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Managing local knowledge about NBS in spatial planning. A group model building approach

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Abstract

Nature-based solutions (NBS) are increasingly adopted as measures for enabling climate change mitigation and adaptation, reducing flood risks and enhancing urban ecosystems. However, several barriers hinder the implementation of NBS in urban areas, in planning activities and strategies. These include the inadequacy of some existing methods based on hard and top-down approaches, the complexity and uncertainty associated with the network of citizens involved and the structuring of the knowledge deriving from that, in urban strategies. Local knowledge could help to understand the success or failure of actions designed only by expert knowledge.

To this aim, this paper contributes to a current debate about methodological approaches to knowledge assessment to adopt in urban planning processes. Specifically, this paper proposes a Group Model Building approach for one of the activities carried out within the planning process for the Master Plan draft of the city of Brindisi, to support NBS implementation.

The results, among others, highlight three important aspects: the importance of building a model to support the elicitation of participants' knowledge, the need to create a well-structured process leading to consensus, and the need to involve the young population in the participatory processes.

Keywords

Sustainable measures; Participatory approach; Planning strategies; System dynamics.

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1. Introduction

The climate variations linked to climate change significantly impact modern cities, subjecting them to new and unprecedented challenges. The resilience of urban contexts, understood as the interconnection of environmental, cultural, economic, political, and institutional processes, is put to the test by the disasters generated by such changes. Extreme weather events, droughts, sea-level rise, coastal erosion, heatwaves, or floods constantly undermine natural and human-altered environments. In a vicious circle, the temperature increase generates a greater energy demand, resulting in higher greenhouse gas emissions and, consequently, further temperature rise and worsening conditions that promote climate change. (Lee, 2018; Sinatra et al., 2023).

The concentration of dark surfaces and the lack of vegetation, replaced by buildings and roads, lead to a gradual increase in air temperature observed in many cities worldwide, resulting in the generation of "urban heat islands". The prevalence of asphalt surfaces, which absorb solar radiation, contributes to the overheating of the air, also reducing soil permeability. Similarly, non-reflective roofs increase the demand for cooling buildings during the summer. Akbari et al. (2001) estimated that in the centre of Los Angeles, from 1930 to 1990, temperatures increased by 0.5°C per decade, leading to an increase of about 500 megawatts (MW) in air conditioning demand per degree in the Los Angeles basin. These phenomena influence the climate, exacerbate energy consumption, and impact the livability of cities, with consequences for health. In essence, urban areas do not benefit from the natural cooling effect of vegetation (Akbari et al., 2001). The structure and configuration of urban environments also heavily influence urban microclimates and surrounding areas, affecting physical environmental parameters such as temperature, humidity, airflow, etc. (Howard, 2012; Sinatra et al., 2023).

The Mediterranean basin, vulnerable to such changes, experiences prolonged droughts, an increase in the frequency of floods, changes in solar radiation, and demographic surges due to often inadequately controlled urbanization processes, leading to an increase in traffic and pollution (Pelorosso et al., 2015).

Over the next 50 years, an average increase in global temperatures of about 3°C is predicted in metropolitan areas (Balletto et al., 2018; Morabito et al., 2021). In Italy, temperatures have increased by over 2°C in the last 60 years, increasing environmental and structural vulnerability and endangering the well-being of citizens (Sinatra et al., 2023).

The resulting increase in territorial fragility has translated into a growth in the Italian surface potentially subject to landslides and floods, according to ISPRA data (2022), from 4% to 19% in just 4 years. Italy is particularly prone to hydrogeological instability due to its endemic geomorphological and structural characteristics, as well as its climatic and topographic features. The situation has worsened due to the lack of adequate planning, impacting not only the environment and the well-being of the population but also the immense cultural heritage, infrastructure, economy, and communities (Bangash & Passuello, 2013).

In this context, there is a need to establish a connection between local and global aspects, adopting risk monitoring and mitigation strategies and a planning process capable of significantly influencing the complex climate-city system (Sinatra et al., 2023). Urban planners cannot tackle the challenge by simply assessing the economic and technological issues of projects, the ability to provide goods and services to human society, and the ability of ecosystems to complete their cycles (Bangash & Passuello, 2013). To better predict risks, an interdisciplinary approach is necessary, requiring the involvement of communities and local institutions, as well as strengthening social learning from past disaster experiences (Imperiale & Vanclay, 2023). In fact, social behaviours can heavily influence future scenarios (Blečić et al., 2023), while knowledge co-production processes can promote greater social resilience (Carnelli & Pedoth, 2023). For these reasons, citizens need to become increasingly attentive to the environment and reclaim the regenerated spaces in which they live.

In this context, the risk mitigation action can be effectively carried out by ecosystem structures, including urban ones, such as green areas (gardens, urban vegetable gardens, spontaneous vegetation) and blue areas (surface watercourses, lakes) capable of introducing more sustainable urban transformations (Pelorosso et al., 2015; Lai et al., 2021; De Noia et al., 2022). Numerous studies indeed demonstrate that the presence of these infrastructures mitigates the impacts of negative stressful events on physical and mental health; nature acts as a protective barrier against the effects of life's stressors (Hazer, 2010; Houlden & Weich, 2018; Poortinga et al., 2021; Van den Berg, 2010). To balance the negative impacts induced by conflicts between nature and human action, and to reduce exposure to disasters, current urban regeneration projects are being called upon to consciously design Nature-Based Solutions (NBS) that protect and manage natural resources. NBS have a wide range of uses across different settings. In cities, urban parks and rooftop gardens act as green lungs, reducing pollution and providing gathering or meeting spaces. In agriculture, sustainable cultivation practices can regenerate soil and enhance crop resilience. Along coastlines, the establishment of natural barriers such as mangroves can provide protection against storms and erosion. Hydrological protection systems can be introduced such as green roofs, permeable surfaces, and artificial wetlands capable of acting on the urban microclimate, for example by mitigating the effects of the heat island or improving the ecological network so increase biodiversity. The benefits introduced by these NBS are not limited to producing pleasant landscapes but add value to the complex and dynamic architectural project of the urban context, bring social and ecological value, improve conditions of comfort and well-being, offer recreational services, play spaces and increase the tourist attractiveness. Ultimately, they contribute to the increase of the social capital (Poortinga, 2021). From this point of view, NBS must be recognized as having an essential multifunctional role in the achievement of higher levels of socio-ecological resilience (Zurlini et al., 2013). Their design must be located into a network of ecosystems integrated with the built environment, engineered, and capable of producing circular approaches that go beyond the traditional problem-solving of structural engineering, providing different solutions that, from time to time, adapt to the particular environmental and landscape context (Recanatesi et al., 2017). Furthermore, a correct methodological approach to these problems requires an effective and efficient plan that adopts a holistic perspective that allows integrating not only ecological aspects but also cultural and social issues.

To this aim this paper shows a multi-step methodology adopted during the drafting of the preliminary programmatic document (DPP), the first document of the master plan (PUG) process, for the city of Brindisi (Italy) aimed at taking advantage of a multi-agent cognitive support system. Its implementation attempts to elicit and exchange participants' perceptions, their knowledge and to promote NBS strategies.

The following section introduces the role of the participatory approach in planning strategies. Chapter 3 presents materials and methods adopted, related to the research effort. Chapter 4 shows the results achieved, including an overall discussion about them. Chapter 5 ends up the paper with some closing remarks.

2. Participatory approach for planning strategies

Given the increasingly intricate relationship between humans and nature, urgent management and protection of ecosystems, natural and urban landscapes, and the conservation of natural resources (water, soil, air) are emphasized. The project and management of multifunctional green infrastructure for the sustainable development of cities are deemed unavoidable.

The planning and implementation of actions for disaster risk reduction have become essential to cope with the increasing frequency of such events. The need for international collaboration is recognized, along with the promotion of investments that respect environments and natural habitats. Nations can intervene in reducing climate change and its resulting environmental damage by adopting policies and measures aimed at curbing land consumption, promoting more controlled and cautious land use, encouraging early warning measures, and improving infrastructure to reduce vulnerability (Velarde et al., 2017). Institutions, governments, and companies are called to encourage the adoption of preventive behaviours capable of mitigating environmental risk. Even citizens' behaviours play a pivotal role as they can influence the impact and recovery time before, during, and after a disaster (Lee, 2018; IPCC). In this context, disaster planning is not merely a complex exploratory process that provides generic procedures to manage unforeseen impacts but should be able to produce carefully constructed scenarios capable of revealing the needs that will arise downstream of foreseeable risks (Aerts, 2018).

