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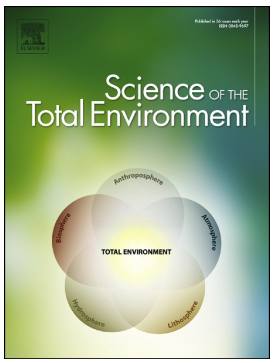

Indicators for the assessment of social resilience in flood-affected communities – A text mining-based methodology

R. Jacinto, E. Reis, J. Ferrão

PII: S0048-9697(20)34502-2

DOI: https://doi.org/10.1016/j.scitotenv.2020.140973

Reference: STOTEN 140973

To appear in: *Science of the Total Environment*

Received date: 1 April 2020

Revised date: 12 July 2020

Accepted date: 12 July 2020

Please cite this article as: R. Jacinto, E. Reis and J. Ferrão, Indicators for the assessment of social resilience in flood-affected communities – A text mining-based methodology, *Science of the Total Environment* (2020), https://doi.org/10.1016/j.scitotenv.2020.140973

Indicators for the assessment of social resilience in flood-affected communities – a text mining-based methodology.

Authors:

JACINTO, R.[1]; REIS, E.[1,] FERRÃO, J.[2]

(1) Universidade de Lisboa, Centro de Estudos Geográficos, IGOT, Lisboa, Portugal (ritajacinto@campus.ul.pt)

(2) Instituto de Ciências Sociais, Universidade de Lisboa, Lisboa, Portugal

Keywords

Social Resilience; Floods; Resilience Indicators; Text Mining; Experts' opinions

Abstract:

This work turns the social resilience concept into a practical and tangible set of dimensions and indicators for social resilience assessment. It further provides an analysis of the social resilience concept in the context of flood risk governance.

Floods are a worldwide recurring phenomenon that causes severe social, economic and environmental losses. In the context of global change, it is very difficult to accurately predict extreme events that may increase disaster frequency; hence the implementation of social resilience is essential to lessen the losses. Indeed, the right balance between natural and social factors and indicators is yet to be found.

Social resilience has been debated extensively for decades, both in scientific and political contexts. It has been a concern in disaster risk reduction and risk governance fields, both of which have strived to implement it. The enlarged conceptual discussion regarding this topic has resulted in some indicator-based assessments that hardly reflect the conceptual discussion developed so far. These indicator-based approaches still lack accurate inclusion of social dynamics and the capacity to learn from experience.

In order to contribute to a comprehensive approach (concept and methods) for assessing social resilience to floods, the evolutionary resilience concept (Davoudi, Simin; Shaw, Keith; Haider, L. Jamila; Quilnlan, Allyson E; Petterson, Garry D.; Wilkinson, Cathy; Fünfgeld, Hartmut; McEvoy, Darryn; Porter, 2012) was considered as a reference in this work, as it can include dimensions that are difficult to evaluate (non-static time and learning-capacity in multi-dimensional systems).

This work addresses the challenge of a conceptual overview of social resilience to include key factors and indicators. Our methodology uses text mining, experts' surveys and bibliography reviews to generate an indicators database.

The contribution of this article to the scientific debate on social resilience assessment is twofold. First, the key-concepts, words and expressions in this field are identified, which provides the basis to build a comprehensive and coherent analytical framework. Secondly, an original indicators database is proposed in line with that framework. The results of a text mining-based methodology and an online survey, involving experts from different countries, show that four of the six dimensions of the indicators database refer to social aspects of risks (Individuals, Society, Governance, and Built Environment), while the remaining two refer to the Environment and Disaster. The results obtained so far suggest the need for a next step aiming to validate the dimensions and the indicators of this database through its application to real case studies.

1. Introduction

The losses caused by worldwide extreme events have escalated in recent decades (Abdulkareem and Elkadi, 2018; Saja et al., 2018). Application of the resilience concept to a social-ecological context emerged as the means to bring about a shift in the disaster risk reduction approaches designed to improve the safety of humans and their well-being (Chuang et al., 2018). In this paper, floods are the natural hazard included in a social resilience assessment.

The concept of resilience in disaster risk management and social-ecological fields has been evolving progressively. Some authors (Alexander, 2013a; Ayyoob Sharifi, 2016; Davoudi et al., 2012b; Folke, 2006) have pointed out that its origin is the Latin word '*resilire'* or *'resi-lire'* which means bounce, which in this context means to bounce or to spring back (Alexander, 2013a; Davoudi, Simin; Shaw, Keith; Haider, L. Jamila; Quilnlan, Allyson E; Petterson, Garry D.; Wilkinson, Cathy; Fünfgeld, Hartmut; McEvoy, Darryn; Porter, 2012). Holling's work has given a major spur to the inclusion of the resilience concept in the social-ecological field (Holling, 1973). For several years thereafter, this inclusion of the resilience concept was based on the comparison between resilience and vulnerability (Cutter et al., 2014; Dyah Kusumastuti et al., 2014; Graziano and Rizzi, 2016; I. Kelman et al., 2015; Schelfaut et al., 2011; Usamah et al., 2014), and between resilience and adaptation/ adaptive capacity (Cutter et al., 2014; Davoudi et al., 2013; Ilan Kelman et al., 2015; Schelfaut et al., 2011; Tanner et al., 2014; Ungar, 2011). The evolution of this inclusion process has progressed through the referred phases up to the most recent evolutionary classification of the concept of social-ecological resilience - evolutionary resilience (Abdulkareem and Elkadi, 2018; Boschma, 2015; Davoudi et al., 2016, 2013; Hogarth and Wójcik, 2016; Sgrò et al., 2011).

A special focus is given in our approach to the evolutionary resilience concept (Abdulkareem and Elkadi, 2018; Davoudi et al., 2016, 2013; Sgrò et al., 2011), as it embeds the challenge of including two dimensions in the social resilience assessment which are not trivial to measure the individuals and communities: 1) evolving capacity with a non-stable time view; and 2) learning ability, the aptitude to respond to changes (Chuang et al., 2018). Hence the idea of equilibrium/stability is put aside by the inclusion of the system's natural tendency to change (Davoudi, Simin; Shaw, Keith; Haider, L. Jamila; Quilnlan, Allyson E; Petterson, Garry D.; Wilkinson, Cathy; Fünfgeld, Hartmut; McEvoy, Darryn; Porter, 2012).

Currently, politicians and international organizations (Cutter et al., 2014; Davoudi et al., 2012a) are pushing for the application and inclusion of resilience-based approaches and assessments (SEI, 2016; UNISDR, 2015) in disaster risk reduction actions and planning, especially since the launch of the Sendai Framework in 2015 (Saja et al., 2018). However, SR still lacks clarity in its conceptual frame(Davoudi, Simin; Shaw, Keith; Haider, L. Jamila; Quilnlan, Allyson E; Petterson, Garry D.; Wilkinson, Cathy; Fünfgeld, Hartmut; McEvoy, Darryn; Porter, 2012) as well as accurate methods of assessment and procedure (Adini et al., 2017; Ayyoob Sharifi, 2016; Barnett et al., 2016; Béné et al., 2017; Chuang et al., 2018; Cutter et al., 2014; Michel-Kerjan, 2015). Quantitative methods are essential whenever observing or analysing any kind of system (Holling, 1973). This lack of accuracy in the assessment methods is more evident when comparing the methods to assess social resilience with, for instance, the methods to assess social vulnerability. The latter has far more applications in many countries around the world, namely in Portugal where this research is being conducted (Gall et al., 2015; Ilan Kelman et al., 2015; Rufat et al., 2017; Sá, Luis; Vicêncio, 2011).

This paper addresses a scientific gap identified through bibliography reviews i.e. the need for a clear conceptual framework that can provide quantitative assessments of social resilience at a given time rather than only in post-disaster situations (Adini et al., 2017; Ayyoob Sharifi, 2016; Béné et al., 2017; Cutter et al., 2014; Davoudi, Simin; Shaw, Keith; Haider, L. Jamila; Quilnlan, Allyson E; Petterson, Garry D.; Wilkinson, Cathy; Fünfgeld, Hartmut; McEvoy, Darryn; Porter, 2012; Linkov et al., 2014; Saja et al., 2018). The aforementioned gap is due to the fact that the resilience concepts and approaches in risk governance developed so far are too broad, since they apply to many different fields (Adini et al., 2017) and therefore are not focused on a specific scientific area or type of disaster.

This paper presents the results of social resilience in flood-affected communities. These results consist of a stable set of keywords, key dimensions and the means to measure them – indicators, framed within a type of disaster such as floods. To reach such results, the proposed methodology included scientific peer-reviewed papers, experts' opinions, and text mining. This work is a contribution to the stabilization of social resilience assessment in the risk governance field, as it presents a scientific basis to outline an indicators database.

