marked advance of the shoreline*, *1*, to *sharp retreat of the shoreline*, *5*. They were also asked to choose three causes to explain this evolution. Response options were based on previous work and on contact with the local population (Pinho, 2012). The questionnaire is available as supporting information (SI – II_Interview and questionnaires).

3 RESULTS

3.1 Baixo Vouga Lagunar Zone

3.1.1 Interview to stakeholders

Our hypothesis was that stakeholders would not frequently attribute the causes of natural hazards in BVL to climate change. As expected, when asked about the effects of climate change on BVL, most stakeholders attributed natural hazards to other causes (56.25%). Figure 2 presents the causes related to problems associated with flooding (and the associated surface salt water intrusion). Seven causes are indicated, namely, as pointed out by most of the interviewed stakeholders, the dredging works carried out in the navigation canals by the Port of Aveiro, as well as changes in tidal dynamics and inadequate agricultural/environmental practices. Detailed information about the dredging activities can be found in Rosa et al., 2011.

3.1.2 Survey by questionnaire to residents

We expected that also residents would not frequently attribute the causes of natural hazards in BVL to

climate change. Figure 3 illustrates the percentages of respondents who pointed out the different causes that had been considered. As expected, climate change was chosen merely 8.91% of the times. The causes that were chosen the most were storms, sea level rise, and erosion. Note that the choice "sea level rise" does not indicate an assignment of this rise as being perceived as linked to climate change among the respondents, as the choice "climate change" itself was available.

The questionnaire results further showed that residents considered that the probability of an extensive flood in the BVL was relatively high (*Mean* = 3.11, *Standard deviation* = 0.57; the response scale ranged between 1 and 4) and that the extent of flooding had increased in recent years (*Mean* = 3.95, *Standard deviation* = 0.71; the response scale ranged between 1 and 5). This suggests that residents perceive extensive flooding as a relevant environmental problem.

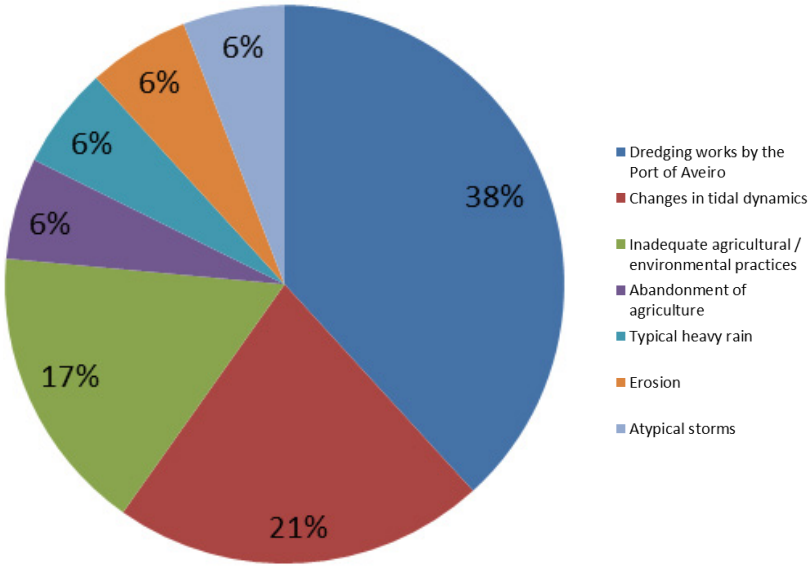

Figure 2 – Causes of natural hazards attributed by stakeholders, in percentage relative to the total number of causes mentioned.

