The disaster resilience assessment of coastal areas: A method for improving the stakeholders' participation

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Arianna Morelli[a,*], Andrea Taramelli[a,b], Fabio Bozzeda[c,d,e], Emiliana Valentini[f], Marina Antonia Colangelo[g], Yandy Rodríguez Cueto[h]

[a] *Istituto Universitario di Studi Superiori di Pavia (School for advanced studies), (IUSS), Palazzo del Broletto, Piazza della Vittoria 15, 27100, Pavia, Italy*

[b] *Istituto superiore per la protezione e la ricerca ambientale (Institute for Environmental Protection and Research), (ISPRA), via Vitaliano Brancati 48, 00144, Roma, Italy*

[c] *Department of Biological and Environmental Sciences and Technologies, University of Salento, DiSTeBA, S.P. Lecce-Monteroni, 73100, Lecce, Italy*

[d] *Research Centre for Fisheries and Aquaculture of Aquatina di Frigole, DiSTeBA, University of Salento, 73100, Lecce, Italy*

[e] *Centro de Investigación en Dinámica de Ecosistemas Marinos de Altas Latitudes (IDEAL), Universidad Austral de Chile, Valdivia, Chile*

[f] *Istituto di Scienze Polari – Consiglio Nazionale delle Ricerche (Institute of Polar Sciences of the Italian National Research Council), (ISP CNR), Via Salaria km 29, 300-00015, Montelibretti, Roma, Italy*

[g] *Università di Bologna, University of Bologna, Via S. Alberto 163, 48123, Ravenna, Italy*

[h] *Universidad Nacional Autónoma de México (National Autonomous University of Mexico), Mexican Center for Innovation in Ocean Energy, Engineering Institute, Univesidad 3000, UNAM-CU, Mexico City, 04510, Mexico*

A B S T R A C T

Increasing frequency, intensity and severity of natural hazards associated to climate change are among the pressing challenges the world is facing requiring greater resilience for communities. This challenge calls for new policies and actions at regional and local level having the concept of resilience as their main driver and core component.

However in order to prioriotirise and invest in the resilience building, the actors involved in the governance of a territory and in the implementation of Disaster Risk Reduction measures must first recognize the multifacted nature of resilience and the importance of its measurement.

Priorities, resilience meaning and metrics are subject to different interpretations, making resilience a societal complex issue.

To this end the paper aims to provide a new method for the incorporation of multilevel stakeholders' view in the assessment of the inherent resilience of a place and in the design of a metric based Resilience Index (RI).

The new approach integrates the Disaster Resilience of Place (DROP) model and the use of semi-structured interviews with a standpoint in the Grounded Theory Methodology to facilitate both the assessment of resilience in a quantitative manner and an in-depth analysis of the context.

The method has been applied in the framework of coastal exposure to flood, by involving 18 municipalites of the Po River Delta (Italy). The interactions of the, physical and anthropogenic processes in the Po River Delta requires a better understanding in terms of resilince to support sustainable management and spatial planning actions in the context of climate change.

The analysis spreads across different administrative boundaries and complex and dynamic natural systems that have recreational, residential and economic functions. The results demonstrate the potentiality of the method to guide different local actors in their disaster resilience strategy and in the identification of priorities.

1. Introduction

In the last decade, major adverse events resulting from natural processes have caused the displacement of an average of 24 million persons per year (UNISDR, 2019). In 2018 "flooding affected the highest number of people", as pointed out in the report "Natural Disasters" (CRED, 2018, 2).

Disasters have their root cause in the human values, activities and decisions that accumulate and create vulnerability over the long-term (Mercer et al., 2008). It is widely accepted that the risk landscape is complex and interconnected, and that people and institutions need the appropriate assets and skills to deal with this complexity (OECD, 2014). Understanding disaster risk as embedded in a social process enables thus a shift in focus from responding to the disaster event towards the un-derstanding of disaster risk (Cardona et al., 2012).

Given the complex nature of risks, the integration of local and scientific knowledge is more and more crucial as already highlighted by the IPCC (2014). Incorporating all essential stakeholders such as local or-ganisations and government bodies allows collecting more inputs that might have positive effects on the decisions outcomes, in particular in an uncertain scenario (Mercer et al., 2008).

With the increase of uncertainties, science must be based on the assumption of unpredictability, plurality of legitimate interests and impossibility to provide absolute certainty for policy recommendation (Funtowicz and Ravetz, 1993). When uncertainity comes into play, the subjective judgement is introduced and the clear distinction between facts and values is eroded (Failing et al., 2007). Based on the above there is a shift towards what Funtowicz and Ravetz (2003) have defined as "post-normal science".

This new type of science emphasises the role of a peer community. To achieve a system as much effective as possible, the inclusion of diverse opinions and experiences becomes thus crucial (Ker Rault, 2008).

Under the uncertainty generated by climate change, where the emphasis of the resilience policy on social processes become even more valuable (IPCC, 2012), stakeholders participation in setting up and implementing solutions is crucial. However there is still little indication on who should be included as a stakeholder and what can be considered best practice (Schiavon et al., 2021).

One of the first challenges to face when introducing the concept of "stakeholder" is the semanthic confusion that characterizes the terms "stakeholders", "citizens" and "public". Ridder et al. (2005) to distinguish between stakeholder and the public suggest to refer to the concept of organization: while stakeholders are organized around common in-terests the public is not. Kessler (2004) adds to the relevance of the element "interest", also the centrality of the decision making process: stakeholders are all those having an interest in the decision-making process. Thus stakeholders can be defined as a group with similar in-terests or rights as suggested by Freeman (1984).

There is a growing recognition that the involvment of stakeholders, intended as those organized around common interests (Ridder et al., 2005), has a high influence on the system (Ozesmi and Ozesmi, 2003). Stakeholders' approaches towards disasters has progressively gained importance, referring to activities such as mitigation, preparedness, response and recovery, (Peek and Mileti, 2002; Altay and Green, 2006). However, their empowerment and participation is a challenging task (Taramelli et al., 2020a,b; Geraldini et al., 2021).

Disaster governance needs a systematic approach where stakeholders can be hold accountable and local communities are actively involved in Disaster Risk Reduction (Gall et al., 2014). Enhancing Disaster Risk Reduction implies to undertake initiatives that are not isolated, but that affect diverse actors and values. The importance of proactive actions aimed at enhancing resilience has been thus increasingly recognized in the policy agenda (World Bank, 2013).

The concept of resilience brings with it theoretical, methodological, and philosophical questions (Aligica and Tarko, 2014). There are plenty of definitions and the need of investing in resilience activities is driving interest in indicators. However, the application of the concept is prob-lematic due to different goals and motivations linked to the resilience measurement (Cutter, 2016).

Resilience is considered a multifaceted concept (Norris et al., 2008; Sharifi and Yamagata, 2016) and although several definitions have been provided, so far few studies have implemented measurement for disaster resilience (Brooks et al., 2014; Knight et al., 2015) and tested the inherent resilience (Cutter, 2016). In this study resilience to natural hazards is intended as the ability of communities to "resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential structures and functions" (UNDRR, 2018, 3). Despite its increasing use, in particular in the disaster risk management terminology, the difficulty of developing practical opera-tional approaches for resilience (Klein et al., 2003; Cutter, 2016) has been debated together with the aspects related to the system dynamics (Walker and Salt, 2006; Martinez, et al., 2017). In this context the recognition of metrics and tools for resilience measurement remains a significant challenge (UNDP, 2014). As a major example, Cutter (2016) has identified 27 disaster resilience assessment approaches that can be divided into three categories: índices, scorecards and tools with score-cards and indicators being the most used.

The theoretical frameworks for assessing resilience can include (Gall, 2013; Sherrieb et al., 2010; Cutter et al., 2010; Costanza, 2012): i) the physical system (e.g. critical infrastructure, communication systems, etc.); ii) the human system (e.g. skills, knowledge, health, education, etc.); iii) the social system (e.g. community networks, trust, civic engagement, norms, etc.); iv. the institutional system (e.g. first re-sponders, response systems, etc.); v) the technical system (e.g. warning systems, emergency plans, etc.); vi) the economic system (e.g. income, productivity, etc.); vii) the environmental system (e.g. fresh water, arable land, etc.); viii) the ecological system (e.g. pollination, carbon sinks, etc.).

Moreover, as explained by Nardo et al. (2008) resilience as a multidimensional concept can be measured through composite indicators which are the result of the collection of individual variables into a single index.

Two types of measurements can be observed: narrow and broad measurement. The first one is developed by organisations interested in a specific aspect of resilience (i.e. resilience in coastal communities - Martinez, et al., 2017; architectural resilience etc.). The broad one in-cludes more components and dimensions (UNDP, 2014).

In addition, assessment frameworks can be top-down or bottom-up. In the first case prescribed indicators are used to assess and benchmark resilience. In the case of the bottom-up approaches, qualitative approaches such as stakeholders' interviews or community surveys are used to derive and contextualize indicators (Parsons et al., 2016).

Given the complexities brought by projected population increase and exacerbation of climatic conditions, traditional top down approaches to resources and disaster management are becoming obsolete (Scolobig et al., 2015; Baudoin et al., 2016).

Although the interest in resilience assessment is widespread there have been few attempts of testing the measurement of disaster resilience (Cutter, 2014, Brooks et al., 2014; Knight et al., 2015).