A conceptual overview, regarding the state of the art and this work view regarding this concept, is found in section 2. The state of the art concerning indicator-based studies on social resilience is presented in section 3. The description of the proposed methodological approach can be seen in section 4. The results and their consequent discussion are explained in section 5. The main assumptions and next steps are in the Conclusion section.

2. Social Resilience

2.1. Overview and main scientific gaps addressed

Despite the widespread discussion amidst the scientific community regarding the concept of SR applied to disaster risk management (Chuang et al., 2018; Cutter et al., 2014), several scientific gaps remain that prevent its wider application. Some of these gaps are identified in scientific publications, the theoretical and methodological proposal of this paper being a contribution to the much-needed enhancement and advancement (Béné et al., 2017) of SR assessment.

SR, just like any social science field, finds its topmost difficulty in the non-static and non-easily quantifiable nature of the study-object - communities and individuals (Saja et al., 2018). The nature of the study-object, the wide conceptual discussion combined with its lack of conceptual clarity and its few robust practical applications (Davoudi, Simin; Shaw, Keith; Haider, L. Jamila; Quilnlan, Allyson E; Petterson, Garry D.; Wilkinson, Cathy; Fünfgeld, Hartmut; McEvoy, Darryn; Porter, 2012), turn SR into a scientific area with large methodological gaps (Pizzo, 2015). SR applies to communities that are groups of individuals (Kwok et al., 2016) with interconnected practices in which social and natural processes take place (Davoudi, Simin; Shaw, Keith; Haider, L. Jamila; Quilnlan, Allyson E; Petterson, Garry D.; Wilkinson, Cathy; Fünfgeld, Hartmut; McEvoy, Darryn; Porter, 2012). Time dependence must, somehow, be contemplated, but the dependence might not be linear given the intrinsic learning capability (Holling, 1973) of communities and individuals. Another question arises about the independence of SR from disasters (Adini et al., 2017), although this is a social and, therefore, a non-spatial phenomenon (Saja et al., 2018). Resilience promotion has a somewhat 'preparedness' facet, which tends to frame SR studies according to some disaster/hazard or threat to the individuals and communities. The purpose of its study is to contribute to resilience promotion within a certain location where individuals are exposed to floods. The third question under consideration concerns the main components that can determine the indicators of SR assessment (Khalili et al., 2015a).

Despite the still inaccurate conceptualization, resilience has become part of the political agenda worldwide (Cutter et al., 2014; Davoudi, Simin; Shaw, Keith; Haider, L. Jamila; Quilnlan, Allyson E; Petterson, Garry D.; Wilkinson, Cathy; Fünfgeld, Hartmut; McEvoy, Darryn; Porter, 2012; Wilson, 2012), and this might result in a two-sided problem: first, the lack of dialogue between academia and politicians (Béné et al., 2017) and secondly, the excessive interdependence between research and political needs. Given the importance of using SR, it is necessary to identify the determinants (Madewell and Ponce-Garcia, 2016) and dimensions to be included in its assessment. For example, an index suitable to respond to the different phases of disaster governance (pre-disaster/prevention, response and recovery) (Khalili et al., 2015a), or an index just to monitor resilience, since it is necessary to find indicators and assessment methods that go beyond the post-risk stage (Davoudi, Simin; Shaw, Keith; Haider, L. Jamila; Quilnlan, Allyson E; Petterson, Garry D.; Wilkinson, Cathy; Fünfgeld, Hartmut; McEvoy, Darryn; Porter, 2012).

2.2. Overview: framing decades of discussion into tendencies

The definition and dimensions of SR may change according to the perspective or field in which SR is used (Saja et al., 2018). Figure 1 shows a summary of some interpretations of the resilience concept within the social-ecologic context over time.

Several works (Alexander, 2013a; Ayyoob Sharifi, 2016; Davoudi et al., 2012b) have described the evolution of the concept of resilience and its inclusion under the disaster risk reduction field. The main scientific tendencies are presented in Figure 1, using some of the mentioned reviews as references, to compare and identify the main differences and similarities amongst them.

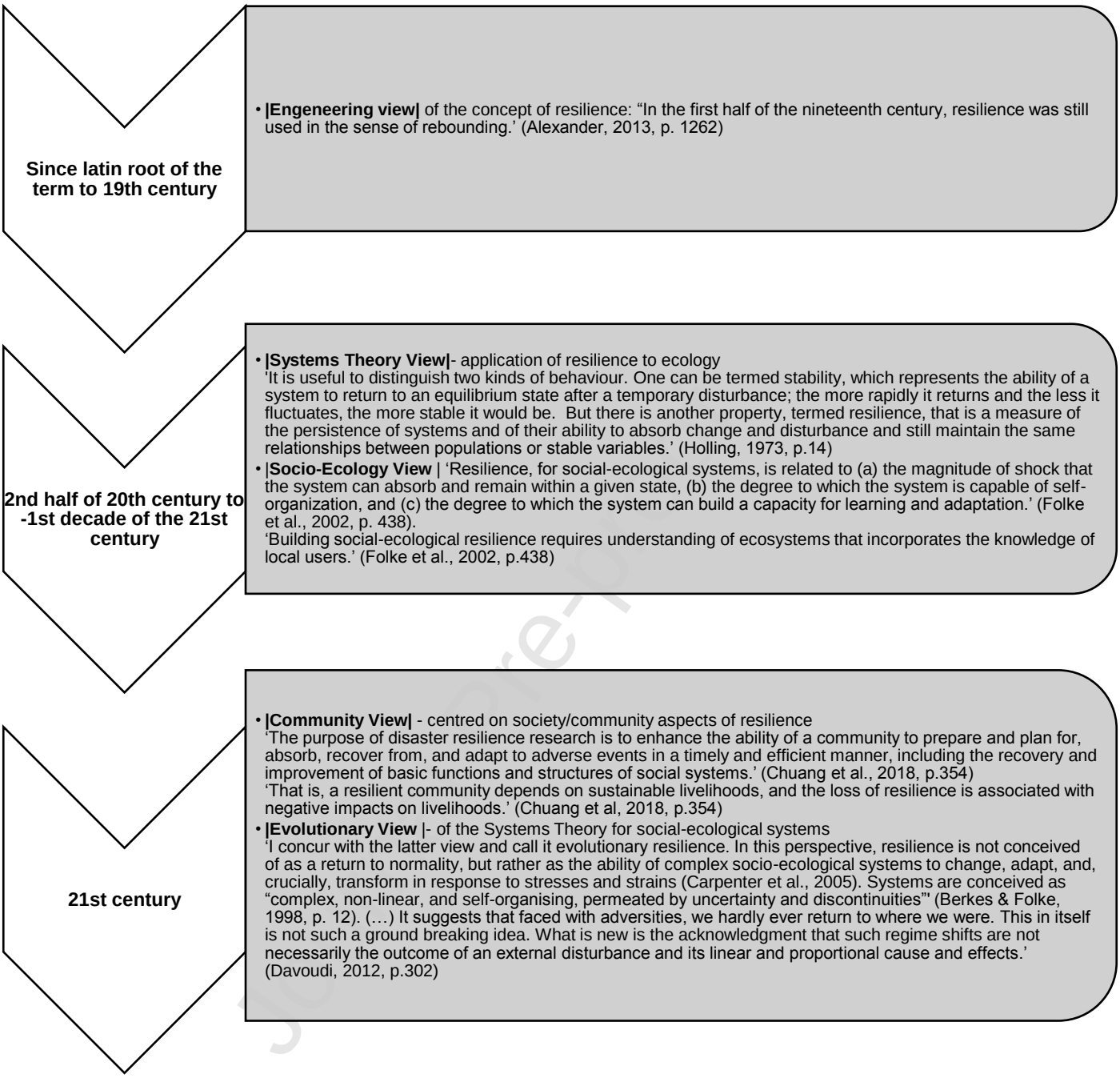

Figure 1 - The resilience concept theoretical influences across time and perspectives (Alexander, 2013a; Chuang et al., 2018; Davoudi, Simin; Shaw, Keith; Haider, L. Jamila; Quilnlan, Allyson E; Petterson, Garry D.; Wilkinson, Cathy; Fünfgeld, Hartmut; McEvoy, Darryn; Porter, 2012; Folke, Carl; Carpenter, Steve; Elmqvist, Thomas; Gunderson, Lance; Hollling, CS; Walker, 2002; Holling, 1973)

Figure 1 shows quotations from different works at different periods that facilitate the comparative analysis of distinct views of the concept of resilience and its integration into the social-ecological field. Those quotations show that, as a cycle, the recently named evolutionary resilience, as proposed by Davoudi (2012), is very similar to the Ecology – Systems Theory proposed by Holling in 1973. In fact, both refer to the ability to change or to absorb change and to the relationships between organizations inside the systems, that were also referred to by Folke et al. (2002)(Davoudi et al., 2012a; Folke, Carl;

Carpenter, Steve; Elmqvist, Thomas; Gunderson, Lance; Holling, CS; Walker, 2002; Holling, 1973). However, there are several works, such as the ones by Alexander in 2013, that compared or overlapped resilience with adaptation or vulnerability(Alexander, 2013b). It might be an attempt to integrate this new and not yet quantifiable concept into existing, established concepts. According to Holling (1973), the main ideas behind the evolutionary view are that time is non-linear; that society has a self-organizing capacity derived from its relationships that can be described as learning capability and it must be taken into consideration, and that resilience is intrinsic and does not emerge only in the face of danger. The recent conceptual approach of evolutionary resilience is, after all, not so different from the one presented by Holling (Holling, 1973) (see table 1), as both recognize the social-ecological systems as being unstable and ever-changing. Therefore, we agree to call it evolutionary resilience, though acknowledging it as being based on the systems theory as proposed in 1973 by Holling.

