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Rome was not built in a day. Resilience and the eternal city: Insights for urban management

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ABSTRACT

Resilience has been intensely investigated as the viable quality of individuals, groups, organizations, and systems to respond productively to notable change without engaging in an extended period of regressive behaviour. Recently, there has been growing attention to the relationship between resilience and cities. To contribute to this stimulating debate, this paper first provides the theoretical framework and links the concept of resilience to urban studies. Subsequently, it enlightens, through a systems perspective and the aspect-based sentiment analysis (ABSA) methodology, the possibility to enrich the information variety endowment of urban policymakers, generated by new information units, to foster resilience capabilities in the urban context. Specifically, a large-scale text analysis study was conducted on the city of Rome to understand the sentiments expressed within the text generated online by citizens and visitors. The positive or negative sentiments linked to the hidden problems of the urban context were organized within collective perception-based maps for each of the analysed points of interest (POIs). Since cities represent complex decision-making contexts, this study aimed to outline a methodology and a tool that would help foster resilient thinking in urban policies by enriching the diversity of the information variety endowment of urban decision-makers.

1. Introduction

From physics to ecology, from engineering to social sciences, resilience has been increasingly investigated as the viable capability of individuals, groups and social systems to respond productively to notable change or challenges without engaging in an extended period of regressive behaviour (Home III & Orr, 1998; Kobasa et al., 1982). Managerial and organizational scholars (Contu, 2002; Durodie, 2003; McManus et al., 2007; Pooley & Cohen, 2010; Seville, 2009; Sutcliffe & Vogus, 2003; K.E. Weick, 1993; K.E. Weick & Sutcliffe, 2006) have further defined resilience as the "ability to survive" while maintaining adaptive, proactive, and reactive strategies to deal with threats, risks, and disruptive challenges.

In recent years, thanks to its usefulness for understanding complex systems such as cities, in urban studies, there has also been a growing effort to uncover what makes an urban context "resilient". Resilience is thus the potential to exhibit resourcefulness by using an available internal and external slack of resources in response to different contextual and developmental challenges.

Accordingly, urban resilience is defined herein not only as the capacity of an urban system to adapt to changes either by absorbing sudden disturbances (*absorption*) or by managing to maintain or restore initial functions without limiting future adaptability (*adaptation*) but also, when intense alterations and disturbances occur, the capacity to design and undertake broader and deeper changes that can even lead to transformation (*transformability*).

By focusing on the city of Rome (Italy) and applying a robust research methodology, this paper aims to contribute to the stimulating debate on the resilience capability of urban contexts and to promote - at both the theoretical and managerial levels- a *resilient thinking* in managing complex urban contexts. As complex systems, urban contexts configure wicked problems (Rittel & Webber, 1973), whose understanding (*requisite variety*) depends on the richness of the *information variety* endowment owned by the decision makers. The methodology (ABSA) and the related tool (collective perception-based maps) proposed herein help to enrich the information variety of the policy-makers

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with respect to their awareness of the "perceived" urban resilience and its dynamic. This draws the attention to the crucial relevance that the "perceived" context should play for policy makers involved in resilient thinking, i.e. a thinking aiming to make the urban context more and more resilient.

To this end, the paper is organized as follows.

First, rooting in the wide and multidisciplinary literature on resilience and in particular from the main contributions on resilience in urban studies, a definition of a "resilient city" is provided together with its main specific dimensions (Sections 1 and 2).

Second, an original field study is described (Sections 3 and 4). It addresses the urban context of Rome: a city with more than 2750 years of the historic urban landscape that represents a valuable example of a resilient urban context. The research is framed according to the aspect-based sentiment analysis (ABSA) methodology (B. Liu, 2012). This methodology – which was developed within marketing research - was here initially applied for the first time to analyse an urban context: the sentiments and opinions expressed in online generated texts by Roman citizens and visitors were analysed to appreciate the vulnerabilities and resilience capabilities of Rome. An original visual tool – collective perception-based maps – is then provided to foster resilient thinking in urban management.

Both the ABSA methodology and the collective perception-based maps allow light to be shed on urban issues in an innovative way. By leveraging the shared perception of users and institutions, it is possible to enhance the awareness of the decision-maker (W.R. Ashby, 1957, 1958) about the vulnerabilities and stresses of the urban contexts in a specific time and foster resilience through planned and consistent interventions (Section 5).

Eventually, future research paths and further potential applications of ABSA in urban management are discussed (Section 6).

2. Theoretical background: resilience and urban studies

The etymology of the word *resilience* goes back to the Latin *resaltare*, which means *to rebound,* or *bounce back*, *to get moving again*, or *to result from*, and possibly from *resilire*, which has the literal meaning *to jump backwards*; it is used to indicate the process of adapting to circumstances in the face of shocking events. The early inspiration for the use of the term in research came from the two different but compatible fields of engineering (focusing on material strengths and robustness) and ecology (focusing on the study of complex ecosystems). Both domains focus on the capacities of the elements of a system to bend, flex, adapt, and mould to continuous changes under environmental conditions. A resilient material, for example, bends and bounces back under stress rather than breaking (Bodin & Wiman, 2004; Gordon, 1978). The ability of a system to withstand the stresses of environmental loading forces is closely associated with the composition and combination of the system's pieces, their interlinkage, and the modality through which the change pervades the whole system. Each system, in fact, naturally contains some degree of internal resilience, which favours its flexibility and adaptation to counteract other resistant forces that would otherwise drive it in the direction of destructive fragility (N.N. Taleb, 2010). This elastic property constitutes the central premise of resilience. Furthermore, given the richness of the concept, several other domains of knowledge have investigated its meaning and implications.

Deepening each of the main fields in engineering resilience describes the ductility together with the resistance and robustness[1] of materials and physical infrastructures (Cardin et al., 2013; Sharifi & Yamagata, 2016; Tyler & Moench, 2012; Van der Leeuw & Aschan-Leygonie, 2005). Mainly associated with resistance and robustness, engineering resilience indicates the ability of a physical structure (e.g., buildings and urban physical infrastructures) to avoid disproportionate damage (e.g.,

Table 1
Definitions of resilience from different fields.

Field of research	Definition of resilience	References
Engineering and physics	The ability of a material to return to its initial shape following an external shock.	Gordon, 1978; Le Coze & Capo, 2006; Van der Leeuw & Aschan-Leygonie, 2005; Woods, 2006; Tyler & Moench, 2012; Cardin et al., 2013; Sharifi & Yamagata, 2016
Ecology and biology	The ability of systems to absorb disturbances and still persist: a positive adaptation in response to a nonstatic environment and its adversities.	Holling, 1973; Gunderson, 2000; Klein et al., 2003; Bodin & Wiman, 2004
Psychology	An individual's ability to successfully adapt to life tasks in the face of social disadvantage or other highly adverse conditions, from family and health problems to the workplace and financial worries.	Kobasa et al., 1982; Zimmerman & Arunkumar, 1994; Rutter, 2008; American Psychological Association, 2014
Social sciences	The ability of groups or communities to cope with external stresses and disturbances due to social, political and environmental change.	Wiley, 1988; Home III & Orr, 1998; Sonn & Fisher, 1998; W.N. Adger, 2000; Norris et al., 2008; Berthoz, 2013
Disaster management	The ability of social units to mitigate hazards, contain the effects of disasters when they occur, and carry out recovery activities that minimize social disruption and mitigate the effects of future disasters.	Riolli et al., 2002; Bruneau et al., 2003; N.N. Taleb, 2007, 2010; Fiksel, 2015
Social-ecological systems (SES)	-The capacity of a system to persist with and adapt to change but also transform away from unsustainable social-ecological trajectories. - The capacity of linked social-ecological systems to absorb recurrent disturbances such as hurricanes or floods to retain essential structures, processes, and feedbacks.	Holling, 1973; Wiley, 1988; Home III & Orr, 1998; W.N. Adger et al., 2005; W.N. Adger, 2000; Godschalk, 2003; B.H. Walker et al., 2006; Rist et al., 2014; Folke et al., 2016; Nyström et al., 2019
Managerial and organizational studies	The ability to effectively respond to significant changes that disrupt the expected pattern of events without introducing an extended period of regressive behaviour.	K.E. Weick, 1993; Contu, 2002; Sutcliffe & Vogus, 2003; Durodie, 2003; K.E. Weick & Sutcliffe, 2006; McManus et al., 2007; Seville, 2009; Pooley & Cohen, 2010
Urban studies	- A system's capacity to absorb disturbance while retaining a state similar to the original and for self-organization. - The ability of an urban system and all its constituent socio-ecological and socio-technical networks across temporal and spatial scales to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change and to quickly transform systems that limit future adaptive capacity.	Klein et al., 2003; S. Meerow et al., 2016; Fitzgibbons & Mitchell, 2019; Béné et al., 2018; Ziervogel et al., 2017; Kaika, 2017; Brown, 2012; Fainstein, 2015; Friend & Moench, 2013; Chelleri, 2012; Gillard, 2016; S. Meerow & Newell, 2016; Davoudi & Porter, 2012; Vale, 2014; Oteng-Ababio et al., 2015; Meriläinen, 2019; Labaka et al., 2019; Desouza & Flanery, 2013; J. Walker & Cooper, 2011

Source: Authors' elaboration.

