

# DIGITAL FLOOD RECORD FOR THE SUSTAINABILITY OF ECONOMIC POLICY

REGISTRO DIGITAL DE CHEIAS PARA A SUSTENTABILIDADE DA POLÍTICA ECONÓMICA  
RECORD NUMÉRIQUE DES CRUES POUR LA DURABILITÉ DE LA POLITIQUE ÉCONOMIQUE

Maria da Glória Gonçalves<sup>1</sup>

**ABSTRACT:** The innovation of this investigation is to propose the creation of periodic reports with the categorized description of the flood events delivered by the publishers of the periodic press, through an application to be submitted on the portal of the Tax and Customs Authority. The periodic communication of events allows building a reliable database for crossing information taxed or not to insurers, of cases of compensation to insured persons, loss reserves and tax obligations, which highlight the consequences. This study is carried out for the hydrographic basin of the Vez River, and shows the number of flood events that actually took place (1900-2015). It was found that there is more data to be collected in the country than what was imagined.

**Keywords:** Floods. Press. Consequences. Taxation. Sustainability.

**RESUMO:** A inovação desta investigação consiste em propor a criação de relatórios periódicos com a descrição categorizada dos eventos de cheias entregues pelos editores da imprensa periódica, através de um requerimento a submeter no portal da Autoridade Tributária e Aduaneira. A comunicação periódica de eventos permite construir uma base de dados confiável para o cruzamento de informações tributadas ou não às seguradoras,

---

<sup>1</sup> Researcher at the Geographical Studies Center of the University of Lisbon, R. Branca Edmée Marques, 1600-276, Lisboa, Portugal. ORCID: <https://orcid.org/0000-0003-3627-5404>. E-mail: [goncalves.gloria@gmail.com](mailto:goncalves.gloria@gmail.com).

Acknowledges: Special thanks to Professor Jorge Trindade, from the Center for Geographical Studies and the Open University, who, in addition to guiding me during the doctorate finished in December 2018, continues to accompany the work I propose to develop. I am also grateful to the Center for Geographical Studies (CEG) of the University of Lisbon, for welcoming me, since 2014, as a collaborative researcher in the Coastal and River Systems group: Dynamics, Environmental Changes and Spatial Planning (SLIF), including the availability of software: ESRI - ArcGIS Spatial Analyst 10.x for Desktop Advanced Student Trial and IBM - SPSS.

Artigo recebido em novembro de 2021 e aceito para publicação em fevereiro de 2022.

de casos de indenizações a segurados, reservas de sinistros e obrigações fiscais, que evidenciam as consequências. Este estudo é realizado para a bacia hidrográfica do rio Vez e mostra o número de inundações que realmente ocorreram (1900-2015). Constatou-se que existem mais dados por recolher no país do aquilo que se imaginava.

**Palavras-chave:** Cheias. Imprensa. Consequências. Tributação. Sustentabilidade.

**SOMMAIRE:** L'innovation de cette enquête est de proposer la création de rapports périodiques avec une description catégorisée des événements d'inondation délivrés par les éditeurs de la presse périodique, via une demande à soumettre sur le site Web de l'Autorité fiscale et douanière portugaise. La déclaration périodique des événements permet de construire une base de données fiable pour croiser les informations taxées ou non aux compagnies d'assurance, les cas d'indemnisation des assurés, les provisions pour sinistres et les obligations fiscales, qui en montrent les conséquences. Cette étude est réalisée pour le bassin du Vez et montre le nombre de crues qui se sont réellement produites (1900-2015). Il a été constaté qu'il y a plus de données à collecter dans le pays que ce qui avait été imaginé.

**Mots-clés:** Inondations. Presse. Conséquences. Imposition. Durabilité.

## **1 INTRODUCTION**

The creation of tool, the digital file with data on the floods, makes it available for various uses. Facts that lead to knowing the frequency of the consequences and the places affected. The researcher's joint work with the press allows the journalist to give information using systematic semantics in a structured language, ready for statistical analysis. The resulting product will be an application with database events (eBD), completed online by the publishers of the periodical press (IP), and made available for consultation and statistical treatment, similar to the examples in the databases on various topics of national interest, from the National Statistics Institute (INE), or even the Directorate General for Territory (DGT). The practical difference of this proposal and the work of these two last mentioned bodies are in a public-private partnership between the Tax and Customs Authority (AT), the IP publishers and the insurance companies. Learning the lesson of past mistakes from other examples of public-private partnerships (CRUZ; MARQUES, 2011), the rules of mandatory responsibility are established for the digital sustainability of the shared Portuguese economy, but under the control of the AT.

The media through IP publishers have always provided services of public interest, through paper editions, and currently also through digital editions on their own platforms, with fields categorized by the publishers themselves, with the respective news. However, a standardized database is needed to collect information on reported weather events, such as floods. There are data in news that need to be systematized in a database application comprising all records, and made available on a website. So far, there is no application for that

purpose, controlled and with sustainable management of information maintenance. The non-implementation of digital technology, contributes to maintaining ignorance and manifests itself in economic and social losses, naming one of the examples: the award of compensation to policyholders with gaps in the truth of the facts, makes it unfair to the interested parties, including the state, namely in the taxed amounts. However, in technological terms, we are in the era of collecting large volumes of information, Big Data, with portability and interoperability, for the capture and processing of social data that unfold through a process that we call data relations, which ensures the natural conversion of everyday life into a data stream (COULDRY; MEJIAS, 2019; MILLS, 2019; SUN, SCANLON, 2019). These data provide valuable evidence for the study of the phenomenon (MILLS, 2019).

The creation of information organization tools for data archives, repositories and digital libraries, demand public or philanthropic investment and serve as valuable sources of information to support disciplinary research, where the technological dimension dominates in discussions in published articles, representing 65% (Eschenfelder et al., 2019). There are many projects for aggregating cultural digital data, but they are fragmented (OLDMAN et al., 2014). To Fuller (2006) and Eschenfelder et al. (2019) the importance of the organizational sustainability of a new project is measured in its future impact, it can reduce costs and increase flexibility, generate opportunities, constraints and provide faster responses. The next step is the continuous maintenance of digital information, which contributes to mitigate human error or malfeasance, natural disasters (such as floods, earthquakes) or technological failures (ESCHENFELDER et al., 2019). A concern aware that the technological, management and financial dimensions dominate, because of the monetary revenue that reverts to economic sustainability (ESCHENFELDER et al., 2019; MORENO et al., 2019).

Private bodies, such as those of communications, to follow the evolution of market needs, adopt Web technologies. Social media platforms emerged in the mid-2000s (ESCHENFELDER et al., 2019; HENSTRA et al., 2019; MORENO et al., 2019), as the example of the one created by the newspaper *Notícias dos Arcos* (2007), with full access to news for subscribing users. Information sharing has highly increased with the social networks that arrived later, making it possible to analyze the impact of the number of devices connected to the network that publish data in real time (BAHGA; MADISSETTI, 2014; ESCHENFELDER et al., 2019; HENSTRA et al., 2019; MORENO et al., 2019). Digital information avoids traveling to libraries for consultation in the collections of national and municipal archives, access is immediate and its transformation into categorized data with systematic semantics reduces the working time for an investigator.

With the potential of data accessible on the Web, it is easy to see that something has failed. Flood maps are a tool to facilitate understanding of the danger, but in past investigations the data on the facts varies considerably in terms of availability and quality (HENSTRA et al., 2019). According to the aforementioned researchers, flood maps in most of the cities studied are of low quality, 62%, and are inadequate to communicate the dangers. This fact reveals a gap that has been maintained in different countries, such as in Portugal: measured by the number of flood events that investigations have presented to justify the facts. Take for instance the national

project Disaster (2010-2014) which, using the IP as a data source, in spatial to national, between 1865 and 2010, presents only 2% of events, compared to the same period overlapped with those collected by Gonçalves (2018), between 1900 and 2015, for the River Vez Basin (BHRVez). It happens that in the investigation by Grosso et al. (2015) for the study and analysis of the policy issue applied to flood risk based on Disaster data, was also limited to the accuracy of the results, due to the source consulted. Omitting the risk of flooding, due to lack of knowledge, affects estimates for the future, as is the case with infrastructures, with roads being the ones that most affect the daily circulation of citizens (UNTERBERGER et al., 2019). Measuring risk and communicating it can mean more or less investment, which contributes to the sustainable development of a given location (RAMACHANDRAN et al., 2019).