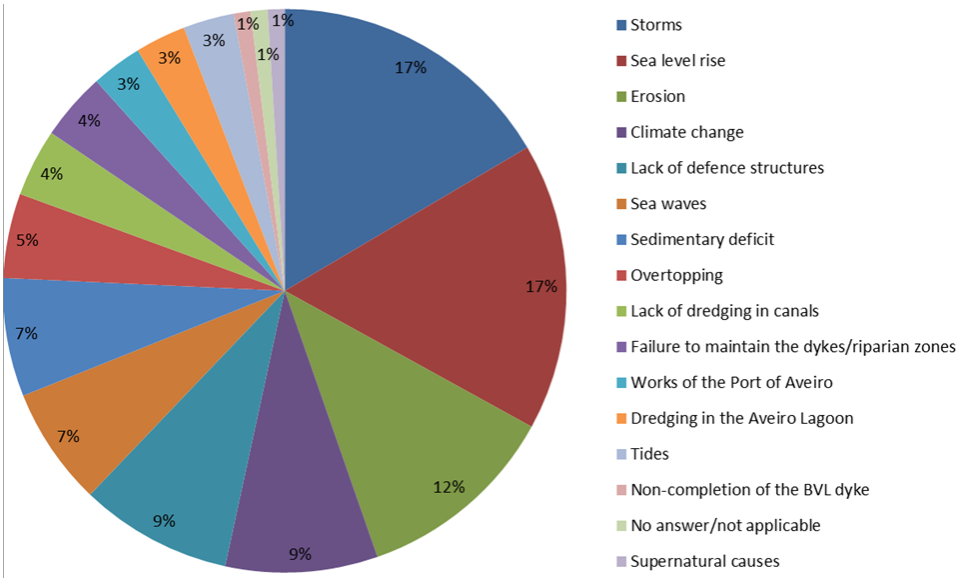

Figure 3 – Causes of the evolution of the extension of flooding attributed by local individuals, in percentage relative to the total number of causes mentioned.

3.2 Comparison of the coastal zone between Esmoriz and Vagueira settlements and BVL

It was expected that individuals in BVL would be relatively less prone to attribute natural hazards to climate change, when compared to those in the coastal zone.

First we analysed if shoreline retreat was also perceived as a relevant environmental problem. Data analysis showed it was: individuals considered that the probability of shoreline retreat occurrence was relatively high (*Mean* = 3.30, *Standard deviation* = 0.75; the response scale ranged between 1 and 4) and that the shoreline had been retreating sharply in recent years (*Mean* = 4.78, *Standard deviation* = 0.42; the response scale ranged between 1 and 5). Most importantly, the cause that was chosen the most for shoreline evolution was climate change followed by sea level rise and lack of coastal defence structures (Figure 4).

As expected, the descriptive analysis of Figures 3 and 4 suggests that individuals indicate climate change as the cause for different natural hazards more often in the coastal zone between Esmoriz and Vagueira settlements than in BVL when selecting the total number of possible choices (31.7% *vs.* 8.9%, considering that each individual could select up to three causes). To test whether there were significant differences between the number of individuals who had or had not selected climate change as the cause of those different natural hazards in BVL ($n = 9$) and in the coastal zone ($n = 13$), the chi-square test of independence ($\chi 2$; see Howell, 2010) was used, setting a significance level of 0.050 ($p < 0.050$; p-value = probability of a test result at least as extreme assuming that the null hypothesis is true). This statistical test determines whether there is a statistical difference between the expected frequencies and the observed frequencies of selecting climate change as the cause of natural hazards. Results suggest that the frequency of choice is lower in BVL when compared to the coastal zone. This result has marginal statistical significance: $\chi 2$ (1, $N = 63$) = 3.64, p =0.056. The phi coefficient (ϕ) was calculated to have a measure of the magnitude of this effect (Howell, 2010). Results suggest a small/medium effect size, $\phi = 0.240$.