Addressing a disaster thus becomes a social process that necessitates an integrated perspective between structural engineering and social sciences on resilience and its construction, involving public support and promoting the participation of a wide range of stakeholders, including technical experts, responders, and citizens. The scientific community now recognizes that reducing social vulnerability to risk is essential for sustainable development. This can be achieved by integrating a socio-psychological perspective into the planning phase. Understanding the viewpoints of these stakeholders regarding mitigation solutions and increasing their awareness enhances the social acceptability of adopted measures (Alexander, 2015). The governance tools employed so far have often prioritized technical aspects rather than encouraging community involvement, despite extensive literature showing that greater awareness of risk prevention and mitigation measures would lead to increased acceptance by communities (Martín et al., 2020).

As a result, alongside more purely engineering factors, it becomes crucial to establish a knowledge base that is independent of planning techniques and regulatory standards, capable of contributing to the construction of a comprehensive knowledge framework. Indeed, the development of technical-scientific methodologies struggles to address the growing complexity of urban systems and socio-ecological interactions due to the high degree of uncertainty arising from continuous territorial transformations and processes of global climate change.

In this context, the development of an emergency plan is similar and parallel to urban and territorial planning processes. Emergency planning is a multi-agency process of systematic preparation for future contingencies, including severe incidents and disasters (Aerts; 2018) which requires the integration of collective participation processes and territorial governance. To this end, the scientific community's interest in involving citizens and their local knowledge has grown. This knowledge, encompassing various cultural and economic aspects, poses the challenge of overcoming the intellectual impasse related to its integration into the domains of risk management and related decision-making processes. On the one hand, this consolidated negligence is the result of technical-methodological criticalities linked to the intrinsic complexity of local, widespread, and multiple knowledge. This proves to be not well-suited for computational treatment and is difficult to translate into structured knowledge for practical use. On the other hand, negligence is the outcome of the importance attributed to more traditional approaches that emphasize expert knowledge, relegating and assigning a secondary role to local knowledge. These methods have promoted rational approaches based on deterministic models that often highlight the limitations caused by uncertainties and the instability of the natural system (Gardner, 2002; Lee et al., 2018). However, the transition to the new method has entailed having to face new challenges in the field of knowledge understanding and management since, particularly in community contexts, information comes from multiple agents generating complex systems of knowledge. To address these complexities, new integrated spatial planning approaches have been developed that combine different calculation methods and tools to interpret the linguistic and semantic differences (so-called "Babel effect") that often occur in participatory situations (Camarda, 2010; Hewitt, 1983). The effectiveness of participatory planning in managing the complexity of territorially extended systems, characterized by territories on a regional scale or by urban contexts of a metropolitan nature, is still being evaluated as these systems involve a vast amount of data coming from a kaleidoscope of agents, representing a particular challenge in defining a method (De Liddo & Concilio, 2017; Lichfield, 1998). According to Khakee et al. (2000), there is a recognized urgent need to draw upon a resilient heritage of social and environmental knowledge, fueled by interactive cognitive processes within the community itself, alongside more conventional knowledge structures. Local-level knowledge goes beyond the physical attributes of places; it also encompasses established spatial relationships, social and economic dynamics, as well as how vital environments within the community are used and protected. This kind of knowledge, far richer and more intricate than initially assumed, stems from direct experience of places or from the observation of urban dynamics and territorial evolution, often remaining undisturbed by institutional constraints. To promote a strategic and effective vision, this socio-environmental complexity requires dedication to conceiving future development scenarios within multi-agent contexts capable of generating interactions that facilitate the elicitation and exchange of such cognitive knowledge contents. The resulting informal knowledge could be hardly obtained otherwise (Borri et al., 2014). In planning instruments, processes are needed to implement technical aspects related to the design and implementation of green measures and consider the complexity associated with their implementation by citizens. In processes of urban transformation and redevelopment that involve the integration of public green spaces, it is necessary to understand which qualities of green spaces are truly appreciated and important to the residents (Heft, 2013). In this context, our hypothesis, supported by the literature, is that it becomes important to enhance citizens' knowledge and understand how people live and perceive urban green spaces and the presence of Nature-Based Solutions (NBS). This contributes to the structuring of a participatory process that provides useful elements for planning choices. This work aims to propose a methodological approach towards a conscientious planning and design of NBS for urban ecosystem services, to achieve a sustainable integration between human activities and environmental considerations. The case study presented in the following sections represents an attempt to introduce a participatory approach to define a complex environmental, ecological, and social system, aimed at gathering and eliciting local knowledge about Nature-Based Solutions (Heft, 2013). The complexity in defining this system depends on several factors such as the number of elements involved, the number of interrelationships among the elements, and the cross-functional connection among the elements of the system (Sterman, 2000). Interactions among the various elements of a system generate complex behaviours (Limburg, 2002) and nonlinear relationships generate dynamic transformations (Morçöl, 2005). Many conceptual frameworks have been developed to support the knowledge and complexity modelling process, emphasizing the direct involvement of participants in the modelling process (Akkermans & Vennix, 1997; Andersen & Richardson, 1997; Rouwette et al., 2002). They are conceptual frameworks that develop dynamic models in which, however, the involvement of participants during the model design process presents several methodological challenges. For example, Andersen, Richardson and Vennix (1997) note that "group model building is still more art than science." To this end, this paper contributes to the current debate on methodological approaches to knowledge assessment to be adopted in urban planning processes. Specifically, this paper proposes a Group Model Building (GMB) approach based on a Causal Loop Diagram (CLD) building for one of the activities carried out as part of the planning process of the draft Master Plan of the city of Brindisi, to support the implementation of NBS. In this context, due to the adopted systemic approach based on knowledge elicitation, it suggests to the administration a tool for mutual social learning, which can provide the urban plan with both a substantive structure and the implementability of participatory and shared visions (Schön & Argyris, 1996).

3. Materials and methods

3.1 Case study: physical framework

Brindisi is a coastal city situated in the southeastern part of the Puglia region in Southern Italy, with a population exceeding 85,000 residents and covering a geographic area of 333 square kilometers (Figg. 1a and 1b). In terms of hydrology, the city encounters a significant hydraulic risk, stressed out in the current regional hydrological plan (PAI) (Fig.1), due to the presence of watercourses.

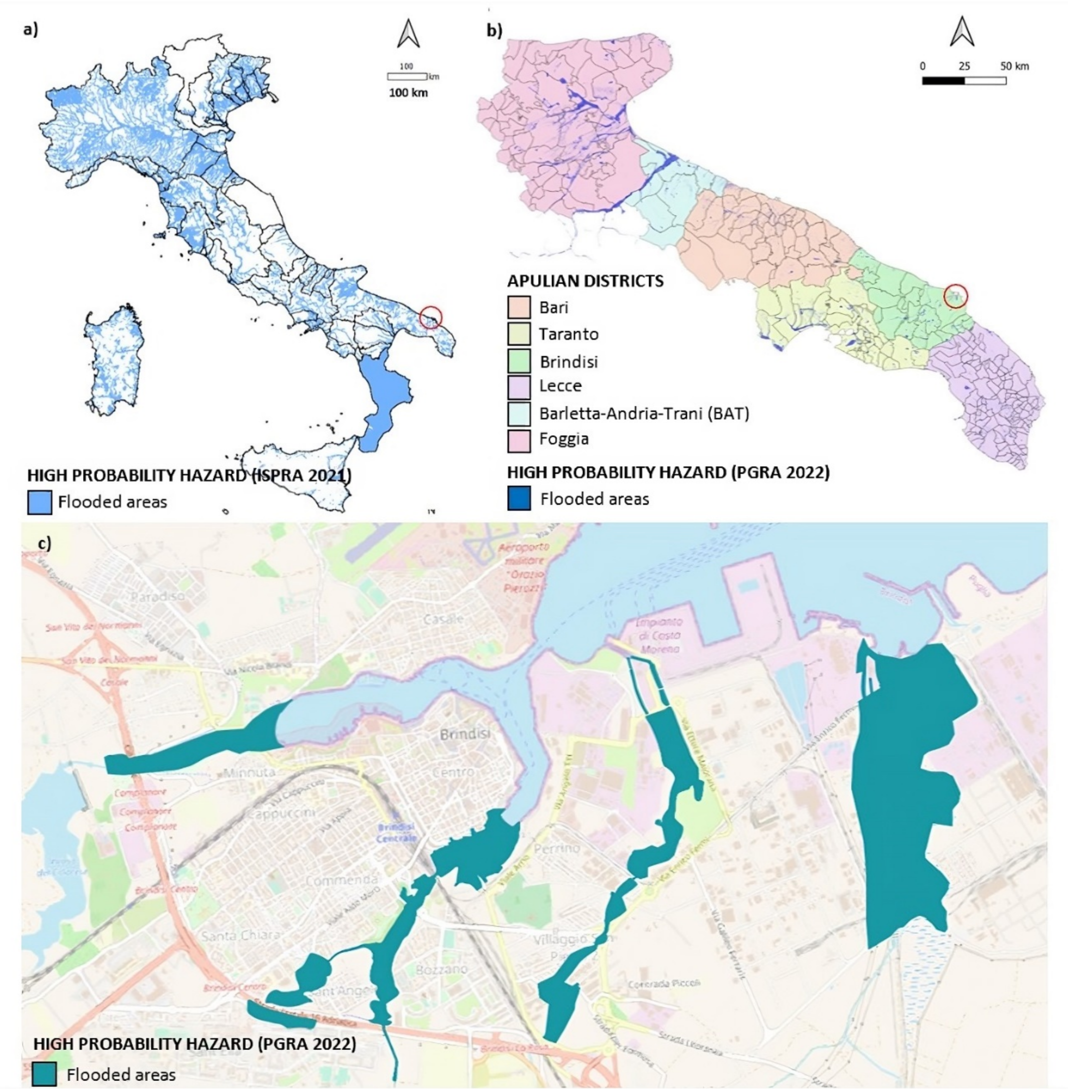

Fig.1 Flood hazard maps (return period: 30 years): (a) national scale; (b) regional scale; (c) urban scale. Source: authors' elaboration

