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Perception of Nature-based Solutions: Preliminary Investigations in the Veneto Region

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Abstract

Flooding from rainfall has become more frequent due to a growing number of extreme rainfall events related to climate change as well as increasing urbanisation. In addition, it is expected that 66% of the world's population will live in urban areas by 2050, making flood prevention and risk reduction increasingly important. Thus, sustainability, resilience, and ecosystem services are essential to increase human wellbeing in urban environments. Nature-based Solutions (NbS) can provide all the benefits of urban green combined with flood mitigation. This thesis aims to provide useful insight to promote NbS adoption to build climate change resilient communities exploring how people's perception and implementation likelihood of some NbS varies in Veneto, a North-Eastern region of Italy. An online survey was conducted to investigate the knowledge and the perception of NbS and grey infrastructures among people in the region. Data analysis found a significative correlation between previous knowledge of water management systems and perceived efficacy of some NbS. Landscape connectedness behaviours were also found to influence NbS perceived efficacy. This thesis provides useful insight to understand the dynamics behind NbS implementation to reduce flood from rainfall and can help policymakers to adapt urban plans to promote NbS adoption.

1. Introduction

Flooding from rainfall has become more frequent due to a growing number of extreme rainfall events related to climate change (Yilmaz, et al., 2014; Walsh & Pittock, 1998; Arnbjerg-Nielsen, 2006) as well as increasing urbanisation (ISPRA, 2020; Recantesi & Petroselli, 2020; Strollo, et al., 2020). In Italy, ISPRA (2020) estimates 21398 km^2 of artificial land cover in 2019 (7% of the national land). Thus, flood prevention and risk reduction have become increasingly important. In addition, because half of the world's population already lives in urban areas, and projections suggest that this share will increase up to 66% by 2050 (Department of Economic and Social Affairs, 2014) sustainability, resilience and ecosystem services are essential to increase human wellbeing in urban environments (Bush & Doyon, 2019). Nature-based Solutions (NbS) are an efficient and cost-effective way to cope with an increase in flood risk and urbanization (Lafortezza, et al., 2018). NbS have emerged as multifunctional infrastructures than can contribute to increase urban resilience with numerous benefits for both people and the environment. As green areas, NbS can mitigate the urban heat island, air and water pollution, and have a great potential to increase human well-being and reduce stress (Panno, et al., 2017). Nevertheless, NbS are not yet widely implemented around the world (Sañudo-Fontaneda & Robina-Ramírez, 2019), especially in urban areas (Chui & Ngai, 2016) and people's perception of NbS, together with urban planning, play a determinant role in their diffusion (Ignatieva, et al., 2020; Bush & Doyon, 2019; Barnhill & Smardon, 2012). I t appears that there is a lack of knowledge about and confidence in NbS by both people, that do not want to invest in something they do not know, and policy makers, that should promote the adoption of NbS to provide more sustainable and resilient cities for their citizens (Alves, et al., 2018). Understanding how people perceive and how much they know NbS is thus a first step in effectively promoting their use.

This study aims to understand how people's perception and implementation likelihood of some NbS varies in Veneto, a region in North-Eastern Italy.

2. Background

2.1. Urban drainage systems: a terminology overview

Over recent decades, the management of urban rainfall has become more complex, with many approaches and systems being developed (CIRIA, 2015; Kabisch, et al., 2017). Urban drainage systems are commonly divided in "grey" and "green-blue" infrastructures. Grey infrastructures include all the conventional engineering systems that have the only aim of reducing flooding (e.g. diversion channels, drainage pipes, large storage tanks). Green-blue infrastructures, on the other hand, come as multipurpose systems to control the quantity of runoff, manage the quality of the runoff to prevent pollution, and create and sustain better places for people and nature (CIRIA, 2015; Brears, 2018). While grey infrastructures move runoff from a place to another with the only goal of diverting water away from cities, green-blue infrastructures control the runoff by attenuating the discharge peak. This can be achieved by slowing, storing, and infiltrating into the soil runoff directly where it falls. Besides, many of these green-blue systems also use vegetation to enhance their ecological value, mitigating heat and air pollution and improving urban ecosystems with new habitats for wild animals and plants.

Over the years, many green-blue drainage systems have been developed all over the world, everyone with its denomination that describes the system's functionality. Consequently, a whole new area of terminology has been developed, but mainly in an informal manner. As found by Ellis et al. (2004) in the Urban Drainage Multilingual Glossary, this informal and, mainly, local evolution leads to a lack of professional terminology that is useful to convey ideas, concepts methods and techniques. After that, Fletcher et al. (2014) seek to document the recent history and evolution around urban drainage systems terminology with the aim to draw out the important principles, processes and objectives which drive this evolving practice. The main terms used to refer to urban drainage systems that include a sustainable approach are green infrastructures (GI), Sustainable Drainage Systems (SuDS) or Sustainable Urban Drainage Systems (SUDS), and Natural-based Solutions (NBS).

GI were initially identified in the USA in the 1990s for their potential ecosystem services and promoted as a network of green spaces to implement in urban planning (Fletcher, et al., 2014). In the same period, in the UK the concerted approach to stormwater management began in the 1980s leads to new guidelines that include a range of technical runoff control options. Currently, the most authoritative guide to SuDS is The SuDS Manual (CIRIA, 2015) which aim to be a guidance that "covers the planning, design, construction and maintenance of SuDS to assist with their effective implementation within both new and existing developments."

Besides GI and SuDS, the Europen Commission use the term Natural Water Retention Measures (NWRMs) to identify adaptation measures that use nature to regulate the flow and the transport of water to smooth the discharge peak and moderate extreme events (European Commission, 2011).

So, while GI seem to be described mainly as vegetated urban elements and SuDS mainly refer to urban drainage systems - with and without vegetation - NWRMs consider all the possible applications, from the direct ecosystem modifications (e.g. ponds, wetlands, river and aquifer restoration) to all the adaptation in land-use and water management practices in agriculture (e.g. meadows, buffer strips), forestry and pastures (e.g. riparian buffers, urban forests), and urban environment (e.g. green roofs, rainwater harvesting, rain gardens).

Nature-based Solutions (NbS) is another widespread term to define the use of ecosystems and the services they provide to address societal challenges such as natural hazards and climate change (Cohen-Shacham, et al., 2016). IUCN (2016, 2) define NbS as: "Actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits".

Besides all these considerations, all of the water management measures considered in this thesis can have a significative impact on the environment in which they are adopted (e.g. changes in land use for the implementation of an expansion basin or the constrution of a concrete diversion channel) or are based on natural practices (e.g. ground infiltration, vegetation), so we will refer to the overall evaluated water management systems as Nature-based Solutions (NbS).

The European Union is also investing in NbS with the EU Horizon project to achieve several goals: job creation, economic growth, and innovation while tackling global environmental challenges for a long term economic competitiveness and security (Maes & Jacobs, 2015).