We further tested if the attribution of natural hazards to climate change would be differently associated (i.e., have different relevance) with the perception of the probability of occurrence of these natural hazards in the case of BVL and the coastal zone, by calculating the coefficients of point-biserial correlation (r_{pb}; Howell, 2010) and setting a significance level of 0.050 ($p < 0.050$). This correlation coefficient measures the robustness of the linear relationship between a dichotomous nominal variable (attributing or not hazards to climate change) and a quantitative variable (perceived probability of hazard occurrence), and ranges from -1 to 1. The results show that the correlation is not statistically significant in BVL, $r_{pb} = 0.23, p = 0.184$. However, in the coastal zone, there is a statistically significant, strong and positive correlation. Attributing shoreline retreat to climate change is related with estimating a higher probability of occurrence of shoreline retreat, $r_{pb} = 0.53$, $p = 0.005$. This indicates that climate change might be perceived as more relevant when discussing climate change impacts in coastal zones but not when discussing impacts in inland areas.

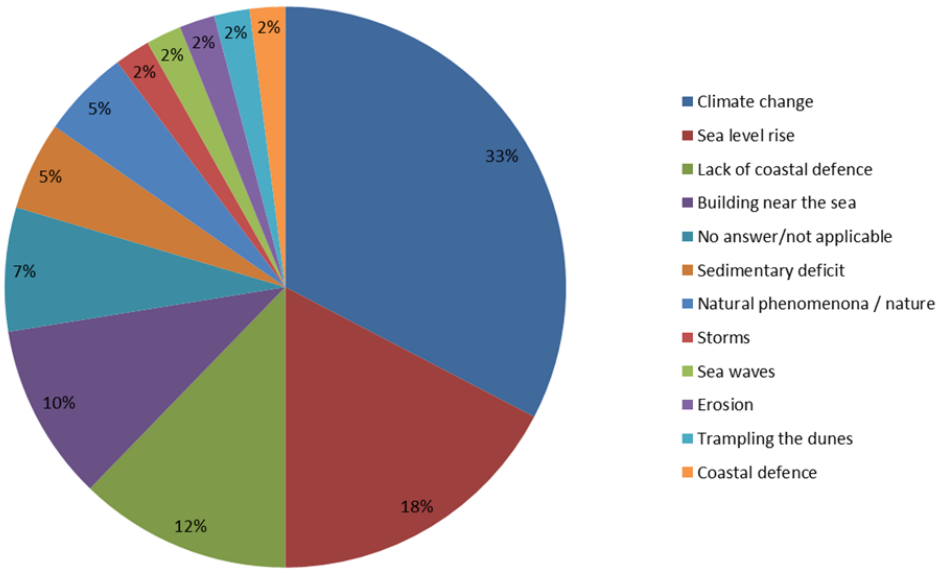

Figure 4 – Causes of the evolution of the shoreline attributed by local individuals, in percentage relative to the total number of causes mentioned.

4. DISCUSSION

The analysis of the interviews suggests that most stakeholders attributed flooding and salt water intrusion in BVL to other causes rather than to climate change. These problems were instead frequently attributed to anthropogenic activities, such as dredging works by the Port of Aveiro, as well as inadequate local practices.

Local individuals also did not, for the most part, attribute the natural hazards in BVL to climate change; when they did, they did so to a lesser extent, when compared to the coastal zone inhabitants. Note that for both considered areas, BVL and the coastal zone between Esmoriz and Vagueira settlements, climate change is not recognized by experts as the main cause of natural hazards. Despite this, lay people perceived climate change as the cause for shoreline retreat in the coastal zone frequently, but not as the cause for extensive flooding in BVL. As such, this lower causal attribution of natural hazards directly to climate change might be an implication of the relative reduction of inland climate change beliefs (Milfont et al., 2014). Interestingly, one of the causes mostly attributed to flooding in BVL was sea level rise, which was selected more often than climate change. This result suggests that individuals might perceive sea level rise as the result of another type of phenomenon, or identify the changes in the lagoon tidal prism as close to the sea level rise effect. Living nearer to the coast can be associated with a higher awareness of climate change, which facilitates the interpretation of experienced natural hazards as related to it. Climate change beliefs might be closely linked to personal experience (e.g., noticing shoreline retreat), when such experience is understood and perceived as related to climate change (e.g., Whitmarsh, 2008). Individuals might spontaneously associate natural hazards with climate change, based on their previously acquired knowledge, or this association might be facilitated by mass media, for instance.