In this challenging context, policy makers are faced with hard choices concerning mitigation and resilience that call for the introduction of a new paradigm. Building resilient communities has become one of the sought-after abilities required by disaster-response professionals, government officials, and academics (Patel et al., 2017).

In order to respond to the need of a resilience assessment tool which is relevant to the local context and applicable by local entities trough the use of secondary data an innovative method could be the result of the combination of: i) the inherent portion of the DROP (Disaster Resilience Of Place) model (Cutter et al., 2008) and ii) interviews with key in-formants based on the Grounded Theory Methodology (Charmaz 2010; Glaser and Strauss 1967).

In-depth interviewing is a qualitative research technique that involves conducting intensive individual interviews with a small number of respondents to explore their perspectives on a particular idea, program, or situation (Boyce and Neale, 2006). In the Grounded Theory Methodology data gathering, data analysis, and concept building have a strong mutual connection and interact simultaneously (Mattoni, 2014). By using the grounded theory, it is the researcher that decides when to stop collecting data because they have achieved some level of “theoretical saturation” (Bryant and Charmaz, 2007; Glaser and Strauss 1967). This means that the conceptual categories emerging during the research are sufficient to collect and analyze data without any further modification (Mattoni, 2014). This approach follows Mottier’s perspective (2005) who highlights that the qualitative research techniques are problem-driven, therefore it is the research question that is being asked that determines them. The final purpose is to carry out a community resilience assessment with an integrated perspective and a multi-stakeholder approach. The identification of the groups to be involved can change according to the part of the system affected by the decision and the class of stakeholders relevant for that decision.

This study proposes a method to integrate the stakeholders’ perspective in the resilience measurement and thus in the indicators’ selections for the construction of a descriptive resilience index. The method has been applied at municipal level in the Po River Delta (Italy).

One of the main features of this area in terms of economic, and cultural value is that the Po River Delta underwent many changes of uses throughout history and still represents one of the most productive and biodiversity-rich areas. The study here proposed focuses on the antecedent conditions of the model (DROP) which are both place-specific and the product of multi-scale processes that occur within and be-tween natural systems, the built environment and social systems (Cutter el at. 2008 a).

Within this, we aknwoledge that the discussion concerning resilience is shaped by groups with different expertise (Steiner and Markantoni, 2014) and that risk reduction is influenced by the variation in the role of scientists, governance structure, interest groups, legislation, resources and external pressures (Scolobig and Pelling, 2016). Since no single organization has all the resources and expertise to address the disaster risk reduction (Hickman, 2018), this study applies a descriptive resilience index obtained by the incorporation of diverse stakeholders’ points of view.

The underlying idea is that metrics can be used as a practical tool, a common operational ground and a starting point to couple the risk governance with a resilience informed interactive governance. Although the developed index is applied to flooding, the proposed method is replicable and adatable to any kind or risk. The subcomponents used to build a resilience index can embrace other variables depending on the considered risk. can be applied to any kind of risk.

The paper is organized as it follows. The introduction provides an overview of the resilience framework. Section 2 describes the study area and the application of the method. The results are illustrated in section 3 and discussed in section 4. Section 5 provides conclusions on the method’s application.

2. Materials and methods

2.1. Study area: the delta po

The Po river is the longest and largest Italian river fed by a main reticulum of 141 major water tributaries (>20 km of length) and by the confluence of a ten time larger secondary reticulum of natural and artificial water bodies, irrigation and reclamation channels, for a total of ~50,000 km. The Po river delta can be described as a river system that covers an area of 73,000 ha, of which 60,000 is reclaimed land and the remainder is brackish lagoons, with dams or open foreshores and emerging sandy banks.

The Po river basin, spreading in 8 regions and 3210 municipalities and with its industrial and agricultural sectors, is crucial for the Italian economy. It is one of the most populated and economically developed natural protected areas in Italy and despite its remote origins the development of the modern multi-lobe Po Delta began after the Porto Viro diversion endorsed by Venetian hydraulic engineers at the beginning of the 17th. Following this human intervention, the Po was forced to flow southward through an artificial delta mouth and began to show its present configuration. The area is characterized by a system of topographic lows and highs that have deeply conditioned the natural water drainage. Important erosive phenomena along the deltaic beaches take place triggered by the heavy reduction of the sediment load of the Po. Many studies (Bondesan et al., 1995; Taramelli et al., 2015, 2018; Valentini et al., 2015) pointed out a general shoreline retreat between 1945 and the second half of the 1990s. The envisaged risk is the rural abandonement by young people and the depopulation (Fanfani and Galizzi, 2002).

The Po Delta, which spreads in two regions Emilia-Romagna and Veneto, is characterized by complex and dynamic natural systems (Corbau et al., 2019; Taramelli et al., 2015b) providing recreational, residential and economic functions. The use of soil is principally dedicated to agriculture and mono-cultivation prevails (maize, sugar beet, corn, soya, poplar), followed by horticultural and viticulture cultivation, while in some areas rice-growing is developed (Simeoni and Corbau, 2009). The main economic activities are agriculture, fisheries and aquaculture. Crop farming, shellfish, salt harvesting, have been coupled to extensive lagoon fish farming. The Po Delta is also an important touristic destination and it has become officially a UNESCO Biosphere Reserve on June 2015. The urban settlements (medium to small size) concentration is greater upstream.

Experiences of participatory approaches are represented by the adoption of the Environmental Plan of the Po Delta Veneto Regional Park (December 2012) and the integrated management and development of water resources promoted by the Po Delta Reclamation Consortium (River contract). Community sectorial policies are implemented through the Local Action Groups GAL Polesine Delta del Po and GAL Delta 2000. Local Action Groups GAL Polesine Delta del Po (for the Veneto part) and GAL Delta 2000 (for the Emilia-Romagna part) are public/private group representing different socio-economic realities of the area. They are in charge to implement the LEADER approach, which promotes and supports rural development projects designed and shared at the local level for the revitalization of the area.

Because of its high natural value, large portion of the territory is included in the EU Natura 2000 network. Two regional parks have been established by the Veneto and Emilia Romagna regions. The Parco Regionale Veneto del Delta del Po comprises almost entirely the geographical delta, it has an area of 12,000 ha and it is located entirely in the province of Rovigo. The Parco Delta del Po Emilia Romagna which develops from the course of the Po di Goro to the Cervia salines, includes the historic delta, a total area of 53,978 ha of territory between the provinces of Ferrara and Ravenna.

The area is particularly vulnerable to flooding and erosion (Travers et al.) and like other deltas higly threatened by SLR and natural and anthropic subsidence (IPCC, 2013).

Together with these aspects other majors are making this region particularly vulnerable to anthropic pressures (e.g., tourism, industry, and fishery) and the effect of climate change (acting on wave dynamics and sea-level rise) (Taramelli et al., 2020a,b; Torresan et al., 2019). As a consequence, it is expected that anthropic pressures (e.g., fishery, tourism and industry) and the effect of climate change (sea-level rise) will affect the mobilization of sediments along the shoreline with possible environmental and socio-econimic impacts (Gallina et al., 2013; 2019).

The municipalities included in the area are: Adria, Ariano nel Polesine, Corbola, Loreo, Papozze, Porto Tolle, Porto Viro, Rosolina, Taglio di Po, Alfonsine, Argenta, Cervia, Codigoro, Comacchio, Goro, Mesola, Ostellato, Ravenna. Nine out the eighteen municipalities are on the coast (Five in the Emilia-Romagna region). Nine of them are located in the Veneto Region and the other nine in the Emilia-Romagna.

2.2. Methodology

The new methodology combines the use of secondary data trough the application of the DROP model and stakeholders’ interviews for the design of an index able to describe and assess the inherent resilience to flooding of communities. A top-down and a bottom-up approch are thus integrated.

The above mentioned municipalities (Fig. 1) have been used as elementary units to compare the resilience index. A community of stakeholders has been involved to discuss through interviews, the selected variables and the resilience's operationalization.

In order to promote a common understanding of the community resilience's concept, the index has been built by asking stakeholders to indicate which dimensions are more relevant to foster resilience. For the set up of a common strategy to build a resilient community the indicators considered relevant for the resilience assessment, should be agreed by all the stakeholders of a given area. To this aim our stakeholders gave qualifications of the indicators and they assigned relative importance to them, according to their experience and knowledge.

In particular, stakeholders have been asked to assign a weight (the range allowed was 0–4) to each of the previously selected variables. Each standardized variable has been then multiplied for the average of the weight assigned by stakeholders. Finally, variables have been summed to obtain a final stakeholders weighted disaster resilience index to be compared to the equally weighted resilience index.