Gori et al. (2019) showed that the floodplain can expand in 100 years up to 12.5% in the entire studied hydrographic basin, subject to urbanization factors, as a result of the estimated projection, while the number of plots within the floodable area can increase up to 18.8%. Considering the places susceptible to floods, urban and rural, measures are taken to reduce the consequences. In Austria, flood risk is supported mainly by the Austrian disaster fund (Katastrophenfonds), financed by 1.1% of the federal share of capital income tax and corporate taxes (HOLUB; FUCHS, 2009). As for prevention technology, there are several methods for detecting flow levels in rivers using ultrasonic waves, transmitting their progression (LO, et al., 2015). There are proposals for these devices to monitor floods, whether the increase in flow, the speed of the waves, or the distance from an element exposed to the river (MARIN-PEREZ et al., 2012; MORENO et al., 2019). It should be noted that a non-relational environment allows data to be easily manipulated (MORENO et al., 2019). However, until now, knowledge about the reports of the consequences is not possible to obtain in the records of the sensors, but only in the IP. This fact has been studied in little detail.

Taking into account the described situation, it is decided to control the availability of flood events in digital, because published studies have shown that this subject can be considered from several points of view: organizational, frequency, social and economic. One of the problems is the lack of an open database, common to all authorized users, for recording the consequences of events, monitoring by AT, and consultation by insurers and insured and uninsured citizens.

The objective is to demonstrate that the relationship between the news from the printed IP on the floods, some works published by various researchers or by public bodies, the data on precipitation and flow, and the lack of a platform such as eBD for Portuguese rivers, contributed to a bias understanding of the real frequency of floods. The second objective is to demonstrate that the record of the consequences of the floods is necessary, for their evaluation and validation by crossing the data, between the record of insured persons with compensation by the insurers, the losses of the insurers and the amounts taxed as imposed by the AT. Therefore, this study aims at the compilation, digital storage, preservation and controlled public availability of the heritage over the floods. A research question that arises is the tax treatment of the consequences of floods, that is, losses and damages. It is hypothesized that IP publishers may submit flood data to the AT, receiving a premium rate in return. A second hypothesis consists of a regulatory rate, applied to insured taxpayers and / or insurers to have the data available whenever required.

## **2 MATERIAL AND METHODS**

### **2.1 River Vez Basin**

BHRVez is located in the northwest of Portugal. It has an area of 263 km<sup>2</sup>, corresponding to 10% of the area of the River Lima basin. It includes part of the municipalities of Monção, Melgaço, Ponte de Lima, Ponte da Barca, Paredes de Coura and Arcos de Valdevez. Arcos de Valdevez, practically includes 94% of its total. It is subdivided into 41 parish unions (UF) / parishes (Directorate General of Territory [DGT], 2017), with characteristics of mountainous relief, with rural and urban landscape, being these: UF Souto and Tabuaço; Paçô; Oliveira; UF Guilhadeses and Santar; Monte Redondo; Miranda; UF AV S. Paio and Giela; UF AV Salvador, V. Fonche and Parada; Vale; Ázere; UF Labrujó, Rendufe and Vilar do Monte; Prozelos; Rio Frio; Couto; Aguiã; Senharei; Rio de Moinhos; Cabana Maior; UF Grade and Carralcova; UF Bico and Cristelo; Vascões; Sabadim; Parada; Soajo; Aboim das Choças; Gondoriz; UF Vilela, S. Cosme, S. Damião and Sá; UF Eira and Mei; Padronelo; Padroso; UF Portela and Extremo; UF Alvora and Loureda; Cabreiro; Sistelo; UF Anhões and Lafões; Gavieira; Merufe; Tangil; Gave; Riba de Moure; UF Parada do Monte and Cubalhão. The headquarters of the Municipality of Arcos de Valdevez has two parish unions, totalling 10 km<sup>2</sup>: Arcos de Valdevez São Paio and Giela, and Arcos de Valdez São Salvador, Vila Fonche and Parada.

In the hydrographic basin, between 1900 and 2011 the buildings constructed had an increase of 49.9%. In 1900, the average density was 22.0 buildings / km<sup>2</sup> and in 2011 it reached 42.5 buildings / km<sup>2</sup> (National Statistics Institute [INE], 1900-2011). It shows an average demographic density of 55.6 inhabitants / km<sup>2</sup>, although in the county headquarters the values are maximum: 312 inhabitants / km<sup>2</sup> in Arcos de Valdevez São Paio and Giela, and 450 inhabitants / km<sup>2</sup> in Arcos de Valdevez São Salvador, Vila Fonche and Parada (INE, 2011).

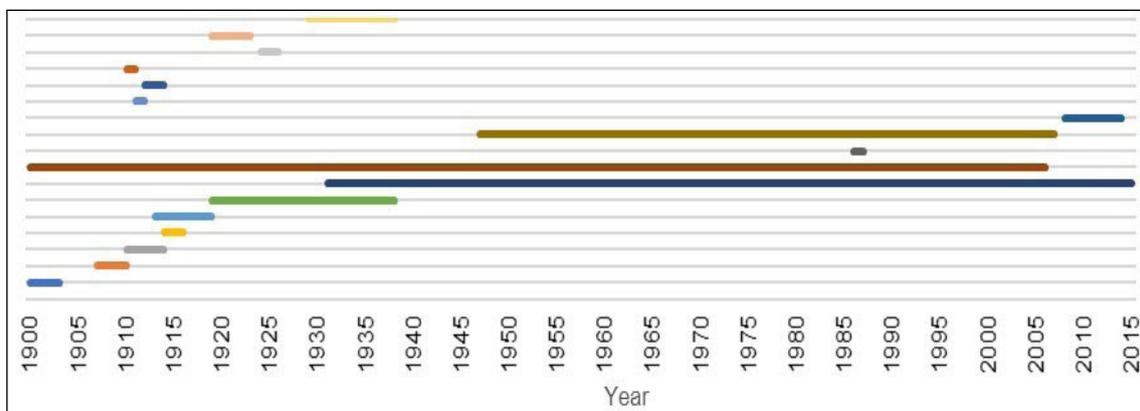
The hydrographic network is 1000.3 km long, with 576.9 km ranked according to Strahler (1953, 1957). The main river course is 41.4 km long (IGeoE, 1996, 1997). The average slope of the River Vez is high, at 33.9 m / km (BELLU et al., 2016). BHRVez shows an average altitude of 525.6 m, the maximum at 1410 m located in Serra da Peneda, and the minimum at 23 m (Army Geographic Institute [IGeoE], 1996, 1997). The lithology is essentially granitic, since it represents 90.3%, and of reduced permeability (MOREIA; SIMÕES, 1998; RAMOS-PEREIRA; RAMOS, 2000).

BHRVez has characteristics where rainfall is among the highest in our country (Ramos-Pereira and Ramos, 1998, 2000). Based on the rainfall recorded at the Casal Soeiro udographic station, of the National Water Resources Information System ([SNIRH], 1959/1990), the hydrographic basin shows an average daily value of 17 mm, and a maximum of 168.5 mm recorded on 30/03/1962. The 90<sup>th</sup> percentile (P 90) of precipitation greater than 1 mm is 38.6 mm, almost double the average daily figure (GONÇALVES, 2018). It can be said that the percentage of precipitation due to one-day events is an indicator of its intensity (BORN; KLEIN, 2019). The higher the precipitation, the greater the probability of a flood occurring. This is one of the criteria to estimate the number of events, in 31 years, at 271. Considering the flow obtained from the hydrometric station of Pontilhão

de Celeiros (SNIRH, 1959 / 1990), the average daily value for values above zero is 15 m<sup>3</sup> / s, the maximum at 1100 m<sup>3</sup> / s reached on 18/01/1968. The daily P 90 of the month with the highest flow rate, February, respectively, at 43.5 m<sup>3</sup>/s (GONÇALVES, 2018), approaching twice the average value in 24 h. From this limit, we are facing a flood flow, at 198 events in 31 years.