Chuang et al. (2018) presented a comparison between ecological resilience and community resilience and found that the main difference concerns the approach to scales(Chuang et al., 2018). The authors also concluded that the application of ecological resilience to community quantitative assessment may be a good way to manage change in systems that include human and natural dimensions and interactions(Chuang et al., 2018). Therefore, it can be assumed that as in any territorial phenomena concerning social-ecological relations, the problem of scales is also a challenge in social resilience to floods.

2.3. Adopted conceptual frame

Having presented a short review of literature highlighting some of the ideas on social resilience, as referred by Alexander (2013), it becomes clear that it is so extensive as to make a full review an almost impossible task (Alexander, 2013a); therefore, a conceptual framework is presented herein.

This research theoretical framework of social resilience – considers SR (see Figure 2) as a relevant dimension of risk governance, whose central concern are the individuals and their sustainability and security. SR is an inherent characteristic of individuals and, therefore, of communities and society. SR is part of a social-ecological context where risk and territory governance are put into practice via public policy actions and agents. In this context, individuals, communities and society present: (i) social resilience – positive characteristics or enhancement of inherent capacities (Asadzadeh et al., 2017) that promote well-being and recovery, as well as the ability to learn; and (ii) social vulnerability – debilities that intensify the possibility of damage or the susceptibility to harm (Jacinto et al., 2015), and a lack of sustainability for the individuals and communities, especially when facing a disastrous event.

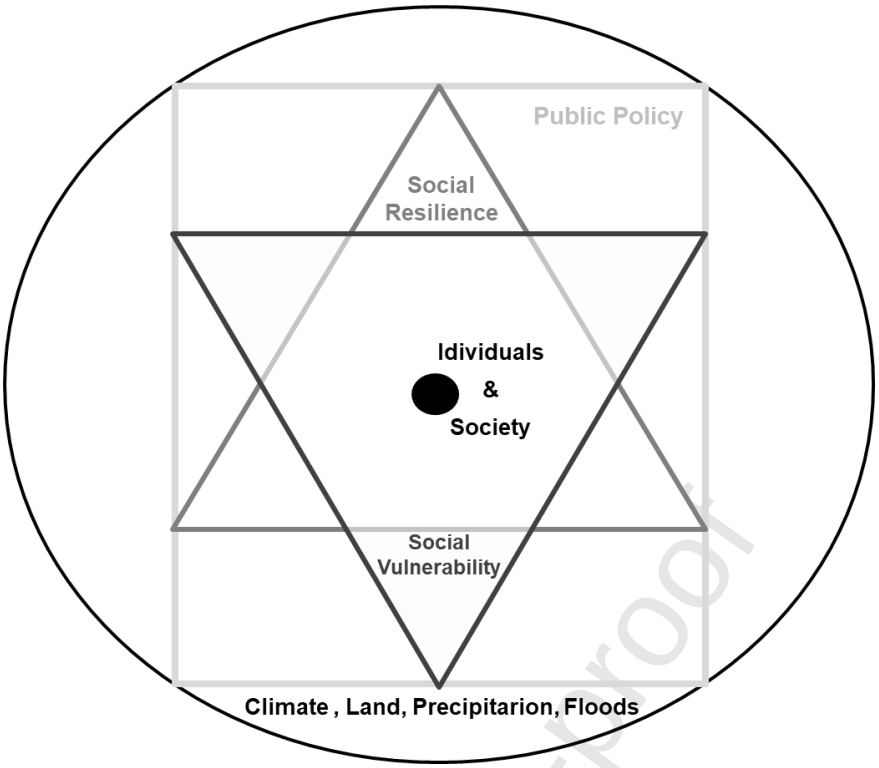

Figure 2 - Conceptual framework

Source: author's elaboration

3. Social Resilience Assessment: a review of indicator-based studies

The measurement of resilience has been pointed out as one of the scientific gaps in this field (Davydov et al., 2010; J. J. W. Liu et al., 2017), as well as the major difficulty for the implementation of the Sendai Framework (SEI, 2016). Measurement/quantification methods need to be developed to: i) evaluate beyond the post-event in the normal state, ii) reveal the multidimensional reality of individuals and communities, which are composed of multiple systems, and iii) capture the reality at different scales (individual, family, community, society). (Allen et al., 2014; Asadzadeh et al., 2017; J. J. W. Liu et al., 2017). The approaches developed so far to assess resilience are indicator-based. As previously mentioned, the political contexts and policy requirements now call for the implementation of resilience assessments. The development of such approaches is of great importance not only to the scientific advancement in the field but also because it may help people and institutions to deal with uncertainties (Folke, Carl; Carpenter, Steve; Elmqvist, Thomas; Gunderson, Lance; Holling, CS; Walker, 2002). These approaches are now starting to use composite indicators (Asadzadeh et al., 2017) and be compared concerning the dimensions they include (Saja et al., 2018). A summary of the main results and conclusions of the ongoing challenge of measuring resilience is presented in this section, by showing different indicator/measurement-based studies over the last decade, and of the resilience assessment in the disaster governance field.

FREEMAM project (Schelfaut et al., 2011), developed from May 2009 to September 2011, was one of the first that attempted to apply the resilience concept to the flood risk management field in Europe. It focuses on three case studies, Flanders (Belgium), Niedersachsen (Germany) and Calabria (Italy), in which the use of indicators was made for three dimensions: the interplay of institutions, flood risk

communication, and flood modelling tools. The increase of both stakeholders participation and bottom-up investments was considered as a crucial point to be strengthened.

Davoudi et al. (2012) regarded the studies that assessed resilience solely by means of indicators, such as time of emergency response, as reductionist approaches (Davoudi et al., 2012b). The authors presented a conceptual model in which the main components/variables to manage a pasture social-ecological system were treated in an integrated way. These main components/variables are external controls (such as climate change, political and social instability, civil war, insurgency and migration), social-ecological system slow-changing components, and social-ecological system fast-changing components.

Focussing on the social dimension of disaster resilience, Khalili and Morley (2015) developed indicators for the pre-disaster, response and recovery phases. They included technical, economic, organizational and social dimensions in the framework of resilience. In this study, resilience indicators were listed based on scientific bibliography reviews. They applied a semi-structured interview to the subject matter experts (SMEs) to gather data about resilience indicators and measurement methods. They concluded that some indicators – such as 'Sense of community, Education, Community Participation, Social Support, Learning, Trust, Exchange of information, Shared information' (Khalili et al., 2015a) – have more impact in the measurement of SR and that those indicators should be considered in the different phases of disaster resilience management. Their conclusion highlighted the need to research the impact of social networks on social resilience within communities to improve community evaluations.

Restemeyer et al. (2015) proposed 'A strategy-based framework for assessing the flood resilience of cities' using a case study-based approach. They concluded that holistic resilience building requires boosting social and political capital and therefore, 'policy-makers should consider social justice and equity aspects.' (Restemeyer et al., 2015).

A framework of eight steps to generate composed indicators was presented by Asadzadeh et al. (2017). Their study showed, through a comparison of different frameworks, that there are mainly two types of methodologies to assess resilience: i) deductive/hierarchical, e.g., usage of expert surveys, and ii) inductive, e.g., Principal Components Analysis. A reference is made in the literature review section to the absence of the environmental dimension in the resilience measurements (Asadzadeh et al., 2017).