Morphologically, the city features a wide natural inlet that has facilitated the development of a port since the times of the Roman Empire. The urbanized area has grown around the main watercourses, i.e.: the Cillarese Canal, characterized by the presence of the homonymous dam along its embankment, the Patri Canal, primarily linked to the urban fabric and, in the industrial area, the Fiume Piccolo and Fiume Grande watercourses (Fig.1c). The intersection of watercourses with the geomorphological attributes of the region, along with the intricate urban network, has led to numerous instances of flooding throughout the years. For further information regarding flood occurrences, see Santoro et al. (2022). The impacts observed during flood events increasingly require urgent hydraulic mitigation measures. While steps are being taken in this direction, the implementation of green solutions remains significantly far from being realized.

3.2 Case study: planning framework

From the point of view of urban planning, the process of the new master plan of the city of Brindisi (Italy), started in the early 2000s, was interrupted in 2011 with a draft of the so-called preliminary programmatic document (DPP) required by the legislation of the Apulia Region. The new Municipal Administration (MA) elected in 2017 resumes the urban planning process with an inclusive and knowledge-oriented approach. The purpose is to intercept the numerous instances of complexity of the urban system through the construction of interactive knowledge bases with the community. The path defined by the MA, now incorporated in the previous process, is defined in Fig.2.

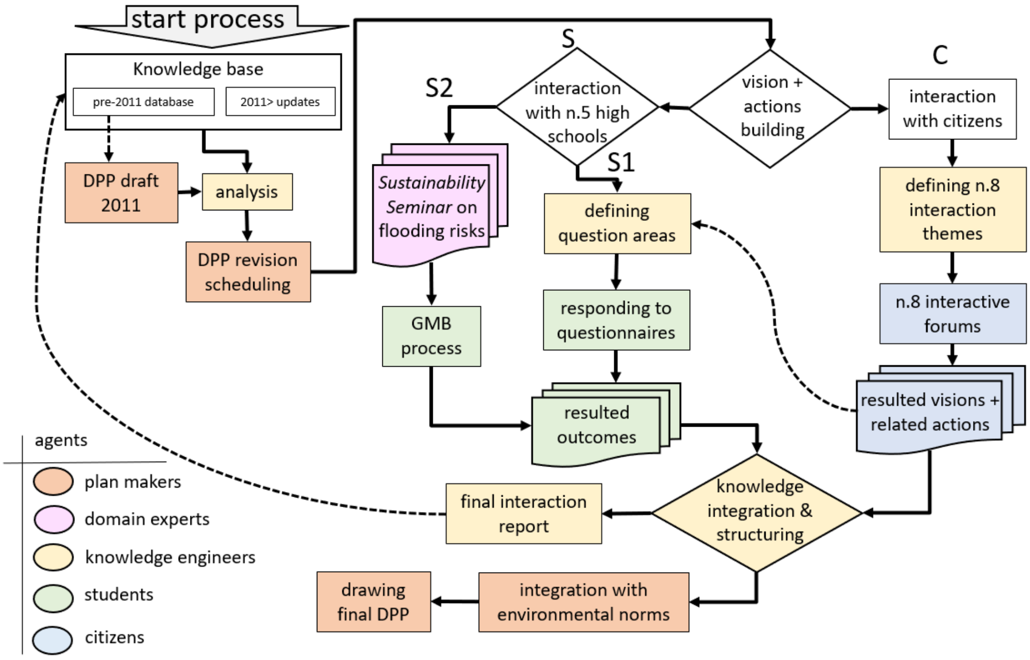

Fig.2 Workflow of the participative process to define the new master plan of the city of Brindisi. Source: authors' elaboration

This process revolves around the pivotal and substantial contribution of cognitive participation. It culminates in the formulation of an updated edition of the DPP, serving as an essential cornerstone for the forthcoming real plan. A spectrum of diverse agents takes part in this process, each assuming distinct roles and carrying out different tasks. Fig.2 visually underscores the most pertinent agent categories through distinct colors. However, it's implied that each category includes a further differentiation among agents. Although apparently irrelevant, at times, yet agents can wield functional roles in shaping the outcomes of the diverse phases of this process, much like the customary occurrences in group behaviors and dynamics (Ferber et al., 2009).

On startup, the process layout defines a phase of analysis of the knowledge base and documentation related to the old draft DPP. Subsequently, it shows the program of the successive phases of the participatory construction of future visions. This is the organization of cognitive exchange arenas, in which the flow of knowledge develops a multidirectional evolution (Schön & Argyris, 1996).

In fact, on the one hand, the knowledge agents gathered in this process learn the general tools and purposes underlying the MA initiative. On the other hand, they express knowledge and needs that are useful for defining contents and strategies for an inclusive and effective plan. Moreover, it is also a horizontal exchange of knowledge between the participating agents themselves, useful for completing a framework of mutual social learning that gives a substantive and implementation structure to the plan (Schön & Argyris, 1996). In the lexicon coming from consolidated experiments and case studies on this topic, the process is mainly oriented towards generating visions of the future and possible actions useful for building paths to achieve those visions (Bell, 2003; Camarda, 2018).

The first phase of interaction is the flow marked in the Fig.2 with the letter C. It develops through a series of 8 structured interactive forums on 8 topics, namely: (i) Territory and city: history and future developments; (ii) Environment, ecology and sustainable development of the territory; (iii) Sustainable infrastructures of the territory; (iv) Agriculture and the city; (v) City, sea and port; (vi) Territory, quality of life and health; (vii) Urban regeneration and new forms of quality; (viii) Towards the smart city: knowledge society and development.

These forums are inspired by the so-called *future workshop* experiences born in the 1990s as an evolution of strategic planning experiments developed by the Tavistock Institute in the UK in the 1970s (Friend, 1969). Brindisi forums are more organizationally simplified, as compared to original future workshops: however, they are still focused on establishing a mutual learning environment between participants, oriented towards building the futures of the community. The 8 thematic forums have developed with the support of semi-computerized environments. In them, knowledge is mutually exchanged in hybrid form, oral and written (via computer or smartphone) and dynamically shown on screen to the participants. Concerning the specific aspects, advantages, and limits of this methodology there is a consolidated and continuously updated literature – which can be referred to for further information (Khakee et al., 2002; Santoro et al., 2020).

In the context of the experiments in Brindisi, the approach has proven to be well-suited for stimulating and effectively exchanging extensive and diverse contents, as well as forms of knowledge. An important advantage of computer-based hybridization is the ability to yield a database at the end of the cycle. This comprises a repository of perspectives and potential lines of action that can be readily consulted for further planned activities. Particularly, upon concluding the activities within flow C, the resulted database was utilized as a primary source by analysts, industry experts, and knowledge engineers to augment the structure of questionnaires at the outset of the subsequent phase.

This second phase corresponds to the streams labelled with letter S in the figure, and it was developed as a cognitive interaction involving students from five high schools in Brindisi. Flow S1 engaged students from the final two academic years (IV and V classes), while flow S2 only involved the students from the last academic year. Flow S1 started with a meeting between the knowledge engineers who defined the areas of investigation, based on the acquired knowledge and structured the questionnaires. The interaction then took place on five different days, one for each school. It was developed by entering the answers in forms prepared on the web portal of the Municipality of Brindisi. The answers were then structured by topic and reported in the final repository as results obtained. Subsequently, after a few months, flow S2 took place – which is discussed more specifically below.

Once all the sub-processes of cognitive interaction were concluded, the outcomes were amalgamated and integrated into a final structured body of knowledge. One notable result is that this database has now evolved into a valuable augmentation of feedback for the initial knowledge repository, so further fueling it for subsequent analytical needs. However, the primary function of this structured knowledge is to facilitate a substantial enhancement of the initial DPP documents, incorporating innovative elements of inclusivity—both in terms of knowledge and widespread requirements. This enhancement was then finalized and actualized in the concluding phase through integration with regional environmental regulations. This culminated in the formulation of the new DPP, which was approved in 2023.