The crucial phases of the proposed method are (Fig. 2):

1) The identification of the relevant stakeholders through snawballing techniques;
2) The variables' selection considering literature review and experts knowledge: variables for the construction of a resilience index have

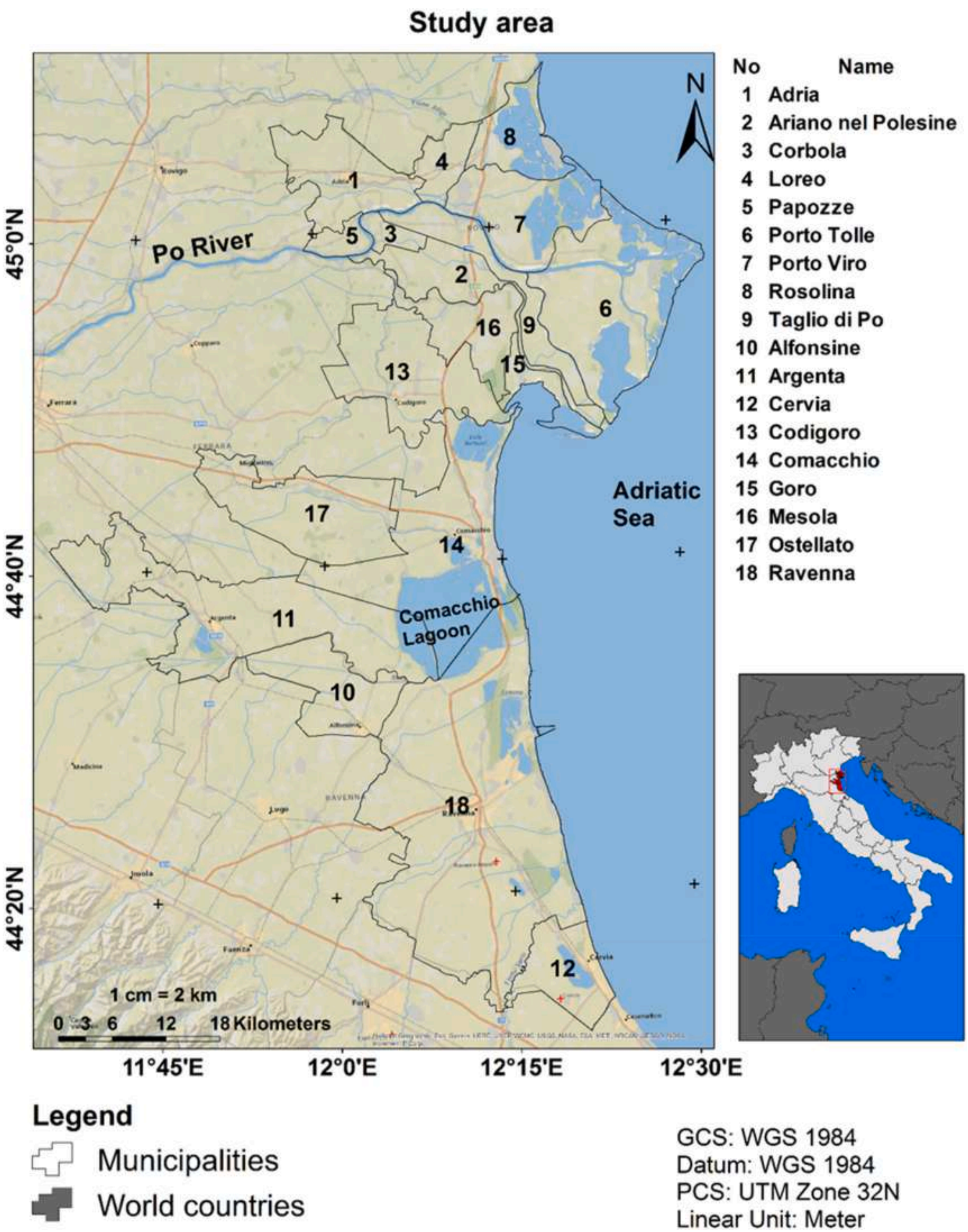

Fig. 1. The Po River Delta and the municipalities and regions of the Delta involved in the study.

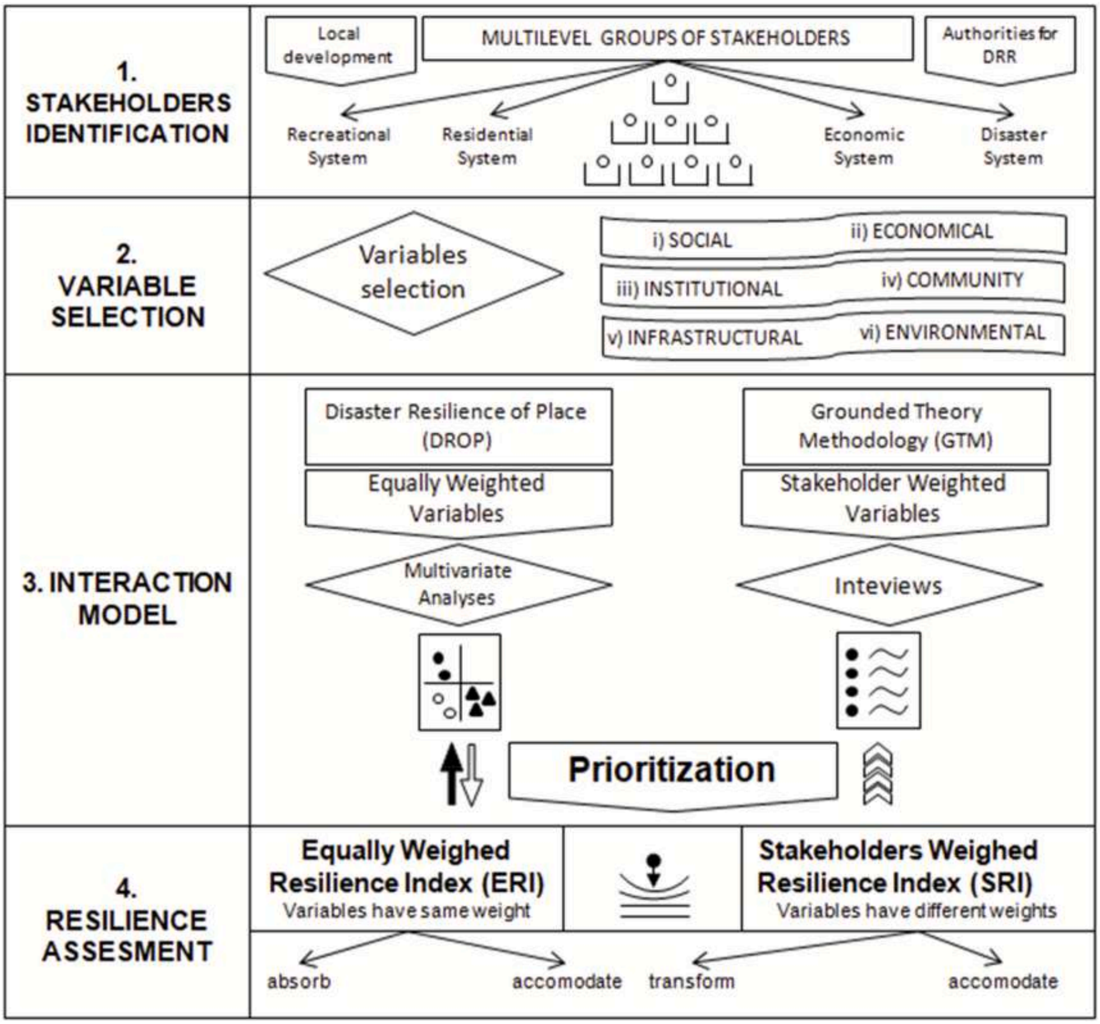

Fig. 2. - Methodological phases Flow Chart.

been selected drawing on literature review and the dimensions of the DROP model present in the work of Cutter et al. (2008, 2016) and Burton (2012). The resilience dimensions considered for the vari-ables selection have been: social, economic, community capital, institutional, environmental.

3) The application of the DROP model and the Gounded Theory Methodology. Stakeholders have been interviewed and asked to assign a weight to the variables previously identified. Variables are listed in Tables 1–6
4) The construction of two community resilience indexes. In the first index all the selected variables had the same weightage. In the second one the selected stakeholders assigned a score to each variable on a ordinal scale (from 0 - "not relevant" to 4 - "very relenvant" for measuring resilience) so that to prioritize the resilience measurement.

2.3. *The application of the drop model and the resilience dimensions*

To select a reasonable set of variables, several steps have been followed. 65 secondary data have been drawn together. Datasources encompassed the national census, organisations and direct contact with agencies and experts in the field. Most of the data were available in the public domain in electronic format even tough interesting data such as the capacity of saving money, are present only at regional level (and not at the municipal one which was the scale of this study).

A correlation analysis (Spearman's) of the set of the 65 variables has been carried out with the aim of removing potential redundancies. The analysis resulted in 20 highly correlated variables (cut off point for elimination Spearman $R > 0.700$) that were eliminated from further consideration.

The remaining 45 variables were analysed through a Principal Component Analysis (PCA). PCAs were carried out in the R statistical environment. Before PCA analyses, variables were standardized to z-scores, each with mean 0 and standard deviation 1.

To decide how many components to retain, in this study it has been adopted the rule of the explained variance. In general for descriptive purposes, the 75% of the cumulative variance explained by the first two or three principal components is suggested. However, the acceptable level of explained variance depends on the purpose of the analysis. Since in this study the aim was to select a set of parsimonious variables to be used both in the resilience index construction and in the discussion with the stakeholders, the threshold for the variablesselection has been set to 70% of the explained variance.

In the selection of the variables emerged from the PCA and that best represent the positioning of the municipalities with respect to the different subcomponents (social, economic, community, institutional, infrastructural and environmental), it has been decided to follow a conservative approach and to consider the variable whose coefficient value was higher than 0.3.

Tables 1–6 provide a full list of the 45 variables selected for representing the resilience dimensions.

Table 1 lists the variables considered for the social resilience

Table 1
– List of the variables measuring the social resilience subcomponent.