The work 'Squaring the Circle: Reconciling the Need for Rigor with the Reality on the Ground in Resilience Impact Assessment', Béné et al. (2017) show the process and the results of a 3-year programme (Béné et al., 2017). In order to enhance resilience, they presented a log frame with indicators grouped by nature, level of intervention and data collection frequency. The data frequency varies with the required inputs of the model (treatment group and control group are required) and with the impact and stressor in the following order: evaluation/initial state - evaluation/final state. The level of intervention varies from the input (some need data before the event, therefore the approach varies depending on the available data) to the impact: programme, individual, household, community or

system levels. According to their nature, indicators can be classified as input measurable indicators, activity/outputs measurable indicators, resilience capacity indicators, effective resilience response indicators, wellbeing indicators, and shock/stressor indicators (Béné et al., 2017). This approach included a control group and a treatment group for validation. The authors noted that resilience assessments are still in the starting phase.

In 2017, Wickes et al. presented indicator-based research, in which the level of stability, the collective efficacy and the social capital of a neighbourhood were analysed in two different periods, before and after a disaster, in order to verify if the analysed community dimensions could persist after a significant shock – flood (Wickes et al., 2017). Some of the main findings of this research were: neighbourhood measurements are very stable across time, regardless of whether the neighbourhood is affected by floods or not; collective efficacy is a dormant characteristic that appears to be activated only when needed. They also suggested that the social processes are relevant at the neighbourhood level and highlighted the need for preparation of non-affected neighbourhoods against risk.

Chuang et al. (2018) presented a comparison of different quantitative methods to access community resilience. They grouped these methods into Place-based resilience metrics (that focus the 'spatial aspects of community resilience and attempted to quantify' it), Coupled social-ecological metrics (which combine system dynamics and system complexity tools to analyse how the components of social-ecological systems interrelate with each other) and Teleconnection metrics (that evaluate the non-linear dynamics in a nested system and is mainly a qualitative analysis, that allows 'to explore and quantify the magnitude of reinforcing and stabilizing feedbacks in a system')(Chuang et al., 2018).

According to the recent history of resilience assessment, several studies show the need to clearly define the variables to be measured to better understand resilience and even to improve its definition. Several works show results about possible dimensions and indicators, based on theoretical discussions or specific case studies. This work's contribution is to set standard dimensions and to present, for each dimension, a group of different indicators based on scientific literature and experts' opinions. The methodology developed in this research is explained in the next section.

4. Methods

In order to reach new conclusions, different perspectives and methods must be attempted. Several questions related to resilience measurement and to the current state of the art need answering. Some of those questions are: i) which dimensions and which indicators pertaining to each dimension should be chosen/selected; ii) which weight should be assigned to the various dimensions, which indicators and dimensions weights are more adequate for each reality, and how to include the natural learning and adaptive capacities of individuals and communities (Béné et al., 2017; Saja et al., 2018; Tyshchuk and Wallace, 2018).

This paper aims to propose a set of indicators based on the state of the art and organized according to resilience dimensions that may compose a social resilience index. The methodology consisted of the selection of scientific papers for the application of text mining and the selection of experts to take part

in a survey. The obtained results are used as a control to validate and compare with the text mining results.

The selection of a set of scientific papers was done through online search engines, mainly Science Direct and Web of Knowledge. The following keywords (Figure 3) were used in the search and selection of papers: 'evolutionary resilience', 'community resilience', 'social resilience', 'resilience to floods', 'resilience assessment' and a combination of the previous keywords. A set of articles considered to be representative of the state of the art and of the thematic were selected for analysis through the application of text mining (TM).

Figure 3**Error! Reference source not found.** shows the methodological flowchart. Selected scientific texts to be analyzed with TM were then organized in two ways: 1. full articles about the two main issues: i) evolutionary resilience, and ii) social and community resilience; and 2. Excerpts about social/community or floods resilience: a) indicators and b) dimensions.

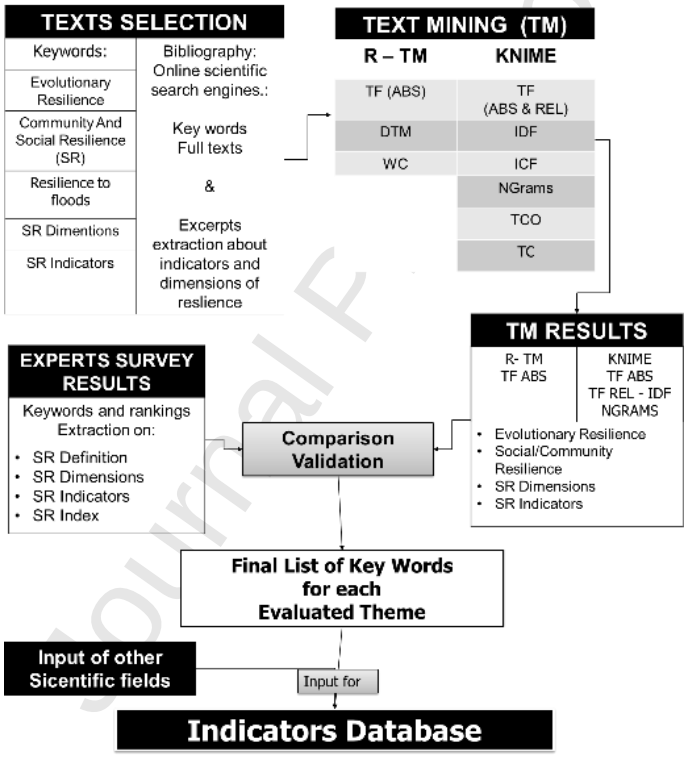

Figure 3 - Methodological flowchart

Source: author's elaboration

4.1. Text Mining

The text mining (TM) approach was chosen to ensure an objective method that takes into account the keywords and key dimensions selection. It was applied to identify the frequency with which terms and expressions occurred in the group of pre-selected, fully or partially extracted, texts of scientific articles.

Text mining (TM) has been used in social sciences and has also been applied, for instance, in Lake Basin Governance studies (Emmanuel Cookey et al., 2017).

Extraction of data was achieved by means of TM application on selected texts. Two software were used, KNIME and R Studio – TM package.

Having applied KNIME and R Studio for term frequency absolute (TF ABS) – the number of times a term appears in a set of texts – the results of the two software were compared. Post-processing of the results was implemented to remove outlier keywords as well as to remove duplicates.

For each TF ABS results, the selection criteria consisted in adopting the 15 most frequent terms since the analysis of the 3rd quartile showed large differences in the number of words between Knime and R (see Table 1). This lack of correlation between the results, resulting from the application of two different software, determined that only one could be used for other indicators. KNIME was chosen to analyze TF ABS and other variables. This means that the selection of bi-grams (a combination of two adjacent terms and the analysis of its frequency in the set of texts), as well as the term frequency relative (TF Rel) (number of times the term appears compared to the other terms in the set of texts) were implemented only on KNIME.

Table 1- Comparison of the absolute term frequency in Q3 for KNIME and R Studio in Evolutionary Resilience texts

Software	Q3 | Nr terms
Knime	14
R-tm package	203

Source: author's elaboration

This research methodology involved selecting keywords and included the comparison of the 15 most frequent terms in KNIME and R-tm, out of which only the five most frequent ones were selected. The term ‘resilience’ was maintained as part of the results, meaning that many composed keywords – bi-grams – contain this term.

Amongst the 15 most frequent bi-grams, the six most frequent ones contained two or at least one of the five selected keywords.

It is important to refer that this research methodology has some limitations, namely, it doesn’t contemplate all the literature on social resilience, it is also conditioned by the keywords and the search engine used to collect the original texts as well as by the authors' selected excerpts. Nevertheless, the adopted research methodology is impartial as the authors' excerpts used to in the current work were not subjected to personal interpretations.

4.2. Experts Survey

Expert opinions were collected via an online survey using eSurvey Creator (www.esurveycreator.com; currently SurveyHero – www.surveyhero.com). The selection of experts was done through literature review and an online search of authors profile in the scientific Academia network. The authors of the

pre-selected texts were contacted and asked to complete a questionnaire. Adini et al. (2017) used a comparable approach, by applying an online survey of experts to extract resilience concepts, approaches and practices (Adini et al., 2017).

Data collected through the online survey gathered the tendencies and keywords on how experts define, assess and evaluate social resilience (SR). Further to the pre-selected options, the experts had the opportunity to express their own ideas using the open and feedback fields (see Table 2).

Survey questions 1, 2 and 3 requested experts to convey their level of agreement (options: disagree; partially disagree; partially agree; agree) to a set of pre-defined sentences. Questions 1-3 dealt respectively with resilience concept (see Figure 4 - the appendix 1), resilience assessment (data and scale of analysis required to evaluate social resilience in flood-affected communities), and methodologies to assess social resilience. Question 4.1. required the selection of one or more dimensions of resilience calculation from a pre-defined list of resilience dimensions and provided the possibility to add other options/dimensions. Question 4.2 was an open question that encouraged experts to give their opinion on whether the dimensions had the same weight.