[1] From the Latin *robusur,* "robustness" indicates vigour, strength and energy.

collapse) due to localized damage. Thus, resilience refers to materials and physical structures capable of utilizing their reserves of resistance until collapse through the activation of multiple alternative routes of loading.

The term resilience has also been documented in the ecological and biological, physical, psychological, social, managerial, and urban literature (W.N. Adger, 2000; Butler et al., 2007; Contu, 2002; Fitzgibbons & Mitchell, 2019; Hamel & Valikangas, 2003; Klein et al., 2003; S. Meerow et al., 2016; S. Meerow & Newell, 2016; Sonn & Fisher, 1998; B. Walker & Salt, 2012; K.E. Weick, 1995) (Table 1).

In ecology and biology, *resilience* has been described as the ability of systems to absorb disturbances while continuing to persist. In this sense, resilience does not imply the absence of vulnerability but rather a positive adaptation in response to a nonstatic environment and its adversities (Gunderson, 2000; Klein et al., 2003). It is a "measure of the persistence of systems and their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables" (Holling, 1973).

In physics, resilience has been defined as the ability of a material to return to its initial shape after an external shock (Le Coze & Capo, 2006), specifically in reference to the magnitude of the initial displacement, the strength of the oscillations, and especially how quickly homeostasis is achieved (Norris et al., 2008).

In psychology, resilience has been described as an individual's ability to successfully adapt to life in the face of social disadvantage or other highly adverse conditions, ranging from family and health problems to the workplace and financial worries (American Psychological Association, 2014; Rutter, 2008).

An even broader meaning is associated with *resilience* when it is used in the "collective sciences". In social sciences, it has been used to refer to "a fundamental quality of individuals, groups, organizations and systems as a whole to respond productively to a significant change that disrupts the expected pattern of events without engaging in an extended period of regressive behaviour" (Home III & Orr, 1998): resilient individuals and societies deal with traumatic events in life and display hardiness and ability to overcome difficulty and recover to continue with their lives (Kobasa et al., 1982). Furthermore, in the context of risk and disaster management, resilience has been identified as the ability of social units to mitigate hazards, contain the effects of disasters, and carry out recovery activities that minimize social disruption while mitigating the effects of future disasters (Bruneau et al., 2003; Fiksel, 2015); it is understood as an unavoidable tool for dealing with complex, fast-moving, and unfamiliar changing landscapes and "black swans" (N. N. Taleb, 2007).

More recently, resilience has been used as a lens to understand social-ecological systems (SESs) and to address biosphere-based sustainability (W.N. Adger, 2000; W.N. Adger et al., 2005; Folke et al., 2016; Nyström et al., 2019). The human footprint is increasingly permeating ecosystems and societies as an effect of the Anthropocene and indicates mankind's ability to fully intervene in natural limits (Crutzen, 2006). On the one hand, the anthropogenic inputs of external resources can dramatically lead to a 'coercion' of resilience; on the other hand, the increasing global connectivity among production ecosystems can obscure signals indicating resilience loss (Rist et al., 2014). In this context, the close connection between social and ecological systems has become more significant than ever. The demand for harvestable biomass is being exacerbated by the industrialization of an increasing number of countries and by the rising living standards and urbanization rate of their populations. To a large extent, this demand has been satisfied by converting ecosystems into global production ecosystems (GPE) (Nyström et al., 2019: 98). Even if these endless ecosystem exploitations occur at local scales, their intertwined and nonlinear feedback loops are provoking changes in the Earth's biosphere at the global scale. These dramatic changes are increasingly requiring recognition of the biosphere as a complex SES. According to this request, resilience has been defined as the capacity of a system to persist with and adapt to change but also transform away from unsustainable social-ecological trajectories (B.H. Walker et al., 2006), and it has been adopted as a conceptual framework that could shed light on responsible paths towards sustainability.

In managerial and organizational studies, the prevailing focus has been on an organization's "ability to survive" while maintaining adaptive, proactive, and reactive strategies to deal with threats, risks, and disruptive challenges, which amounts to the potential to exhibit resourcefulness by using an available internal and external slack of resources in response to different contextual and developmental challenges (Durodie, 2003; McManus et al., 2007; Pooley & Cohen, 2010; Sutcliffe & Vogus, 2003; K.E. Weick & Sutcliffe, 2006).

Eventually, the concept of resilience has gained relevance in urban studies from the perspective of urban systems, mostly when investigated as complex adaptive socio-ecological systems (Collier et al., 2013; Fitzgibbons & Mitchell, 2019; S. Meerow et al., 2016; S. Meerow & Newell, 2016; Olsson et al., 2004; Vale, 2014; B. Walker et al., 2004).

Likewise, definitions of urban resilience can be reported based on a "dual discourse" (Meriläinen, 2019) and analysed by combining both frameworks from international organizations and contributions from the academic literature.

Klein et al. (2003) defined urban resilience as (1) the amount of disturbance a system can absorb while retaining a state similar to the original and (2) a system's capacity for self-organization, and this definition can allow distinguishing between resilience intended as city 'robustness' and resilience intended as city 'self-organization'.

According to the first strand, city resilience translates into 'robustness', which is intended as the capacity of a city itself for resisting unpredicted natural sudden events. In this sense, urban policy and governance efforts should be considered to guarantee safety and stability to the city, which is primarily seen as an economic entity that must satisfy economic needs and, consequently, must be safeguarded from disasters and shocks. In this sense, the city becomes 'robust' when it is possible to rapidly restore infrastructure and services and when the building and structural planning processes are centred on increasing future resilience capacity.

From the above, a static vision of the city emerges, which requires top-down planning to preserve the status quo in a decontextualized and reductionist view that does not consider the communities or the people who live it. How reconstructions occur aftershocks or how top-down planning is carried out to prevent disasters do not consider how land, spaces, and wealth are redistributed. Paradoxically, therefore, to make urbanism resilient, the excluded parties might even be encouraged to stay out of cities altogether and be resilient on land instead (Fitzgibbons & Mitchell, 2019; J. Walker & Cooper, 2011).

This strand includes the City Resilience Framework (CRF), an integrated framework developed by Arup with the support of the Rockefeller Foundation, which aims to offer a lens for understanding the complexity of the city and the drivers that contribute to its resilience. In this sense, it is possible to identify areas of weakness and programmatic actions to undertake aimed at improving city resilience (Index, 2014). Based on the CRF, the "100 Resilient Cities" project, which was also supported by the Rockefeller Foundation, identified the following seven characteristics a city should have to be resilient:

a. *Inclusive*, which means prioritizing broad consultation to create a sense of shared ownership in decision making;
b. *Integrated*, which means bringing together a range of distinct systems and institutions;
c. *Flexible*, which means having the willingness and ability to adopt alternative strategies in response to changing circumstances;
d. *Resourceful*, which means recognizing alternative ways to use resources;
e. *Robust*, which means having well-conceived, constructed, and managed systems;
f. *Redundant*, which means having spare capacity purposefully created to accommodate disruption; and

Table 2
Bridging the '100 Resilient Cities' characteristics with ABSA methodology.

Characteristics and description		ABSA methodology contribution
a. Inclusive	Prioritize broad consultation to create a sense of shared ownership in decision making.	Inclusion of stakeholders in the decision-making process in order to detect resilience capabilities and vulnerabilities of a city and to create consonant relations with them.
b. Integrated	Bring together a range of distinct systems and institutions.	Adoption of a holistic perspective able to analyse the several correlated urban assets present in a city.
c. Flexible	Willingness, ability to adopt alternative strategies in response to changing circumstances.	Capacity to select a variable number of stakeholders, with several levels of detail, in order to define different effective strategies.
d. Resourceful	Recognizing alternative ways to use resources.	Ability to manage the resources present in urban asset basing on the developed awareness through the opinions expressed by the community, both to evaluate the main attractions of an urban area and to detect the symptoms of a principle of discontent.
e. Robust	Well-conceived, constructed, and managed systems.	Definition of an extended and inclusive framework for managing the city regarding several fields (health and wellbeing, infrastructure and ecosystems, leadership and strategy, and economy and society).
f. Redundant	Spare capacity purposefully created to accommodate disruption.	After the data analysis is possible to identifying alternative systems that can support the operation of a structure for the well-being of occupants and reduce other negative impacts should a disruption or failure occur.
g. Reflective	Use past experience to inform future decisions.	Due to ABSA and the collective perception-based map, it is possible to bring out resilience capabilities and vulnerabilities of an urban context to support the decision-makers in searching for alternative and more sustainable approaches.