## 2.2 Database with floods records

The printed sources of newspapers are used as criteria for expanding knowledge about a given hydrographic basin and about the flood events that occur there (BOUDOU et al., 2016; TURCONI et al., 2014). These sources may correspond to news from national, regional and local newspapers (BOORSTIN, 1971; BOSOMPRA, 1989; GASHER et al., 2007; GONÇALVES, 2018; RILO et al., 2015). For this study the eBD with flood records at BHRVez, from 1900 to 2015 (eBD, 2018), were collected by rational non-probabilistic sampling at the regional and local IP, in the collection of the Municipal Library of Porto's City Hall. 31 newspapers were discovered, 11078 available editions were consulted, with information on the studied hydrographic basin (Figure 1). Of these, 14 with circulation practically limited to 1 or 2 years and with few accessible editions, therefore, without any news about floods. There are 17 identified and analyzed for the purposes of the 3386 entries by eBD, with the events and the respective occurrences (repeated and not repeated). Of these (Figure 1), the first five contributed 95% of the information, notably *Notícias dos Arcos*, with 67%.



**Figure 1.** Timely distribution of the analyzed journals (Periodical Press, 1900/2015). 31 identified newspapers: *Jornal dos Arcos*, *O Arcoense*, *Alvorada*, *Alvorada do Vez*, *Regionalista*, *A Concórdia*, *Notícias dos Arcos*, *O Povo da Barca*, *Notícias da Barca*, *Vanguarda*, *Notícias Arcoenses*, *Galhofa*, *A Semana*, *O Ferrão*, *A Troça*, *O Zé Pouza*, *O Evolucionista*, *A Campanha*, *O Vez*, *Echos do Vez*, *Voz dos Arcos*, *Avante*, *Correio dos Arcos*, *O Concelho*, *A Voz de Soajo*, *Noticioso*, *O Realista*, *A Voz do Minho*, *Ecos da Nossa Terra*, *A Zebra de Gondoriz e Credo*. In the order of the lower-upper reading of the graph, the 17 newspapers on eBD: *Notícias dos Arcos*, *Vanguarda*, *Notícias Arcoenses*, *A Voz do Minho*, *O Povo da Barca*, *Concórdia*, *O Arcoense*, *Alvorada do Vez*, *O Vez*, *Jornal dos Arcos*, *Alvorada*, *Regionalista*, *Notícias da Barca*, *A Semana*, *O Realista*, *Echos do Vez* and *Noticioso*.

293 flood events were collected, distributed over 970 occurrences. In 116 years of study, 32.9% of the occurrences belong to the first half of the time, followed by 67.1% in the remainder. Data validation is a criterion to follow with the analysis of flood events and occurrences deducted from IP (BAYLISS; REED, 2001; BELMONTE; BESCÓS, 2004). Therefore, the IP events were validated, using the date as the key to the relationship with the precipitation (P) and flow (Q) events, guided by the thresholds of  $P^{90} = 38.6 \text{ mm}$  and  $Q^{90} = 43.5 \text{ m}^3 / \text{s}$ . An event, whether it is a flood of IP, P and / or Q, can last more than one day, when the date of the news makes this reference or the values of  $P^{90}$  and / or  $Q^{90}$  are equal to or above the referred thresholds. The reach of the content validity index at 84.3% is considered good, as it exceeds the 80% defended by Fortin (2009). The news unexplained by the data of  $Q^{90}$  and / or  $P^{90}$  may be due to the lack of effective consequences, to the semantics itself, or to the way the journalist interpreted the phenomenon.

Taking into account the IP data sources, the distribution of occurrences with the distance radius from the georeferenced points to the nearest river obtained by the Jenks natural scale for the hierarchy (STRAHLER, 1951) and the magnitude of the drainage network (SHREVE, 1966), the floodable area, occupies  $59.7 \text{ km}^2$  (equation 1), corresponding to 23% of BHRVez's total (Figure 2). The delimitation of each flood point only by the centroids (flood center) and radius with a maximum of 635.9 m, for 100% of the data, and that obtained by the P 90 at 290.2 m, are criteria of maximum homogeneous reach of the location of the points relatively to the nearest river (flood centroids or flood center). The average distance from the points to the nearest river of 112.09 m exceeds 100 m from the watercourse margin line.

$$A = \pi r^2$$

(1)

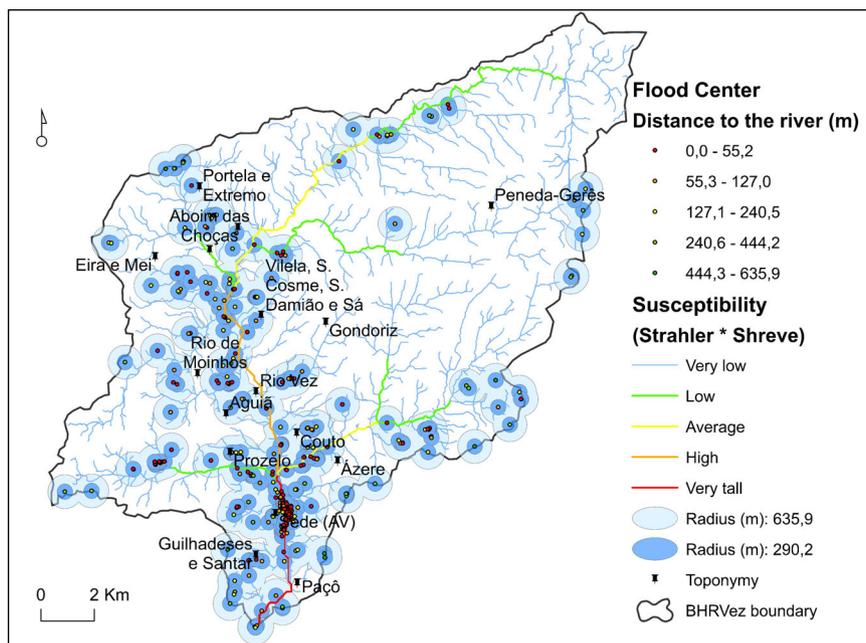


Figure 2. Distance radius (dist.) between occurrences and the river (Portugal's Military Map, IGeoE, 1996, 1997, 2013; Periodical Press, 1900/2015).

From the collection of information, the analysis is made by type of geographical space and by number of records, identifying itself as: urban: 396; agricultural: 179; mountainous: 44; beds: 232; and unspecified: 119. Taking into account these reported records; it was possible to classify 87.0% of the geographic space where the events took place. The consequences are measured by typology and frequency of the number of records, observing: built (housing, commerce, industry, services): 109; circulation routes: 235; infrastructure: 98; the rest being unidentified: 528. It was possible to classify 46.0% of the consequences. These data triggered the criteria for recording the consequences in eBD in this study. In a single event the consequences can be diverse: the erosive properties of water from moving floods can weaken the foundations of bridges and housing structures, increasing victims and causing damage (MORENO et al., 2019).

A large part of the consequences of the verified floods, 60%, were located on the banks of the River Vez, in Arcos de Valdevez, and in the influents of a larger scale of susceptibility Strahler \* Shreve. The occurrences are more frequent in the headquarters of the municipality of Arcos de Valdevez [AV], more specifically in the Union of Parishes Arcos de Valdevez (São Paio) e Guela, 118, and São Salvador, Vila Fofó e Parada, 118, then in the parishes of Couto, 37, Ázere, 13, Prozelo, 21, and Aguiã, 5. 21% were located in the vicinity of smaller and larger influents, as happened at the Union of Parishes Portela e Extremo, Frades' place in the flood of 7 December 2000 where 4 fatalities were recorded. The remaining 19% unspecified the exact geocoded location, or happened at the confluence of the River Vez with the Lima River.