Table 2 - Experts Survey Structure

Section	Questions	Type of question
SR Concept and its applications	• Concept	Closed | Agreement level
	• Assessment	Closed | Agreement level
	• Methods	Closed | Agreement level
SR to Floods Components/Dimensions	• Components of an index	Closed | Multiple choice Open | Text box
	• Methods	Closed | Multiple choice Open | Text box
Feedback	• Commentaries	Closed | Y/N Open | Text box
	• Future collaboration	Closed | Y/N Open | Text box

Eleven experts from seven countries, mostly in Europe (U.K.: 5; Germany: 2; Australia: 1; Portugal: 1; Sweden: 1; U.S.A.: 1), provided complete answers. Results from the experts' survey were used for validation of the selected keywords and bi-grams. The number of complete answers was expected to be larger, nevertheless, it was already relevant that some of the answers were from widely cited authors which articles have been in the base of this research theoretical frame.

4.3. Other scientific fields

As referred in the first three sections of this research, social resilience assessment must be multi-scale and observe both individual and collective/community indicators. Most of the scientific works that used

TM and the majority of the experts who contributed to the applied survey were from the geography and disaster risk management scientific fields. A literature review of other scientific fields revealed that social psychology provides the most useful information regarding the need for an evolutionary resilience approach. A social psychology approach to resilience confirms the need for multiple scales of analysis: individuals, community, multiple spheres of the same reality (such as individual resilience, family resilience) and neighbourhood, as well the following dimensions: geographical, health, society, environment; and evolving time concept (Bhana and Bachoo, 2011; Davydov et al., 2010; D. Liu et al., 2017). This review was very useful in the selection of indicators to evaluate the resilience of individuals and social networks (see Table 3).

4.4. Validation through the comparison of TM and ES

Only the five sentences from the experts' survey (ES) that scored the highest number of "totally agree" and "partially agree" choices were selected.

A comparison of the lists of results (words and expressions/bi-grams and top agreement options) of TM and ES was made in order to validate the results of TM, and this comparison resulted in the acceptance of the TM results with a satisfactory certainty. Out of the total TM keywords and key-expressions extracted from the referred lists, 95% had correspondence with the ES results.

The comparison of the two approaches – TM and experts surveys – provided key information to establish the social resilience to floods dimensions and, therefore, the type of indicators to be included in an indicators database (Figure 5).

The results of the text mining-based methodology depend on the papers selected for analysis. A systematic mapping of articles related to social resilience assessment allows a broad and comprehensive spectrum of perspectives, representative of different approaches and publication dates.

The results of the experts' survey depend on the responses received. In this case, it was not possible to assure identical representativeness of different approaches, since the completion of the survey depends on the availability of the experts who were contacted. However, there was a significant convergence between the answers given by experts of seven countries, which suggests that the results are robust.

Besides, there is a significant consistency between the results of the two methodologies used.

5. Results

The main result of this paper is a database of indicators organized by dimensions. The indicators were collected from peer-reviewed papers and international projects outputs and reports; the source/reference is presented together with each indicator (see Table 3). The resulting SR to floods dimensions is an output of the comparison of TM with ES as previously explained (see Figure 5). These dimensions are independent of the type of risk to which the community/individual are exposed, as it generally includes the disaster/shock/stressor dimension/indicator; it further includes the propensity of the community/individual to be affected.

The results show, through the application of TM and ES, that four of the six dimensions refer to the social aspect of the risks (1. Individuals, 2. Society, 3. Governance, 4. Built Environment) and that two relate to the environment and to disaster.

TM & ES & Bibliography review Results: Concept Keywords & Key-expressions

- Institutions and Governance
- Social Political
- Disaster Reduction
- Change
- Adapt to Change
- Climate Change
- Recovery
- Resilience Management
- Community Resilience
- Evolve over time
- Research

TM & ES Results: SR Dimensions/Components

Dimension/Component	Other Keywords/expressions in dimensions results
Political / Governance	Participatory processes; Planning; Assessment
Disaster	Disaster Reduction; Preparedness; flood recovery
Social Networks	Sense of community; Perception
Socio-Economic	Social capital; economic
Adaptation	Adaptive capacity; Coping Capacity
Change	Climate change

TM & ES Results: SR Indicators

Indicators	Other Keywords/expressions
Management	Political Context
Environmental	
Community	Safety- net;
Community	Social Capital; Income/ Economy; socio-economic
Individuals	Demographic; Health; Human Capital
Local level	Built Environment; Infrastructure resistance

TM & ES & Social Psychology Bibliography Results: SR Scales of analysis

Individual	Family	Neighborhood	Community/local/municipality

Dimensions	Individuals	Society	Governance	Built Environment	Natural Environment	Disaster
Type of indicator (examples)	▪ Psychology ▪ Health/Disability ▪ Age & Demograpy ▪ Perception ▪ Learning capacity ▪ Migration	▪ Associativism ▪ Social Networking ▪ Religion/spirituality ▪ Institutions ▪ Livelihood conditions ▪ Insurance	▪ Planning ▪ Research ▪ Prevention ▪ Participatory	▪ Infrastructures ▪ Buildings resistance ▪ Conservation	▪ Hazard ▪ Susceptibility ▪ Exposure ▪ Natural environment	▪ Learning from the past ▪ Historic database: ▪ Disasters and Recovery

Figure 5 - Social Resilience to Floods Dimensions and Indicators results from TM and ES. Source: author's elaboration

Another result of this work is an enlarged set of indicators organized per dimension – see Table 3, that were extracted from published scientific articles and grouped by dimension according to the results presented in Figure 5. The transition from Figure 5 to Table 3 was done keeping the identified dimensions and using the 'type of indicators' as categories to group indicators extracted from the literature. In order to shorten the table, some indicators were re-written, or simply grouped in one line, as they were considered equivalent and might be chosen or dismissed according to the reality of the case study where it should be applied.

Table 3 - Summarized Database of Dimensions and Indicators for Social Resilience Assessment

Dimension		Category		Indicator	References
nr	Name	nr	Name	General	Based on
1	Individuals	1.1	Psychology - Adaptive Capacity	Confidence	(Bobby Rahman et al., 2016; Davydov et al., 2010; J. J. W. Liu et al., 2017)
				Social Skills	(Bobby Rahman et al., 2016; Tanner et

				al., 2014)
			Capacity to deal with changes and stress, self-control and regulation	(Béné et al., 2017; Bobby Rahman et al., 2016; Davydov et al., 2010; J. J. W. Liu et al., 2017; Madewell and Ponce-Garcia, 2016; Tanner et al., 2014)
			Security and feeling of control over one's own life	(Madewell and Ponce-Garcia, 2016)
			Positiveness	(Madewell and Ponce-Garcia, 2016)
			Individual health	(Cutter et al., 2014; Khalili et al., 2015a)
			Motivation	(Madewell and Ponce-Garcia, 2016)
			Knowledge	(Béné et al., 2017; Bobby Rahman et al., 2016; Davydov et al., 2010; Khalili et al., 2015a; Madewell and Ponce-Garcia, 2016; Schelfaut et al., 2011; Tyshchuk and Wallace, 2018)
			Sense of belonging	(Davydov et al., 2010; Tyshchuk and Wallace, 2018)
		1.2 Health/disability	Health care	(Cutter et al., 2014; Edwards et al., 2017; Khalili et al., 2015a; J. J. W. Liu et al., 2017; Madewell and Ponce-Garcia, 2016)
		1.3 Age and Demography	Demography	(Cutter et al., 2014; Davydov et al., 2010; Khalili et al., 2015a)
			Household	(Béné et al., 2017; Kelman, 2017; Khalili et al., 2015a)
			Household resources	(Cutter et al., 2014; Khalili et al., 2015a)
		1.4 Migration	Native language proficiency	(Cutter et al., 2014)
			Place attachment	(Cutter et al., 2014)
			Population diversity	(Cutter et al., 2014; Edwards et al., 2017; Wickes et al., 2017)
2	Society	2.1 Associativism	Volunteerism	(Béné et al., 2017; Butler and Walker-springett, 2016)
		2.2 Social networking	Sense of community & collective efficacy	(Béné et al., 2017; Butler and Walker-springett, 2016; Khalili et al., 2015a; Wickes et al., 2017)
			Community building	(Bobby Rahman et al., 2016; Butler and Walker-springett, 2016; Cutter et al., 2014; Khalili et al., 2015a)
			Informal safety net	(Béné et al., 2017; Butler and Walker-springett, 2016)
		2.3 Institutions	Governance	(Adger, 2000; Béné et al., 2017; Butler and Walker-springett, 2016; Cutter et al., 2014; Schelfaut et al., 2011)
			Interaction involving formal and informal actors	(Adini et al., 2017)
		2.4 Livelihood conditions	Household characteristics	(Adger, 2000; Béné et al., 2017; Cutter et al., 2014; Khalili et al., 2015a; Tanner et al., 2014)
		2.5 Insurance	Insurance capacity	(Cutter et al., 2014; Khalili et al., 2015a)
3	Governance	3.1 Planning and Governance	Strategies	(Adini et al., 2017; Béné et al., 2017; Bobby Rahman et al., 2016; Cutter et al., 2014)
			Policy/governance approach	(Adini et al., 2017; Bobby Rahman et al., 2016; Khalili et al., 2015a; Tanner et al., 2014)