Variables	Literature source
Young people living alone	http://ottomilacensus.istat.it/(Italian National Institute of Statistics) WHO - Commission on Social Determinants of Health, 2008 Raphael (2004) Obrist et al. (2010)
Percentage of people with no special needs	Heinz center, 2002 Morrow (2008) Wood et al. (2010)
Foreign children attending schools	Morrow (2008) Norris et al., 2008 Cutter et al., 2010
Ratio adults with college degree to adults with no high school diploma	Norris et al. (2008) Morrow (2008) Tobin (1999)
Incidence of families with potential economic problems	Morrow (2008)
Adults in lifelong learning programs	Greenham et al. (2013)
Percentage of people living in an area at flood risk. High and medium risk	Adger et al., 2005 Berke and Campanella (2006) Cutter et al., 2008 Chang et al. (2006)
Pharmacy every 10000 abitanti Hospital beds pr 10,000 inhab Percentage of people having access to broadband Internet	Lochner et al. (1999) Lochner et al. (1999) Aguirre et al. (2005) UNDESA, 2007 Schneiderbauer and Ehrlich (2006)
Percentage of italian residents [no immigrants]	Cumming et al., 2005 Cutter et al., 2008

Table 2
List of the variables measuring the economic resilience subcomponent.

Variables	Literature source
Employment rate	Cutter et al. (2010) Norris et al. (2008) UNDESA, 2007 Rose 2004, 2007 Rose and Krausmann, 2013 Sherrieb et al. (2010)
Incidence of the population employed in the commercial sector [so not emplyed in the primary sector]	Cutter et al. (2010) Burton (2012)
Percentage of homeownership	Cutter et al. (2010) Haveman and Wolff (2005) Pendall et al., 2010
Number of commercial activities (big and small) per capita	U.S. Indian Ocean Tsunami Warning System Program, 2007 Cutter et al., 2008 Burton (2012)
Incidence young aged 15–29 that either do not study or work	U.S. Indian Ocean Tsunami Warning System Program, 2007
Per capita n° of cars on the total population [vehicle access]	Cutter et al., 2008
Birth/death of enterprises	Sherrieb et al., 2010 Cumming et al., 2005 Greenham et al. (2013) Cumming et al., 2005
Percentage of scientific/techical activities over the total activities	
Percentage of industrial activities on the total activities	Greenham et al. (2013) U.S. Indian Ocean Tsunami Warning System Program, 2007
Percentage of people working in entreprises in medium flood risk areas	
Percentage organisations for the social promotion and knowledge intensive business services	Cumming et al., 2005 Glaeser and Berry, 2005

assessment based on litterature analysis.

Table 2 provides an overview of the variables selected to represent the economic resilience based on litterature analysis.

Table 3 lists the variables that have been selected for the measurement of the community capital's sub-component based on litterature analysis.

Table 3
– List of the variables measuring the community capital's subcomponent.

Variables	Literature source
Civic organisations every 1000 inhab	Morrow (2008) Sherrieb et al. (2010) Walsh (2007) Murphy et al., 2007 Uphoff, 1998
Percentage of volunteers on the total population Disaster volunteerism (percentage of volunteers in civil protection and social assistance on the total population)	Cutter (2016) Paton and Johnston, 2006
Percentage of population employed in high professional occupation	Cumming et al., 2005 Glaeser and Berry (2005)
Libraries per 10000 inhab	Cumming et al. 2005

Table 4
– List of the variables measuring the institutional resilience subcomponent.

Variables
Municipality's debt
Financial autonomy, independence from the central government
Reliability of local government credits

Table 5
– List of the variables measuring the infrastructural resilience subcomponent.

Variables	Literature Source
Housing good quality	Mileti (1999) Theckethil (2006)
Surface of housing cluster	Geis and Kutzmark (1995) Cutter et al., 2008
Percent of housing that is vacant	Cutter et al. (2010)
Building expansion index, land cover change, rapid urban growth	Heinz Center, 2002 Morrow (1999)
Hotels/camping beds per 1000 inhab	Johnson, 2007 Tierney (2009) Cutter et al., 2010
Artificial surface in medium risk area	Heinz Center, 2002 Trigila et al. (2015)
Percentage of cultural heritage in low risk area	Heinz Center, 2002

Table 6
– List of the variables measuring the environmental subcomponent.

Variables	Literature Source
Percentage of no- consumed land	Heinz Center, 2002 Adger et al. (2005)
Percentage of not consumed land in the Protected areas	Heinz Center, 2002 Adger et al. (2005)
Percentage of consumed land at 150 m distance from water	Heinz Center, 2002 Adger et al. (2005)
Percentage of no- consumed land in medium risk areas	Heinz Center, 2002 Adger et al. (2005)
Percentage of no- consumed land in flooding high risk areas	Heinz Center, 2002 Adger et al. (2005)
Loss of ecosystem services (by using the maximum value)	Heinz Center, 2002 Adger et al. (2005)
Percentage of land area under protected status	UNDESA, 2007 Klein et al., 2003
Per capita consumed land	Geis and Kutzmark (1995) Heinz Center, 2002 Adger et al. (2005)

The institutional subcomponent is the one that poses more challenges in terms of measurement. In the Po Delta case study it was not possible to use proxies recognized in the literature such us percentage of households covered by insurance (Cutter et al., 2010; Erwann and Kunreuther, 2011); disaster education and outreach programs (Tobin, 1999); percentage of the population participating at preparedness pro-grams (Heinz Center, 2002), since this information was not available. It has thus been decided to use data related to the municipality economic balance.

The proxies used for the index construction have therefore been linked to the balance: municipality's debt; financial autonomy, independence from the central government; reliability of local government credits (Table 4). The above-mentioned variables have been selected since measurable. The selection has been then discussed with interviewees who have also provided a weight.

Table 5 identifies the variables used for measuring the infrastructural resilience.

Table 6 lists the variables considered for the environmental subcomponent.

The selected groups of variables have been standardized in a range between 0 and 1 to create a set having homogeneous measurement scale (where 0 is the lowest value and 1 the maximum). In addition, a negative directionality has been assigned to those variables having a negative effect on resilience.

The variables have been summed to obtain a final disaster resilience index at sub-component level: i. social resilience index; ii. economic resilience index; iii. community capital resilience index; iv. Institutional resilience; v. infrastructural resilience; vi. environmental resilienc (Ta-bles 1–6).

The equally weighted resilience indexes obtained for each subcomponent have been then summed to get a total composite equally weighted resilience index for each municipality.

2.4. Stakeholders interviews

The following phases characterize the in depth-interviews process a qualitative research technique that involves (Boyce and Neale, 2006): i. identification of decision makers and stakeholders to be involved; ii. the identification of information needed and from whom; iii. creation of a stakeholders/decision makers list to be interwieved based on their ca-pacity to represent diverse institutions.

For the stakelhoders/decision makers' selection, it was followed the theoretical sample approach as explained by Logli (2015) where the total sample is not selected ahead of time. The researcher begins with an initial sample chosen for its relevance to the research problem. The investigator is then led to the next participant and interview questions.

Considering the stakes "Disaster Risk Reduction" and "local development", we have selected a group of individuals concerned by that stakes and particularly knowledgeable about or experienced with them in the Po Delta area. As illustrated in Table 7 below, the interviewed consist of 17 participants working for regional and local authorities in charge of managing disasters risks, and actors from the third sector having a role in promoting the local community's development. Considering the stake "Disaster Risk Reduction and Resilience", we have selected a group of organisations concerned by that stake in the Po Delta area. In particular we have selected actors having first-hand knowledge and holding first managerial responsibilities with a prominent role in setting out the strategy of the selected organisations. We have identified two groups of actors: the first one having a primary public role in pre-vention, mitigation, preparedness, response and recovery; the second one more focused on local development and in particular on measures for the enhancement of the economic, social, environmental and cultural assets of the area.

All the interviewees holded first managerial responsibilities and had a prominent role in setting out the strategy of their organizatons in sectors such as risk reduction, local development and environmental protection.

Table 7
- List of the interviewed stakeholders, their role and belonging institution (names are not showed due to privacy reasons).

Institution type	People interwied and role
Consorzio di Bonifica of Veneto Region (Reclamation consortium: in charge of the water management for agricultural irrigation; soil protection; maintenance of the hydraulic infrastructures)	Top management – 1 person
Emilia-Romagna regional coordination office for risk (forecasting and prevention)	Top management – 1 person
Grass-root environmental group operating in the Emilia Romagna region	Top management and academic- 1 person
Grass-root environmental group operating in the Veneto region	Top management of the environmental group – 1 person
Trainer of the Civil protection's volunteers (Emilia-Romagna)	Executive – 1 person
Vice Mayor of one of the municipalities of the Po Delta	1 person
Emilia- Romagna Institute for the cultural heritage and landscape protection	Middle management – 1 person
Emilia-Romagna Regional Agency for Prevention, Environment and Energy - Hidro-Meteo-Climate Department	Top management – 1 person
Research center for the tourism and commerce sectors (working in cooperation with the Italian Enterprise Confederation)	Top management – 1 person
Politician - Member of the Emilia-Romagna legislative assembly	1 person
Local Action Group (GAL) for the valorisation of the Po Delta area (actuator of the Community sectorial policies of the Veneto Region)	Top management – 1 person
Veneto Region - Civil protection – Department for the Emergency Coordination	Top management – 1 person
Veneto Region - Civil protection –Department for Planning	Top management – 1 person
Regional office for Land and Coastal defense	Middle management – 1 person
Emilia-Romagna Regional office for the biodiversity protection	Top management – 1 person
Local Action Group (GAL) for the valorisation of the Po Delta area (actuator of the Community sectorial policies of the Emilia-Romagna Region)	Top management – 1 person
Italian Farmer's Confederation - Headquarter of the Ferrara Provincial Office (the interviewee is also vice president of the Consorzio di Bonifica Pianura di Ferrara – Reclamaion consortium of the Emilia-Romagna)	Top management – 1 person

Since the main purpose of the research was to elicit information from actors having first-hand knowledge and to understand how much the resiliene concept has entered the practices of governance, in the selec-tion process have been included participants holding first managerial responsibilities in their institutions and that, given their leadership po-sitions, had a prominent role in setting out the strategy of their in-stitutions on risk management, coastal defence, water management, local economic development and environmental protection.