2.2. Literature review on NbS perception

Since the approach to NbS implementation is based on the *in-situ* management of rainfall (CIRIA, 2015), the best place to install a nature-based solution is where runoff starts. In an urban environment, this means that NbS must be installed near buildings and hard surfaces, and most of them will be in or near private properties. At this point, a possible limitation for a wide implementation of NbS may occur. As found in previous studies, the self-protective behaviour by people that live in a flood-prone urban area can reduce monetary damage by 80% (Grothmann & Reusswing, 2006), so there will be less need for public investments in flood risk management. On the other hand, there is often a lack of knowledge and confidence in NbS (Thorne, et al., 2015; Baptiste, et al., 2017; Sharma, et al., 2016), and projections show an intensification of heavy rainfall events in the future (Rajczak, et al., 2013; Semmler & Jacob, 2004), so flood risk management will be one of the major challenges. People's attitude toward NbS is also useful to help policymakers improve urban planning by promoting the adoption of NbS (Foley, 2012; Ugolini, et al., 2015; Mell, et al., 2013), to achieve both human well-being and environmental benefits (Alves, et al., 2018). Previous studies found that people have varied levels of awareness of the presence and multifunction of SuDS (Williams, et al., 2019) and in South Australia Sharma et al. (2016) found that the water conservation and flood mitigation of NbS are well recongnised by residents. Also, Baptsite et al. (2014) found that there is a strong willingness to implement green infrastructure whether provided free or whether a savings is accrued with implementation. Other studies also explored NbS implementation through people's willingness to pay to adopt them (Chui & Ngai, 2016; Mell, et al., 2013) and found that, despite a general low knowledge on NbS, their adoption is supported by residents. Finally, previous studies mainly focus on single city experience while this thesis explore the attitudes through NbS on a regional scale.

3. Methods

3.1. Study area

The study area is the Veneto Region, in Northeastern Italy. The region has about 4.9 million inhabitants (ISTAT, 2021).

The territory is quite heterogeneous, and many land geomorphologies can be found. In the east, the region borders with the Adriatic Sea. The southern part of the region lays in the Po Plain. The floodplain is divided into the high and low plain by the line of resurgence. In the north, the landscape becomes hilly with many valleys with a north-south orientation. Beyond the hills, there are the Dolomites that are part of the Southern Limestone Alps.

The climate changes significantly from an area to another but the Region can be placed in the transition zone (ARPAV, 2011). Considering the average annual temperature, the average annual rainfall and land morphology factors, the Region can be divided into three main climatic zones: plain, pre-alpine, and alpine. The plain climate is characterised by continental conditions with an average temperature of 13-15 °C, cold and dry winter, and hot summer. The total rainfall varies between 600 and 1100 mm/y (Figure 1). The pre-alpine climate is characterized by rainy spring and autumn, with a total rainfall of about 1100-1600 mm/y. The average temperature is 9-12 °C and winter is the less rainy season. The alpine climate is typical of the dolomitic area and is strongly conditioned by the local morphology. In these areas, the average temperature varies between 7 and -5 °C and the total rainfall is about 1600 mm/y.

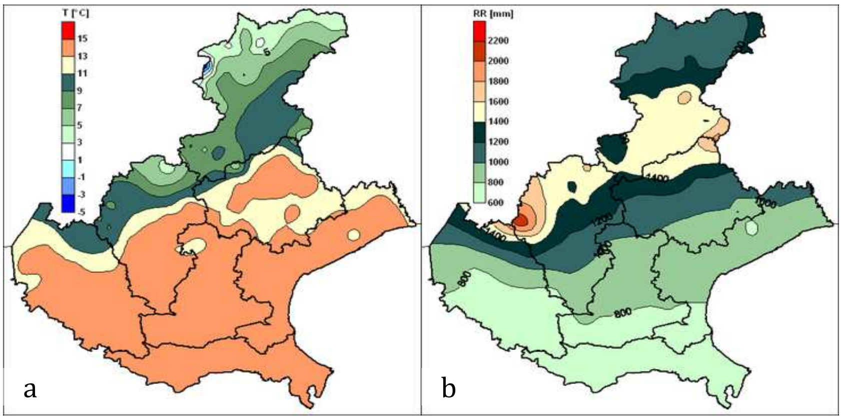

Figure 1 a) average temperature and b) average annual rainfall in Veneto Region in the period 1985-2009 (ARPAV, 2011).

Also, Veneto is the second Italian Region for land consumption with 2176 km^2 of urban areas in 2019 (11.9% of the total regional area) (ISPRA, 2020), resulting in an increase in flood risk. According to ISPRA (2018), 25.2% of Veneto's regional area is at risk of flooding and 9.5% of Veneto's residents lives in a flood-prone area (Figure 2).

This land and climatic variability, combined with the high flood risk and the increasing urbanization of the region, represent a good opportunity to investigate the likeliness to adopt NbS among Veneto's population.

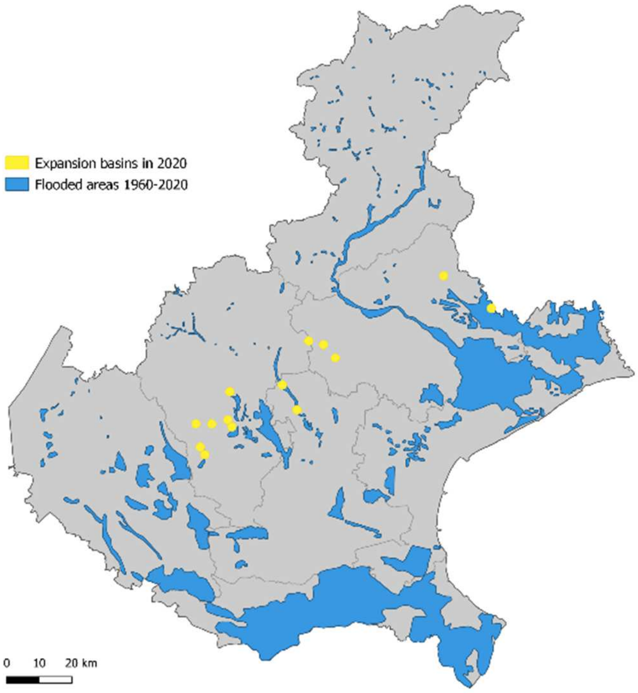

Figure 2 Existing expansion basins in the Veneto region in 2020 and flooded areas from 1960 to 2020. (ARPAV, 2011)

3.2. Description of evaluated NbS and grey infrastructures

Since there are many different NbS, this thesis examines the ones that may be implemented successfully in urban areas (i.e. soakaways, rain harvesting, pervious pavements, green roofs and bioretention systems) or may have an impact on urban areas (i.e. diversion channels, expansion basins).

Soakaways are excavations of different form and volume that are filled with a void-forming material (e.g. gravel) that allow the temporary storage of rainfall before it soaks into the soil below (CIRIA, 2015). These systems could be implemented where there is no surface space to create a green area because the structure is completely buried under the ground. Small soakaways are suitable for a home-scale implementation, but larger designs can be adapted to catch the runoff from large hard surfaces (e.g. parking areas). These systems manage rainwater near the area where it falls and do not use the urban drainage system.