### **2.3 Combination of the relationship of factors and respective criteria**

A meta-analysis is carried out to combine the results of studies already published (FORTIN, 2009) to ensure the value of the application of two proposals presented in this work, and described in the results chapter: on the creation and availability on the Web of an eBD application and creating a rate to ensure that data is entered into the application and made available whenever required. It is a question of innovate the reproducibility of methods already applied in the scope of economic policies, contributing to their sustainability.

#### **2.3.1 Taxation**

Political power has shown an interest in transferring some responsibility for flood risk management to the public, for example, by encouraging private individuals to purchase flood insurance, in addition to adopting private protection measures (THISTLETHWAITE et al., 2018). The tax treatment of the forecast of losses is seen as a judicious factor to avoid tax evasion. Based on the same opinion as Cheng et al. (2019), the state is considered to have regulation when it owns, in addition to the established tax legislation, strict data files. The researchers Hoopes et al. (2012) suggest a corporate tax in the IRS declaration. This hypothesis has already been tested in the United States of America (USA), identified in the IRS records by postal code, tested for data between 2009 and 2016, to compare the

average real income obtained from properties in areas subject to flood risks, classified as Special Flood Hazard Areas (SMITH; WHITMORE, 2019). The income and rate of family insurance are controlled by the IRS of each taxpayer, which are relevant factors for families in places subject to dangerous flooding processes (LINNEROOTH-BAYER et al., 2018; SMITH; WHITMORE, 2019). Companies or organizations also have a taxpayer number and IRS that can be controlled (CHENG et al., 2019).

The consequences of the floods revert to economic values where losses and expenses are part of the IRS. Due to the consequences of high impact floods, economic resources are needed to reduce the loss. Public authorities after the occurrence of events with great impact, seek financing, for example, by raising taxes, reallocating budget resources or making loans, and alternatively ask for international assistance (LINNEROOTH-BAYER et al., 2018). At the extreme when support is needed is public assistance: internationally, the World Bank and the European Union Solidarity Fund (HOCHRAINER-STIGLER et al., 2017). As an option, the European Union for projects, such as those in Central Europe, recommends a discount rate for municipal insurance of 3.5% (PÁLINKÓ; SZABÓ, 2012). Expansion of flood risk insurance on private property, if done properly, is beneficial to public well-being and interest (BORN; KLEIN, 2019). Among the measures used to promote the rate of adherence to flood insurance, one of them is the inclusion of benefits in the IRS.

### **2.3.1 Insurance market**

The market for insurance against the risks of climate change, such as floods, has several limitations (SCHÄFER et al., 2018). Insurers have to set up financial reserves to cover losses when policyholders trigger the policy to proceed with claims. The financial results of the insurers are communicated to AT. The insurance sector constitutes an economically significant part in financial terms for the economy (CHENG et al., 2019). Insurers depend on loss reserves. Due to loss forecasts, some insurance companies often turn to banks (ANDRIES et al., 2017). The need for financial banking support is overcome when insurers carry out the control, with an annual financial report containing the estimated economic reserves, including the tax component, and the forecast of losses (CHENG et al., 2019; GUENTHER et al., 1997). Forecasting losses, deducted from taxable profit, by insurance companies is an expense (CHENG et al., 2019). Insurance companies' financial reserves and tax incentives are related: higher reserves less tax rate in taxes (BRADFORD; LOGUE, 1999). Average annual loss reserves are approximately 10% of total assets (CHENG et al., 2019). The insurance companies' reserve fund for the uncertain future, called loss adjustment expenses, express the amount the company expects to pay in the future to cover policy-maturing payments with associated claims, including, for example, litigation costs associated with claim settlement (BRADFORD; LOGUE, 1999). Biases in loss reserve estimates can distort the real financial conditions of insurance companies, which play an important role in the financial sector and the general state of the economy (CHENG et al., 2019). Insurers' reserves and associated tax positions are reflected in audits induced by the fiscal year (HOOPES et al., 2012)

The interests of the management of the insurance companies and the decisions of the managers in demonstrating results of the balance sheet of the financial performance are factors that can inflate the profit and declared surplus (BRADFORD; LOGUE, 1999; FAMA, 1980; JENSEN; MECKLING, 1976). The hypothesis of insurance manipulation of reserves to smooth gains over time was confirmed by Smith (1980). The trend seems to have diminished, due to the fact of the aforementioned: higher reserves lower tax rate in taxes (BRADFORD; LOGUE, 1999).

The control of losses reserves reported by the best estimate of future payment obligations is associated with a risk that can, in the extreme case, lead to insolvency of the insurer, without access to insurance protection or reinsurance, where insurance regulators, such as the state, can increase the level of surveillance and intervention, and ultimately take on the financial condition of the company and manage it (BRADFORD; LOGUE, 1999; LINNEROOTH-BAYER et al., 2018). The risk of insurers is higher than that of reinsurers (UNTERBERGER et al., 2019).

The idea of privatization of flood insurance, as in the examples in the USA and Australia, is seen as an improvement in current practices, where insurers, may include clauses to increase the underwriting of the policy (BORN; KLEIN, 2019; UNTERBERGER et al., 2019). Insurance, as one of several risk financing instruments, provides reimbursement in return for the payment of a premium in such a way that municipalities, businesses and families can recover from the damage caused by extreme events (LINNEROOTH-BAYER et al., 2018; SCHÄFER et al, 2018).

### **2.3.1.1 Insurance for grouped recipients**

The government of the USA created, in 1968, the National Flood Insurance Program (FRIMPONG et al., 2019; MOSS, 2004) to manage flood risk. It used historical data on floods to study the consequences on populations, where the danger was identified, extending the study to several communities: as in Alabama, with 359 and Mississippi, with 267 (FRIMPONG et al., 2019). The program included delimited areas that are at least 1% likely to be affected by floods each year, that is, the 100-year floodplain. These are known as Special Flood Hazard Areas, a second program created in 1983, subject to the limits of the policies prescribed by its legislation and the legal limits of the policy (BORN; KLEIN, 2019; FRIMPONG et al., 2019; GORI et al., 2019). The minimum risk of flooding was set at 0.2% (BORN; KLEIN, 2019).

Regional insurances (micro insurances), as preventive instruments, serve as a compensatory response to the reduction of hazards, and equitable to public-private losses and damages, attributed to the climate resulting from extremes (LINNEROOTH-BAYER et al., 2018). The risk of floods, for public infrastructure and the consequent implications for budgets, has been little investigated, although it can be reduced with formalized insurance compensation agreements, reducing the charges (UNTERBERGER et al., 2019). Expected expenditure on insurance premiums at the municipal level plus unrestricted reconstruction costs puts pressure on government budgets, both at district and political level (UNTERBERGER et al., 2019). Depending on the groupings of policyholders, the communities adhering to the so-called

Community Classification System program, created in 1990 in the USA, may be included in the policy discount agreement, depending on the areas classified from 1 to 9, with classes between 5 and 9 the most susceptible to floods (FRIMPONG et al., 2019).

### **2.3.1.2 Families**

In a study carried out in New York they found that in order to face the consequences of the floods, substituting subsidies for premiums with affordable policy prices for families with low incomes, can guarantee that these are insured, at the same time contributing to the public economy by stopping under-charging taxpayers (MILLER et al., 2019). The effects of screening on families that benefit from public aid policies, such as the example of the National Flood Insurance Program in the USA, have an impact on the economy, which must be controlled by AT. In the absence of insurance, to recover after the disaster, resorting to bank credit or informal financing has been a solution (LINNEROOTH-BAYER et al., 2018).