A choice regarding the type of interviews that would at best match the purpose of this research has been made before going into the field.

Semi-structured in-depth interviews appeared to better serve the aim of: i. Grasping the multiplicity of factors shaping different/ similar resilience views; ii. have a better understanding on which resilience metrics are better recognized by stakeholders.

Semi-structured in-depth interviews allow the researcher to add new questions in the course of the interaction or to skip some others that turn out to be irrelevant (Blee and Taylor, 2002).

We gathered and analysed 17 in-depth interviews and decided to not go any further for the following reasons: i. when analyzing the last in-terviews, we noticed that we were not adding anything new and the emerged categories were sufficient to analyze data (Morse, 2004), ii. with the interviews we covered the sectors and actors of interest for this research. The decision is based on both the Glaser (2001) and Charmaz (2010) indication to continue until the pattern does not show new properties and on the two types of data saturation identified by Hennink et al. (2016). The authors indicated two types of saturation: code satu-ration and meaning saturation, suggesting that the first could be reached at nine interviews when researchers "heard it all" and the second one between 16 and 24 interviews when researchers "understand it all" (Hennink et al. (2016), p.1). In order to have a good quality interview attention has been given to the following aspects: i. short length of the questions ii. relevance of the answers; iii. follow-up questions with a clarifying aim; iv. interpretation of answers throughout the interviews; v. verifications of answers over the course of the interview (Brinkmann and Kvale, 2009).

The first interviews have not only provided initial data, but also oriented subsequent ones either by raising new aspects or by suggesting changes in the way of approaching stakeholders.

In order to allow stakeholders to undertand the aim of the study and to foster a participatory approach, a brief explanation of the method was provided to each of them. Moreover it was explained that the identifi-cation of the most relevant indicators for the resilience measurement is important for the promotion of actions towards a more resilient community.

The interviews consisted of three parts (see Annex): i. the first one was focused on the resilience concept and interviewees were asked to define disaster resilience and to indicate the variables potentially useful for its measurement in the Po Delta area; ii. the second targeted the governance dimension and involved questions aiming at investigating resources and initiatives put in place at local level to foster the resilience to flooding; the multi-layered institutional coordination (and possible bottleneck); the presence of participatory processes; iii. in the third part, stakeholders were asked to assign a weight to the variables selected for the resilience index construction.

This study illustrates the outcomes of the third part of the interviews.

3. Results

3.1. *The resilience index weighted by stakeholders*

The average of weights assigned by stakeholders has been in most cases higher than 2 (41 variables out of the 45 identified for the study). In Table 8 are reported the variables that obtained weights > than 2.5 and that thus encountered a major agreement about their relevance (29 out of 45 variables identified for measuring resilience).

These variables could be used as a starting point for a discussion around policies to be implemented to foster a resilient community and indicators to be used to monitor the policy objectives in the Po Delta Area.

3.2. *Comparison of the two indexes*

A Spearman's correlation analysis (cut off point for elimination Spearman R > 0.472) between the equally weighted and the stake-holders weighted resilience indexes at subcomponent level (social, economic, community, institutional, infrastructural and environmental) has been carried out.

The analysis showed that the equally weighted and the stakeholders weighted resilience indexes are highly correlated and thus demonstrated that the selected metrics used to build the first index (the equally weighted) are recognized by stakeholders as able to represent a resilient community. Stakeholders have therefore shown a general agreement on the variables used for the indexes construction. The high correlation has also geopgraphyc evidence when the spatial visualization of the total resilience scores for each municipality is reported in a classified the-matic map (Fig. 3).

The maps above (Fig. 3) show some interesting spatial aspects in the study area. First, there is a separation among communities according to the equally weighted and weighted indexes, with northern communities, around Po river mouth, and two of the southern communities (Alfonsine and Ravenna) with high values of indexes; and central communities with low or middle values of indexes. Second, two (Loreo and Ostellato) out of three communities with low values of indexes are far from coastline, which is an interesting aspect related to resilience in delta regions. Third, it is interesting how the community with lowest value (Loreo) and the community with highest value (Rosolina) are neighbors and share common frontier.

Final results (Fig. 4) does not show major deviations in the resilience ranking. In particular it is the same for the first three and the last six positions, whereas in cases such as the municipality of Adria and Comacchio a change in the ranking (from n. 12 to 9 and from n.9 to 11) can be observed.

The resilience indexes can be also compared at subcomponent level. In the maps below infrastructural resilience and social resilience indexes are spatially represented (Figs. 5 and 7).

As it can be observed, the two indexes do not register major deviations.

In the case of the infrastructural resilience both indexes showed a north-to-south reduction. The northern communities have the highest values of indexes, while the southern ones have the lowest values. In this case, there is a minor change in the ranking, with Alfonsine presenting the lowest value of equally weighted infrastructural resilience index and Ravenna showing the lowest value of stakeholders weighted infra-structural resilience index. The rest of the communities show a similar position (or ranking) for both the equally weighted and the stake-holders' weighted indexes. It is interesting how the communities around the Po river mouth have high values of infrastructural resilience index, while the communities far away from river mouth have low values of infrastructural resilience index.

This observation is confirmed in Fig. 5 where the resilience ranking does not show significant deviations between the two indexes (equally

Table 8
– Variables recognized as more relevant by stakeholders.

Variables	Obtained average
Incidence of families with potential economic problems	2.765
Adults in lifelong learning program	2.765
People living in high and medium risk areas	3.059
Percentage of people with broad band Internet access	2.765
Employment rate	3.235
Young people (15–29) that either do not study or work	2.765
Survival of economic activities	3
Scientific and technical activities over the totality of economic activities	3.412
Knowledge intensive business services	3.412
Presence of civic organisations	2.824
Percentege of volunteers on the total population	3
Percentage of volunteers in civil protection	3
Percentage of population employed in high professional occupation	3.118
Municipality debt	2.588
Financial autonomy	2.765
Reliability of local government credits	2824
Housing good quality	2.706
Incidence of the surface occupied by housing cluster	2.647
Percent of housing that is vacant rental unit	2.647
Building expansion index	2.588
Artificial surface in low risk areas	2.765
Percentage of no-consumed land	3
Percentage of no-consumed land in the Protected areas	2.588
Percentage of consumed land at a 150 m distance from the hydraulic source	2.765
Percentage of no – consumed land in medium risk areas	2.647
Percentage of no – consumed land in high risk areas	3.235
Loss of ecosystem services	2.706
Percentage of land under protected status	2.941
Per capita land consumption	3.118

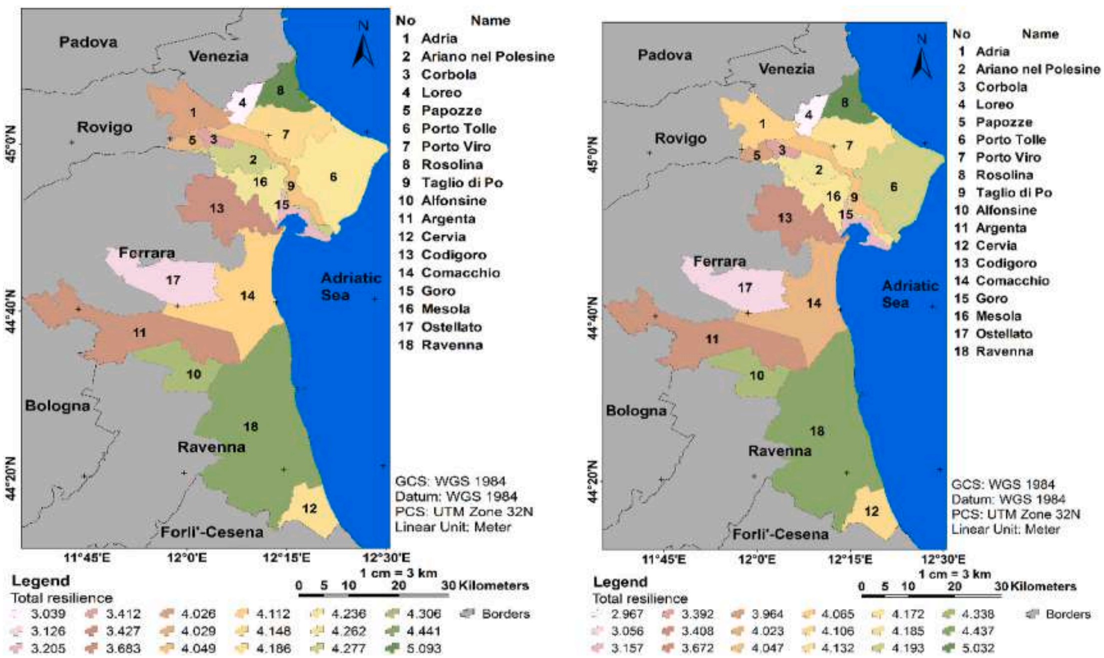

Fig. 3. Spatial representation of the equally weighted and weighted total resilience indexes.