Rain harvesting consists in the collection of rainwater runoff from impermeable areas (i.e. roofs and other impermeable areas) for later use (CIRIA, 2015). Runoff can be stored in tanks (or ponds) of various volume, treated (when required) and used as a water supply for domestic, commercial, industrial and/or institutional properties. Rain harvesting systems can help reduce the runoff from a site, reduce the water demand of the building and may reduce the volume needed for other nature-based management systems implemented in the site (e.g. a combined system with storage tank and soakaway to manage the excess water). Rain harvesting systems could be very simple systems (e.g. rain barrels near a building for domestic irrigation purposes) but also more complex, for example when combined with a water treatment system (e.g. use of rainwater in the toilets).

Pervious pavements allow rainwater to infiltrate through the surface and into the underlying ground while providing a pavement suitable for pedestrian and/or vehicular traffic (CIRIA, 2015). Pervious pavements can manage rainwater directly where it falls, reducing the volume of runoff from paved areas. These systems could be virtually implemented in every paved area, if the underlying layers are permeable too.

Green roofs are areas of living vegetation installed on the top of a building. Reasons to install a green roof are various: visual benefits, ecological value, enhanced building performance and reduction of runoff (CIRIA, 2015). There are two main types of green roof: extensive and intensive. Extensive roofs have a low substrate depth (i.e. 8-12 cm), simple planting, low maintenance requirements and they usually are not accessible. Intensive green roofs have deeper substrates that can support a wide variety of plants, but they tend to need a more intensive maintenance. They are usually accessible like a garden. Depending on the construction features (i.e. substrate composition and depth, presence of a storage layer), green roofs can store modest volumes of rainwater and lengthen the discharge time. The overall effect is less runoff from the roof. Green roofs can be combined with other water management systems, such as rain barrels or soakaways.

Bioretention systems are shallow vegetated depressions that can reduce runoff rates and volumes and also treat pollution thanks to vegetation and soil properties. Water can be directly infiltrated into the ground or collected by a drainage system and sent to another infiltration/management system. However, bioretention systems may have different designs (e.g. rain gardens, infiltration trenches, swales). Their common features are the creation of a landscaped vegetated depression with an engineered substrate that collects water directly from hard surfaces or combined with other water management systems (e.g. the excess water from green roofs or rain harvesting systems). In the case of rain gardens, they could also have a high ornamental value, in addition to all the benefits that a green space brings along, such as biodiversity and habitat, microclimate regulation and water pollution treatment. These areas should drain all the surface water in 24-48 hours to avoid insects pullulation and rotting of organic matter.

All the Nature-Based Solutions can be implemented alone or in combination with others to maximize the benefits. For example, a domestic water management system could be structured with a green roof followed by some rain barrels and the excess water from them could be drained into a soakaway. There is not a definitive design to manage rainfall and any site should be wisely evaluated to find the best solution to use water as a resource, manage rainwater close to where it falls and allow it to soak into the ground, control water pollution, promote biodiversity and the creation of urban green spaces.

To shed light on potential different perceptions, three grey water management systems are also taken into account (i.e. temporary flood defence barriers, expansion basins and diversion channels). These grey infrastructures are already implemented in the study area (Figure 2), which means that people may already know them and could compare them with the less spread NbS.

Temporary flood defence barriers are quite simple and cheap systems to prevent water to enter a building. Usually, sandbags or wood/metal barrier are preferred but other systems exist. In case of imminent flood risk, temporary barriers are placed on doors and then removed when the danger ends. The maximum water amount that temporary barriers can protect from is the height of the barrier itself.

Expansion basins are non-urban areas bounded by banks near a watercourse. During a flood event, part of the water can be stored in the basin preventing flooding in the downstream area. When the water level lowers, the basin is emptied. Though these areas are often rural and cultivated, soil infiltration of water is not significant because of the large amount of water and the general low permeability of the soil (that could be already saturated by previous rainfall).

Diversion channels are artificial channels built to redirect part of the water from a watercourse at risk of overflowing to another that can manage the excess water during a flood event. They are often made of hard materials (e.g. concrete) and, eventually, they flow underground. Typically, diversion channels are built in recent over-urbanized areas where there is the need to divert water before it fills the original channel.

Figure 3 shows examples of the water management systems proposed in the survey.

Figure 3 Examples of the water management systems presented in the survey: a) temporary flood barriers; b) expansion basins; c) diversion channels; d) soakaways; e) rain harvesting systems; f) pervious pavements; g) green roofs; h) bioretention systems.

3.3. Data collection

A survey was conducted to investigate the knowledge and the perception of NbS and grey infrastructures among people in the Veneto Region. The survey was administered online through Google Modules, and, considering the explorative nature of the survey, participants were recruited through convenience sampling (Galloway, 2005; Kam, et al., 2007). Due to the pandemic caused by the Sars-COV-2 virus in 2020 and the consequent limitations imposed by the governmental response, this method was deemed the most suitable to reach as many people as possible in the available time. Before accessing the survey, respondents were informed about the aim of the research project and personal data processing. People that agree with the conditions were then redirected to the survey form. Table 1 shows the sample characteristics in terms of size, gender and age distribution. A total of 120 respondents filled in the survey. Of this, 70.8% of respondents live in urban or suburban areas and 61.7% have lived in the same house for more than 20 years. Compared to the available census data, the distribution of the sample is quite representative of the overall population, though women were slightly overrepresented in the sample (57%, compared to 51%, ISTAT). As expected, and because the survey was initially shared through social media and the university, 51% of the respondents are less than 30 years old.

Almost half (48%) of the respondents live in an independent house, 29% of them live in a small building (max four household) and the remaining 23% live in an apartment block (more than 4 households). Also, 88% of respondents own their house and while the remaining 12% live in a rented home.

Table 1 Sample characteristics.

N	Gender		Age			
	male	female	min	max	mean	SD
120	43%	57%	21	73	37.2	16.2

As previously mentioned, this study focuses on six NbS (soakaways, rainwater harvesting systems, permeable-porous pavements, green roofs, and rain gardens) and three grey infrastructures (temporary flood defences, expansion basins, and diversion channels). These designs were selected to show different water management methods, from a "greyer" infrastructures approach (e.g. diversion channels) to the "green" design on NbS such as green roofs and rain gardens.

The survey was structured in seven sections:

I. Territorial features: people were asked where they live and for how many years they have lived there.

II. General risk perception: different potentially dangerous events were proposed (e.g. earthquake, climate change, epidemic, windstorm, theft, drought, wildfires, flood) and people had to express their perception on a Likert scale from 1 (not at all) to 5 (severe threat).

III. Water management systems knowledge: the drainage systems proposed were briefly described and some explicative pictures were shown. For every design, people were asked if they knew the system before the survey and what is their perceived efficacy of the drainage infrastructure.

IV. Efficacy perception and implementation likelihood: in this section people were asked to evaluate the perceived efficacy of the drainage systems and at what scale they think every system should be implemented. Respondents were also presented with a contingent valuation with a dichotomic choice for a bioretention house-scale implementation project.