4. Methodology

The adopted methodology used the GMB-CLD. It is a participatory approach for extracting knowledge through formal and facilitated activities (Hernantes et al., 2012). It has the advantage of helping participants to define, clarify and organise their ideas into a shared vision (Château et al., 2012). GMB can be traced within the Theory of System Thinking to a broader process known as the Designing thinking process.

According to Brown (2008), the Design Thinking process provides a structured and systematic approaches to problem solving and is divided into two phases (Fig.3). The divergent thinking phase, which represents the problem space in which multiple different pieces of information are contained, and the convergent thinking phase, which represents the solution space in which, based on existing problems and constraints, shared solutions and strategies are devised.

The Design Thinking process is composed by a three-stage cycle: *inspiration, conception or ideation* and *implementation*. The inspiration stage aims to identify and describe the problem to be addressed. The information from this stage is formalised and submitted to the ideation stage. This stage provides a unique opportunity to involve stakeholders in the ideation process. The implementation phase focuses on the evaluation of proposed solutions and potential scenarios (Brown, 2008).

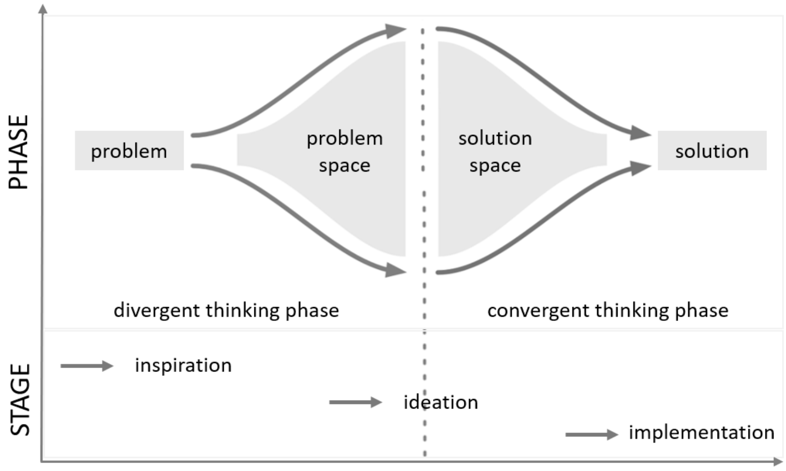

Fig.3 Design Thinking Process. Source: authors' elaboration. Adapted from Brown (2008)

Among several useful models for structuring the process, the Causal Loop Diagram (CLD) was chosen. According to Sterman, 2000, CLDs are very helpful in assisting non-expert stakeholders in developing a better understanding of the main interconnections in a complex system.

As can be seen from Fig. 4, a CLD consists of four basic elements: the variables, the links between them, the signs on the links (showing how the variables are interconnected. The CLDs are connected by arrows with polarity either positive (+) or negative (−) to indicate their interdependency and the ring sign (indicating the type of behaviour the system will produce).

The construction of the CLD took place according to the following six steps (Hördur Haraldsson, 2004): (i) identification of the variables, (ii) determine causality between variables, (iii) assess a link, (iv) assess a polarity of a link, (v) write the feedback, (iv) write the loop behaviour: reinforced feedback loop (R) or balance feedback loop (B).

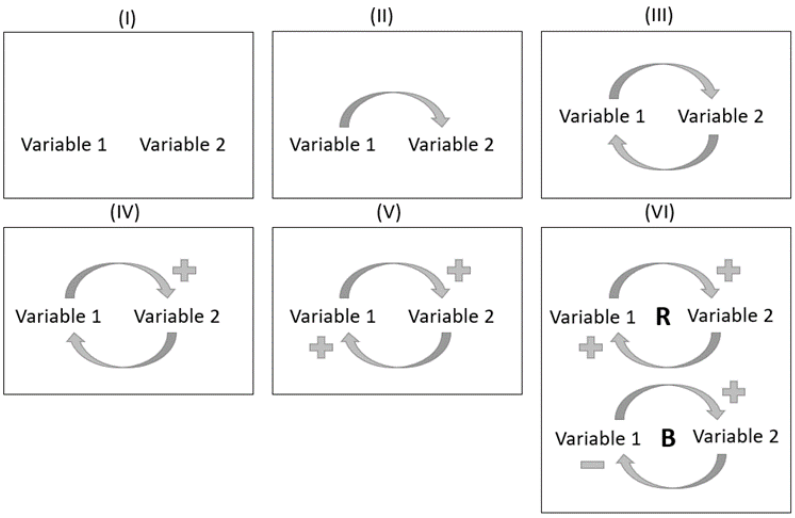

Fig.4 The Causal Loop Diagram building process. Source: authors' elaboration. Adapted from Hördur V. Haraldsson, 2004

Specifically, according to the type of connections, the variables can be divided into ordinary (with incoming and outgoing connections), drivers (outgoing connection) and receivers (incoming connection).

The variables can also be classified according to the degree index. Specifically, the sum of incoming and outgoing connections generates the centrality index. The outgoing connection generates the outdegree index and the incoming connection generates the indegree index. These indices therefore generate a ranking of the most representative variables in the model (Freeman et al., 1991). The activities of GMB have been organised in three phases: pre-meeting activities, activities during the modelling sessions and follow-up activities (Bérard, 2010).

The pre-meeting activities are part of the *inspiration stage* and are aimed at structuring the situation. To this end (i) a literature analysis and construction of the theoretical framework of the CLD model were created.

The students' activities represented the *ideation stage* in which storytelling; working group were carried out; this phase also included the *implementation stage* which was adopted through implementation and validation of the model; generation of future scenarios.

During the follow up activities scenarios, measures and strategies for the implementation of the NBS were developed by the analyst from the results achieved.

The GMB activities are summarized in Fig.5.

DESIGN THINKING PROCESS	DESIGN THINKING PHASES	divergent		convergent
	DESIGN THINKING STAGES	inspiration	ideation	implementation
GROUP MODEL BUILDING PROCESS	GROUP MODEL BUILDING ACTIVITIES	pre-meeting	during meeting	after meeting/ follow up
		literature review CLD theoretical model building	storytelling working group CLD implementation and validation	scenario building measures and strategies for NBS implementation in urban planning

Fig.5 The application of GMB activities in Design Thinking Process. Source: authors' elaboration

5. Results and discussion

A model was constructed concerning the benefits of implementing Nature-Based Solutions in the urban context, drawing from the literature. At the end of the activity, students were requested to present the outcomes of their process in a collective discussion. The information developed by both groups was deliberated upon, and the connections within the model were jointly validated. The model validation and implementation activity resulted in the incorporation of new variables highlighted in Fig.8. Through the group exercise, students highlighted the outcomes of urban regeneration, which would encourage the adoption of maintenance actions in public spaces, both diminishing impermeable surfaces and recovering abandoned buildings. Urban regeneration was also perceived as a non-structural and socially engaging measure to address delinquency.

More specifically, urban regeneration would contribute to the reduction of impermeable areas, referring to surfaces that don't absorb water and consequently amplify runoff in two specific areas: Perrino (yellow ring n.4, Fig.9) and Larosa (yellow ring n.3, Fig.9). This factor stands as a notable contributor to flood risk, an issue acutely felt in the city. According to a study conducted by Santoro et al. (2022), based on the dataset of Italian Vulnerable Areas (AVI Project), there were sixty-four flood events recorded between 1951 and 1999. Subsequently, from 1999 onward, an average of a couple of flood events annually has been registered (Santoro et al., 2023). Among the urban regeneration activities that enhance the feasibility of implementing NBS, there's the revitalization of abandoned buildings. As acknowledged in the literature, these solutions bring benefits not only to the microclimate of the structures but also to the surrounding environment, promoting cooling, mitigating the urban heat island effect, and enhancing air quality (Gunawardena et al., 2017). According to discussions among the students, the neighborhoods where this type of intervention is needed include Paradiso (yellow ring n.1 Fig.9), Sant'Elia (landmark n.2 Fig.9) neighborhoods.