				Community involvement	(Béné et al., 2017; Bobby Rahman et al., 2016; Tanner et al., 2014)
				Research	(Béné et al., 2017; Bobby Rahman et al., 2016; Cutter et al., 2014; I. Kelman et al., 2015)
				Risk governance – prevention	(Adini et al., 2017; Béné et al., 2017; Bobby Rahman et al., 2016; Butler and Walker-springett, 2016)
4	Built Environment	4.1	Infrastructures	Technologies	(Adini et al., 2017)
				Transportation	(Béné et al., 2017; Cutter et al., 2014)
				Services	(Adini et al., 2017; Béné et al., 2017; Cutter et al., 2014)
		4.2	Buildings resistance	Types and conservation of buildings	(Adini et al., 2017; Cutter et al., 2014)
5.	Natural Environment	5.1.	Hazard, susceptibility and exposition analysis	Hazard assessment and proxy indicators	(Bobby Rahman et al., 2016; Cutter et al., 2014)
		5.2.	Natural environment		(Adger, 2000; Béné et al., 2017; Cutter et al., 2014)
6.	Disaster	6.1	Learning from the past	Resilience and DRR evaluation	(Adini et al., 2017; Béné et al., 2017; Cutter et al., 2014; I. Kelman et al., 2015; Khalili et al., 2015a)
		6.2.	Disasters and recovery	Assistance to citizens	(Adini et al., 2017; Béné et al., 2017)
				Recovery	(Adger, 2000; Bobby Rahman et al., 2016)
				Action during crisis	(Adini et al., 2017; Béné et al., 2017)
				Risk Communication	(Béné et al., 2017)

Source: author's elaboration

6. Discussion

The question 'Resilience for whom?' arises from the conclusions of Asadzadeh et al. (2017). When setting the conceptual foundation of a framework to assess resilience, it is important to know whose resilience will be boosted (Asadzadeh et al., 2017). In this paper's conceptual frame, individuals and community are the central elements (section 2.3). This can be seen as a two-sided argument to deal with when choosing the indicators and components weight if they are to be used in one index/composed indicator or any quantitative method. Indeed, the characteristics of individuals and community might be given more weight since it is important to boost their resilience. Conversely, if we want to boost the resilience of individuals and institutions, we need to put in place adequate policies and infrastructures to protect the community and individuals. Pizzo (2015) considered that most resilience studies focussed on the hazard, whereas few studies addressed the multidimensional reality of resilience that includes different dimensions (Pizzo, 2015). This research results showed that multiple dimensions met this requirement. The scientific gaps identified so far show the need to apply the results of this paper to different case studies with different weights, to try to find a standard way of applying such indicators to a given context.

Table 3 is a useful database of indicators. Its enlarged version is shown in appendix 2, as it is a comprehensive descriptive set of indicators organised by dimension and category (indicator). It is an example of data to be collected (specific indicators). Its usage must comply with certain analysis and there must be critical opinions about what the researchers/institutions wish to focus on; according to Asadzaeh et al. (2017), whether the focus is on the social skills and capacities of resilience or on the infrastructures and assets. Another way to analyse the table is to focus on certain aspects of the resilience cycle/time frame (when) or 'persistence (robustness), recovery (constancy), and adaptive capacity (transformative)'(Asadzadeh et al., 2017). It might also be the case that the indicators are applied with a focus on resilience management, in which instance scaling should be seen from this perspective not only regarding each indicator (Holling 1973) but also in a regional rather than a local context (Holling, 1973). The database contains duplicates of examples concerning the type of data collected (specific indicators), e.g., the individual dimension and the social dimension both relate to the characteristics of households. The causes of these duplicates are: (i) the usage of scientific works with different scales of analysis and distinct focuses: individuals and community; and (ii) limited experience in applying the dimensions to case studies. It would be useful to know which data (individual/community) and scale are available and to identify to which dimension a higher weight/relevance should be assigned to accurately reflect the reality of each case study. The choice was to leave the duplicates, as it allows for greater freedom of discussion and for making different combinations when creating scientific research applications.

The usage of this database requires the inclusion of the aforementioned dimensions and the testing of the indicators in different types of case studies in order to set types of resilience approaches, to test the weight of indicators and dimensions, and to have real-world experience about the available data and the adequacy of each indicator to the reality under analysis. The next step of this research will focus on these unsolved issues.

Definition of the most adequate indicators to each social-ecological context depends on its testing in case studies. The adoption of a social resilience index needs knowledge acquired from other case studies. The analysis of social resilience in flood-affected communities through such indicators will also need to be tested regarding the conciliation of objective and subjective indicators, and statistical and spatial indicators. There's no universal practice for the choice of the procedures for data transformation, categorization, aggregation, visualization and validation (Asadzadeh et al., 2017), therefore case studies are required to validate such approaches.

The next steps of the current research will deal with the application of this indicators database to different case studies in Portugal, to test which are the most suitable indicators for the Portuguese context taking into account the type of floods that occur in each case study area.

7. Conclusions

For several decades, the wide debate surrounding the resilience concept and its applicability to social-ecological systems have drawn attention to the need to find tangible ways to assess social resilience and include it in risk governance strategies and plans. The current state of the art in this field points to

an evolutionary resilience concept based on the systems theory. The social-ecological systems are multiple coupled systems. According to this view, time is not linear as the systems evolve and learn across time. Consequently, challenges arise to assess multiple dimensions of these multi-systems and to find the key dimensions and indicators that will reshape the concept of social resilience.

This paper, therefore, presents a methodology to compile and summarize the dimensions that should be included in risk governance of social resilience, combining literature review, text mining, and experts' opinions. The obtained results (see Figure 5 and Table 3) show that text mining can be an appropriate tool to support decision making and research in social fields and theoretical research, as its results converge with the opinions of experts. The combination of the two methods has lent robustness and certainty to the results (see Figure 5), and confidence to organize a database of indicators based on scientific literature review. The information provided by the experts' survey was used to compare and validate the text mining-based methodology: (i) the 5 most mentioned words in the answers to each of the questions; and (ii) the categories 'totally agree' and 'partially agree'. The selected words were synthesized in key expressions. The later plus the sum of the categories 'totally agree' and 'partially agree' correspond to more than 90% of the answers given by the experts (high internal coherence). In order to validate the results of text mining, a comparison was made with the results of the experts` survey. Out of the total of keywords and key expressions extracted through the text mining-based methodology, 95% corresponded to the results of the experts` survey (high external coherence).

Comparing evolutionary resilience with social and community resilience highlights the changing and learning capacity of individuals and communities through time. The challenge is to find the dynamic indicators that adequately reflect this capacity of individuals and communities. The solution might be the inclusion of psychological indicators through social media (Hernantes et al., 2017). Collecting psychological data requires intensive fieldwork, social media is accessible worldwide and it is massively used by individuals on a daily basis to share their life and emotions.

This research findings point out the next steps: the need for real world cases as any indicator-based approach requires its application to specific case studies, while the generalization and standardization of such approaches require the application to as many diverse real-world cases as possible.

Acknowledgements: This research was funded by the FCT - Fundação para a Ciência e Tecnologia (Portuguese Foundation for Science and Technology), I.P. [grant number SFRH/BD/119228/2016 to Rita Jacinto; UIDB/00295/2020 + UIDP/00295/2020].