V. Landscape connectedness: respondents were presented with statements on risk management, flood risk, personal trust in the local community and flood risk management, to which they had to express their level of agreement on a scale from 1 (completely disagree) to 5 (completely agree).

VI. Socio-demographic variables: age, gender, educational level and current occupation.

The survey was developed to be understood and filled by people that may not be knowledgeable about NbS, so a pre-test with 15 people was conducted before the official data collection. The final survey was accessible online between October 2020 and March 2021. The full survey form can be found in the Appendix and Table 2 reports the main variables, related questions, and available answers.

Table 2 Variables, questions and answers considered in this thesis.

Variable	Questions and available answers	
Risk perception	On a scale of 1 (no danger) to 5 (severe danger), can you indicate to what extent do you believe that [hazard]* could represent a danger to you personally or to the house where you live?	1 (no danger) to 5 (severe danger)
	On a scale of 1 (no danger) to 5 (severe danger), to what extent do you think floods are a danger to: Yourself Your home Your town	1 (no danger) to 5 (severe danger)
Previous knowledge of NbS and grey infrastructures	Before this survey, what was your personal knowledge of [flood risk mitigation system]**	1 (none) to 5 (high)
Perceived efficacy of NbS and grey infrastructures	How effective do you think [flood risk mitigation system]** are to reduce flood damage in the area where you live?	1 (in no way) to 5 (very effective)
	Considering only the domestic adoptable water retention measures, on a scale from 1 (not at all) to 5 (very much), to what extent would you be willing to adopt [NbS]*** at your home (regardless of the actual technical practicality or total costs)?	1 (in no way) to 5 (very much)
	On a scale of 1 (very negative) to 5 (very positive), how do you see the introduction of [NbS]*** in urban public spaces?	1 (very negative) to 5 (very positive)

* Wildfires, windstorm, climate change, theft, epidemic, wild animal, earthquake, drought

** Soakaways, rain harvesting, pervious pavements, green roofs, bioretention systems, temporary barriers, expansion basins, diversion channels

*** Soakaways, rain harvesting, pervious pavements, green roofs, bioretention systems

3.4. Data analysis

Data were analysed using R 3.6.3 statistical software (R Core Team, 2020) and the responses investigated using ordinal logistic regression (95% confidence interval).

Descriptive parameters (i.e. previous knowledge of water management systems, likeliness to adopt NbS, scale implementation perception of water management systems and incentives to implement NbS) were summarized in graphs for a simpler visualization and used as a first exploration of the sample. Qualitative responses were used to better understand the result of the ordinal logistic regressions.

3.5. Limitations

While the methods employed in this thesis were selected to answer the research question in the most appropriate manner, some limitations remain. Sample size is rather small and convenience sampling may not provide an adequate representativeness of the Veneto region. In addition, an online survey may not represent adequately the whole territory, especially with a small sample. Considering the explorative purpose of this thesis and the restriction due to the Covid-19 emergency, these limitations were accounted for, and the survey was developed to minimize questions' misunderstanding. Data analysis considered these limitations and focused on variables that could be less influenced by the sample distribution (e.g. age, occupation of respondents).

4. Results and discussion

4.1. Risk perception

Respondents report an average high perceived safeness to the life in their communities (61% of the responses was 4 or more score 1-low safeness to 5-high safeness Likert scale). When few potential threats were presented, the most perceived threats with a 4 or more score on a 1 (no danger) to 5 (severe danger) Likert scale were climate change (36%), epidemic (26%), theft (25%) and windstorm (25%) (Figure 4). The high perception of climate change was also confirmed in section V of the survey, where 88% of the respondents completely agree with the statement “*climate change is a serious challenge that needs to be addressed as soon as possible*”. This behaviour could be related to the recent activism on climate change demonstrated by the youngest generation and the average low age of the sample (Cloughton, 2021). Also, 23% of respondents reported having a degree related to environmental and natural science and 15 respondents were current students in environmental or natural disciplines, so it is likely that these respondents showed higher concerns about climate change.

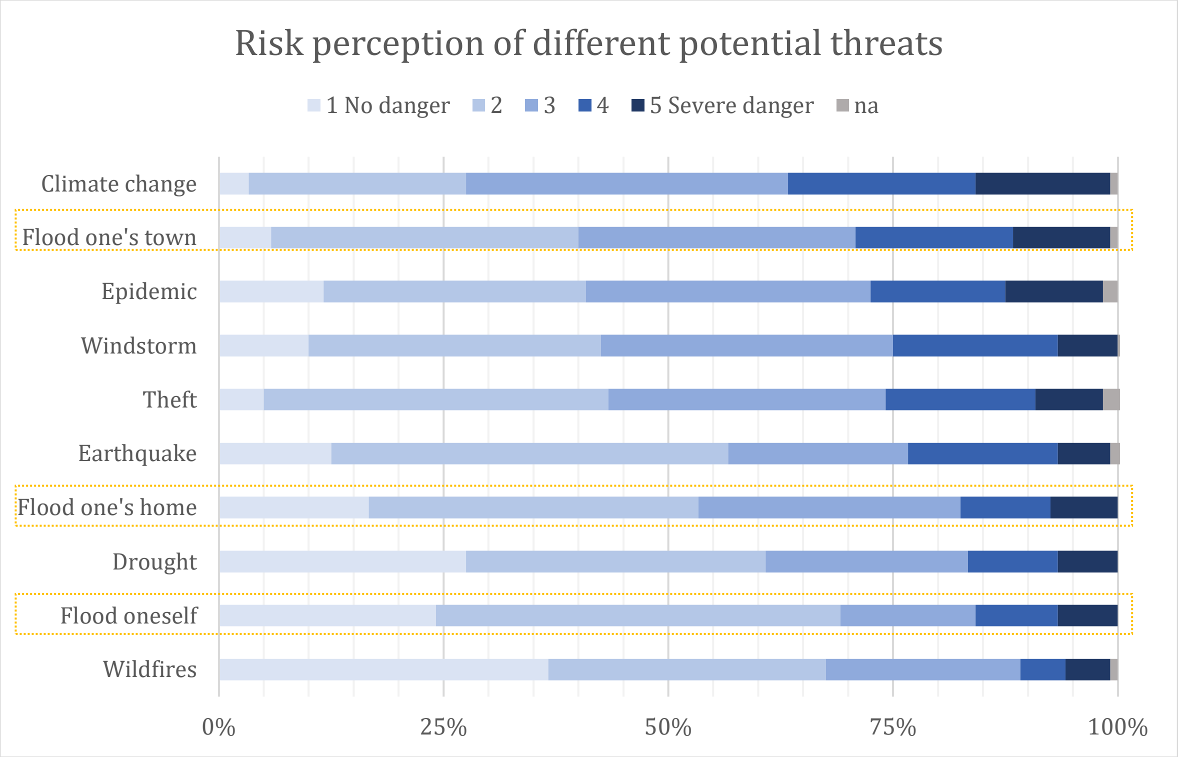

Figure 4 Risk perception of different potential threats. Flood risk perception is highlighted in yellow boxes.