Source: Authors' elaboration.

g. *Reflective*, which means using past experience to inform future decisions.

On the other hand, the second strand on urban resilience emphasizes the importance of self-organization among the most vulnerable and focuses the attention of policies on this topic. From the perspective of a robust city, resilience is understood here as the capacity (and necessity) to plan responsibly, involving populations, both as individuals and as a community, that may be affected by disasters and shocks. In this sense, vulnerability is associated with individuals who are organized into groups that live in the city and that, when revealing self-organization, are members of a community (Desouza & Flanery, 2013; Fitzgibbons & Mitchell, 2019; Labaka et al., 2019; Meriläinen, 2019).

Given the above-described variety of definitions, together with the interdisciplinary vocation of the notion of resilience itself, the need for a shared definition of urban resilience emerges.

S. Meerow et al. (2016), after a bibliometric analysis, provided a definition of urban resilience that attempts to encapsulate the different streams and approaches found in the literature. According to this definition, "Urban resilience refers to the ability of an urban system and all its constituent socio-ecological and socio-technical networks across temporal and spatial scales to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change and to quickly transform systems that limit future adaptive capacity." (S. Meerow et al., 2016, p. 39).

From this analysis, Meerow and Newell extrapolated a framework in which they highlighted the need to consider the complex trade-offs of urban resilience through the "5 W's": whose resilience is prioritized, against what shocks or stresses, when, where and why (S. Meerow & Newell, 2016).

The consideration of these elements defines and directs urban management actions focused on resilience, both in terms of infrastructure planning and in terms of actions that can influence the self-organization of the population.

This is also in consideration of the fact that resilience could be intrinsically conservative, slowing down the social progress of populations and maintaining inequalities, especially in dysfunctional and unjust urban contexts (Béné et al., 2018; Brown, 2012; Davoudi & Porter, 2012; Fainstein, 2015; Fitzgibbons & Mitchell, 2019; Friend & Moench, 2013; Gillard, 2016; Kaika, 2017; S. Meerow & Newell, 2016; Oteng-Ababio et al., 2015; Vale, 2014; Ziervogel et al., 2017).

Accordingly, this means that a limited notion of resilience intended only as robustness and without consideration of self-organization capability or social tradeoffs may lead to preservation of the status quo. This is without considering the interactions (relationships activated between individuals and between an individual and environment) that evolve dynamically and develop recursively within the city itself.

In essence, a city no longer assumes a purely structural or economic connotation. Together with the natural, cultural, artistic, technological, and infrastructural endowments that are objectively identifiable, what matters is the interactions among them and the individuals, organizations and institutions that, with their visions and needs, can persist within a specific urban context or reconfigure it.

Therefore, shifting from the concept of a 'resilient city' to 'urban resilience' (Chelleri, 2012), we highlight the need to consider both the structural and a systemic perspectives of urban resilience to enable cities and communities to properly respond to disruptive changes.

Accordingly, we can couple the first literature strand with the concept of 'city resilience'. This strand refers to a more structural definition of resilience, as it is mostly related to the notion of robustness, promotes a static vision of the city linked to top-down planning and governance processes, thus assuming a reductionist view and decontextualizing the local communities from their living city contexts.

Consequently, we can couple the second literature strand with the concept of 'urban resilience'. This strand refers to a more systemic definition of resilience, as it is more focused on notions such as self-

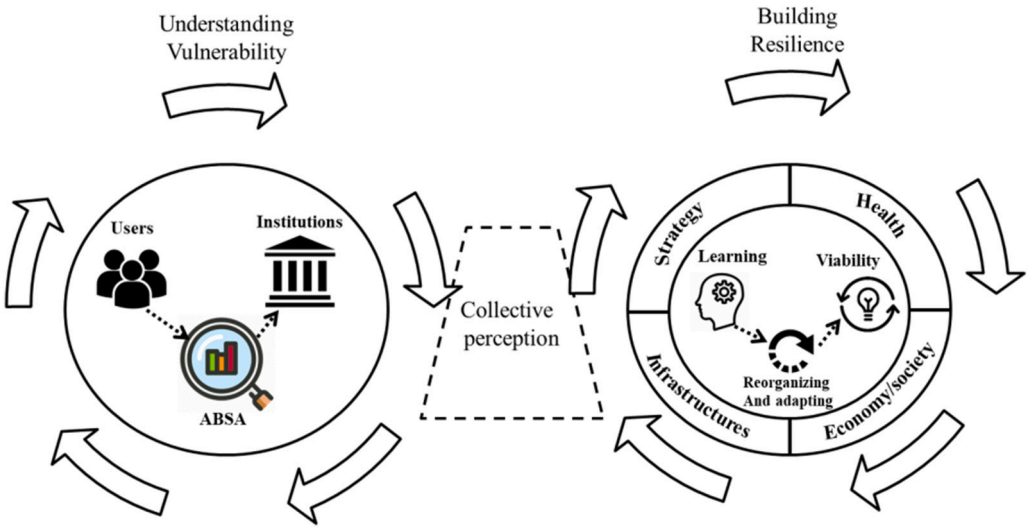

Fig. 1. From understanding vulnerability to fostering resilience.

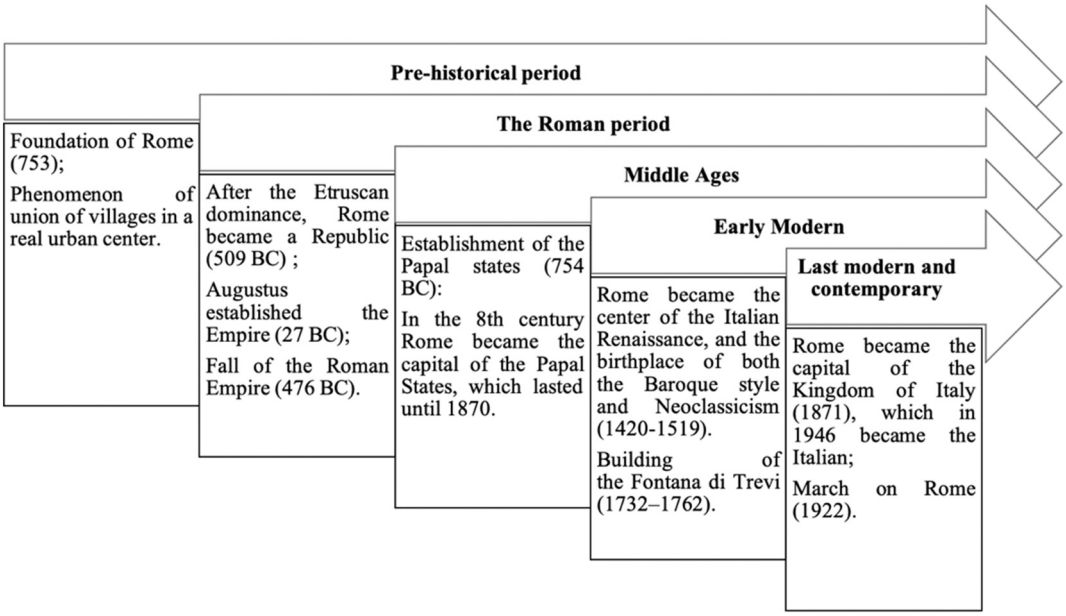

Fig. 2. Rome evolution timeline.

organization and interactions. It promotes a dynamic vision of the city, in which communities participate in planning and governance processes, thus assuming a concept of the city that can respond to disturbances and sudden changes across space and time, even transforming itself to avoid unsustainable trajectories.

Consistent with the aim of this paper, this second approach to urban resilience was embraced.

Therefore, we define an urban system as a combination of structural endowments and socio-ecological and socio-technical components that dynamically interact, evolve, and develop through self-organization processes.

Accordingly, urban resilience is not only the capacity of an urban system to adapt to changes either by absorbing sudden disturbances (*absorption*) or by managing to maintain or restore initial functions without limiting future adaptability (*adaptation*) but also, when intense alterations and disturbances occur, the capacity to design and undertake broader and deeper changes that can even lead to transformation (*transformability*). Similar to the SES approach to resilience described above, urban resilience becomes not only the ability to "bounce back" by absorbing and adapting in response to sudden changes but also the ability to "bounce forward" (Manca et al., 2017) by learning from past difficulties and being able to positively transform in response to shocks that are seen as opportunities rather than threats.