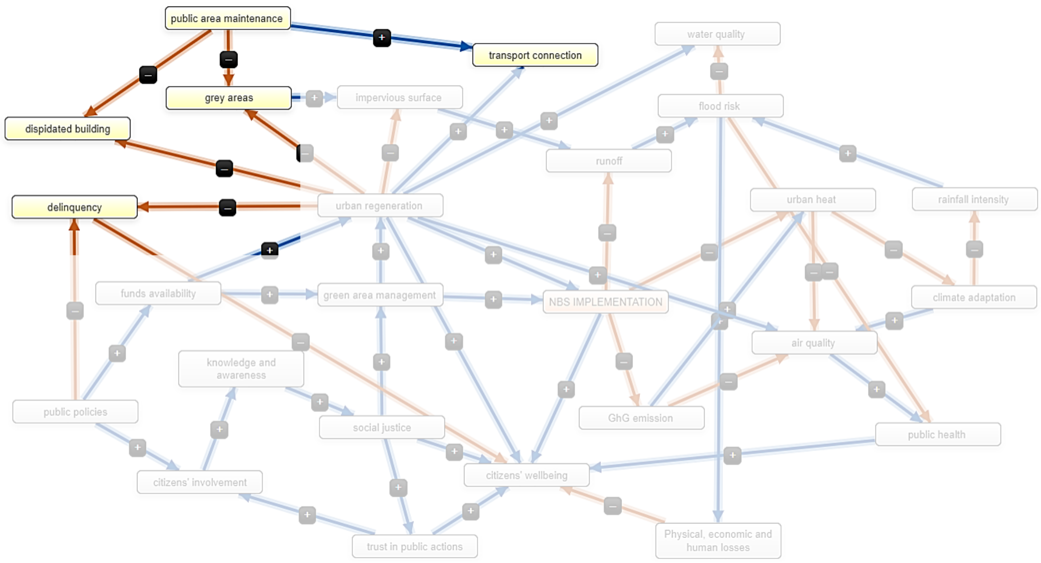

Fig.8 CLD resulted from plenary discussion. The portion about the theoretical model is slightly obscured. Source: authors' elaboration

Furthermore, as emerged from the discussion, urban regeneration can have significant implications for reducing delinquency. This concept is in line with the integrated approach to urban regeneration, which combines economic and environmental spheres with social and cultural elements (Alpopi & Manole, 2013). Another aspect arising from the public discussion is the enhancement of the transportation network, a desirable outcome of proper management of public areas. A concern spanning the entire city but amplified in the Larosa (yellow ring n.3, Fig.9) and Paradiso (yellow ring n.1, Fig.9). Rocha et al. (2023) provide policymakers insights into incentives that could more effectively boost the use of public transportation. The adoption of such strategies not only strengthens services but also reduces environmental impact, improves air quality, and reduces city congestion stemming from car traffic.

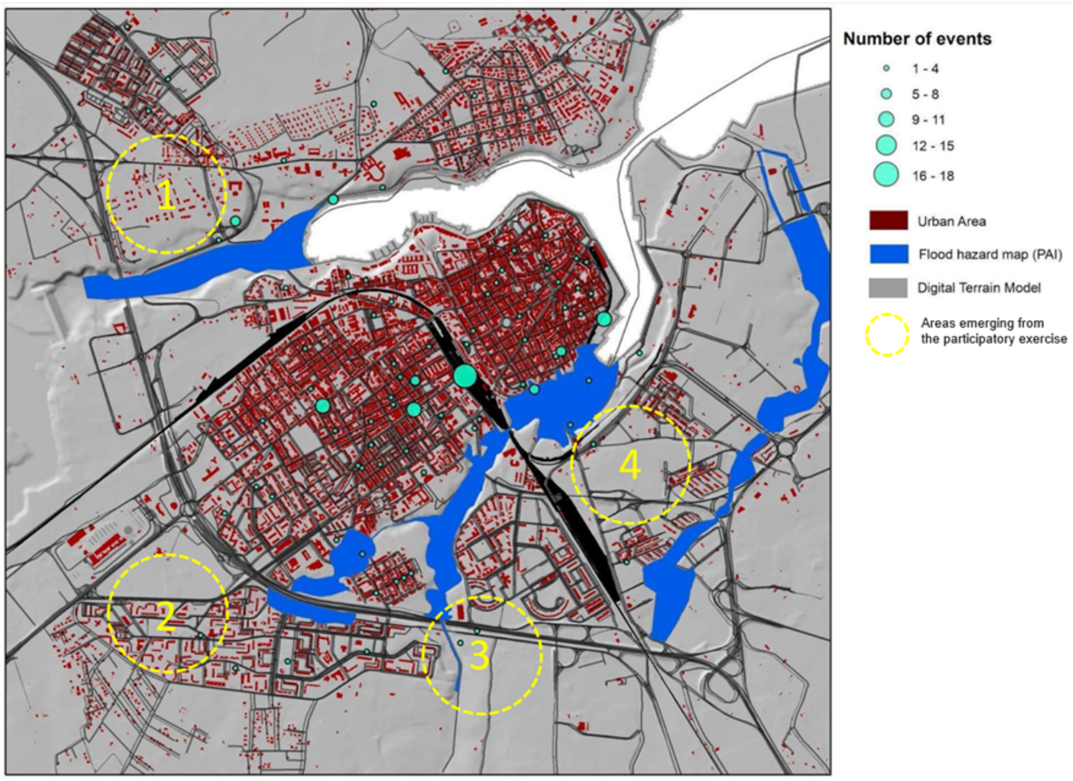

Fig.9 Geolocalised historical flood event. The size of the sphere indicates the number of events recorded. Source: authors' elaboration

Looking at the centrality indices (Tab.3) it is possible to note that the ranking of the variables remains almost unchanged. The urban regeneration indices (from 7 to 11) and citizens' well-being (from 6 to 7) have improved. To underline the validation of the theoretical framework of CLD.

Component	Indegree	Outdegree	Centrality	Type
urban regeneration	2	9	11	ordinary
citizens' wellbeing	7	0	7	receiver
air quality	4	1	5	ordinary
flood risk	2	3	5	ordinary
green area management	2	2	4	ordinary
social justice	1	3	4	ordinary
urban heat	2	2	4	ordinary
delinquency	2	1	3	ordinary
public area maintenance	0	3	3	driver
grey areas	2	1	3	ordinary
impervious surface	2	1	3	ordinary
trust in public actions	1	2	3	ordinary
public policies	0	3	3	driver
GhG emission	1	2	3	ordinary
funds availability	1	2	3	ordinary
public health	2	1	3	ordinary
citizens' involvement	2	1	3	ordinary
climate adaptation	1	2	3	ordinary
runoff	2	1	3	ordinary
dispidated building	2	0	2	receiver
transport connection	2	0	2	receiver
rainfall intensity	1	1	2	ordinary
Physical, economic and human losses	1	1	2	ordinary
water quality	2	0	2	receiver
knowledge and awareness	1	1	2	ordinary

Tab.3 Variables' index of theoretical CLD

The after-meeting activities provided a scenario analysis. Specifically, two types of scenarios were constructed. Business and Usual (BAU) scenario and Optimistic scenario.

The BAU scenario describes the situation in the event that the implementation of NBS is not adopted. To do this, the polarity of the NBS implementation variable was set to the value -1. For the creation of the optimistic scenario, the variable assumed polarity +1.

Fig.10 illustrates in red the variation of the variables according to a BAU scenario while in green the optimistic scenario with the implementation of NBS. Examining the scenarios, it appears that the BAU scenario paints a picture of the existing situation. The flood risk is alarmingly high (0.97), and all environmental and social parameters register negative values. However, through the cause-and-effect relationship with the assumptions of NBS implementation, a noteworthy decline in flood risk, urban heat island effect, and air quality degradation is achievable, leading to enhanced climate adaptation. This, in turn, boosts public safety and citizen well-being. A notable aspect to improve lies in citizen involvement.

Given the city's history with flood risk, one might have thought that the implementation of NBS would serve solely as risk mitigation. Instead, the knowledge that emerged from the students also suggested other types of functions.

These results confirm once again that the structuring of a participatory model in a decision-making plan process can improve both the quality of design choices and promote greater urban sustainability. In this sense, in recent years, numerous academic studies have underlined the importance of the significant involvement of citizens and urban planning, highlighting that an effective participatory model can play a fundamental role in promoting democracy, equity and sustainability in planning choices (Ernst, 2019; Friedmann, 1992; Forester, 1999; Innes & Booher, 2004; Healey, 2003; Sandercock, 2003).