## **2.4 Application**

When information is received on a digital platform, the extent of the damage can be assessed, decreasing the likelihood of fraud on the part of those involved (SCOTT, 2019). The capture of images and / or video allows us to obtain useful information for policyholders, insurers or even for AT, which can be used in the compensation process for the estimated replacement of the loss and in the control of the taxed amounts (DAVIS et al., 2019). In the diversity of examples and uses of the typology of information that justifies the facts, the identification of the place becomes essential. The Satellite Positioning Service (GPS) receiver system method on a mobile device circumscribes the exact latitude and longitude of the user's location and / or infrastructures in the floodplain, with reference to 100 years old, and correlates latitude / longitude to apply for insurance rate against the danger of flood (CATALANO; PANEQUE, 2019). According to the aforementioned researchers, the flood insurance rate determined by the coordinate system involves the use of algorithms, flood insurance rate maps, in addition to legal regulations.

## **3 RESULTS**

IP has always been reporting on the floods and their consequences, as was the case for BHRVez. As the facts prove the validity of these data, the result of this study is a proposal to implement and replicate throughout the country. The proposed interface for programming the eBD application on the Ministry of Finance portal receives data from authorized IP publishers and stores them in the database. IP publishers periodically submit information to AT. Thus, the control carried out by the AT is facilitated by the crossing between the data received from IP, with the communication of the consequences of the floods, with the compensation paid by the insurers and data from the insured. The information contained in each taxpayer is reflected in the IRS's annual statement.

### 3.1 eBD Application

The proposal of the eBD application was tested, in an offline environment, and corrected whenever necessary, as data collected in the IP was inserted. Information on flood events was validated at 84.3%, considering a good result, according to Fortin (2009). The relationship between IP events and  $P^{90}$  and  $Q^{90}$  events exceeded twice the daily average values. With good Pearson correlation, being  $r > 0.7$  and significant for  $p < 0,05$  (Table 1), by comparison with the criteria of the scale proposed by Cohen of 1988 (FAUL et al., 2009), all of which predictions between variables are an average (PESTANA; GAMEIRO, 2014). The values in Table 1, of the correlations raised to the square correspond to the coefficient of determination  $R^2$ , necessary to verify the linear association for the various scores: IP and  $Q^{90}$  with  $R^2$  at 0.59 and significant, IP and  $P^{90}$  with  $R^2$  at 0.48, not significant. As the  $Q^{90}$  and  $P^{90}$  explain the centroids of IP occurrences in a proportion of at least 0.50, the remaining factors are explained by the density of buildings and demographics and their distance from the river by the average forecast at 112.09 m. The affected places are determined by the territorial map, delimited by borders of the centroids of the occurrences and respective radius of distance to the river. The flood analysis is validated and the results of the information from the eBD application are confirmed.

**Table 1.** Relation between the variables: floods associated with IP,  $Q^{90}$  and  $P^{90}$ , between 1959-60 and 1989-90.

| Pearson's correlation and significance | $Q^{90}$      | $P^{90}$     |
|--|---------------|--------------|
| IP                                     | 0.774 (0.003) | 0.692 (0.13) |
| $Q^{90}$                               | --            | 0.863 (0.00) |

\*\* . The correlation is significant at level 0.01 (bilateral).

The density of buildings at BHRVez, from 1900 to 2011, increased by 49.9%, similarly, the occurrences of floods also increased from 1958 to approximately double. 34.2% more frequency observed compared to the previous period studied. A dependent and positive association relationship between the two variables, buildings and occurrences is admitted, although without verifying the linear trend of the Mantel Haenszel test. It is natural that constructions close to river sections are affected by floods, with consequences reported in the news.

The relation of one of the main concepts studied, floods, with the consequences, shows that the eBD application (Table 2), corresponds to the expected, ready to implement and make available on the AT portal, for the registration of future events. The sooner an application receives information on a digital platform, the lesser the likelihood of tax fraud (SCOTT, 2019). The bet is on non-relational technology (CUNHA; PEREIRA, 2016), as it allows data to be easily exported to statistical and geospatial analysis software, such as the examples in the Statistical Package for the Social Sciences (SPSS) and ArcGIS. In addition, access to information is immediate, with all the advantages that come with it, reverting to public economic savings.

**Table 2.** eBD application form to be made available on the AT portal.

| Categories   | Fields and remarks in the filling of the form   |  |
|--|---|--|
| <b>IP's Sources of Information</b>   | 1. Record source (periodicity)  |  |
|  | 2. Record source (name)   |  |
|  | 3. Date of the source   |  |
|  | 4. News reliability   |  |
|  | 5. Size of the whole news (nr of words)   |  |
|  | 6. Size of the disaster news (nr of words)  |  |
|  | 7. Page of the news   |  |
|  | 8. Needs to be checked with other sources   |  |
| <b>Time space referencing</b>  | 9. Start date   |  |
|  | 10. End date  |  |
|  | 11. Time of occurrence  |  |
|  | 12. X and Y coordinates   |  |
|  | 13. INE Code  |  |
|  | 14. Type of georeferencing (non-existent, exact, approximate)   |  |
|  | 15. Type of georeferencing (dimension: location, parish, municipality)  |  |
|  | <b>Typology of the phenomenon</b>   | 16. Phenomenon: unspecified, precipitation without wind, storm, which corresponds to precipitation with wind.  |
|  |   | 17. Type of Incident / occurrence: unspecified, flood, high waters, precipitation, storm, snow, earthquake, other.   |
|  |   | 18. Triggering factor: intense and long-lasting precipitation, [ $\geq 1$ day and $\leq 2$ days]; intense and short-term precipitation, [ $<1$ day]; shallow and long-lasting precipitation, [ $> 2$ days]; dam discharge. |
| 19. Subtype of occurrence: rapid flood, [few hours $<1$ day]; progressive flood, [several hours $\geq 1$ day]; urban flooding, [urban areas adjacent to the flood bed]; flooding of buildings, [inside damaged buildings and exterior facades]; other floods, [falling trees, "others"]. |   |  |
| <b>Consequências</b>   | 20. Individuals involved: unspecified, firefighters, City Hall, Parish Council, Central Government, Community and or "others"   |  |
|  | 21. Nr of dead  |  |
|  | 22. Nr of injured   |  |
|  | 23. Nr of evacuees  |  |
|  | 24. Nr of displaced people  |  |
|  | 25. Nr of people missing  |  |
|  | 26. Nr of survivors without help  |  |
|  | 27. Goods of first necessity: unspecified, water, food, electricity or telephone, accommodation, communication routes.  |  |
|  | 28. Shallow structures  |  |
|  | 29. Functional structures   |  |
|  | 30. Structural structures   |  |
|  | 31. Roads' shallow damage   |  |
|  | 32. Road traffic cut  |  |
|  | 33. Duration of outage in minutes   |  |
|  | 34. Other functional damages  |  |
|  | 35. Indirect damages  |  |
|  | 36. Type of building affected: unspecified, housing, commerce, industry, services, bridge or small bridge, mill or watermill, others [irrigation, weir, sewage, supply, ...], several of all types, roads [paths, squares, circulation routes, ecovia]. |  |
|  | 37. Number of buildings affected  |  |
| 38. Height of water in the building: to specify, $\geq 1$ m, $> 0.5$ m and $<1$ m, $<0.5$ m, = 0 inside, urban flooding and flooding only outside  |   |  |
| <b>Sustainability</b>  | 39. Population: unspecified, health, activities, participation, satisfaction, others.   |  |
|  | 40. Housing and buildings: unspecified, disabled, maintains, new, intervention.   |  |
|  | 41. Trade, industry, services and agriculture: unspecified, maintain deactivated, new, intervention.  |  |
|  | 42. Structures and routes of communication: unspecified, maintain deactivated, new, intervention.   |  |
|  | 43. Floodable areas: unspecified, runoff, inert, intervention, place referred to as flooded, several.   |  |
|  | 44. Type of land use: unspecified, urban [may or may not be flood bed], leisure parks and parking, agricultural, forest, beds and "others".   |  |
|  | 45. Agents: unspecified, administrations, companies, organizations, citizens, "others".   |  |

This is the eBD application to be made available on the AT portal with authorized access by authentication to the IP publishers with a commitment to record the occurrences and periodically submit the respective data. For this application, the standardization of semantics must be considered for system interoperability. *Notícias dos Arcos* was the newspaper that contributed most to the effects of eBD, of the 17 newspapers used, with 67%. This information allows us to confirm that there is a natural pre-selection of the journal publishers taking into account the typology of the themes of the published news to consider their integration in the national project together with the AT. Taking into account the amount of data from the newspaper *Notícias dos Arcos*, it should be chosen and invited as one of the pioneers in the insertion of information about future events. As for events in the past, such as those already collected for the BHRVez case, from 1900 to 2015, data can be granted to be made available on the AT portal, reflecting the history of the trend of the affected locations, as expected, serving as basis of control, through future comparison of the number of occurrences to be collected so that in the remaining hydrographic basins an approximate percentage of data is reached.