3. Material and methods: Rome, or more than 2750 years of a historic urban landscape

3.1. The methodology: framing the aspect-based sentiment analysis in fostering city resilience

Not all cities are the same in terms of their resilience level (Oteng-Ababio et al., 2015), but each city needs specific approaches and systemic responses as well as tailored resilience-building policies. Accordingly, a methodology was adopted to illustrate the resilience characteristics of a city in terms of the interaction of the individuals with the urban context through their sentiments expressed online. Consistent

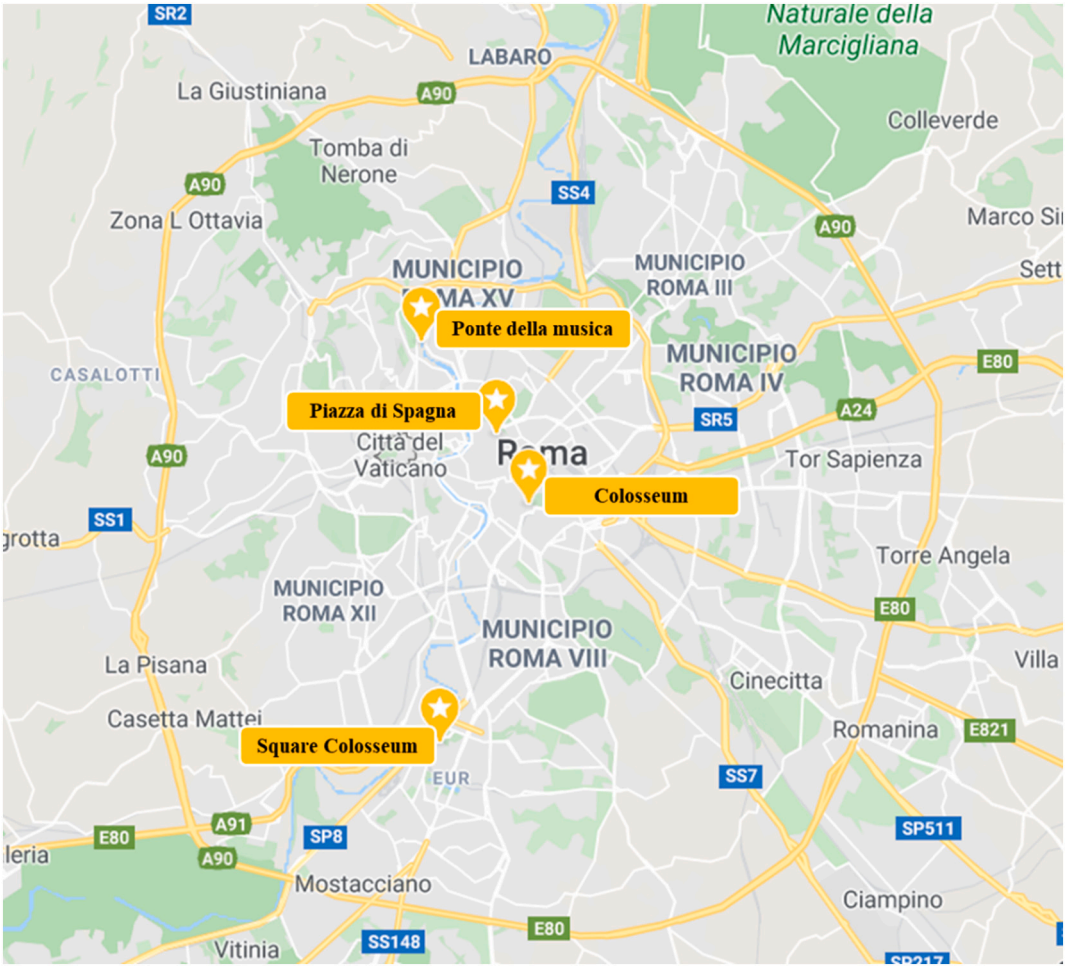

Fig. 3. Points of interest.

with the aim of this paper, the methodology adopted herein follows a systems perspective and emphasizes the role of individual involvement, allowing us to map out urban issues in a new and original way. Thus, it is possible to support decision-makers by widening their information variety endowment and to define, consequently, policies and government actions aimed at improving and fostering overall urban resilience.

Hence, to understand vulnerabilities and resilience capabilities, aspect-based sentiment analysis (ABSA) was applied in this study.

The ABSA methodology, which is an evolution of sentiment analysis (Pang & Lee, 2008), is able to provide information no longer on the whole "sentiment" level but on the various components of the same, allowing a more precise and accurate analysis (B. Liu, 2012; Pavlopoulos, 2014). Through this methodology, which is generally used in marketing analysis, it is possible to extract useful information from the existing online product reviews of consumers. Specifically, this technique analyses and extracts sentiment polarity on product reviews based on a specific aspect of the product (Mubarok et al., 2017).

In this work, the ABSA was applied for the first time in the urban context.

The purpose was to increase the awareness of the collective opinions regarding the different characterizing aspects of a point of interest, thanks to the possibility of obtaining aggregate analyses at different levels of granularity (Pedrycz & Chen, 2014). Consequently, at the end of the process, it is possible to explore the dataset at different levels of detail. According to Liu's approach, ABSA identifies the feelings expressed by the online users of the community under analysis, called "*holders*", concerning the individual "*aspects*" of urban resources (monuments, places of interest, services, etc.), and establishes whether they are positive or negative. To this end, we defined the *opinion-city* as the quintuple (e_i, a_{ij}, s_{ijkl}, h_k, t_l) where:

- e_i is the name of the *entity* (for example, a monument, a square, a point of interest, etc.);
- a_{ij} is *an aspect* of e_i (for instance statues, square, etc. stair that compose the point of interest);
- s_{ijkl} is the *sentiment* about the aspect a_{ij} of the entity e_i (e.g., "graceful");
- h_k is the *opinion holder* (the user that expresses the sentiment); and
- t_l is the *time* at which opinion is expressed by h_k.

To apply this methodology, the text extracted from online was analysed to assess the level of "sentiment" of both the selected urban elements and their correlated aspects (B. Liu, 2012). Subsequently, by an aggregation function, the graphical representation of the results has been drawn.

Therefore, considering the large amount of data produced on the web, through a process of data extraction, it is possible to carry out an ABSA on contents regarding the urban area to increase actor involvement. In this way, by leveraging the collective perception (Lynch, 1960), it is possible to enhance the awareness of the decision-maker about the vulnerabilities linked to user perception of an urban context at a specific time. Indeed, the urban management process requires conceiving of targeted interventions and solutions regarding different issues concerning social and economic aspects, infrastructures, health and well-being, and strategy and leadership (Fig. 1) (Index, 2014; Simone et al., 2018).