Considering that the Covid-19 pandemic was in an acute phase during the data collection period (Worldometer, 2021), epidemic concerns were expected to be high.

The quite high concern showed among windstorm may be related to the Vaia storm, which occurred in October 2018 in the Northern Italy (European Forest Institute, 2018), causing the felling of 8 million cubic meters of standing trees (Motta, et al., 2018). Since damages caused by it are still being recovered, it is plausible that the event is still in the memory of residents of the affected areas.

Considering flood risk, respondents reveal an optimistic bias also detected in previous studies (Mondino, et al., 2020; Scolobig, et al., 2012): they seem to be more worried when they think about their community compared to when they think about themselves or their home (Figure 4). Despite the difference in the type of hazard, the perceived flood risk in one's town is a bit higher than the potential danger caused by an epidemic (29% vs. 26% responses with a 4 or higher score) but lower when compared with climate change perception.

4.2. Previous knowledge of NbS and grey infrastructures

Respondents report a quite variable previous knowledge about the proposed water management systems (Figure 5). With a score of 4 or higher score on a 1 (no previous knowledge) to 5 (high previous knowledge) Likert scale, temporary barriers (42%), rain harvesting systems (41%), pervious pavements (39%), and expansion basins (37%) were the most known by respondents. On the opposite side, with a 2 or less score, the less known water management systems were bioretention systems (68%), soakaways (66%), diversion channels (57%) and green roofs (48%).

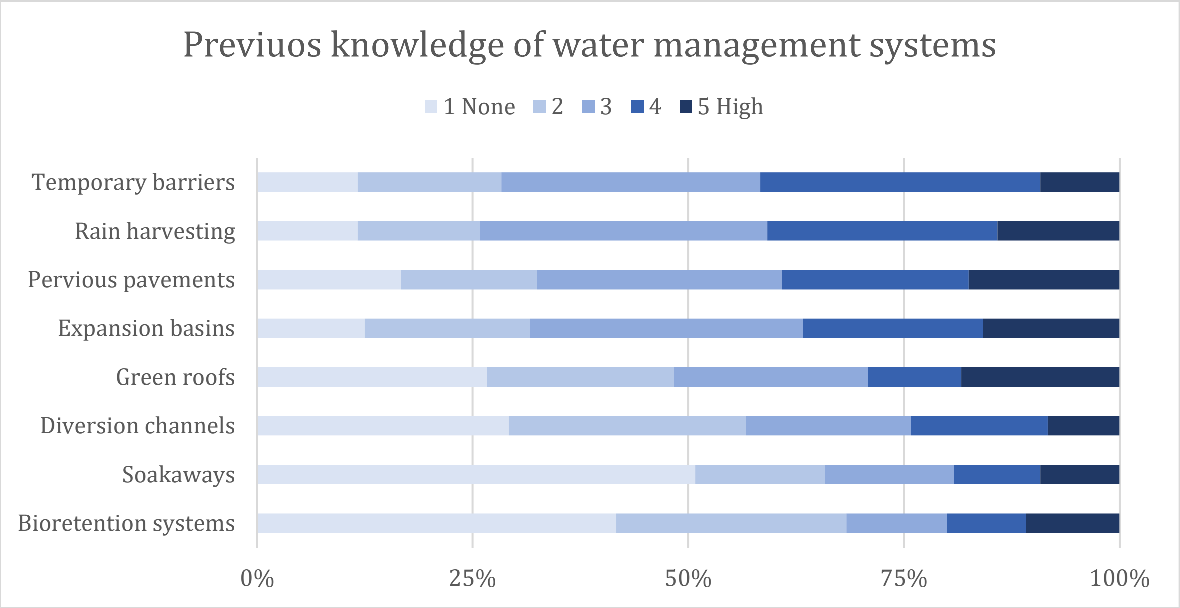

Figure 5 Previous knowledge of NbS and grey infrastructures.

A higher previous knowledge on temporary barriers and expansion basins was expected since they are commonly seen by people in flood news services - especially in recent years where local extreme rainfall often occurs (MeteoWeb, 2021) - and several expansion basins are currently under construction (Regione Veneto, 2021). The quite low previous knowledge about diversion channels could be due to the implementation techniques of these systems. They are often built underground, and the surface structures may be confused with irrigation channels or other artificial watercourses that are common in the Po Plain.

Moving to NbS, because rain harvesting systems can have a very simple design and respondents were expected to easily figure out what they are (e.g. rain barrels and use of the water for garden irrigation), a high previous knowledge of them was expected. Bioretention systems and soakaways were the least known systems. This low knowledge may be related to the low spread of NbS in the study area. Soakaways were the second less known NbS, but the qualitative responses regarding their perceived efficacy are quite heterogeneous and do not provide a clear picture of the reasons why this measure is not so well known. Some people reported useful applications of soakaways to explain their perceived efficacy, showing that they understand soakaways' functionality, but many others reported concerns about a higher hydrogeological risk due to the implementation of soakaways. This highlights a potential misunderstanding of these structures, so further investigations are needed. Green roofs demonstrated quite low previous knowledge and, also in these case, qualitative data on the reasons why are not useful to explain this behaviour. The only plausible hypothesis is that green roofs are better known for their environmental benefits (Berardi, et al., 2013) or their ornamental value, since several respondents report these points rather than their hydrological benefits.

4.3. Perceived efficacy of NbS and grey infrastructures

After the previous knowledge about NbS and grey infrastructures, respondents were asked to express their perceived efficacy of the proposed systems on a 1 (not at all) to 5 (highly effective) Likert scale (Figure 6). With a score of 4 or higher, expansion basins (53%) and pervious pavements (50%) were the water management measures perceived as most useful. On the other hand, the water management measures perceived as least useful, with a score of 2 or lower, were green roofs (36%), soakaways (33%) and temporary barriers (31%). Expansion basins are considered effective by many respondents, as 21% of those who motivate their answer (43% of the total responses) stated that expansion basins *"can collect the excess water from a watercourse and so avoid flood"*. This statement highlights that people may recognise flood risk causes mainly in flooding from watercourses and not so much in heavy rainfall, or in heavy urbanisation. Few respondents also stated that "*expansion basins are more useful to prevent floods to the downstream towns from the basin location"*. Pervious pavements were identified as a good substitute for hard and non-permeable surfaces in the urban environment to allow water to be absorbed in the ground and so reduce flooding from rainfall-runoff. Green roofs perceived efficiency was trickier to understand. Despite the low perceived efficacy, there were not many clarifications about this perception in the qualitative questions. Some respondents believed that green roofs are not so useful to reduce flood risk mainly because of the limited water volume they can collect or because they think green roofs are not easy to implement on existing buildings. Only one respondent stated that "*green roofs could be a good choice if combined with other water management systems"*. Having also 34% responses with a score of 2 or lower, it is supposed that the functionality of green roofs is not completely understood, as reported by few respondents. The main reasons for the low perceived efficacy of soakaways were low permeable soil and surface aquifers that do not allow water to infiltrate into the ground and some concerns about the hydrogeological risk that were mentioned previously. Despite this low perceived efficacy, many respondents reported benefits as a lower reliance on urban drainages and the effectiveness to manage runoff from heavy rainfall. Efficacy of temporary barriers seemed to be more related to previous flood experience. On the side of high perceived efficacy, there was the chance to avoid water entering one's home and someone reported personal experience in successful usage of temporary barriers during flood events. On the other side (low perceived efficacy), there was the uselessness of temporary barriers in one's living area because respondents thought they did not live in a flood-prone area and that the rainwater should be managed upstream from towns. Someone reported low effectiveness for temporary barriers because of personal experience with flash floods with a high water level in which temporary barriers would not be enough to reduce damages.