Stakeholders and local BVL individuals attributed different causes to flooding. This result may be due to the different experiences and knowledge that they have, considering that stakeholders have specific responsibilities and are in charge of dealing with the natural hazards that may arise in BVL on a daily basis. Taking these differences into account, it is suggested that possible communication strategies about natural hazards and climate change should vary according to the specific beliefs of these key players.

Public engagement might create an opportunity to include different types of knowledge, parameters, interests, approaches, and experiences into decision-making, making it more likely that decisions will fully explore opportunities, while simultaneously anticipating unintended effects in the process of planning adaptation to climate change. To promote engagement, it is important to explore climate change beliefs, and to consider that these might be influenced by the distance to the coast. To facilitate communication and promote engagement, it is important to discuss not only the causes of natural hazards as defined by experts and technicians, but also the perceptions and knowledge that other stakeholders have on natural hazards. The distinction between causes associated with global climate change and specific causes related to local human actions — such as the construction of groins (see Veloso Gomes, 2007) or dredging activities — also matters, as well as the interaction between these variables.

This study has limitations that must be acknowledged. In particular, the number of stakeholders and local individuals was reduced and, therefore, it might be more difficult to find statistical differences as the analysis of data from small samples often yields less statistically significant differences than data from larger samples. Indeed, the statistical difference between selecting climate change as the cause of natural hazards in the BVL and in the coastal zone was only marginally significant. Nevertheless, we also calculated the effect size of this difference, which is independent of sample size, and found evidence of a smaller/medium attribution of climate change to natural hazards of inland inhabitants when compared to the coast. The sample of local individuals was also not representative, covering only young adults with a secondary or higher level of education, which inhibits the generalization of these results to other types of individuals. However, it should be noted that research suggests that both age and education are not predictive of beliefs about climate change (e.g., Mase et al., 2015). It would also be important to confirm the importance of the distance to the shoreline, by investigating the same type of natural hazard, in order to control the existence of factors that might be related to the hazard itself (for instance, related with the particularities of shoreline retreat or flooding), and by also investigating if the main factor at play is distance from the shoreline or visibility and interaction with the sea. Furthermore, data was collected in different timeframes and this might have some influence in the results. Despite these limitations, this study provides empirical evidence for the existence of differences in beliefs about the causes of local natural hazards (in particular about the local effects of climate change). Such differences may be due to the distance from the shoreline, suggesting the need to conduct more research in this area and to consider these differences in local processes of adaptation to climate change. To the authors' best knowledge, this is also the first study on climate change beliefs in a coastal lagoon ecosystem, such as the one in Ria de Aveiro, that considers the distance from the coastline.

5. CONCLUSIONS

This study constitutes a starting point on the understanding of the effects of the distance from the coastline in the causal attribution of climate change to natural hazards and provides recommendations that can contribute to improving local and regional management processes of adaptation to climate change.

Beliefs on the local effects of climate change might be influenced by proximity to the coast, as well as the local history on the impact of other anthropogenic activities. Different geographical areas experience different natural hazards (e.g., shoreline retreat along the coastal zones and flooding in particular inland zones) which might be differently perceived as related to climate change.

The lesser consideration of climate change as cause, in part, of natural hazards might result in a minimization of the need for local adaptation to climate change and the need for public engagement in this process. It might also create difficulties in terms of communication between different key players engaged in processes of planning adaptation to climate change. Therefore, even in the face of technical and scientifically robust knowledge on climate change (e.g., ADAPT-MED, 2015), the processes of adaptation might be challenging, particularly when overlapped with other environmental problems with marked effects at the present scale.

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