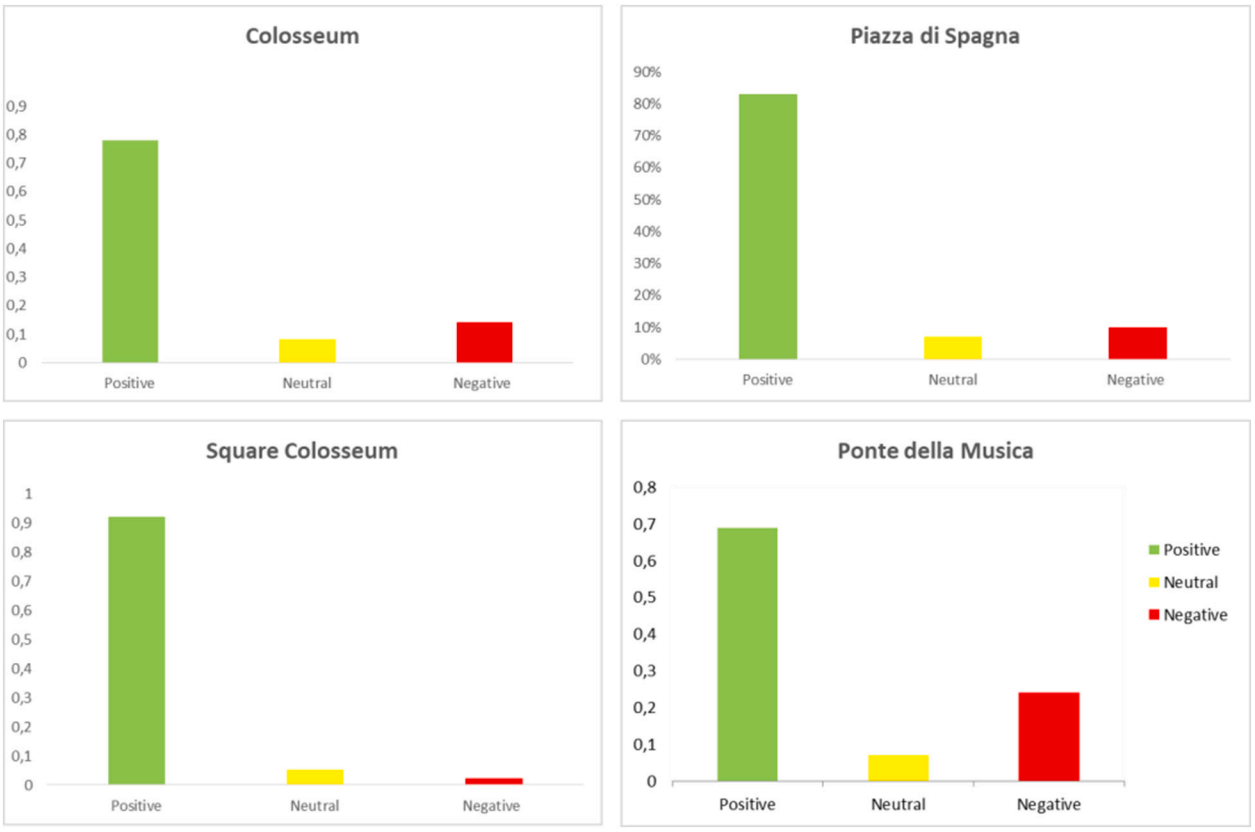

Fig. 4. POI level of sentiment.

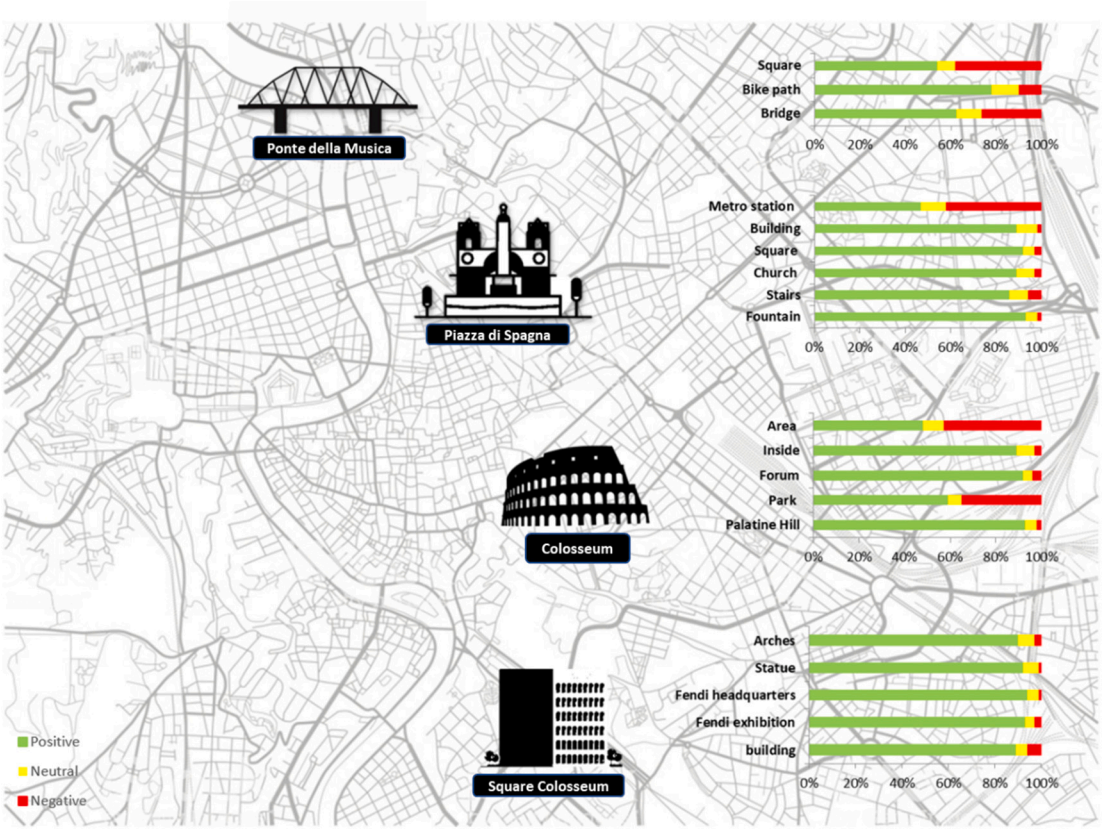

Fig. 5. Rome: a collective perception-based map.

3.2. Research design

A large-scale text analysis study was conducted on the city of Rome to understand the main sentiments expressed within the texts generated online by citizens and visitors.

The city of Rome is located in the central-western portion of the Italian Peninsula along the shores of Tiber. Additionally, called "the Eternal City" and "Caput Mundi", Rome is a unique example of 2700 years of architectural history and urban art solutions concentrated in the same urban space that can still be admired today (Fig. 2). For this reason, it is an excellent example of a resilient city, and it was also chosen among 100 cities to join the project mentioned above started by Rockefeller Foundation (100 CRF). The mission is to help cities around world become more resilient in the face of environmental challenges, rapidly changing social and economic developments in the 21st century.

According to Lynch's theory (1960), a community develops mental maps of a city by considering fundamental physical urban assets (paths, margins, neighbourhoods, nodes, and references) that can affect the perception of the city. In this direction, we considered four representative points of interest (POIs) from different historical Roman periods. Then, as shown in Fig. 3, we analysed:

- A very famous landmark, the Colosseum, which is considered the most impressive monument of ancient Rome;
- A much-visited node, the Piazza di Spagna, which dates back to the early Baroque period (early modern stage);
- The Square Colosseum, one of the most representative references to Fascist architecture; and
- A bridge, the "Ponte della Musica - Armando Trovajoli", which was inaugurated in 2011 (contemporary stage).

The collection of user opinions took place on the community of a website, TripAdvisor.com, which is a travel web portal that publishes user reviews about hotels, B&Bs, apartments, restaurants and tourist attractions, which, with over 60 million reviews and opinions, represents the largest travel site in the world and is capable of dynamically connecting a vast network of relationships.

3.3. Data mining

The reviews were collected using an automated program through a process of web scraping: this has permitted the retrieval of semi-structured documents from the Internet with the aim of obtaining data. In this case, the Python programming language was used to create the scripts (Bird et al., 2009).

The sample refers to the reviews provided by the top travel reviewers (which left at least 50 evaluations in the community). In particular, for "Piazza di Spagna", *189* reviews were analysed; regarding "Colosseo", *269*; concerning the Square Colosseum, *78*; and regarding Ponte della Musica, *42*.

Again, through a text mining approach, the crawler allowed the identification, selection, gathering and classification of many words; accordingly, the main relevant keywords for understanding the selected POIs aspects have been highlighted (M. Hu, Liu, 2004a, 2004b). Specifically, after a first phase of determining the grammatical functions of the words, we proceeded with word indexing on words with a frequency of more than 1% (M. Hu, Liu, 2004a, 2004b). Consequently, we have grouped the words with similar meanings into homogenous categories. Subsequently, a further screening of the extracted words was performed to minimize the risk of a blurred interpretation of the results. For instance, the crawler automatically ignored individual letters, definite and indefinite articles (a, an, the), prepositions (from, by, with and so on) and other terms that individually considered would not have in any way helped the understanding of the findings. The process of data extraction has been implemented within the chosen online community for seven continuous months: from the beginning of April to the end of October 2019. This long time span has allowed the detection of the emergence of a wide variety of relevant vulnerabilities and resilience capabilities connected to POIs.

3.4. Data analysis

After crawling, to verify the positive or negative sentiments regarding the POIs and their correlated aspects, a significant number of reviews were analysed using sentiment analysis with the software SentiWordNet (Baccianella et al., 2010; Esuli & Sebastiani, 2007; Troisi et al., 2018).

The lexical resource adopted was a text mining tool (Denecke, 2008; Ohana & Tierney, 2009) that enables the understanding of the overall polarity of a set of words (Esuli & Sebastiani, 2007). The most frequent words identified and extracted in the previous stage were transferred to the sentiment check submodule. Specifically, the adjectives related to the identified words were compared with a codified lexicon to establish their potential positive, negative or objective value (Baccianella et al., 2010).