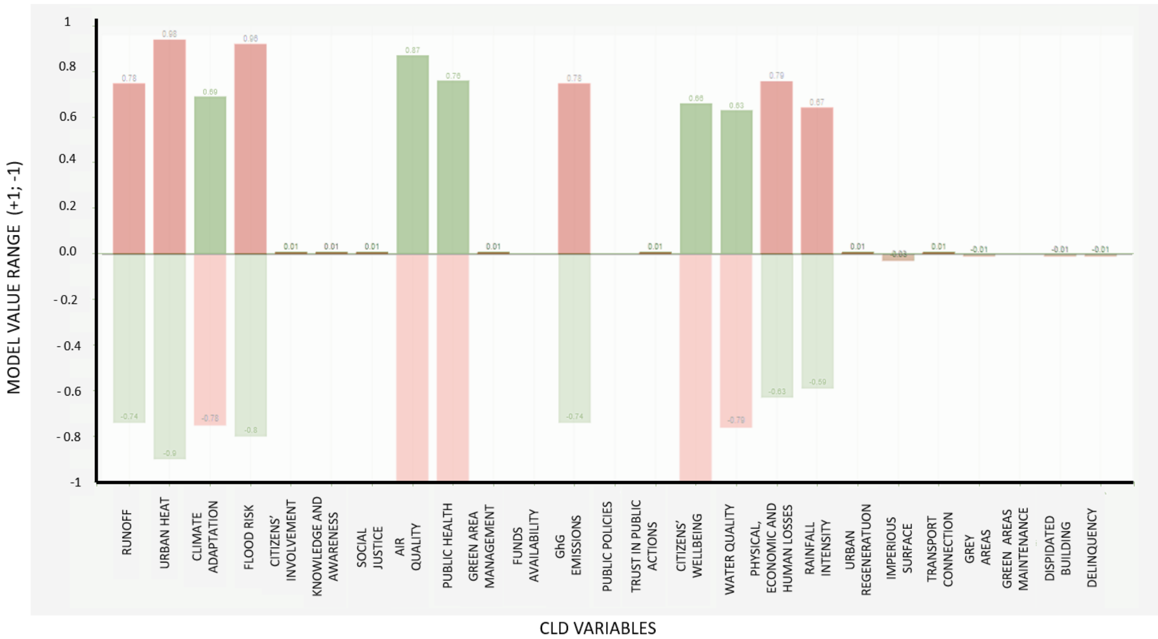

Fig.10 Scenario building. Source: authors' elaboration

A recent literature review study by Puskàs et al. (2021) on the topic argues that the role of landscape architects and urban planners should go beyond the role of experts to become facilitators and motivators, to enable broader and deeper participation of communities in defining of their future.

It is with this aim that this work seeks to contribute to sector studies by highlighting the potential and importance of participatory approaches and offering a methodology that develops a replicable model to facilitate participation at various levels and offer practical and usable knowledge on the application.

6. Conclusions

The path toward widespread adoption of NBS is not without challenges, as it requires a holistic approach. Lack of awareness, the need for integration across different sectors, and evaluating long-term effectiveness are all critical aspects. Furthermore, designing and managing NBS demands a deep understanding of local ecosystems. A substantial body of research now indicates that engagement processes and active participation are key factors in effectively adopting solutions to contrast climate change. Transformations toward effective local sustainability require strategies that enhance social learning (Armitage et al., 2017; Berke & Ross, 2013; Imperiale & Vanclay, 2023; Samaraweera, 2013).

Adopting an interdisciplinary approach that combines traditional engineering with behavioral and socio-ecological sciences has led to the emergence of "social resilience thinking" over the past decades as a crucial element for risk reduction and disaster impact mitigation. Nonetheless, numerous cultural and political-institutional obstacles make the necessary processes for achieving these goals challenging (Imperiale & Vanclay, 2023). However, there is a growing awareness that disaster risk reduction must extend beyond vulnerability reduction and paternalistic technical assistance. It must consider communities' perceptions and experiences of risks, take into account social capital, and adopt transparent communication, resource sharing, technology sharing, and shared responsibility.

More recently, the benefits of distributed information resources (GIS systems) can be used on digitally enhanced participatory workshops involving communities to facilitate the creation of future scenarios and co-production processes of risk knowledge, with the aim of building community resilience in disaster-prone areas (Carnelli & Pedoth, 2023; Samaraweera, 2013).
This work represents an effort in this direction undertaken during the planning process in Brindisi. From this perspective, it is evident that the experience described in this article has enabled the enhancement of locally constructed knowledge.
It has been a significant component within a process entirely structured around the exchange of distributed knowledge. In this regard, the approach demonstrates that compared to a traditional process solely reliant on expert knowledge, certain aspects are more relevant.
The first pertains to expanding the knowledge base, bringing together non-expert, common-sense, and experiential forms of knowledge that are extremely valuable and otherwise not available in formalized terms. The second concerns knowledge that proceeds in the opposite direction, enhancing the cognitive interactivity of the process by inducing dynamic self-learning within the local community. A third aspect relates to knowledge shaped towards implementation, as it manages to include perceptual, emotional, and behavioral elements crucial for transforming knowledge into practical activities—particularly useful in scenarios such as flood risk.
A fourth aspect strengthen the critical importance of models and structuring architectures for exchanged data, especially those of informal nature. This latter point, in particular, opens the way for the creation of platforms to support informed, and even dynamic, policy decision-making during plan implementation.
The challenge in this context is ensuring that the relational articulation and richness of the collected databases are maintained. This places issues within the broader matter of managing cognitive and environmental complexity, which remains vividly present in our disciplinary debates.
Ontological modeling approaches, for example, are increasingly seen as a promising perspective, especially regarding environmentally based systems. Our research group's focus is oriented in this area and will be further explored as a future outlook.
On the other hand, important limitations that hindered this type of approach must be considered, too. One of them, particularly clear in our case study and in many research-in-action contexts, is the complex administrative reality from which these processes are supposed to be stimulated and driven. In the case of Brindisi, in fact, an articulate phase of citizenship involvement in general had been planned (phase C). This, however, had only a very partial development due to local political and administrative difficulties. Consequently, the analysis of the interaction protocols, participating profiles and the study of the related results had to be set aside and could not complement the GMB methodology development.
Furthermore, just when the local administration was ready to start a new political effort toward operationally implementing results, it entered into a political crisis. The new elections then brought about a government that was basically opposed to an knowledge-inclusive approach, preferring a traditional top-down regulatory framework. As a matter of facts, these are known and recurring problems in medium-long term planning processes - often facing decisions that are sudden and subject to the short times and ways of politics.
Overall, however, it is useful here to mention the substantive value of the results obtained in the experimental process, which suggest the importance of the transition of administrations towards knowledge-based decision support models in risk conditions. From this point of view, the approach used by this study was fortunately (yet deliberately - being driven by research aims) developed with the objectives of building replicable system architectures, and not of exclusively area-based analysis.
Starting from this point it will therefore be possible to more substantially develop further experiments, thus generating useful contextual follow ups in the future.

References

Aerts, J. C. J., H, Botzen, W. J., Clarke, K. C., Cutter, S. L., Hall, J. W., Merz, B., Michel-Kerjan, E., Mysiak, J., Surminski, S. & Kunreuther, H. (2018). Integrating human behaviour dynamics into flood disaster risk assessment. *Nature Climate Change*, *8 (3),* 193–199.

Akbari, H. (2005). Energy Saving Potentials and Air Quality Benefits of Urban Heat Island Mitigation. *Lawrence Berkeley National Laboratory*, Berkeley, CA, H_Akbari@lbl.gov, http://HeatIsland.LBL.gov/

Akkermans, H.A. & Vennix, J.A.M. (1997) "Clients' opinion on group model-building: an exploratory study". *System Dynamics Review, 13* (1), 3-31. https://doi.org/10.1002/(SICI)1099-1727(199721)13:1<3::AID-SDR113>3.0.CO;2-I

Alexander, D. (2015). Disaster and Emergency Planning for Preparedness, Response, and Recovery. *Oxford Research Encyclopedia of Natural Hazard Science*, Oxford University Press: Oxford, 1-20. https://doi.org/10.1093/acrefore/9780199389407.013.12

Alpopi, C. & Manole, C. (2013). Integrated Urban Regeneration – Solution for Cities Revitalize. *Procedia Economics and Finance*, *6*, 178-185. https://doi.org/10.1016/S2212-5671(13)00130-5

Andersen, D.F. & Richardson, G.P. (1997). Scripts for group model building. *System Dynamics Review*, *13* (2), 107-129. https://doi.org/10.1002/(SICI)1099-1727(199722)13:2<107::AID-SDR120>3.0.CO;2-7

Armitage, D., Dzyundzyak, A., Baird J., Bodin, O., Plummer, R. & Schultz, L. (2017). Approach to Assess Learning Conditions, Effects and Outcomes in Environmental Governance, Environmental Policy and Governance. Wiley online Library, https://doi.org/10.1002/eet.1781

Balletto, G., Borruso, G. & Donato, C. (2018). City dashboards and the Achilles' heel of smart cities: putting governance in action and in space. In *Computational Science and Its Applications, Proceedings of ICCSA 2018*, Melbourne, VIC, Australia, July 2-5, 2018. https://doi.org/10.1007/978-3-319-95168-3_44

Gervasi, O., Murgante, B., Misra, S., Stankova, E., Torre, C. M., Rocha, A. M. A., Taniar, D., Apduhan, B. O., Tarantino, E., & Ryu, Y. (2018). Computational Science and its Applications – ICCSA 2018. In *Lecture notes in computer science*. https://doi.org/10.1007/978-3-319-95165-2

Bangash, R. F., Passuello, A., Sanchez-Canales, M., Terrado, M., López, A., Elorza, F. J., Ziv, G., Acuña V. & Schuhmacher, M. (2013). Ecosystem services in Mediterranean river basin: Climate change impact on water provisioning and erosion control. *The Science of the Total Environment*, 458-460C, 246–255. http://dx.doi.org/10.1016/j.scitotenv.2013.04.025

Bell, W. (2003). *Foundations of Futures Studies: History, Purposes, and Knowledge*; Transaction Publishers: New Brunswick (NJ).