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APPENDIX 1

1. Concepts | Mark the sentence(s) according to the level of agreement, regarding the Social Resilience (SR) concept: *

	disagree	partially disagree	partially agree	agree
1.1. | SR is about recovery	◯	◯	◯	◯
1.2. | SR is a natural capacity of individuals	◯	◯	◯	◯
1.3. | SR is a natural capacity of groups of individuals/communities	◯	◯	◯	◯
1.4. SR is about maintaining the same capacities, characteristics and functions	◯	◯	◯	◯
1.5. | SR is about coping with change, being able to adapt to different conditions	◯	◯	◯	◯
1.6. | SR is the opposite of social vulnerability	◯	◯	◯	◯
1.7. | SR is the same as social vulnerability	◯	◯	◯	◯
1.8. | SR and social vulnerability are both part of Risk	◯	◯	◯	◯
1.9. | SR is the same as Adaptive Capacity/Adaptation	◯	◯	◯	◯
1.10| SR and Adaptation are part of Risk	◯	◯	◯	◯
1.11| SR is a result or outcome of policy measures taken	◯	◯	◯	◯
1.12| SR is about social institutions, governments and governance	◯	◯	◯	◯
1.13| SR is about a group the individuals	◯	◯	◯	◯
1.14| SR s bout a community that lives within a certain area	◯	◯	◯	◯
1.15| SR is about institutions that manage a certain area	◯	◯	◯	◯
1.16| SR is about individuals, community and institutions within a certain area	◯	◯	◯	◯
1.17| SR is about maintaining certain functions as a community and evolve over time	◯	◯	◯	◯
1.18| SR is about maintaining the community in a certain equilibrium and safety	◯	◯	◯	◯
1.19| SR is the same as community resilience and livelihood resilience	◯	◯	◯	◯

Figure 4- Experts Survey question 1
Source: author's elaboration

APPENDIX 2

Dimension		**Category**		**Indicator**		**References**
nr	**Name**	**nr**	**Name**	**General**	**E.g. data to collect**	**Based on**
1	Individuals	1.1	Psychology - Adaptive Capacity	Confidence	Strong sense of purpose	(Bobby Rahman et al., 2016; Davydov et al., 2010; J. J. W. Liu et al., 2017)

					Feels that can achieve goals and/or is the pride of the achievements	
					Prefer to take the lead in problem-solving	
					Positive self-concept	
				Social skills	Coping style and appraisal (the active coping style in confronting a stressor)	(Bobby Rahman et al., 2016; Tanner et al., 2014)
					The individual and collective response to shocks, stressors, adversity and environmental change	
				Capacity deal with changes and stress, self-control and regulation	Under pressure focus and think clearly	(Béné et al., 2016; Bobby Rahman et al., 2016; Davydov et al., 2010; J. J. W. Liu et al., 2017; Madewell and Ponce-Garcia, 2016; Tanner et al., 2014)
					Capable of making an unpopular decision	
					Can handle unpleasant feelings	
					Shows capacity to recover from stress, shock and negative events	
				Security and feeling of control of own life	Finds meaning in challenging circumstances	(Madewell and Ponce-Garcia, 2016)
					Effective self-regulation of emotions	
				Positiveness	Past success gives confidence for the new challenge	(Madewell and Ponce-Garcia, 2016)
					Acceptance that things happen for a reason	
					Positive affect, positive emotions such as optimism and humour	
				Individual Health	Health behaviours and other key biological indicators	(Cutter et al., 2014; Khalili et al., 2015b)
					Doesn't have special needs/disabilities	
				Motivation	Strong sense of purpose, work to attain goals, best effort no matter what	(Béné et al., 2017; Bobby Rahman et al., 2016; Davydov et al., 2010; Khalili et al., 2015b; Madewell and Ponce-Garcia, 2016; Schelfaut et al., 2011; Tyshchuk and Wallace, 2018)
					Doesn't give up when things look hopeless, not easily discouraged by failure	
				Knowledge	Know where to turn for help, know how to plan and prioritize, have historical knowledge, level of education	(Béné et al., 2017; Bobby Rahman et al., 2016; Davydov et al., 2010;

						Khalili et al., 2015b; Madewell and Ponce-Garcia, 2016; Schelfaut et al., 2011; Tyshchuk and Wallace, 2018)
					Access to information and seek additional information/confirmation. Obtain, propagate and understands warnings.	
					Preparedness: Level of knowledge and awareness about flood/risk amongst residents	
					Confidence and flexibility to learn and experiment	
				Sense of belonging	Religion/spirituality and Normative believe (such as perceived expectations of important referent individuals or groups competence)	(Davydov et al., 2010; Tyshchuk and Wallace, 2018)
					Social attachment, close and secure relationships	
					Exposure of social media users to normative beliefs (calculated using the co-affiliation network of social media)	
		1.2	Health/disability	Health care	Access to health care and mental health care	(Cutter et al., 2014; Edwards et al., 2017; J. J. W. Liu et al., 2017; Madewell and Ponce-Garcia, 2016)
		1.3	Age and Demography	Demography	Age	(Cutter et al., 2014; Davydov et al., 2010; Khalili et al., 2015b)
					Gender	
					Marital status	
				Household	Household size and income	(Béné et al., 2017; Kelman, 2017; Khalili et al., 2015b)
					Kinship networks	
				Household resources	Transportation and communications capacity	(Cutter et al., 2014; Khalili et al., 2015b)
					Economic status: level of income and health insurance	
		1.4	Migration	Native language proficiency	Speaks reads and writes in the language of the country	(Cutter et al., 2014; Khalili et al., 2015b)
				Place attachment	Percentage of residents who are not recent immigrants	(Cutter et al., 2014; Khalili et al., 2015b)
					population stability	
				Population diversity	Races and ethnicity	(Cutter et al., 2014)
2	Society	2.1	Associativism	Volunteerism	Presence of support workers and volunteers and number of NGO workers	(Béné et al., 2016; Butler and Walker-springett, 2016)

		2.2	Social networking	Sense of community and collective efficacy	Collective action; People having a sense of agency, including abilities to effect change and engagement with decision-making processes	(Béné et al., 2017; Butler and Walker-springett, 2016; Khalili et al., 2015b; Wickes et al., 2017)
					Social cohesion based on the frequency of exchange of favours; willingness to help neighbours; trusting the neighbours; sharing the same values	
					Feeling of belonging to a community or place. A group shared belief in their collective power to produce specific changes; their own capabilities of performing and completing jobs	
				Community building	Strengthening community organization and voice: promote communication and information interchange and share information within the community	(Bobby Rahman et al., 2016; Butler and Walker-springett, 2016; Cutter et al., 2014; Khalili et al., 2015b)
					Keep in touch networks, (dinner or other forms of social meetings)	
					Community Capital and Social Capital - Community's investment, access, and use of resources surrounded by social networks to gain returns	
					Community creativity and innovation to devise a solution for enhancing resilience, promoting access to technologies, improving access to markets and employment, ensuring secure living conditions	
				Informal safety net	Informal safety-net (non-governmental organizations, associations, institutions)	(Béné et al., 2016; Butler and Walker-springett, 2016)
					Women empowerment	
					Social networks	
					Businesses offering services and donating to relief efforts	
		2.3	Institutions	Governance	Centralize and manage assistance to provide services to an as large as possible portion of the population	(Adger, 2000; Béné et al., 2016; Butler and Walker-springett, 2016; Cutter et al., 2014; Schelfaut et al., 2011)
					Institutional fragmentation, spatial planning, type of local governance and jurisdictional coordination	
					Institutional cooperation and coordination: institutions working towards ensuring that social infrastructures are in place which can effectively harness the contributions of convergent volunteers, agencies, and communities	
					Institutional rules which govern the social systems	
					Preparedness of emergency services	
				Interaction between formal and informal actors	Consider the impact of interdependencies and interaction between actors on resilience management; Establish a common terminology concerning resilience management across institutions and authorities	(Adini et al., 2017)

		2.4	Livelihood conditions	Household characteristics	Socioeconomic characteristics (income level/medium income/annual household income, education); and Demographic characteristics (household age and gender and size)	(Adger, 2000; Béné et al., 2016; Cutter et al., 2014; Khalili et al., 2015b; J. J. W. Liu et al., 2017; Tanner et al., 2014)
					Promotion of economic vitality: employment and homeownership/right to housing and property; non-resilience on a narrow range of resources; equality of income distribution amongst the population (across races/ethnicities and genders).	
					Efficient use of water and energy	
					Social/Human Rights: Access/right to medical care; Right to housing and property; Food security/Right to food; Access to social services	
					Recorded crime rates	
					Residential instability and geographical location	
		2.5	Insurance	Insurance capacity	Health, Business, Risk related insurance (floods) insurance capacity	(Cutter et al., 2014; Khalili et al., 2015b)
3	Governance	3.1	Planning and governance	Strategies	Positive coping strategies	(Adini et al., 2017; Bobby Rahman et al., 2016; Khalili et al., 2015b; No, 2015; Tanner et al., 2014)
					Sustainable adaptive and/or transformative strategies	
					Set plans: flood management plans; emergency response plans; plan for reinforcement of resources in resilience management	
					Flexible resilience management systems to handle different types of situations	
					Articulation between resilience management and other plans and regulations	
					Establish routines of revision, checklists, guidelines for resilience management planning	
					Set an adaptive capacity developing strategy	
				Policy/governance approach	Political context/power structure	(Adini et al., 2017; Bobby Rahman et al., 2016; Khalili et al., 2015b; No, 2015; Tanner et al., 2014)
					Participatory policy making; decentralized and participatory decision making	
					Strengthening links between local, district/regional and national levels	
					Respect human rights principles	
				Community involvement	Promoting integrated approaches to livelihoods, disasters and climate change	(Béné et al., 2016; Bobby Rahman et al., 2016; Tanner et al., 2014)
					Protection of citizens as an obligation of governments	
					Number of households attending workshops and activities	