The submodule has returned for each adjective value in the (0–1) range that represents the adjective positivity, negativity, or neutrality, with a sum total of 1. In detail, for each term, the relative values were evaluated as positive Sp_i, negative Sn_i $\mathrm{Sn_i}$or neutral Su_i $\mathrm{Su_i}$as shown below:

$$\mathrm{Sp_i} = \frac{\sum_{k=1}^{K} \mathrm{p_k}}{\mathrm{K}}$$

$$\mathrm{Sn_i} = \frac{\sum_{k=1}^{K} \mathrm{n_k}}{\mathrm{K}}$$

$$\mathrm{Su_i} = \frac{\sum_{k=1}^{K} \mathrm{u_k}}{\mathrm{K}}$$

where K is the total number of adjectives found and evaluated and p_k, n_k and u_k are the kth positivity, negativity and neutrality value, respectively, for the kth adjective. After aggregating the level of sentiment of the aspects through an aggregation function, the polarity of each POI was determined (details in Table 1 and 2 - Appendix A).

3.5. Results

Overall, with the use of the crawler, the reviews published on TripAdvisor.com by top users from all over the world were analysed, and through the processes of text mining and sentiment analysis, the level of sentiment of the selected POIs was depicted as follows.

As shown in Fig. 4, it appears that the collective opinions were mainly positive, confirming the highest level of attractiveness of the selected POIs (details in Figs. 1-4 - Appendix A).

Thus, to understand whether there is the emergence of positive sentiment or, on the contrary, negative opinions possibly connected with hidden problems of the urban context, we have analysed the different aspects of POIs. As shown in Fig. 5, it was possible, in light of the results obtained, to organize the data in an original visual tool of urban management: the collective perception-based map.

4. Discussion

From Fig. 5, it was possible to synthetically represent the polarities of each aspect of the analysed POIs (details in Figs. 5-8 - Appendix A).

Regarding Colosseum, there is a strong positive perception connected with the aspects "*Palatine Hill*" and "*Forum*", as shown by sentiments such as "*impressive*", "*amazing*", "*spectacular*", and "*historical*".

Therefore, the Colosseum was considered a unique and wonderful

POI in Rome and was perceived by the actors as an unmissable and iconic monument. Connected to "*Colosseum*", the sentiment "*educational*" underlines the instructive and informative potential of the monument that can have a good impact on people and could be emphasized by local communication policies. For a more accurate analysis, it should be noted that, although to a lesser extent, there were some early symptoms of discontent on the part of the community concerning particular aspects. These negative opinions revealed veiled signals that must necessarily receive attention. In fact, the level of "sentiment" associated with the "*area*" aspect was mainly negative, since, considering the analysed text, the connection with the adjective "*dangerous*" has emerged several times, probably due to the presence of pickpockets in the surrounding area. This is a symptom of a principle of strongly negative perception by users concerning the place of interest that underlines the need to manage the local security resources with greater capillarity to reduce this negative perception. Again, the aspect "*park*" was connected to the adjective "*dirty*". This information can be of particular relevance for the institutions to allocate the resources devoted to the disposal of waste in the affected green area as well as to apply the extant laws for protecting the environment.

Regarding "Piazza di Spagna", there was a strong positive perception not only regarding the general POI but also considering several correlated aspects. Indeed, there were some aspects that were observed as particularly positive. Especially regarding the aspects "*church*", "*fountain*" and "*stairs*", users expressed a strongly positive opinion linked to expressions such as "*beautiful*", "*wonderful*" and "*fantastic*", respectively. The urban policy-maker could benefit from this information and strengthen the positive collective perception by implementing actions aimed at emphasizing the beauty of the place and the attractiveness linked to Italian history and culture (Li & Petrick, 2008). In addition to these perceptions of aesthetic appearance, the adjective "*safe*" was often connected to "*stairs*": this enlightens adequate control practices in the area that contributed to making tourists feel safe. Only focusing on the aspect "*metro station*", some negative perceptions were highlighted. Indeed, in some reviews, the aspect was correlated to "*closed*" and "*problem*". This implies the need to guarantee to visitors and citizens a higher level of mobility services. Moreover, investing in smart mobility could improve perception by enhancing the accessibility and availability of modern transportation systems (Buhalis & Amaranggana, 2013). Our results suggest that some problems can arise from POI inaccessibility. However, the results connected to the "*stairs*" aspect and "*inaccessible*" were quite low.

Regarding the Square Colosseum, the current perception was very positive. In contrast, the older reviews (dating to 2013) were mainly negative, which was probably connected to an adverse perception of the historical period in which it was built. The subsequent reviews, instead, are very different. Indeed, especially regarding some aspects such as the "*Fendi exhibition*" and "*Fendi headquarters*", the users expressed a very positive perception through expressions such as "*interesting*" and "*welcoming*". In fact, during 2013, an agreement between Square Colosseum and Fendi granted the latter permission to rent the palace for 15 years until 2028. Therefore, the group announced the construction of an area on the ground floor intended for public display. This result highlights how public-private collaboration can bring a strategic advantage to the city, making it more resilient and attractive for users (Viale Pereira et al., 2017).

Instead, concerning Ponte della Musica, the perception was not particularly positive. In fact, even though the aspect "*structure*" was often connected to the adjectives "*modern*" and "*suggestive*" and the perception is mainly positive, often associated with "*square*", we found the adjectives "*dirty*" and "*unusable*". Thus, this modern bridge should be managed with more attention by investing in the neighbouring area both with cleaning activities and with the organization of events.

5. Implications for urban management: the role of sentiment analysis and collective perception-based maps in fostering resilient thinking

The sentiment analysis and the collective perception-based maps proposed in this work lead to mapping of urban issues in an innovative way and suggest interesting exploitations for fostering resilient thinking in urban management. The complex nature of the urban context — several and heterogeneous parts intertwined by several emergent and unpredictable feedback loops — has serious implications: the effort to collect, organize and manage the information is quite high, and the decision-maker risks to not possess — if not the best — at least a *satisficing* set of information to deeply understand the complex system and its dynamics. The latter is a key issue in any urban context. In this direction, beyond the case analysed, the content of our work becomes strongly connected to international aspects and the related applied policies.

According to W.R. Ashby (1957, 1958), the understanding of a complex system (*requisite variety*) depends on the *information variety* endowment owned by the decision makers. Moving from these premises, in order to understand and effectively manage a complex urban context, the greater the complexity of the system under focus (expressed in terms of its variety) increases, the greater the level of the information variety (i.e., richness, diversity of the information endowment) possessed by the decision maker must increase. The recognition of the limitation implied by the law of requisite variety may, in time, also prove useful by ensuring that planned strategies for the complex urban context shall be ad hoc strategies that were originally conceived according to the specific peculiarities of the complex urban context (S. Barile et al., 2018; S. Barile & Di Nauta, 2011; Iandolo et al., 2019; Polese & Minguzzi, 2009). This is of crucial relevance for facing the challenges of urban management. Urban management issues configure typical wicked problems (Rittel & Webber, 1973): they do not have univocal solutions, and these solutions are usually just "satisficing" (i.e., they are often far from the "one best way"), they involve a no objective stopping rule, the full feedbacks of the solutions cannot be foreseen at all until the effects have entirely run out, and they are affected by the subjective and bounded information variety endowment of the decision-maker (policy maker, urbanist, architect, etc.). In such a "wicked" decisional context, sentiment analysis and collective perception-based maps enrich the information variety endowment of urban decision makers to effectively manage the complexity of the urban context, which is consistent with W. R. Ashby (1960): "variety can destroy variety". According to this, the proposed methodology and tools have the potential to enhance the urban decision makers' information variety about the urban context due to the process of transforming *unstructured* data into *structured* data. The urban decision-makers can use this output to carry out both qualitative and quantitative analyses to deeply evaluate the opinions of the main urban stakeholders and then increase the resilience capability of the urban context.

On the one hand, by adopting the ABSA methodology, it is possible to support and promote the urban resilience characteristics provided by the '100 Resilient Cities' project and described in Section 2 above. Table 2 shows how this bridging can contribute to resisting, answering and adapting more rapidly to the stress by taking appropriate and prompt actions for each of the defined characteristics.