Bérard, C. (2010). Group Model Building Using System Dynamics: An Analysis of Methodological Frameworks. *The Electronic Journal of Business Research Methods, 8* (1), 35 - 46. Available online at: https://academic-publishing.org/index.php/ejbrm

Berkes, F. & Ross, H. (2012). Community Resilience: Toward an Integrated Approach. *Society & Natural Resources*,*26* (1), 5–20. https://doi.org/10.1080/08941920.2012.736605

Blečić, I., Carrus, A.S., Muroni, E., Saiu, V. & Saliu, M.C. (2023). Engagement and Inclusion Experiences for Energy Communities. An Ongoing Case Study in Cagliari, Italy. In: Gervasi, O., et al. Computational Science and Its Applications – ICCSA 2023 Workshops. ICCSA 2023. *Lecture Notes in Computer* Science. 14109. Springer, Cham. https://doi.org/10.1007/978-3-031-37120-2_33

Borri, D., Camarda, D. & Pluchinotta, I. (2014). Planning for the microclimate of urban spaces: Notes from a multi-agent approach. In *Cooperative Design, Visualization, and Engineering,* Luo Y (ed.); Springer, Berlin, Germany, 179-182. https://doi.org/10.1007/978-3-319-10831-5_27

Brown, T. (2008). Design thinking. Harvard Business Rev. *86* (6), 84-95.

Brown, T. (2019). Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation. 2nd ed. New York. NY: Harper Business.

Camarda, D. (2010). Beyond citizen participation in planning: Multi-agent systems for complex decision making. In *Handbook of research on e-planning: ICTs for urban development and monitoring*, Nunes Silva, C., Ed.; IGI Global: Hershey PA, 195-217.

Camarda, D. (2018). Building sustainable futures for post-industrial regeneration: the case of Taranto, Italy. *Urban Research & Practice, 11*, 275-283, doi:10.1080/17535069.2018.1498196.43

Carnelli, F. & Pedoth, L. (2023). Enhancing Risk Governance by Addressing Key Risk Communication Barriers during the Prevention and Preparedness Phase in South Tyrol (Italy). *Sustainable Development*, Wiley online Library.

Château, P. A., Chang, Y. C., Chen, H. & Ko, T. T. (2012). Building a stakeholder's vision of an offshore wind-farm project: A group modeling approach. *Science of the Total Environment*, *420*,43-53.

Chen F., Yang X. & Zhu W. (2014). WRF simulations of urban heat island under hot-weather synoptic conditions: The case study of Hangzhou City, China. *Atmospheric research*, *138*, 364-377. https://doi.org/10.1016/j.atmosres.2013.12.005

De Liddo, A. & Concilio, G. (2017). Making decision in open communities: Collective actions in the public realm. *Group Decision and Negotiation*, *26*, 847-856, doi:10.1007/s10726-017-9543-9

De Noia, I., Favargiotti, S. & Marzadri, A. (2022). Renaturalising lands as an adaptation strategy. Towards an integrated water-based design approach. *TeMA - Journal of Land Use, Mobility and Environment*, *15* (2), 263-286. https://doi.org/10.6093/1970-9870/9074

Ernst, A. (2019). Review of factors influencing social learning within participatory environmental governance. *Ecology and Society*, *24* (1). https://www.jstor.org/stable/26796921

Farrugia, S., Hudson, M. D. & McCulloch, L. (2013). An evaluation of flood control and urban cooling ecosystem services delivered by urban green infrastructure. *International Journal of Biodiversity Science, Ecosystem Services & Management*, *9* (2), 136–145. https://doi.org/10.1080/21513732.2013.782342

Ferber, J., Stratulat, T. & Tranier, J. (2009). Towards an integral approach of organizations in multi-agent systems. In Handbook of Research on MultiAgent Systems: Semantics and Dynamics of Organizational Models, Dignum, V., Ed.; IGI: Hershey, 51-75. https://doi.org/10.4018/978-1-60566-256-5.ch003

Forester, J. (1999). *The deliberative practitioner: Encouraging participatory planning processes*. MIT Press.

Freeman, L. C., Borgatti, S. P. & White, D. R. (1991). Centrality in valued graphs: A measure of betweenness based on network flow. *Social networks*, *13* (2), 141-154. https://doi.org/10.1016/0378-8733(91)90017-n

Friedmann, J. (1992). *Empowerment: The politics of alternative development*. John Wiley & Sons.

Friend, J.K. & Jessop, W.N. (1969). *Local Government and Strategic Choice*. Tavistock: London.

Gardner, J. (2002). Natural Hazards Risk in the Kullu District, Himachal Pradesh, India. *The Geographical Review*, *92* (2), 282-306. https://doi.org/10.1111/j.1931-0846.2002.tb00008.x

Gunawardena, K. R., Wells, M. J. & Kershaw, T. (2017). Utilising green and bluespace to mitigate urban heat island intensity. *Science of The Total Environment*, Volumes 584–585, 1040-1055. https://doi.org/10.1016/j.scitotenv.2017.01.158

Haraldsson, Hördur V. (2004). *Introduction to System Thinking and Causal Loop Diagrams*. Lund: Lund University.

Hazer, M., Formica, M. K., Dieterlen, S. & Morley, C. P. (2018). The relationship between self-reported exposure to greenspace and human stress in Baltimore, MD. *Landscape and Urban Planning*, *169*, 47–56. https://doi.org/10.1016/j.landurbplan.2017.08.006

Healey, P. (2003). Collaborative planning in perspective. *Planning Theory*, *2*, 101-123. https://doi.org/10.1177/14730952030022002

Heft, H. (2013). Environment, cognition, and culture: Reconsidering the cognitive map. *Journal of Environmental Psychology*, *33*, 14-25. https://doi.org/10.1016/j.jenvp.2012.09.002

Hernantes, J, Labaka, L., Laugé, A., Sarriegi, J. M. & Gonzalez, J. J. (2012). Group model building: a collaborative modelling methodology applied to critical infrastructure protection. *International Journal of Organisational Design and Engineering, 2* (1), 41-60. https://doi.org/10.1504/IJODE.2012.045904

Hewitt, K. (1983). The idea of calamity in a technocratic age. In *Interpretations of Calamity from the Viewpoint of Human Ecology*, 1st ed.; K. Hewitt ed; Routledge, London, UK.

Houlden, V., Weich, S., Porto de Albuquerque, J., Jarvis, S. & Rees, K. (2018). The relationship between greenspace and the mental wellbeing of adults: A systematic review. *PloS ONE*,*13* (9). https://doi.org/10.1371/journal.pone.0203000

Howard, E., Hubelbank, J. & Moore, P. (1989). Employer evaluation of graduates: use of the focus group. *Nurse Educator 14* (5), 38–41. 10.1097/00006223-198909000-00019

Howard, L. (2012). *The Climate of London: Deduced from Meteorological Observations*, vol. 1, Cambridge University Press, Cambridge.

Imperiale, A., J. & Vanclay, F. (2023). Re-designing Social Impact Assessment to enhance community resilience for Disaster Risk Reduction, Climate Action and Sustainable Development. *Sustainable Development*, Wiley online Library. https://doi.org/10.1002/sd.2690

Innes, J.E. & Booher, D.E. (2004). Reframing public participation: Strategies for the 21st century. *Planning Theory & Practice, 5*, 419-436. https://doi.org/10.1080/1464935042000293170

ISPRA (2023). https://www.isprambiente.gov.it/it/istituto-informa/comunicati-stampa/anno-2022/dissesto-idrogeologico-quasi-il-94-dei-comuni-a-rischio-frane-allu-vioni-ed-erosione-costiera (accessed on 26 June 2023)

Khakee, A., Barbanente, A. & Borri, D. (2000). Expert and experiential knowledge in planning. *Journal of the Operational Research Society*, *51*, 776-788. https://doi.org/10.2307/253959

Khakee, A., Barbanente, A., Camarda, D. & Puglisi, M. (2002). With or without? Comparative study of preparing participatory scenarios using computer-aided and traditional brainstorming. *Journal of Future Research 6*, 45-64.