### 3.2. Rates

The management of sustainable public-private economic-financial information, insurance regulation, minimization of fraud and a more equitable economy for citizens has costs and benefits. In this study, as a result of the efforts of the new eBD application, it is proposed to maintain balance through the application of two rates: premium rate for IP publishers and the regulatory rate for insurers and / or policyholders. The result of the two rates is controlled by the AT taxation. Therefore, economic savings in this matter is possible and can be measured according to equation 2, adapted from the rate to assess exposure to insurance regulation (GRACE; LEVERTY, 2012). The premium rate and law enforcement supported by the public economy and the regulatory rate by insurers and insured taxpayers.

$$\text{Exposure rate} = \sum \text{IP premium rate} \times \sum \text{Law enforcement} - \sum \text{Regulatory rate} \quad (2)$$

#### 3.2.1 Premium rate

For IP publishers that are candidates to contribute in filling out the form data presented in the eBD application, tax benefits must be safeguarded in the IRS towards the AT, or alternatively, public policies regulate and apply a premium rate for each event record and respective occurrences. The average number of occurrences in the 116 years and per month is 3.6, the maximum observed for the months of greatest precipitation, between October and March, in the month of December at 4.5. It is estimated that the maximum time per event, with an average of 4.5 occurrences to be filled in the eBD application, corresponds to the journalist's one-hour work (Table 3). When allocating the Premium Rate, the forecast of economic

investments under the government’s responsibility must be calculated taking into account the average frequency of past IP events and occurrences per month, without disregarding their relationship with the months of greatest precipitation. Only with data collected, as was the case for BHRVez, did it become possible to achieve these forecast values.

**Table 3.** Estimation of the premium rate per event (IP, 1900/2015).

| IP  | Oct | Nov | Dez | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Events [E] (nr)                                   | 21  | 34  | 38  | 56  | 50  | 36  | 14  | 13  | 12  | 6   | 4   | 9   |
| Occurrences [O] (nr)                              | 80  | 120 | 170 | 155 | 134 | 101 | 26  | 24  | 63  | 13  | 20  | 64  |
| Average = E/O (nr)                                | 3.8 | 3.5 | 4.5 | 2.8 | 2.7 | 2.8 | 1.9 | 1.8 | 5.3 | 2.2 | 5.0 | 7.1 |
| Premium rate/E = [Average (nr) * work (h)]/1h (h) | 0,8 | 0,8 | 1   | 0,6 | 0,6 | 0,6 | 0,4 | 0,4 | 1,2 | 0   | 1,1 | 1,6 |

### 3.2.1 Regulatory rate

The proposal for a regulatory rate per number of insured taxpayers it’s seen as a possibility for resource management and control by the AT. Alternatively, the regulatory rate can be applied to insurers, in a percentage per insurance contract, with the benefit of having access to the eBD application data. For insurers the obligation to adhere to the eBD application, access to data is guaranteed, for the purposes of the policy value and future indemnities, allowing for comparison with what are presented by the client. With facts it is possible to cross it in the event of compensation for losses to policyholders and insurers, minimizing fraud, both by the customer and the tax authorities towards AT. The regulatory rate may have an estimated average value equal to or higher than the premium rate, never lower for the purposes of public economic sustainability. This measure also has an advantage for insurers - triggering the insurance policy without apparent cause or with facts caused by negligence on the part of the insured, the amount of the compensation is dependent on the facts recorded in the eBD controlled by AT, making it difficult to present false information. At the same time, it can demand that citizens request more for the presence of journalists, to the detriment of other civil authorities, as they will make a record.

## 4 DISCUSSION

As for Eschenfelder et al. (2019) all the scientific articles examined that presented sustainability as something positive, none argued whether the projects should be allowed to continue or end, or be reformulated. What is positive about sustainability is the development that can result from it. In this study, the conceptual framework allowed to collect data never discovered, to connect the IP with the distance of the centroids from the occurrences to the river, the insurers, policyholders, digital technology and AT. Given that the occurrences of floods observed in the IP for BHRVez approached the hydrological reality, there is a relationship between these and the thresholds of P<sup>90</sup> and Q<sup>90</sup>, which leads

to the statement that the collection of this information allowed to confirm that the problem of low-quality flood maps (HENSTRA et al., 2019) can be resolved. So far, there is an inaccuracy of the data that justify the published works, including the flood maps, which explains that the retraction of the insured's easier acceptance against the risk of flooding by the insurers has continued, with little accession by the insured, and political actions were limited to little development of investigations.

Among the 280 municipalities analyzed by Henstra et al. (2019) and located in Canada, 85% had flood maps available online, but many of these were difficult to locate and most were unsuitable for risk communication purposes. In the USA, this problem of the accuracy of flood maps also arises (BORN; KLEIN, 2019). In Portugal, for the 308 municipalities, the problem is repeated, being visible in the number of events published in various scientific documents and in public bodies. The most notable is the result presented by the national project Disaster, with only 2% of the data compared to the 98% we collected in this study, for the same location, BHRVez. Therefore, in Portugal we are facing an opportunity to reverse the situation, update the flood maps after the collection, which will have to be exhaustive and which is missing, for the construction of a database of the past, still preparing to record future events, following Big Data technology.

The IP information contains data on the consequences of the floods for BHRVez. These were systematized in eBD by categories and respective variables, validated by crossing with  $P^{90}$  and  $Q^{90}$ , allowing information to be obtained by type of geographical space and by consequences, with good association results. With these data, insurers give a fairer response to each insured, being able to measure damages and losses by the trend of distribution in the territory. Comparing with the value of the sensors that is a technology that has been developed, for flood warning, these do not register the consequences. Therefore, the continuation of IP publishers' work to inform, with the possibility of converting news into text, by categories with standardized semantics and respective variables in eBD, is seen as necessary and emerging. IP's work in the area of social responsibility actions deserves attention as it reduces the danger that flood events can cause. The value of the work of the press is proven. To provide positive rewards for these social actions in the municipalities, regulations may include changes, giving value to the work of IP (UNTERBERGER et al., 2019). Political actions can help and support human actions aimed at stimulating risk reduction -, for regional governments, insurance against risk in public infrastructure has a notable monetary impact, around 50% (UNTERBERGER et al., 2019). Reason why it justifies a systematic work in partnership with the publishers of IP and AT, including insurance companies, in order to be able to compare the data of the occurrences, the consequences, the indemnities and the taxed amounts.

## **CONCLUSION**

The usefulness of the methodology in this study allows us to demonstrate that, over time, the recording of data in digital databases as they increase also does reliability, usefulness, availability, portability and interoperability. Without data, it is not possible to

have reliable studies, a problem that has been dragging on and limits the implementation of human actions that contribute to public and private national economic savings, avoiding losses of human lives that jeopardize generations of families. When AT is fully aware of all relevant and complete information, in tax audits the assessment is fair. The government's action in cases of flood risk is all the more reliable the more facts registered in the eBD application exist.

If companies are under greater public scrutiny and pressure from the capital market, they are less likely to overestimate loss provisions for tax purposes (CHENG et al., 2019). The probability of the expected value to cover insurance losses, in addition to taxation, is improved with data that is closer to hydrological reality, such as data by eBD, contributing to better performance and less negligence. Tax deductions are dependent on profit and losses, when they have less taxable income to protect; deductions are lower - meaning less money in public safes. Demographic and building data can be analyzed, comparing data from the intensification of land use and occupation with the centroids of the occurrences and their distance from the river. With the eBD application online on the AT portal, rates, premium and the regulator see it as an incentive to implement actions for the government and insurance companies.