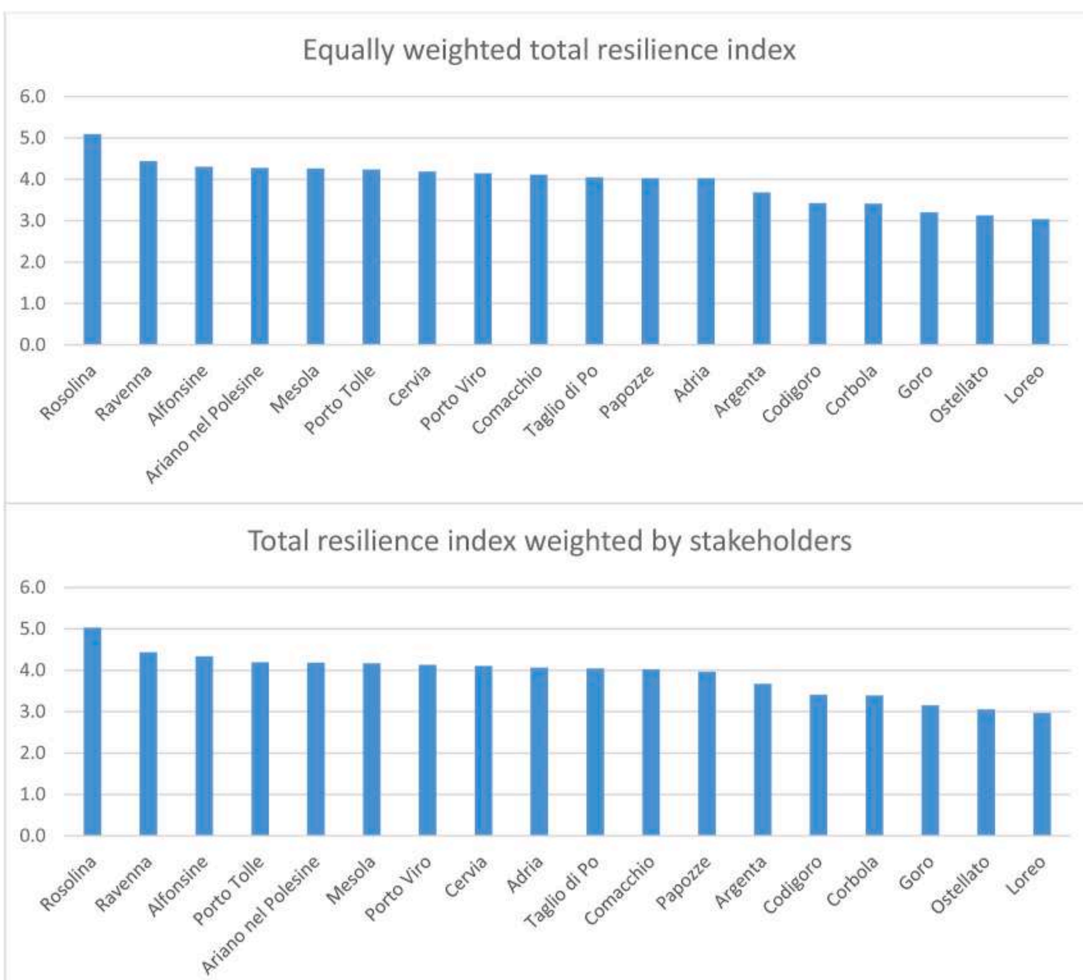

Fig. 4. Comparison between the equal weighted and the stakeholders' weighted total resilience indexes.

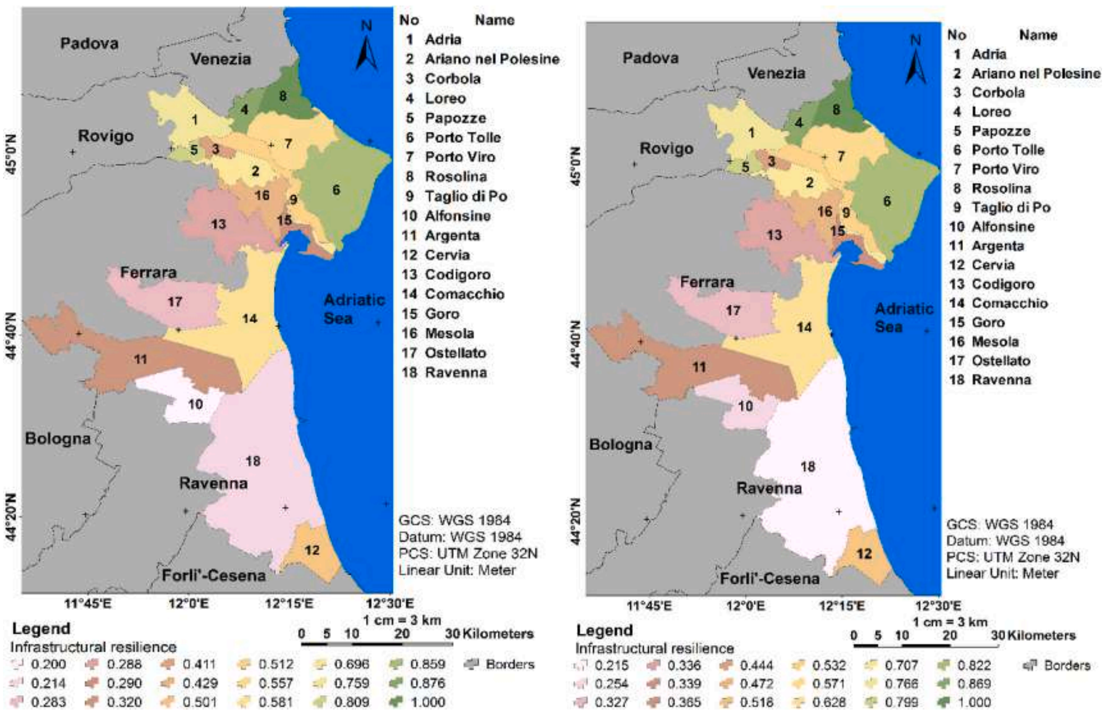

Fig. 5. Spatial representation of the equally weighted (a) and weighted (b) infrastructural resilience indexes.

weighted and stakeholders' weighted).

In the case of the social inherent resilience indexes, more deviations can be observed in the ranking of the municipalities. The maps below (Fig. 7) show that the lowest values are concentrated in the center of the area, specifically in Codigoro, Goro and Mesola communities. It is interesting that the two lowest values correspond to communities which are side by side, in this case Goro and Mesola. The highest social weighted resilience index value corresponds to Adria. In particular Adria has among the highest values of "people with no special needs", "people with college degree" and "adults in life-long learning programs". In parallel it has the lowest values of "% of people living in areas at flood risks". Stakeholders have assigned a great importance to the variables "adults in lifelong learning programs" and "percentage of people living in areas at flood risks". Most of them, indeed, assigned the value 3 (the range allowed was 0–4). The final average resulting in 2.8 for the var-iable "adults in lifelong learning" and 3.1 for the variable "people living in high and medium flood risk areas".

4. Discussion

The need to operationalize resilience has triggered attention in indicators as means for assessing and achieving a more resilient community.

To promote a resilience-informed decision making, metrics validated and discussed with the actors moving around the DRR stake are central. However resilience cannot be analysed with a normative aspiration, since in the construction of a resilient community, each context will follow its own path according to its features. The challenge of moving the resilience concept from a theoretical to an operational domain is related to the identification of metrics linked to the specific context that are recognized as valid by the organisations and institutions operating in the selected area. In this research the inclusion of diverse opinions and experiences demonstrate to be crucial (Ker Rault, 2008). What has emerged is that stakeholders have showed a general agreement on the selected variables that, according to the literature (Cutter et al., 2008, 2016 and Burton (2012), are valuable proxies for the measurement of the social, economic, community capacity, infrastructure and environment resilience of communities.

The average of weights assigned by stakeholders to variables has been in most cases higher than 2 (41 variables out of the 45 identified for this study). Moreover, as shown in Table 8 the variables that obtained a weight > than 2.5, thus encountering a major agreement about their relevance, have been 29. This has allowed to better understand which drivers of resilience are most important to stakehiolders and which proxies may be best to measure those drivers in their context (IPCC, 2014; Burton, 2012; Norris et al., 2008; Cutter et al., 2008, 2010, 2016).

The proposed method allows to construct a descriptive resilience index through the involvment of stakeholders and the use of secondary data, so that to respond to the challenge of developing practical opera-tional approaches for resilience (Klein and al., 2003; Cutter, 2016; Taramelli et al., 2020a,b).

The inherent portion of the DROP (Disaster Resilience Of Place) model (Cutter et al., 2008) combined with interviews with key informants based on the Grounded Theory Methodology (Charmaz 2010; Glaser and Strauss 1967) responds to the need of having a resilience measurement tool which is relevant to the local context and applicable by local entities trough the use of secondary data (Brooks et al., 2014; Knight et al., 2015).