Kitzinger, J. (1994). The methodology of Focus Groups: the importance of interaction between research participants. *Sociology of Health & Illness 16* (1), 103–121. https://doi.org/10.1111/1467-9566.ep11347023

Lafortezza, R., Chen, J., Van Den Bosch, C. K. & Randrup, T. B. (2018). Nature-based solutions for resilient landscapes and cities. *Environmental research*, *165,* 431-441. https://doi.org/10.1016/j.envres.2017.11.038

Lai, S., Isola, F., Leone, F. & Zoppi, C. (2021). Assessing the potential of green infrastructure to mitigate hydro-geological hazard. *TeMA - Journal of Land Use, Mobility and Environment*, *Special Issue*, 109-133. https://doi.org/10.6093/1970-9870/7411

Lee, J., Burton, H. & Lallemant, D. (2018). Adaptive decision-making for civil infrastructure systems and communities exposed to evolving risks. *Structural Safety*. *75*, 1-12. https://doi.org/10.1016/j.strusafe.2018.05.001

Lee, Y. J. (2018). Relationships among Environmental Attitudes, Risk Perceptions, and Coping Behavior: A Case Study of Four Environmentally Sensitive Townships in Yun-lin County, Taiwan. *Sustainability, 10* (8), 2663. https://doi.org/10.3390/su10082663

Lichfield, N. (Ed.) (1998). Evaluation in planning: facing the challenge of complexity, 47, Springer Science & Business Media.

Limburg, K.E., O'Neill, R.V., Costanza, R. & Farber, S. (2002) "Complex systems and valuation", *Ecological Economics, 41*, 409-420. https://doi.org/10.1016/S0921-8009(02)00090-3

Martín, E. G., Giordano, R., Pagano, A., Van Der Keur, P. & Costa, M. M. (2020). Using a system thinking approach to assess the contribution of nature-based solutions to sustainable development goals. Science of the Total Environment. 738, 139693. https://doi.org/10.1016/j.scitotenv.2020.139693

Mazzeo, G. & Polverino, S. (2023). Nature-based solution for climate change adaptation and mitigation in urban areas with high natural risk: Proposals of possible measures for a municipality in the Vesuvius area. *TeMA - Journal of Land Use, Mobility and Environment, 16* (1), 47-65. https://doi.org/10.6093/1970-9870/9736

Merton, R.K., Fiske, M. & Kendall, P.L. (1990). *The Focused Interview: A Manual of Problems and Procedures*, 2nd edn. Free Press, New York.

Morabito, M., Crisci, A., Guerri, G., Messeri, A., Congedo, L. & Munafò, M. (2021). Surface urban heat islands in Italian metropolitan cities: tree cover and impervious surface influences. *Sci. Total Environ*, *751*, 142334. https://doi.org/ 10.1016/j.scitotenv.2020.142334

Morçöl, G. (2005). A new systems thinking: implications of the science of complexity for public policy and administration, *Public Administration Quarterly*, *29*, 297-320.

Pelorosso, R., Gobattoni, F., Geri, F., Monaco, R. & Leone, A. (2015). Evaluation of Ecosystem Services related to Bio-Energy Landscape Connectivity (BELC) for land use decision making across different planning scales. *Ecological Indicators, 61.* http://dx.doi.org/10.1016/j.ecolind.2025.01.016

Poortinga, W., Bird, N, Hallingberg, B., Phillips, R. & Williams, D. (2021). The role of perceived public and private green space in subjective health and wellbeing during and after the first peak of the COVID-19 outbreak, *Landscape and Urban Planning*, *211*.

Puskás, N., Abunnasr, Y. & Naalbandian, S. (2021). Assessing deeper levels of participation in nature-based solutions in urban landscapes–A literature review of real-world cases. *Landscape and Urban Planning, 210,* 104065. https://doi.org/10.1016/j.landurbplan.2021.104065

Recanatesi, R., Petroselli, A., Ripa, M. N. & Leone, A. (2017). Assessment of stormwater runoff management practices and BMPs under soil sealing: A study case in a peri-urban watershed of the metropolitan area of Rome (Italy). *Journal of Environmental Management,* 201- 6-18. https://doi.org/10.1016/j.jenvman.2017.06.024

Rocha, H., Filgueiras, M., Tavares, J.F. & Ferreira, S. (2023). Public Transport Usage and Perceived Service Quality in a Large Metropolitan Area: The Case of Port. *Sustainability*, *15* (7), 6287. https://doi.org/10.3390/su15076287

Rouwette, E.A.J.A., Vennix, J.A.M. & van Mullekom, T. (2002) "Group model building effectiveness: a review of assessment studies". *System Dynamics Review*, *18* (1), 5-45. https://doi.org/10.1002/sdr.229

Samaraweera, H. U. S. (2023). Exploring complexities of disaster risk and vulnerability: Everyday lives of two flood-affected communities in Sri Lanka. *Sustainable Development*, Wiley online Library, https://doi.org/10.1002/sd.2723

Sandercock, L. (2003). Out of the closet: The importance of stories and storytelling in planning practice. *Planning theory & practice, 4* (1), 11-28. https://doi.org/10.1080/1464935032000057209

Santoro, S., Totaro, V., Mastrodonato, G. & Balena, P. (2023). Mapping Citizens' Knowledge and Perception. What Support for Flood Risk Planning? Some Tips from Brindisi Case Study. In: Gervasi, O., et al. Computational Science and Its Applications – ICCSA 2023 Workshops. ICCSA 2023. *Lecture Notes in Computer Science*, vol 14109. Springer, Cham. https://doi.org/10.1007/978-3-031-37120-2_2362

Santoro, S., Totaro, V., Lovreglio, R., Camarda, D., Iacobellis, V. & Fratino, U. (2022). Risk perception and knowledge of protective measures for flood risk planning. The case study of Brindisi (Puglia region). *Safety science, 153*, 1057961. https://doi.org/10.1016/j.ssci.2022.105791

Santoro, S., Stufano Melone, M.R. & Camarda, D. (2020). Building strategic scenarios during Covid-19 lockdown. *TeMA - Journal of Land Use, Mobility and Environment*, *13*, 229-240. https://doi.org/10.6092/1970-9870/6917

Schön, D.A. & Argyris, C. (1996). *Organizational Learning II: Theory, Method and Practice*; Addison-Wesley: Reading MA.

Sinatra, F., Balletto, G. & Borruso, G. (2023). Minimum Environmental Criteria and Climate Issue in the Metropolitan Urban Ecosystem. In *Computational Science and Its Applications*, Proceedings of ICCSA 2023, Athens, Greece, July 3 – 6, 2023 Gervasi O., Murgante B., Rocha A.M. A. C., Garau C., Scorza F., Karaca Y., Torre C.M (Eds.), *Springer Nature Switzerland AG*, 49-65. https://doi.org/10.1007/978-3-031-37120-2_4

Sterman, J.D. (2000). *Business dynamics: systems thinking and modeling for a complex world*, New York: Irwin-McGraw-Hill.

Tayefi Nasrabadi, M. (2022). How do nature-based solutions contribute to urban landscape sustainability? *Environment, Development and Sustainability, 24(1),* 576-591. https://doi.org/10.1007/s10668-021-01456-3

The Intergovernmental Panel on Climate Change (IPCC): The United Nations body for assessing the science related to climate change, https://www.ipcc.ch/ (accessed on 12 June 2023)

Twinn, S. (1998). An analysis of the effectiveness of focus groups as a method of qualitative data collection with Chinese populations in nursing research. *Journal of Advanced Nursing 28* (3)*,* 654–661. https://doi.org/10.1046/j.1365-2648.1998.00708.x

Van den Berg, A. E., Maas, J., Verheij, R. A. & Groenewegen, P. P. (2010). Green space as a buffer between stressful life events and health. *Social Science & Medicine, 70* (8), 1203–1210. https://doi.org/10.1016/j.socscimed.2010.01.002

Velarde, Ma. D., Fry, G. & Tveit, M. S. (2017). Health Effects of Viewing Landscapes – Landscape Types in Environmental Psychology. *Urban Forestry & Urban Greening, 6* (4)*,* 199-212. https://doi.org/ 10.1016/j.ufug.2007.07.001

Zurlini, G., Petrosillo, I., Jones, K.B. & Zaccarelli, N. (2013). Highlighting order and disorder in social -ecological landscapes to foster adaptive capacity and sustainability. *Landscape Ecology, 28* (6), 1161-1173.

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Fig.6: authors' elaboration;

Fig.7: photo;

Fig.8: authors' elaboration;

Fig.9: authors' elaboration;

Fig.10: authors' elaboration.

Author's contribution

Conceptualization: S.S., D.M, G.M; methodology: S.S.; software: S.S.; data collection: S.S.; data curation and analysis: S.S.; writing—original draft preparation: S.S.; writing—review and editing: sect.1: G.M, S.S.; sect 2: G.M, S.S.; sect. 3.1: S.S.; sect.3.2: D.C.; sect.3.2.2: S.S.; sect. 4: S.S; sect.5: S.S., G.M. and D.C.
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