				Research	Evaluate readiness to cope with crisis	(Béné et al., 2016; Bobby Rahman et al., 2016; Cutter et al., 2014; I. Kelman et al., 2015)
					Application of long-term perspective for disaster risk reduction	
					Understanding the trends and their local impact on the community to promote adaptive capacity	
					Research on flood risk	
				Risk Governance - prevention	Early warning	(Adini et al., 2017; Béné et al., 2017; Bobby Rahman et al., 2016; Butler and Walker-springett, 2016)
					Hazard prevention and protection capacity	
					Develop procedures for expected and unexpected events	
					Local disaster training	
					Development of human agency through institutional actions and initiatives	
					Provision and access to infrastructures and information needed	
4	Built Environment	4.1	Infrastructures	Technologies	Back up and alternative methods in case technologies fail	(Adini et al., 2017)
					Information standardization to ensure the reliability of information systems	
					High-speed internet infrastructure	
				Transportation	Kilometres of road constructed	(Béné et al., 2016; Cutter et al., 2014)
					Evacuation routes	
				Services	Public services and markets, industrial re-supply	(Adini et al., 2017; Béné et al., 2016; Cutter et al., 2014)
					Temporary housing/shelter availability	
		4.2	Buildings resistance	Types and conservation of buildings	Analysis of houses and buildings infrastructures prior to, during and after emergencies, disasters and crises; Study housing types and Housing stock construction quality	(Adini et al., 2017; Cutter et al., 2014)
5.	Natural Environment	5.1.	Hazard, susceptibility and exposition analysis	Hazard assessment and proxy indicators	Hazard analysis and pressure	(Bobby Rahman et al., 2016; Cutter et al., 2014)
					Natural flood buffers	
					Using wetlands as a proxy indicator for natural hazard buffers	
		5.2.	Natural environment		Qualities of the environment that enhance the absorptive capacity of coastal surges and freshwater flooding	(Adger, 2000; Béné et al., 2016; Cutter et al., 2014)
					Natural resources; Food security and local food suppliers	
6.	Disaster	6.1	Learning from the past	Resilience and DRR evaluation	Measurements in the beginning, during and at the end of the Programs and/or a disaster	(Adini et al., 2017; Béné et

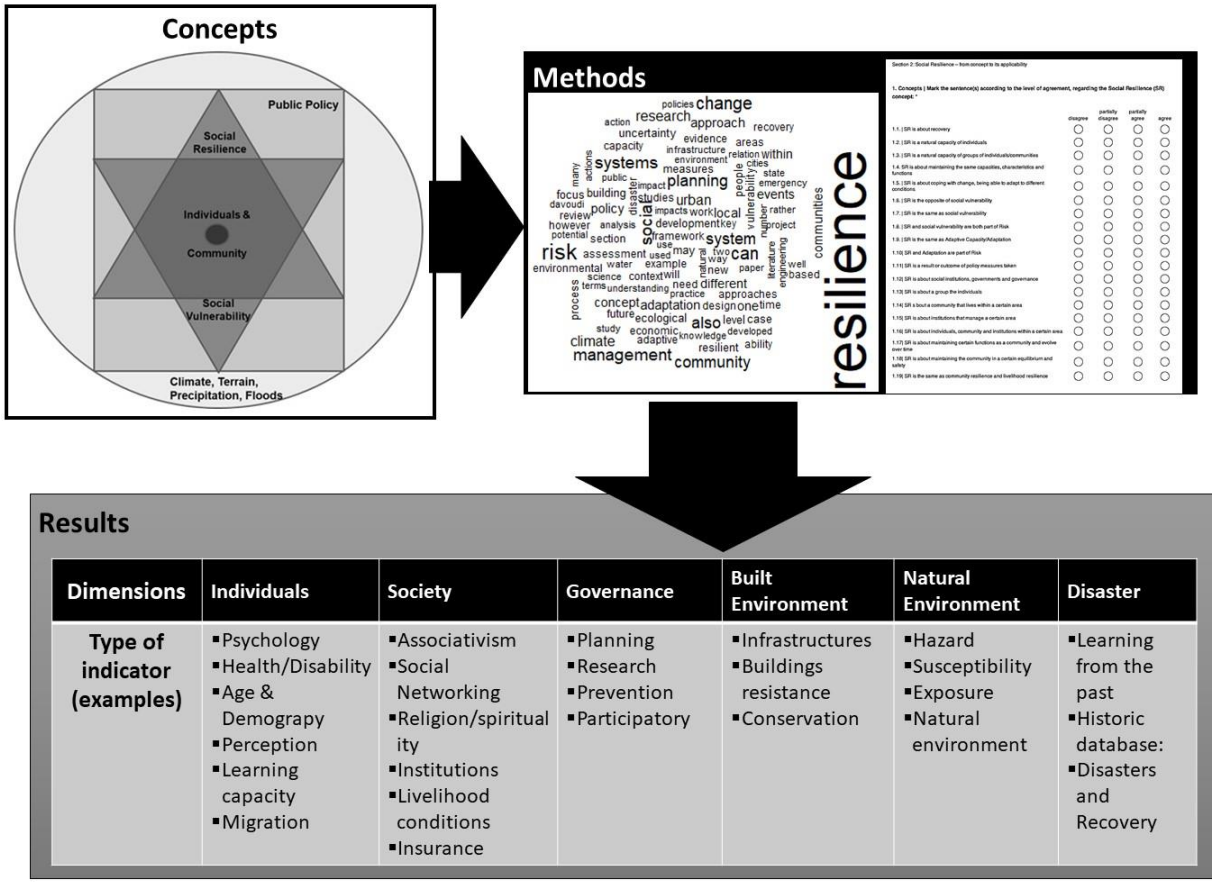
						al., 2016; Cutter et al., 2014; I. Kelman et al., 2015; Khalili et al., 2015b)
					Learning from previous disaster aid experience; Integration of history, past work into research, policy and practice	
					Level of Knowledge about flood	
		6.2.	Disasters and recovery	Assistance to citizens	Donor payments timing, kits distribution	(Adini et al., 2017; Béné et al., 2016)
					Coping Strategy Index (CSI) as defined in Maxwell and Cadwell (2008)	
					Training and exercises to enable improvise while handling situations	
				Recovery	Recovery speed; Rebuilding strategy (build back better)	(Adger, 2000; Bobby Rahman et al., 2016)
				Action during crisis	Adjust procedures during a crisis	(Adini et al., 2017; Béné et al., 2016)
					Having river flood data, rainfall data and others in real-time, to allow a choice of strategy	
				Risk communication	Communication of risks; communication during events	(Béné et al., 2016)

CRediT author statement

Rita Jacinto: Conceptualization; Investigation; Methodology development and Software application; Data curation and validation; Writing – original draft preparation; Writing- Review and Editing. **Eusébio Reis***:* Supervision; Writing- Review and Editing. **João Ferrão:** Supervision; Writing- Review and Editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.



Dimensions	Individuals	Society	Governance	Built Environment	Natural Environment	Disaster
Type of indicator (examples)	▪Psychology ▪Health/Disability ▪Age & Demograpy ▪Perception ▪Learning capacity ▪Migration	▪Associativism ▪Social Networking ▪Religion/spirituality ▪Institutions ▪Livelihood conditions ▪Insurance	▪Planning ▪Research ▪Prevention ▪Participatory	▪Infrastructures ▪Buildings resistance ▪Conservation	▪Hazard ▪Susceptibility ▪Exposure ▪Natural environment	▪Learning from the past ▪Historic database: ▪Disasters and Recovery

Graphical abstract

Highlights

- ✓ This paper aims at presenting an innovative methodology to compile and summarize the analytical dimensions able to evaluate Social Resilience in Flood affected communities.
- ✓ The methodology combines literature review (LR), text mining (TM), and experts' opinions (EO?).
- ✓ The main result is a database of indicators organized by analytical dimensions based on LR.
- ✓ Through the application of TM and EO to that database, we found that four of the six dimensions refer to social aspects of risks (1. Individuals, 2. Society, 3. Governance, and 4. Built Environment) and that the remaining ones refer to the natural environment (5) and to disaster (6).