The eBD application form presented in this investigation has the categories and respective variables validated by the IP events being 84.3% coincident with those of P<sup>90</sup> and Q<sup>90</sup>. The empirical data collected in the IP gave reliable results regarding the approximation of the reality of the hydrological regime of the River Vez, reason for compiling them in eBD with standardized semantics, and for the continuity of the project with control by a reference body, AT.

As the consequences obtained from IP, these publishers must submit the periodic report of occurrences to the AT. By valuing the work of IP combined with that of AT, in many cases it can avoid the presence of civil authorities to take care of the occurrence, leading to public savings in travel and hours of service, and an increase in these available human resources. Thus, there is corporate transparency for the implementation of public policies. There is a better quality of the reserve estimate for losses, more gains, reduction of the global risk of insurance companies, the state itself and the citizens in general and those involved who claim compensation for losses. In addition, citizens insured in the annual IRS statement can provide proof of insurance expenses.

The safety of people and goods against natural phenomena is improved when there is information about the centroid of events and the radius of the distance to the river. The consequences of the floods can jeopardize essential goods: housing, road access, the temporary interruption of the supply of electricity, water or even telecommunications. The provision of services, such as electricity and water supply system, must be guaranteed (RAMACHANDRAN et al., 2019). Now, when we are facing random events related to the climate, there must be a guarantee of the replacement of the affected goods in a timely manner whenever required. Having AT as a regulatory / supervisory entity is an added value, ensuring more security in the sustainable management of information, as well as its permanence, in addition to ensuring consistent taxation.

## BIBLIOGRAPHY

- ANDRIES, K., GALLEMORE, J., E JACOB, M. The effect of corporate taxation on bank transparency: Evidence from loan loss provisions. **Journal of Accounting and Economics**, 2017, 63(2-3), 307-328. <http://dx.doi.org/10.2139/ssrn.2732354>.
- BAHGA, A.; Madisetti, V. **Internet of Things: A Hands-on Approach**; VPT/Create Space Inc.: Atlanta, GA, USA, 2014; ISBN 978-0-9960255-1-5.
- BAYLISS, A. C., E REED, D. W. The use of historical data in flood frequency estimation. **Centre for Ecology and Hydrology**, 2001.
- BELLU, A., FERNANDES, L. F. S., CORTES, R. M., E PACHECO, F. A. A framework model for the dimensioning and allocation of a detention basin system: The case of a flood-prone mountainous watershed. **Journal of Hydrology**, 2016, 533, 567–580.
- BELMONTE, A. M. C., EBESCÓS, A. La creciente ocupación antrópica del espacio inundable y el aumento de la vulnerabilidad en las poblaciones del bajo Arga (Navarra). **Boletín de la Asociación de Geógrafos Españoles**, 2004, (37), 101-118.
- BOORSTIN, D. J. From news-gathering to news-making: A flood of pseudo-events. **The process and effects of mass communication**, 11650, 1971.
- BORN, PATRICIA; KLEIN, ROBERT W. Privatizing Flood Insurance in the United States: Options, Challenges, and Pitfalls. **Challenges, and Pitfalls (February 8, 2019)**, 2019.
- BOSOMPRA, KWADWO. African news in the world press: A comparative content analysis of a North and a South newspaper. **Africa Media Review**, 1989, 3.3: 58-69.
- BOUDOU, M.; DANIÈRE, B.; LANG, M. Assessing changes in urban flood vulnerability through mapping land use from historical information. **Hydrology and Earth System Sciences**, 2016, 20.1: 161-173.
- BRADFORD, DAVID F.; LOGUE, Kyle D. 7. **The Influence of Income Tax Rules on Insurance Reserves**. University of Chicago Press, 2007.
- CATALANO, B. P., E PANEQUE, L. **U.S. Patent Application**. 2019, No. 16/043,061. <https://patents.google.com/patent/US10210577B1/en>.
- CHENG, J., CHOW, T., LIN, T. T., E NG, J. **The Effect of SSAP 101 on Loss Provisioning by Property-Casualty Insurers**, 2019.
- COHEN, J. P., DANKO III, J. J., E YANG, K. Proximity to a water supply reservoir and dams: Is there spatial heterogeneity in the effects on housing prices?. **Journal of Housing Economics**, 2019, 43, 14-22. <https://doi.org/10.1016/j.jhe.2018.09.010>.
- COULDRY, N., & MEJIAS, U. A. Data colonialism: Rethinking big data's relation to the contemporary subject. **Television & New Media**, 2019, 20(4), 336-349. <https://doi.org/10.1177/1527476418796632>.
- CRUZ, C. O., & MARQUES, R. C. Revisiting the Portuguese experience with public-private partnerships. **African Journal of Business Management**, 2011, 5(11), 4023-4032.
- CUNHA, JOSÉ PEDRO; PEREIRA, JOSÉ LUÍS. Column-Based Databases: Estudo exploratório no âmbito das Bases de Dados NoSQL. **Atas da Conferência da Associação Portuguesa de Sistemas de Informação**. 2016. p. 440-459. <http://dx.doi.org/10.18803/capsi.v15.440-459>.

- DAVIS, T. J., engelhorn, a., e kornelis, C. S. **U.S. Patent Application**, 2019, No. 10/210,577. <https://patents.google.com/patent/US10210577B1/en>.
- DIREÇÃO GERAL DO TERRITÓRIO [DGT]. **Regiões hidrográficas portuguesas**. <http://mapas.dgterritorio.pt>. Regiões Hidrográficas do INAG em 2006, Hayford Gauss Datum Lisboa Militar (EPSG: 20790), 2006.
- DIREÇÃO GERAL DO TERRITÓRIO [DGT]. **Carta Administrativa Oficial de Portugal (CAOP)**, 2017.
- eBD. Eventos em base de dados para a BHRVez entre 1900/2015. Hayford Gauss Datum Lisboa Militar. **Imprensa periódica regional. Obra autónoma**, 2018.
- ESCHENFELDER, KRISTIN R., et al. A nine dimensional framework for digital cultural heritage organizational sustainability: A content analysis of the LIS literature (2000–2015). **Online Information Review**, 2018.
- FAMA, EUGENE F. Agency problems and the theory of the firm. *Journal of political economy*, 1980, 88.2: 288-307. <https://doi.org/10.1086/260866>.
- FAUL, Franz, et al. Statistical power analyses using G\* Power 3.1: Tests for correlation and regression analyses. **Behavior research methods**, 2009, 41.4: 1149-1160. <https://doi.org/10.3758/BRM.41.4.1149>.
- FORTIN, MARIE-FABIENNE. **Fundamentos e etapas do processo de investigação**. Lusodidacta, 2009.
- FRIMPONG, Eugene, et al. Flood insurance and claims: The impact of the Community Rating System. **Applied Economic Perspectives and Policy**, 2020, 42.2: 245-262.
- FULLER, DAN. Now what do we do? Sustaining statewide digital libraries for a second decade. **Teacher Librarian**, 2006, 34.1: 14.
- GASHER, MIKE, et al. Spreading the News: Social Determinants of Health Reportage in Canadian Daily Newspapers. **Canadian journal of communication**, 2007, 32. <https://doi.org/10.22230/cjc.2007v32n3a1724>.
- GONCALVES, M. G. S. **As cheias na bacia hidrográfica do rio Vez durante os séculos XX e XXI e a sustentabilidade**. (Tese de Doutoramento). Universidade Aberta, 2018. <https://repositorioaberto.uab.pt/handle/10400.2/7981>.
- GORI, AVANTIKA, et al. Characterizing urbanization impacts on floodplain through integrated land use, hydrologic, and hydraulic modeling. **Journal of Hydrology**, 2019, 568: 82-95. <https://doi.org/10.1016/j.jhydrol.2018.10.053>.
- GROSSO, N., et al. Continental portuguese territory flood social susceptibility index. **Natural Hazards and Earth System Sciences**, 2015, 15.8: 1921-1931.
- GUENTHER, David A.; MAYDEW, EDWARD L.; NUTTER, SARAH E. Financial reporting, tax costs, and book-tax conformity. **Journal of Accounting and Economics**, 1997, 23.3: 225-248. [https://doi.org/10.1016/S0165-4101\(97\)00009-8](https://doi.org/10.1016/S0165-4101(97)00009-8).
- HENSTRA, DANIEL; MINANO, ANDREA; THISTLETHWAITE, JASON. Communicating disaster risk? An evaluation of the availability and quality of flood maps. **Natural hazards and earth system sciences**, 2019, 19.1: 313-323. <https://doi.org/10.5194/nhess-19-313-2019>.
- HIPÓLITO, J. R., E VAZ, Á. C. **Hidrologia e Recursos Hídricos (2.ª)**. Instituto Superior

Técnico de Lisboa, 2013.