As a consequence, with respect to the resilience ranking of the municipalities, relatively small differences are detected in the case of the equally weighted and the stakeholders' weighted total resilience indexes (from the more to the less resilient). This aspect has been evident in the Spearman's correlation analysis carried out among the equally weighted and the stakeholders' weighted total resilience indexes (cut off point for elimination Spearman R > 0.472) in Table 9 where a high correlation has been observed. The magnitude of the correlation coefficient in fact is between 0,96 and 0.97, showing that the indexes are highly correlated.

This is evident also in the spatial representation of the total resilience indexes (equally weighted and stakeholders'weighted) (Fig. 3) where no major differences are observed.

The identification of metrics meaningful for stakeholders is a valuable resource to use in the decision-making process and represents a progress beyond the construction of valuable resilience indexes based on secondary data, such as the DROP model (Cutter et al., 2008).

Table 9
- Spearman correlation analysis of the Resilience indexes (equally and stakeholders' weighted indexes).

	social	*economic*	*community*	*Institut.*	*Infrastruct.*	*Environm.*	*relience index*
Social	1						
Economic	0,583075	1					
Comm.	0,304438	0,430341	1				
Institut.	0,496388	0,69453	0,50258	1			
Infrastruct.	0,296182	−0,30237	−0,0258	−0,14757	1		
Environm.	−0,28173	−0,36842	−0,06914	−0,26935	−0,08772	1	
Res. index	0,376677	0,380805	0,783282	0,632611	0,089783	0,285862	
SocialW	0,964912						
Econ.W		0,975232					
Comm.W			0,997936				
InstvarW				0,993808			
Infrastruct.					0,997936		
Enironm.lW						0,995872	
resilienceindexW							0,977296

At subcomponet level the same trend has been observed. The comparison of the ranking of the municipalities in the case of the infrastructural and social resilience did not register major deviations between the equally weighted and the stakeholoders' weigted indexes (Figs. 5–8).

If we look at the social resilience index weighted by stakeholders, we notice that Adria ranked first, while it was second in the case of the equally weighted index. The difference in the ranking is not relevant, however it is interesting to look closer to the data.

Adria had among the highest values for the variables "people with no special needs", "people with college degree" and "adults in life-long learning programs". In parallel it had the lowest values of "percentage of people living in areas at flood risks".

As seen, stakeholders intended as those organized around common interests (Ridder et al., 2005, Table 7) have assigned a great importance to the variables "adults in lifelong learning programs" and "percentage of people living in high and medium flood risks areas". Most of them, indeed, assigned the value 3 (the range allowed was 0–4). The final average resulting in 2.8 for the variable "adults in lifelong learning" and 3,1 for the variable "people living in high and medium flood risk areas". The same analysis could be done for each municipality and used as

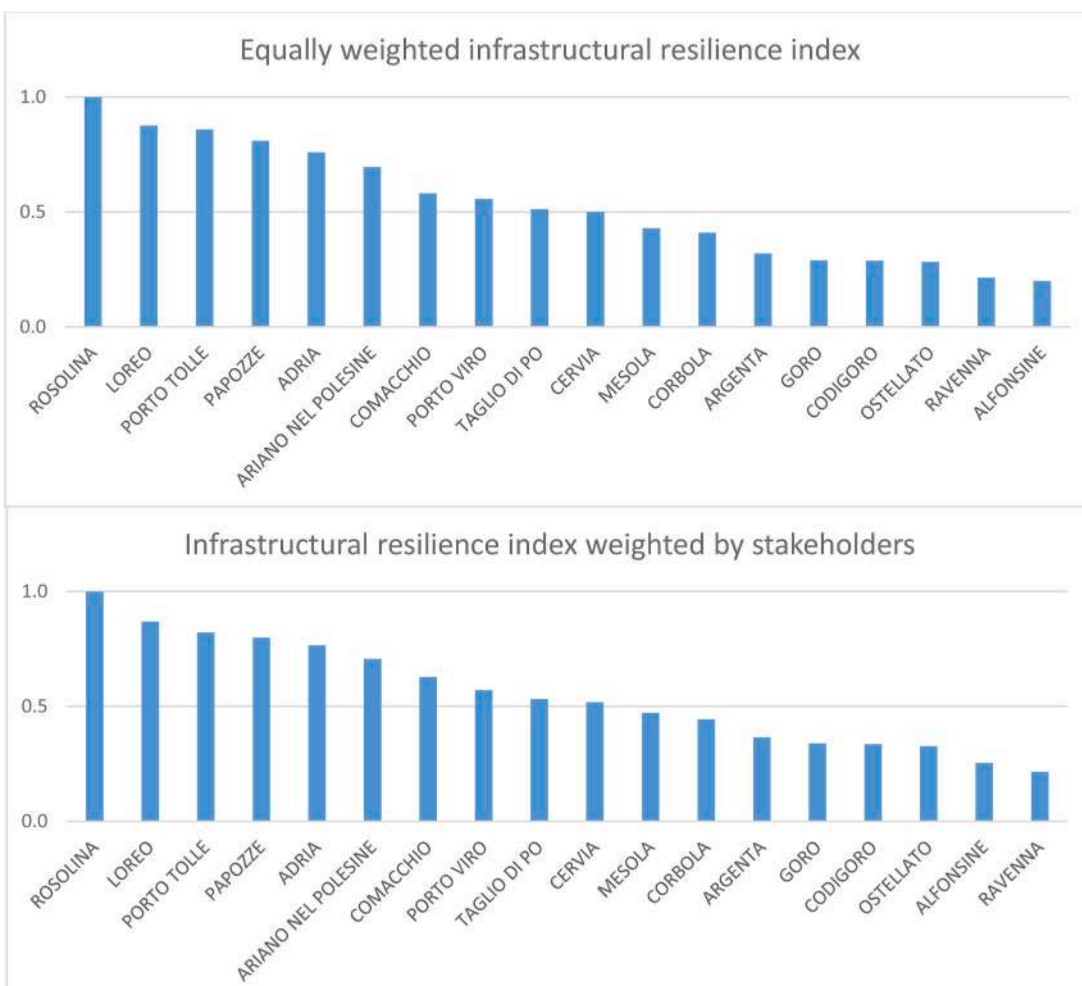

Fig. 6. – Comparison between the equally weighted and the stakeholders' weighted infrastructural resilience indexes.

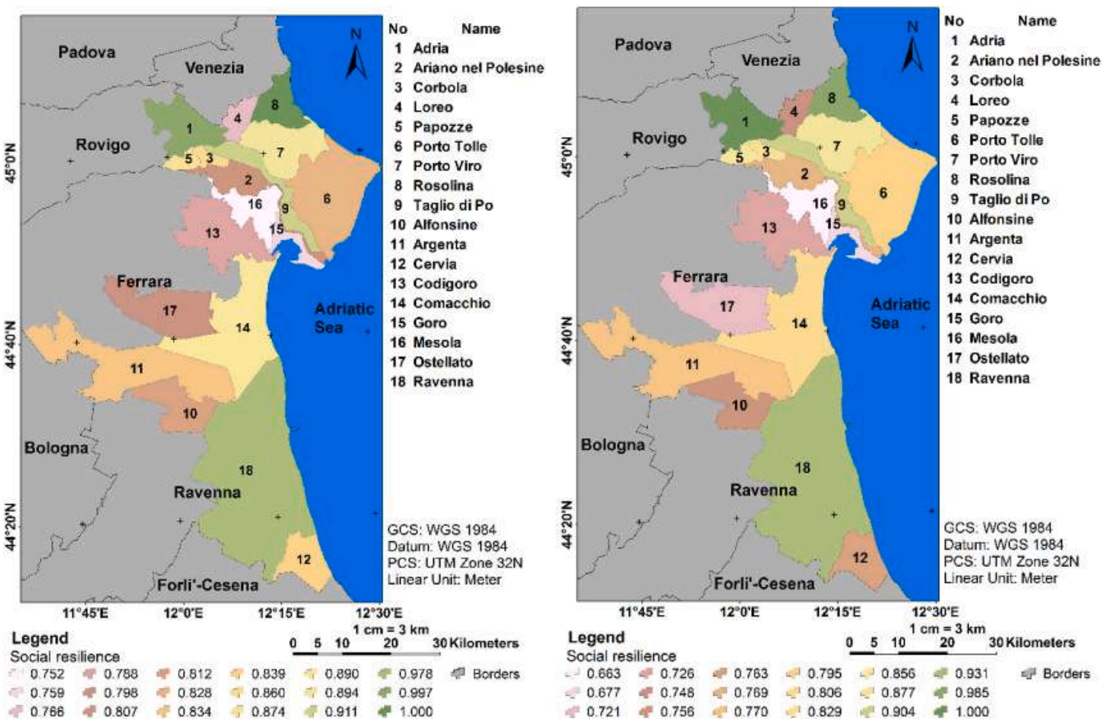

Fig. 7. Spatial representation of the equally weighted (on the left) and weighted (on the right) social resilience indexes.

starting point for a discussion among stakeholders (Ozesmi and Ozesmi, 2003; Geraldini et al., 2021) on which policy can implement and foster a resilient community and which indicators to use to monitor the policy objectives around resilience (Tables from 1 to 6 - Variables for the measurement of the social, economic, community, institutional, infra-structural and environmenalt resilience; Table 8 - Variabels recognized as more relevant by decision makers and stakeholders; Figs. 4–8 Com-parison of the resilience indexes).