The general perception of rain harvesting efficacy was quite high (42% of 4 or more score). The main reason in favour of rain harvesting systems was the chance to not waste and reuse water (e.g. garden irrigation) while the one against rain harvesting was the thought that these systems *could have limited efficacy due to the low volumes that they usually can store*. Perceived efficacy of bioretention systems was also high (44% with a score of 4 or higher) and environmental benefits were the main stated reason in favour of these systems. Also, for bioretention systems, few respondents state that they will be more efficient if combined with other NbS. Similar to bioretention systems, diversion channels had 43% of the responses with a score of 4 or higher and the main drivers to their effectiveness were *their potential to reduce flood risk in watercourse if they are kept in good conditions with ordinary maintenance*.

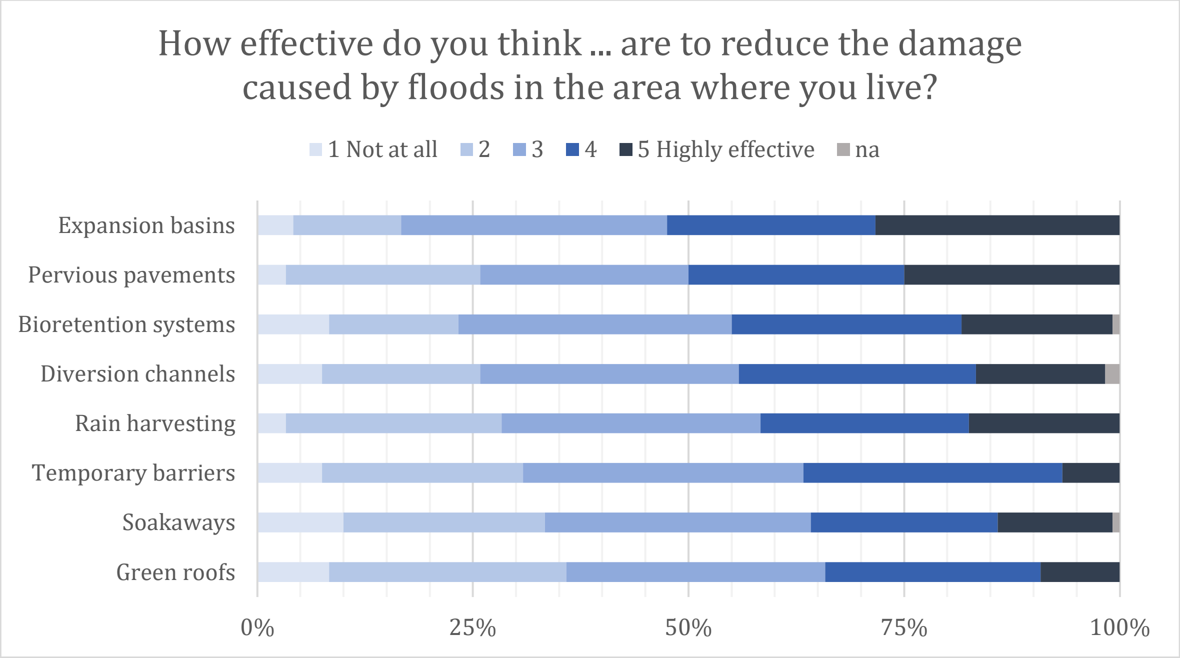

Figure 6 Perceived efficacy of NbS and grey infrastructures.

Ordinal logistic regressions were used to investigate relations between the perceived efficacy of NbS and grey infrastructures and other variables from the survey. Previous knowledge was found to have an effect on perceived efficacy of the water management systems only for diversion channels and pervious pavements (see Table 3).

Table 3 Effect of previous knowledge on perceived efficacy of water management systems.

	OR	CI $_{95\%}$	P
Soakaways	1.07	0.99-1.14	0.08
Rain harvesting	1.06	0.97-1.15	0.22
Pervious pavements	**1.08**	**1.00-1.16**	**0.05**
Green roofs	1.04	0.98-1.11	0.34
Bioretention systems	1.04	0.96-1.12	0.28
Temporary barriers	1.04	0.95-1.14	0.40
Expansion basins	1.07	0.99-1.15	0.09
Diversion channels	**1.09**	**1.01-1.17**	**0.03**

Other indicators that may provide useful insights to predict how people perceive the efficacy of NbS and their likeliness to adopt these systems were also investigated. Respondents who report a higher perceived efficacy for soakaways and green roofs are also more likely to report that their private implementation can reduce flood risk in the local community, while this was not significant for the other NbS (Table 4).

Table 4. Effect of perceived efficacy of NbS on the belief that private implementation can reduce flood risk in the local community.

	OR	CI $_{95\%}$	P
Soakaways	**1.11**	**1.00-1.23**	**0.05**
Rain harvesting	1.07	0.97-1.18	0.20
Pervious pavements	1.05	0.96-1.16	0.30
Green roofs	**1.12**	**1.01-1.25**	**0.04**
Bioretention systems	1.06	0.96-1.17	0.26

In addition, respondents who believe that grey infrastructures are the best way to reduce flood risk also report a higher perceived efficacy for pervious pavements, bioretention systems, expansion basins, and diversion channels (Table 5). Since pervious pavements and bioretention systems are NbS, this result was quite unexpected. It seems that respondents who prefer grey infrastructures see similarities between these two NbS and the functionality of grey infrastructures (e.g. temporary storage of water in bioretention systems).

Table 5. Effect of the belief that grey infrastructures are the best way to reduce flood risk on the perceived efficacy of water management systems.

	OR	CI $_{95\%}$	P
Soakaways	1.04	0.95-1.15	0.36
Rain harvesting	1.07	0.98-1.17	0.14
Pervious pavements	**1.09**	**1.00-1.20**	**0.05**
Green roofs	0.97	0.88-1.06	0.50
Bioretention systems	**1.10**	**1.00-1.21**	**0.04**
Temporary barriers	1.07	0.98-1.18	0.15
Expansion basins	**1.10**	**1.01-1.20**	**0.03**
Diversion channels	**1.13**	**1.03-1.24**	**0.01**

Awareness of living in a flood-prone area, concerns about climate change, and gardening skills were not correlated with perceived efficacy of NbS and grey infrastructures.