HOCHRAINER-STIGLER, STEFAN; LINNEROOTH-BAYER, Joanne; LORANT, Anna. The European Union Solidarity Fund: an assessment of its recent reforms. **Mitigation and Adaptation Strategies for Global Change**, 2017, 22.4: 547-563. <https://doi.org/10.1007/s11027-015-9687-3>.

HOLUB, Markus; FUCHS, SVEN. Mitigating mountain hazards in Austria—legislation, risk transfer, and awareness building. **Natural Hazards and Earth System Sciences**, 2009, 9.2: 523-537. <https://doi.org/10.5194/nhess-9-523-2009>.

HOOPES, JEFFREY L.; MESCALL, Devan; PITTMAN, Jeffrey A. Do IRS audits deter corporate tax avoidance? **The accounting review**, 2012, 87.5: 1603-1639. <https://doi.org/10.2308/accr-50187>.

INSTITUTO GEOGRÁFICO DO EXÉRCITO [IGeoE]. **Carta Militar de Portugal**. Folhas: 3, 4, 8, 9, 16, 16, 28 e 29. [www.igeoe.pt](http://www.igeoe.pt). Escala 1:25 000, 1996, 1997.

INSTITUTO NACIONAL DE ESTATÍSTICA (INE). **Recenseamento da População e Habitação**, 1900-2011.

JENSEN, MICHAEL C.; MECKLING, WILLIAM H. Theory of the firm: Managerial behavior, agency costs and ownership structure. **Journal of financial economics**, 1976, 3.4: 305-360. [https://doi.org/10.1016/0304-405X\(76\)90026-X](https://doi.org/10.1016/0304-405X(76)90026-X).

LINNEROOTH-BAYER, JOANNE, et al. Insurance as a Response to Loss and Damage? **Loss and Damage from Climate Change**. Springer, Cham, 2019. p. 483-512. <https://doi.org/10.1007/978-3-319-72026-5>.

LO, Shi-Wei, et al. Cyber surveillance for flood disasters. **Sensors**, 2015, 15.2: 2369-2387. <https://doi.org/10.3390/s150202369>.

MARIN-PEREZ, RAFAEL; GARCÍA-PINTADO, Javier; GÓMEZ, Antonio Skarmeta. A real-time measurement system for long-life flood monitoring and warning applications. **Sensors**, 2012, 12.4: 4213-4236. <https://doi.org/10.3390/s120404213>.

MILLER, BENJAMIN; DIXON, Lloyd; CLANCY, Noreen. Reasonable and risk-based? Replacing NFIP generally subsidized rates with a means-tested subsidy. **Southern Economic Journal**, 2019, 85.4: 1180-1195. <https://doi.org/10.1002/soej.12329>.

MILLS, K. A. Big Data for Qualitative Research. **Routledge**, 2019. <https://doi.org/10.4324/9780429056413>.

MORENO, CARLOS, et al. RiverCore: IoT device for river water level monitoring over cellular communications. **Sensors**, 2019, 19.1: 127. <https://doi.org/10.3390/s19010127>.

MOSS, D. A. **When all else fails: Government as the ultimate risk manager**. Harvard University Press, 2004.

DOERR, MARTIN, et al. Realizing lessons of the last 20 years: A manifesto for data provisioning & aggregation services for the digital humanities (a position paper). **D-lib magazine**, 2014, 20.7/8. <https://doi.org/10.1045/july2014-oldman>.

PÁLINKÓ, Éva; SZABÓ, MÁRTA. Application of social discount rate in public projects. **Public Finance Quarterly**, 2012, 57.2: 184.

PESTANA, M. H. E GAMEIRO, J. N. **Análise de dados para ciências sociais. A complementaridade do Spss**. Edições Sílabo, 2014.

- RAMACHANDRAN, Vijay; GELB, Alan; BUEHLER, Martin Reto. **Service Performance Guarantees for Public Utilities and Beyond**. 2019.
- RAMOS, CATARINA. A influência das situações anticiclónicas no regime da precipitação em Portugal. **Finisterra**, 1987, 22.43.
- PEREIRA, A. RAMOS; RAMOS, CATARINA. **Avaliação da diversidade biofísica do território** (base administrativa). 1998.
- RILO, A., et al. Historical flood events in the Tagus estuary: contribution to risk assessment and management tools. **Safety and reliability of complex engineered systems, natural hazards**. CRC Press, Taylor and Francis Group, London, 2015, 4281-4286.
- SHINKO, T.; MECHER, R.; HOCHRAINER-STIGLER, S. The risk and policy space for loss and damage: integrating notions of distributive and compensatory justice with comprehensive risk management. **Loss and damage from climate change: concepts, methods and policy options**, 2019, 83-110.
- SCOTT, J. B. **U.S. Patent Application, 2019 No. 16/194,905**. <https://patents.google.com/patent/US20190087909A1/en>, (Consulta a 4 de maior de 2019).
- SHREVE, RONALD L. Statistical law of stream numbers. **The Journal of Geology**, 1966, 74.1: 17-37. <https://doi.org/10.1086/627137>.
- SISTEMA NACIONAL DE INFORMAÇÃO DE RECURSOS HÍDRICOS [SNIRH]. **Dados sintetizados**. Agência Portuguesa do Ambiente, 1959/1990. <http://snirh.apambiente.pt>.
- SMITH, BARRY D. An analysis of auto liability loss reserves and underwriting results. **Journal of Risk and Insurance**, 1980, 305-320. <https://doi.org/10.2307/252334>.
- SMITH, V. Kerry; WHITMORE, BEN. **Amenities, risk, and flood insurance reform**. National Bureau of Economic Research, 2019.
- STRAHLER, ARTHUR N. Hypsometric (area-altitude) analysis of erosional topography. **Geological society of America bulletin**, 1952, 63.11: 1117-1142.
- STRAHLER, ARTHUR N. Quantitative analysis of watershed geomorphology. **Eos, Transactions American Geophysical Union**, 1957, 38.6: 913-920.
- SUN, ALEXANDER Y.; SCANLON, BRIDGET R. How can Big Data and machine learning benefit environment and water management: a survey of methods, applications, and future directions. **Environmental Research Letters**, 2019, 14.7: 073001. <https://doi.org/10.1088/1748-9326/ab1b7d>.
- THISTLETHWAITE, JASON, et al. How flood experience and risk perception influences protective actions and behaviours among Canadian homeowners. **Environmental management**, 2018, 61.2: 197-208. <https://doi.org/10.1007/s00267-017-0969-2>.
- TURCONI, L.; NIGRELLI, Guido; CONTE, R. Historical datum as a basis for a new GIS application to support civil protection services in NW Italy. **Computers & Geosciences**, 2014, 66: 13-19. <https://doi.org/10.1016/j.cageo.2013.12.008>.
- UNTERBERGER, CHRISTIAN, et al. Future public sector flood risk and risk sharing arrangements: An assessment for Austria. **Ecological economics**, 2019, 156: 153-163. <https://doi.org/10.1016/j.ecolecon.2018.09.019>.