On the other hand, the collective perception-based maps (Fig. 5) configure a useful managerial tool characterized by a high potential for application in a wide range of urban contexts and cities. In fact, these maps highlight the potentialities and vulnerabilities of different urban assets: starting from two-dimensional maps, it is possible to obtain a sentiment map of the most important and influential resources. This allows a deeper understanding of the urban landscape and supports the decisional processes to carry out critical urban investments and activities. For all the above reasons, the collective perception-based maps concretely support the urban decision-makers as follows:

- *by capturing*. The collective perception-based maps are a simplified representation of the perceptions about the complex urban landscape. However, they are a helpful tool for capturing and promoting a common language between urban decision-makers and stakeholders share their ideas in order to formulate them in a way that everybody understands;
- *by visualization*. On the one hand, Aristotle underlined that the soul never thinks without images; on the other hand, Simon and Barnard (1947) remembered that the human ability to successfully process complex information is quite limited. As can be shown theoretically and empirically, processing information through a visual system can significantly increase the capability to manage complexity (Ioppolo et al., 2012; R.S. Kaplan & Norton, 1992, 1996; Osterwalder, 2004; Porter & Millar, 1985; Rode, 2000). Applying collective perception-based maps means that with little additional effort, the complexity of managing urban contexts can be presented graphically;
- *by enlightening*. The relationship between the different dimensions of the urban context is not always immediately observable. Therefore, collective perception-based maps help to identify and understand the prevalent sentiment dimensions in a specific urban place and the relationships among them;
- *by communicating and sharing*. By expressing many bundles of sentiment in a "visible" way, collective perception-based maps facilitate communication and knowledge sharing among decision makers;
- *by detection*. The collective perception-based maps allow the detection of ongoing congruity, i.e., a) measuring the consistency with the programme and emphasizing, through feedback, the links between urban policies and the related implementation processes; b) evaluating the congruence of governance by assessing the consistency with the overall territorial policies (e.g., at regional or macro-regional level).

Sentiment mapping highlights why some cities behave as a *structure* but do not effectively behave as a *system*. In so doing, the collective perception-based maps represents a relevant tool for supporting the decision-making process as they allow the decision makers to more deeply understand the complexity of the urban landscape, expanding the urban decision makers' cognitive endowment and fostering resilient thinking. This increases the possibility that a structure collapses into a system. Considering the collapse of a structure into a system, i.e., considering a dynamic perspective, also leads to a dynamic application of ABSA and the collective perception-based maps. In fact, both ABSA and the collective maps could be applied not only in static terms, i.e., with reference to a specific Time (x) as discussed above, but rather both the ABSA and the maps could also be considered for dynamic (diachronic) applications in order to conduct comparative analyses over times: in so doing, a systematic dynamic-based application of the ABSA and the collective maps should foster a "learning process" (e.g., capitalization on the "lesson learned") useful for supporting intertemporal decisional processes and for monitoring the desired/unwanted outputs urban management achieve over time.

6. Conclusion and future directions

Today's circumstances always ask for the ability of the decision-maker to define the context and to identify the relevant systems and possible solutions.

Furthermore, the current information environment appears able to accelerate the processes of enrichment of the information variety, acting on the dimensions and the characteristics of which it is constituted (S. Barile, 2009): in particular, on the levels of the information units and interpretative schemes.

New information and communication technologies (ICTs) offer to policy decision-making processes new solutions, especially in the stages of goal setting and choosing among policy alternatives (Myeong & Choi, 2010). The huge amount of data available in current markets, in increasingly rapid and previously unimaginable times, changes the configuration of urban territories and increase the possibility to improve public services. The opportunities offered by multiple and interconnected technological channels (Rangaswamy & Van Bruggen, 2005) make communication and the exchange of data and information potentially continuous. However, even if the existence of multiple touchpoints with citizens offers great advantages, there is the need to understand how the big flow of data can be optimized to exploit the potentials of the current ICTs by avoiding to turn these advantages into threats (Gandomi & Haider, 2015).

In conclusion, rereading from a systems perspective, together with methodology such as ABSA, which contributes to increasing awareness of an irreducible link that binds each entity into a single large viral network (Capra, 1997), arises from the need for a profound rethinking of the analysis approach and consequent resolution of the problems related to urban management.

The variety of perspectives and perceptions present in the reference context is the origin of the typical problems linked to its government. In this direction, the proposal of a tool for urban management allows overcoming of the traditional approaches, which are attentive exclusively to the physicality of its the structural components of a city.

Indeed, it is necessary for an urban policy maker to base decisions on participatory logic, which can act as a guide towards a shared goal. In fact, by implementing initiatives in the interest of the city itself and by adopting a unified vision, it is possible to transform a potential alignment of expectations of several systems in an effective one.

Therein lies one of the most original contributions of the work. This study was not intended to formulate or provide indicators for measuring urban resilience, unlike most of the existing works aimed at this topic (Schlör et al., 2018; Suárez et al., 2016). Instead, it has provided a methodology (ABSA) and a tool (collective perceptions-based maps) to map out urban issues in a new and original way with the aim of fostering resilient thinking in urban policies according to a qualitative-quantitative approach (B. Liu, 2015). Accordingly, together, the ABSA methodology and the collective maps constitute an integrated approach that could be considered an insightful and complementary, i.e., not alternative, approach to the extant approaches. On the other hand, urban management generally addresses very complex problems, and for this reason, it is not conceivable to assume that all related complex issues can be effectively managed by a merely quantitative approach. Thus, in this study, the proposed tool can be considered valid support for urban management decision-making activities, proposing shared assessments of the levels of sentiment perceived by the community with respect to the points of interest identified. In light of the information obtained from the synthetic frameworks and the map, urban manager is able to implement a series of interventions aimed at increasing the resilience qualities, as shown in Table 2. In conclusion, aspect-based sentiment analysis can be considered a new frontier for opinion mining techniques and poses new challenges in a very thought-provoking and fascinating domain – worldwide web and big data computation. The ABSA, rather than other sentiment analysis techniques, offers fine-grained sentiment analysis for online reviews and plays an increasingly important role in many applications by efficiently extracting multi-grained aspects, identifying associated opinions, and classifying sentiment polarity (Tang et al., 2019).

Nevertheless, the study is not without limits. The first limitation of this research is the number of reviews that composed the sample and the non-normal distribution of the number of reviews for each point of interest selected. However, it should be noted that this choice was conducted consistently with Lynch's model: according to this, the analysis should not ignore that some POIs, despite being characterized by a low number of reviews, can influence the overall value of collective perception.

The second limitation is related to the technique used to collect and analyse the data.

In fact, despite large-scale data analysis (a very large number of

reviews extracted in a period span of 7 months), the automated collection of people's comments made it difficult to deepen the analysis of their opinions and perceptions (Ciasullo et al., 2018). Accordingly, to integrate the methodology proposed here, a complementary qualitative approach, such as one based on in-depth interviews, could be helpful.

Furthermore, to strengthen the results of the case study carried out and to ensure greater consistency, it could be very thought-provoking to compare the results obtained from Tripadvisor.com with the results obtained from a different online community.

Finally, it would be of relevant interest to extend the analysis to the possible changes over time in collective perception. This could be particularly useful to know the collective feedback about new urban policies: the awareness of the interventions' effectiveness could strengthen, in a virtuous learning circle, the resilience capability to make a city "eternal".

CRediT authorship contribution statement

Cristina Simone: Conceptualization, Writing - review & editing, Supervision. **Francesca Iandolo:** Conceptualization, Methodology, Writing - review & editing, Supervision. **Irene Fulco:** Methodology, Writing - review & editing. **Francesca Loia:** Writing - review & editing, Methodology.

Appendix A

Table. 1
POIs polarity.

	Level of sentiment
Colosseum	0,78;0,08;0,14
Piazza di Spagna	0,84; 0,07; 0,09
Square Colosseum	0,92; 0,05; 0,02
Ponte della Musica	0,65; 0,1; 0,2

Source: Authors' elaboration.

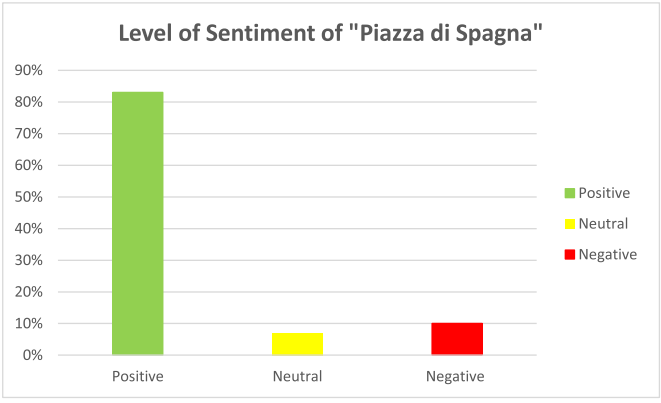

Fig. 1. Piazza di Spagna - Level of Sentiment.

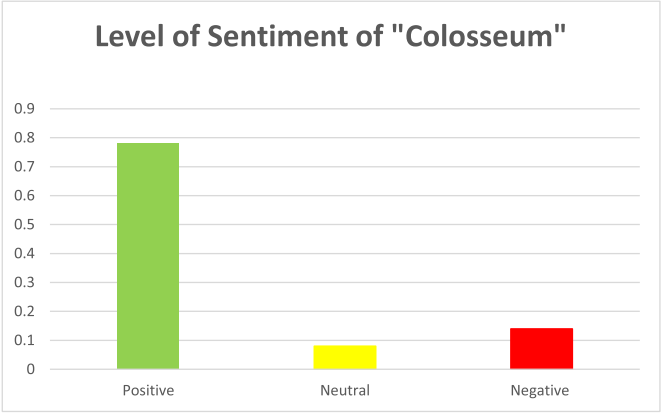

Fig. 2. Colosseum - Level of Sentiment.