4.4. Implementation of NbS

The likeliness to implement NbS was investigated asking people to what extent would they be willing to adopt NbS in their home, regardless of the real practicality and the total costs. This disclaimer was added to avoid negative responses caused by contexts in which people cannot independently decide what to do in their homes (e.g. renters, apartment blocks). In this question, temporary barriers were also considered because they are a common domestic flood risk mitigation measure. Respondents could express their willingness to adopt these systems on a 1 to 5 Likert scale in which 1 was associated with low willingness to adopt and 5 with high willingness to adopt the water management measure (Figure 7).

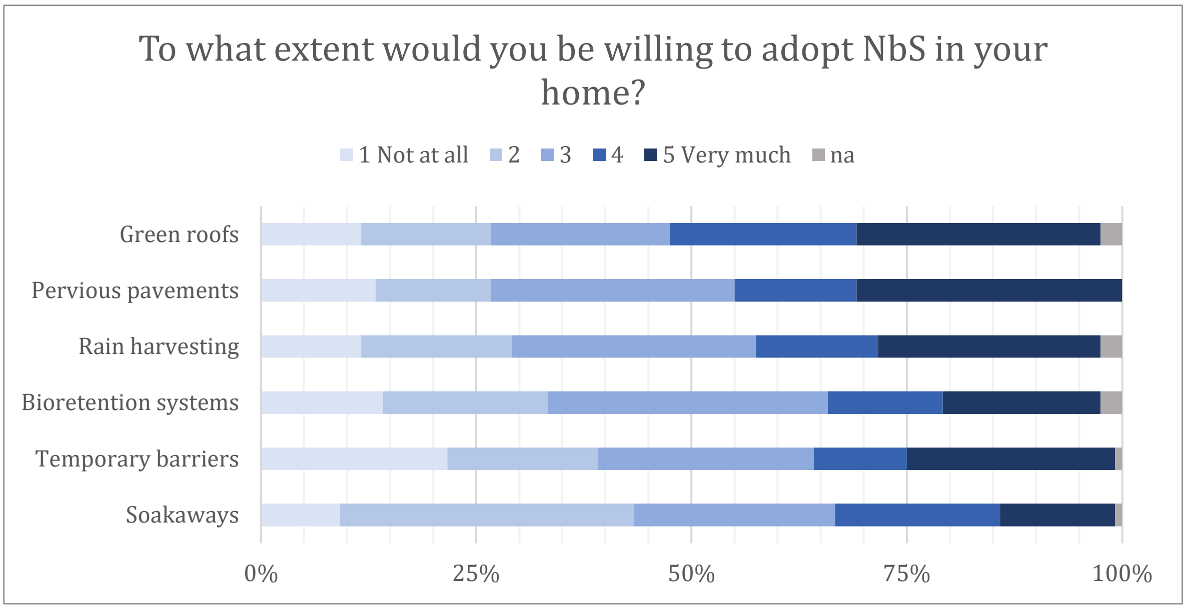

Figure 7 Likeliness to adopt NbS and temporary barriers in one's home (regardless of the technical practicality and the total costs).

With a score of 4 or higher, respondents express a general high willingness to adopt green roofs (50%), pervious pavements (45%), and rain harvesting systems (40%). On the other hand, with a score of 2 or lower, there were soakaways (43%) temporary barriers (39%), and bioretention systems (33%).

Respondents who are likely to adopt NbS are also more likely to believe that private implementation can reduce flood risk in the local community for pervious pavements and green roofs (Table 6).

The perceived efficacy had a positive effect on the likeliness to adopt NbS only for soakaways and green roofs (Table 7).

Table 6. Effect of Likeliness to adopt NbS on the belief that private implementation can reduce flood risk in the local community.

	OR	CI $_{95\%}$	P
Soakaways	1.02	0.92-1.13	0.70
Rain harvesting	1.10	0.99-1.22	0.08
Pervious pavements	**1.15**	**1.04-1.27**	**0.01**
Green roofs	**1.11**	**1.00-1.22**	**0.05**
Bioretention systems	1.05	0.94-1.17	0.38

Table 7. Effect of perceived efficacy of NbS on Likeliness to adopt them.

	OR	CI $_{95\%}$	P
Soakaways	**1.10**	**1.01-1.19**	**0.02**
Rain harvesting	1.08	0.99-1.18	0.07
Pervious pavements	1.07	0.99-1.16	0.08
Green roofs	**1.09**	**1.00-1.19**	**0.04**
Bioretention systems	1.00	0.92-1.08	1.00

However, the perception to live in a flood-prone area, a job in contact with nature, and the time of residence in the same place do not have an effect on the likeliness to adopt NbS.

Expecting that respondents may not have experience with NbS implementation, they were presented with a contingent evaluation where a realistic hypothesis of NbS implementation was described (i.e. rain barrels combined with a bioretention system) for adoption by an average sized house and then asked if they would be willing to adopt the whole infrastructure (the contingent evaluation can be found in the Appendix). The answer options were "yes" or "no" and 76% of respondents replied positively. We also ask to motivate their answer to better understand why they accept or decline the infrastructure. The main reasons for the "yes" were the chance to reuse rainfall for irrigation, a good cost-benefit ratio, environmental benefits, and sustainability. On the other hand, the main reasons to decline were the risk of pullulation of unwelcome insects due to backwater and lack of space in the property.

Incentives to encourage the adoption of NbS systems were then investigated. Solutions that are cheap to construct and maintain (88% of the responses) and economic support (87% of the responses) are the main incentives to adopt NbS systems confirming what Baptiste et. (2014) found. Urban planning modifications follow with 75% of the responses while environmental benefits (64%), pilot projects (54%) and a better knowledge of the systems (32%) follow with less interest (Figure 8). We may suppose that people do not need to know how NbS work but, if these structures are needed (e.g. due to changes in urban planning) they would be willing to adopt them if there are economic incentives and the maintenance of the system is easy.

Lastly, respondents were asked to identify the best scale to implement both NbS and grey infrastructures. Three implementation contexts were proposed: local scale (e.g. private property), medium-scale (e.g. neighbourhood) and large scale (e.g. district, region). As shown in Figure 9, respondents seem to understand quite well at what scale every water management system would be more useful, except for bioretention systems that were considered more useful on a medium-large scale. This shows that part of the respondents may associate bioretention systems to expansion basins, because both systems store water on their surface, with the difference that expansion basins only store water while bioretention systems allow water to infiltrate into the ground.