Metrics (Table 8) could be used to build a field level interaction, a relational space that provides organisations with the opportunity to involve themselves with other actors (Wooten and Hoffman, 2008) in a resilience discourse and assessment where the DRR and resilience dimensions interact.

Labels facilitate the attachment of monetary resources and are important to suit purposes and build a new field of intervention (Grodal, 2007). The resilience discourse could be then used as a relational space where structuring common and recognized actions by using the previ-ously selected metrics as a tool (Tables from 1 to 6 - Variables for the measurement of the social, economic, community, institutional, infra-structural and environmenalt resilience; Table 8 - Variabels recognized as more relevant by decision maker and stakeholders; Figs. 4–8 - Com-parison of the resilience indexes).

We can thus identify not only how the resilience of municipalities changes at subcomponent level, but also which variables are more significant to stakeholders and which is their effect on the ranking.

At the operational level, the proposed method provides the decision maker with a picture of the state of the community resilience's components. Through the proposed tool, the different components of community resilience are assessed in relation to the perception of the questioned stakeholders. In this way the decision maker, in the presence of a limited budget, can decide which components to strengthen and which to keep unchanged.

The importance of proactive actions aimed at enhancing resilience has been increasingly recognized in the policy agenda (World Bank, 2013). Through this systematic approach local stakeholders can be actively involved in the Disaster Risk Reduction (Gall et al., 2014).

Knowing which resources are most likely to predict later resilience is a complex challenge for community developers (public bodies and private sector), but crucial because it allows to identify a common language useful to address strengths and weaknesses of the area under analysis.

To promote a resilience informed decision making and governance, metrics are needed but these should be validated and discussed with actors moving around the DRR stake. Actors belonging to various fields (government officials, organisations dealing with local development and environmental aspects) and having different objectives and responsabilities, could thus be held together around the label of resilience in order to produce actions repeated over time and with resources attached to them. The transfer of conceptual resilience propositions into applied strategies is a challenging task. What it is argued in this study is that increasing attention should be paid to the integration of resilience into sectoral policies, so that to develop specific plans (Failing et al., 2007; Funtowicz and Ravetz (2003).

How organisations can implement actions relevant for achieving community resilience and translate the concept into concrete actions often still remains uncertain. To face this challenge, the identification of metrics meaningful to stakeholders is a valuable resource that this study proves to be important in the decision-making process.

As widely recognized, resilience is still insufficiently supported by empirical data. How organisations can operationalize principles for achieving resilience and translate the concept into concrete actions often remains vague. To increase the understanding of the concept and its measurement, metrics are valuable tools and can be used in the decision-making process. The challenge is to develop metrics that are meaningful for stakeholders.

The use of tools such as the one illustrated in this study can allow different stakeholders to work together and to adopt a common approach in operationalizing resilience (Peek and Mileti, 2002; Altay and Green, 2006; Gall et al., 2014; Taramelli et al., 2020a,b).

The challenge of moving the resilience concept from a theoretical to an operational domain is related to the fact that the concept must be clearly adopted in established by institutional and organisational frameworks. Despite the different definitions provided by stakeholders, this study shows that metrics can be a practical tool, a common operative ground and starting point to couple the risk governance with what is

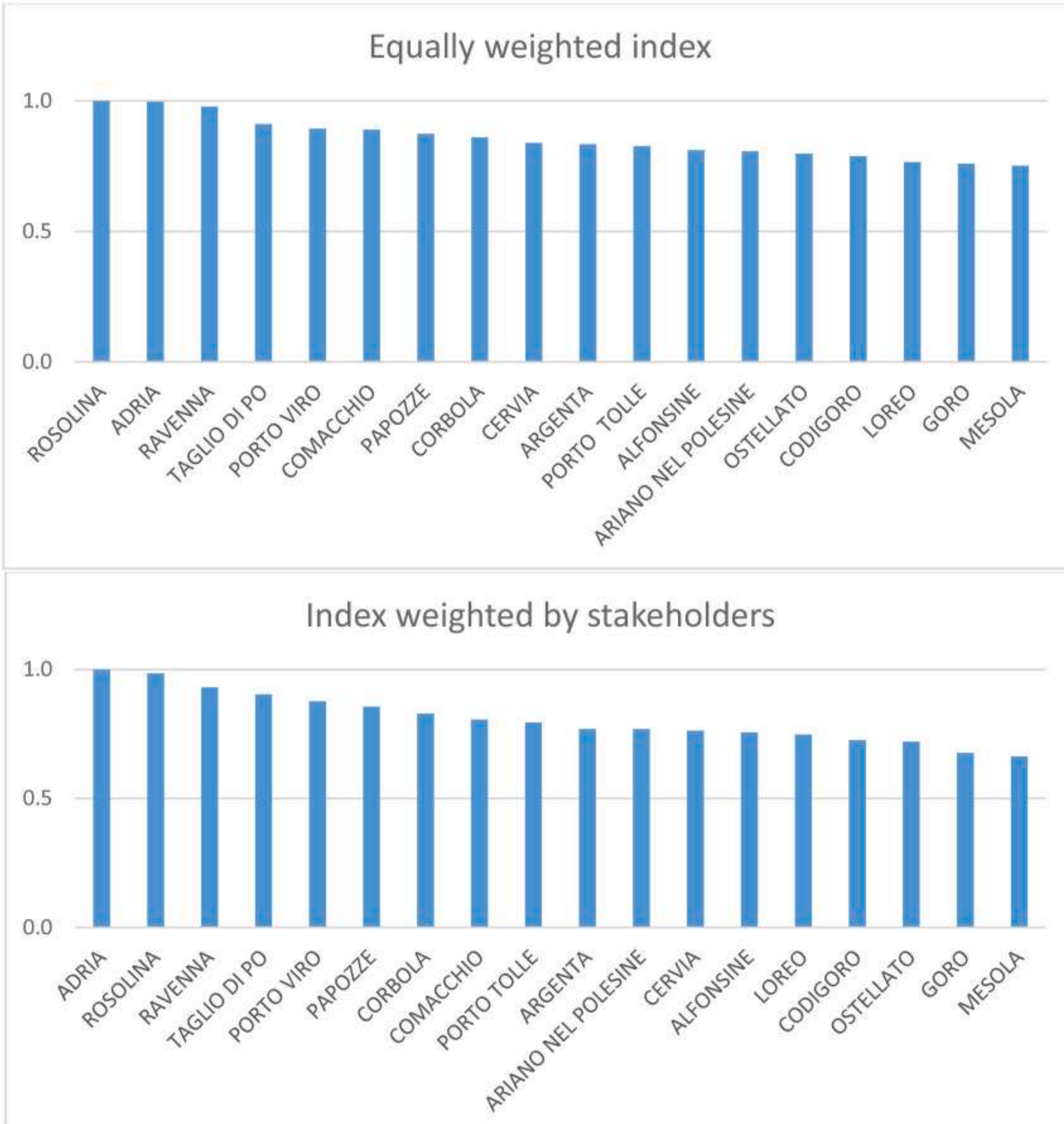

Fig. 8. - Comparison between the equal weighted and the weighted by stakeholder's social resilience indexes.

defined a resilient informed interactive governance. In order to operationalize the concept and make it an anchor around which to develop governance practices, it is necessary to identify and validate metrics that are meaningful to stakeholders and that can be used to develop methodological frameworks. The policy literature highlights that since disasters are likely to increase while public resources decrease, the understanding of what are the characteristics and actions that communities can put in place to foster an efficient recovery and how to facilitate the process becomes relevant.

5. Conclusion

Resilience is a wicked concept for which it is difficult to formulate a singular root-cause and to prescribe normative solutions. What makes the concept so wicked is its fragmentation: stakeholders have a different idea of what a resilient community is.

This makes the introduction of the concept in the governance practices challenging. The participation of relevant actors of a given area in the identification of metrics to be used to inform policies will enhance the application of the disaster resilience principles. Although indicators are important for the analysis of the resilience's key points, the selection of strategies to put in place for the achievement of a resilient community is a policy action. Policy makers propose political agendas, commit resources and should promote a debate around the issue. In parallel institutions and organisations operating in the selected area should take part to that debate.

To adopt policies and programs informed by disaster resilience implies to enhance the understanding of the different points of view, criteria, preferences and trade-offs involved in decision-making and in particular the features and hurdles of the concept as perceived by different stakeholders.

Stakeholders are central for the decision on what metrics are most useful to operationalize resilience in a given context especially when stakes are different and facts uncertain, to verify the availability of place-specific metrics, as well as to have a better understanding of the effectiveness of the resources allocation.

The proposed methodology highlights the importance of the stakeholders' involvement in the construction of a composite resilience index to be used as a decision-making benchmark for building resilience. The similarities in the equally weighted and in the stakeholders' weighted resilience indexes and thus in the resilience ranking of the municipalities has shown a general agreement on the proposed resilience subcomponents and their use may indicate how resilience changes over time depending on investments put in place. The authors consider the study a definition of an explicit tool for resilience assessment in deltaic systems and a contribution in terms of knowledge to the local man-agement and planning component. This approach is a starting point for researchers and institutions to develop new approaches and evolve more detailed and scalable models to policies.

Further research is needed for better understanding to what extent institutions and organisations involved in the governance of an area, recognize the concept of resilience as relevant to inform policies and local initiatives. Normative and cultural-cognitive dimensions of the practice of institutions in addressing and promoting resilience should be addressed.

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.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ocecoaman.2021.105867.

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