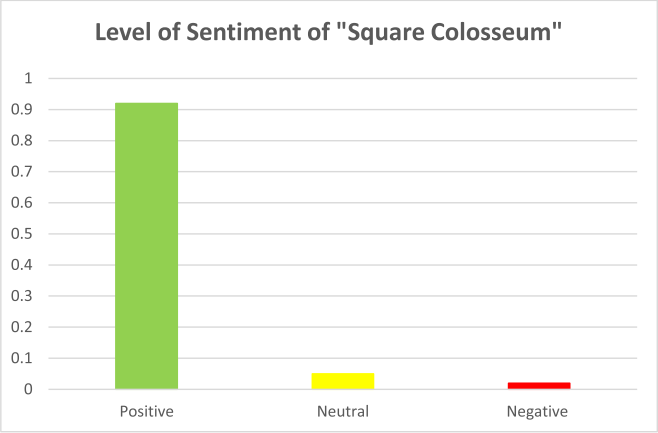

Fig. 3. Square Colosseum- Level of Sentiment.

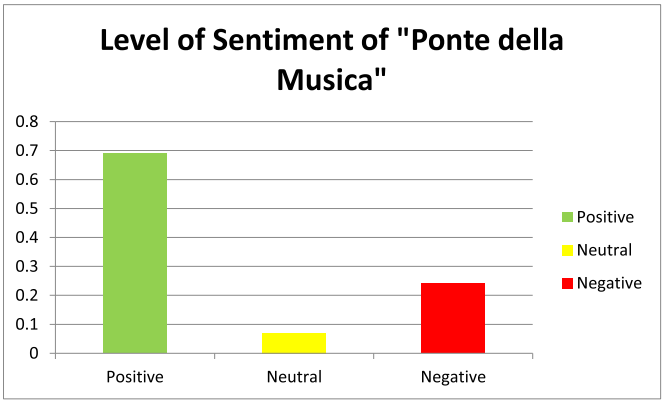

Fig. 4. Ponte della Musica- Level of Sentiment.

Table 2
Polarity of "Tiber River", "Colosseum", "Piazza di Spagna", "Square Colosseum", and "Ponte della Musica" Aspects.

Entity	Aspect	Polarity		
Piazza di Spagna	*GENERAL- Piazza di Spagna*	0,91	0,07	0,02
	Fountain	0,93	0,05	0,02
	Stairs	0,86	0,08	0,06
	Church	0,89	0,08	0,03
	Square	0,92	0,05	0,03
	Building	0,89	0,09	0,02
	Metro station	0,47	0,11	0,42
Colosseum	*GENERAL- Colosseum*	0,91	0,07	0,02
	Palatine Hill	0,93	0,05	0,02
	Park	0,59	0,06	0,35
	Forum	0,92	0,04	0,04
	Inside	0,89	0,08	0,03
	Area	0,44	0,17	0,39
Square Colosseum	GENERAL - Square Colosseum	0,91	0,07	0,02
	building	0,89	0,05	0,06
	Fendi exhibition	0,93	0,04	0,03
	Fendi headquarters	0,94	0,05	0,01
	Statue	0,92	0,07	0,01
	Arches	0,9	0,07	0,03
Ponte della Musica	GENERAL - Ponte della musica	0,67	0,11	0,22
	Bridge	0,63	0,11	0,266
	Bike path	0,78	0,12	0,1
	Square	0,54	0,08	0,38

Source: Authors' elaboration.

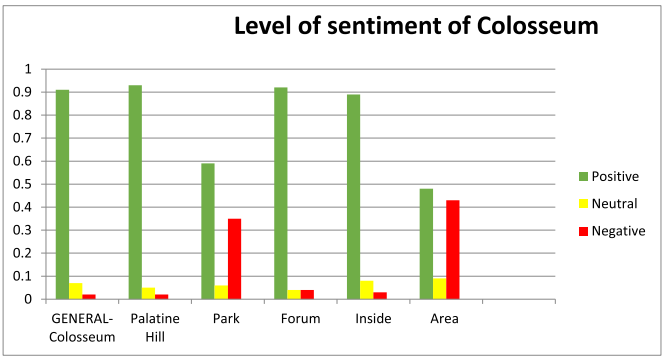

Fig. 5. "Colosseum" Aspects - Level of "Sentiment".

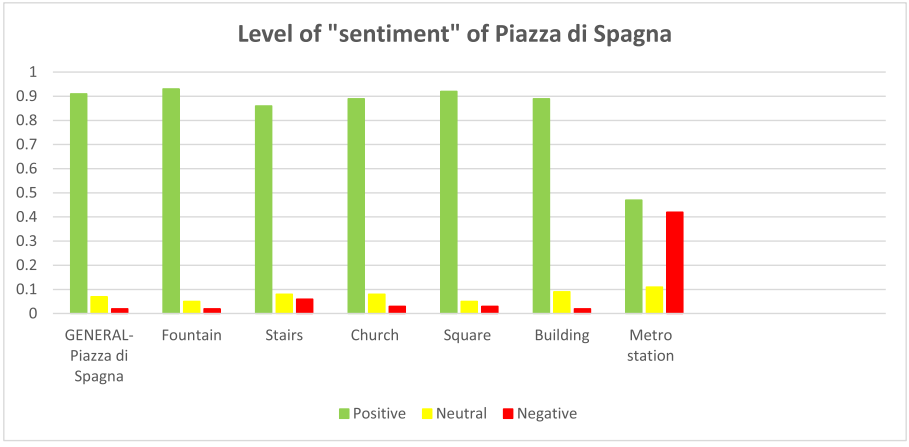

Fig. 6. "Piazza di Spagna" Aspects - Level of "Sentiment".

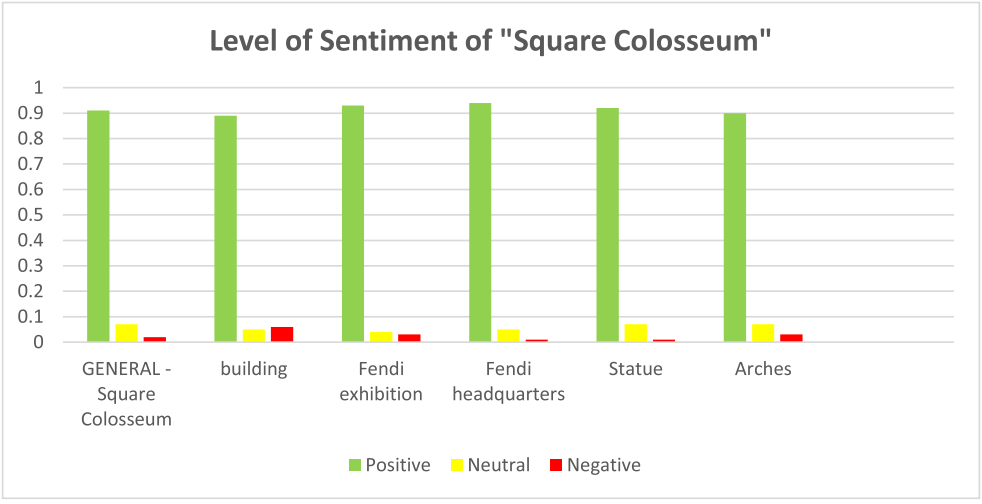

Fig. 7. "Square Colosseum" Aspects - Level of "Sentiment".

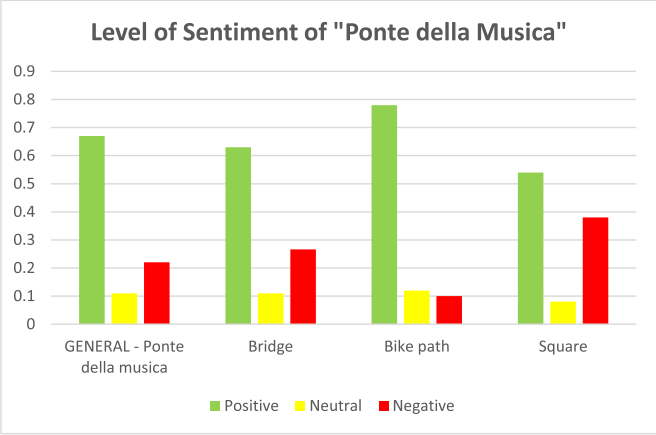

Fig. 8. "Ponte della Musica" Aspects - Level of "Sentiment".

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