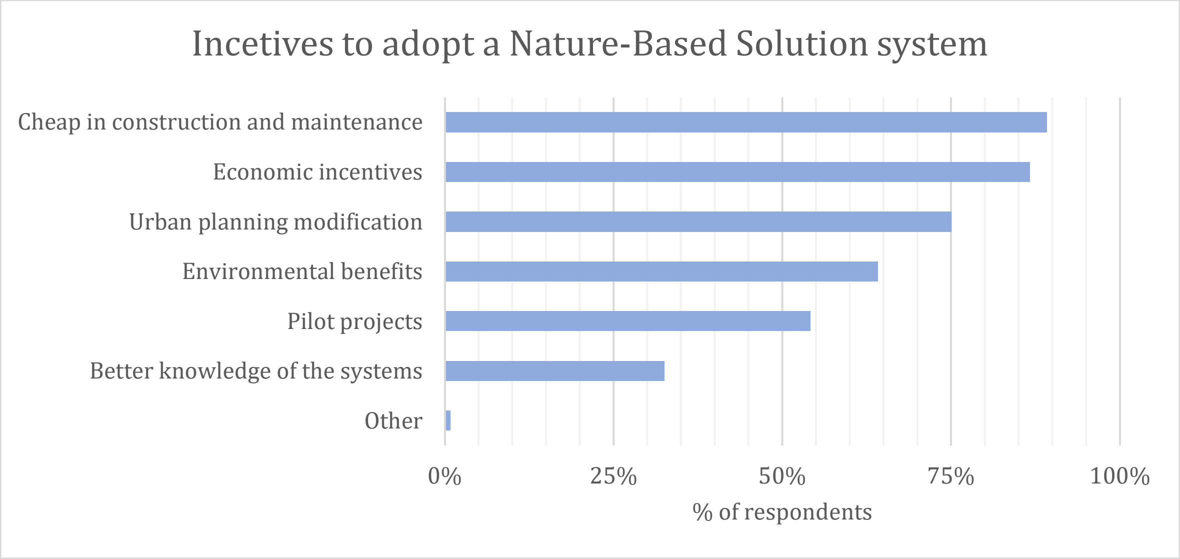

Figure 8 Main incentives to adopt the NbS system proposed in the survey.

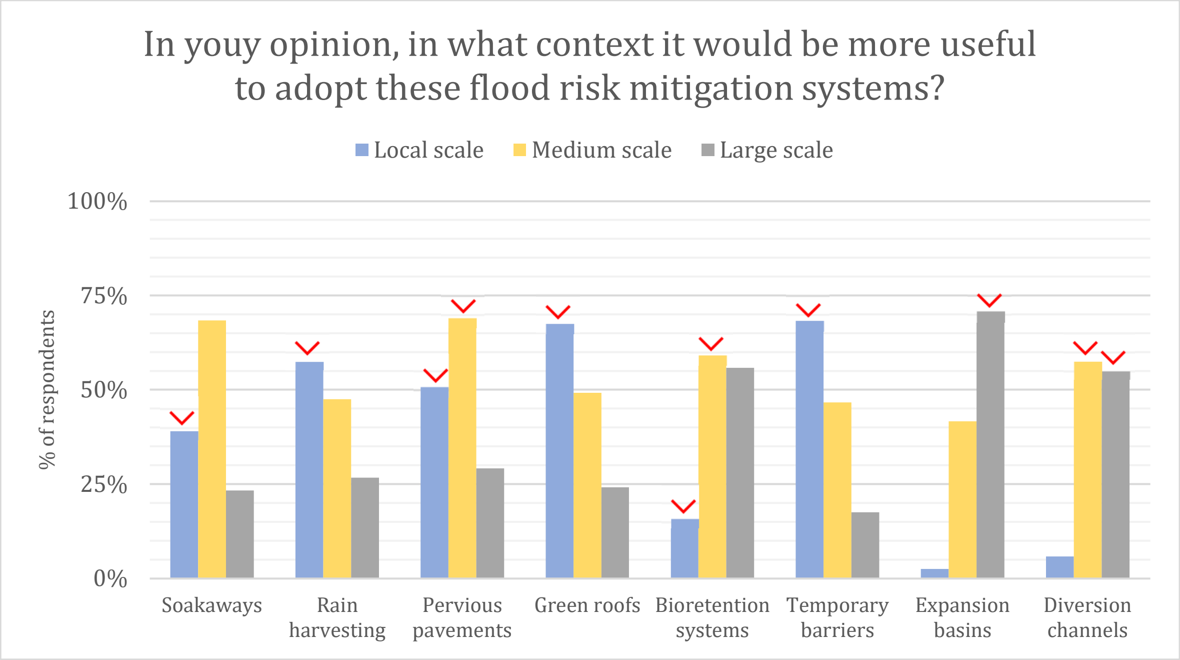

Figure 9 Perceived implementation scale of NbS and grey infrastructure. The most suitable implementation scales for each measure are highlighted with a red pin.

5. Conclusions

This thesis explores through an online survey how people's perception and implementation likelihood of some NbS varies in a North-Eastern region of Italy and aims to provide useful insight to promote NbS adoption. Respondents seem to understand quite well at what scale every water management system would be more useful, except for bioretention systems, but a general lack of knowledge on NbS emerged from the survey. It also seems that some people believe that flood risk is mainly connected to watercourse flood and not to heavy rainfall combined to hard urbanization, or, maybe, they have a different perception on flood from rainfall and watercourse flood. This point needs to be further investigated to understand how common this behaviour is and if a non-specific definition of "flood" can lead to misunderstanding in flood cause, to find what are the best ways to communicate flood from rainfall risk to people. Also, the effect of previous flooding experience on NbS efficacy perception need to be further investigated. Data analysis found that previous knowledge on water management systems and the belief that grey infrastructures are the best way to reduce flood risk have a significative correlation with the perceived efficacy of some NbS. Looking at landscape connectedness behaviours, a correlation emerged between the belief that private implementation can reduce flood risk in the local community and the perceived efficacy of NbS. Also, likeliness to adopt and the perceived efficacy NbS are positively related to the belief that private implementation can reduce flood risk in the local and the likeliness to adopt NbS. Moreover, solutions that are cheap to construct and maintain and economic support, as well as urban planning modifications, could incentive the spread of NbS. It appears that something is missing between the willingness to adopt NbS by people and policy makers who should promote their implementation. A clearer and simpler communication on NbS - highlighting their multifunctionality and the *in-situ* water management approach - among both people and policy makers could increase the confidence on these systems and promote their adoption to reduce flood from rainfall risk and have all the environmental benefits connected to NbS.

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7. References

Alves, A. et al., 2018. Combining Co-Benefits and Stakeholders Perceptions into Green Infrastructure Selection for Flood Risk Reduction. *Environments.*

Arnbjerg-Nielsen, K., 2006. Significant climate change of extreme rainfall in Denmark. *Water Sci Technol,* Issue 54.

ARPAV, 2011. *Il clima in Veneto.* [Online]
Available at: https://www.arpa.veneto.it/temi-ambientali/climatologia/approfondimenti/il-clima-in-veneto
[Accessed april 2021].

Baptiste, A. K., Foley, C. & Smardon, R., 2017. Understanding urban neighborhood differences in willingness to implement green infrastructure measures: a case study of Syracuse, NY. *Landscape and Urban Planning.*

Barnhill, K. & Smardon, R., 2012. Gaining Ground: Green Infrastructure Attitudes and Perceptions from Stakeholders in Syracuse. *Environmental Practice.*

Bastien, N. R. P., Arthur, S. & McLoughlin, M. J., 2011. Valuing amenity: public perceptions of sustainable drainage systems pond. *Water and Environment Journal.*

Berardi, U., GhaffarianHoseini, A. & GhaffarianHoseini, A., 2013. State-of-the-art analysis of the environmental benefits of green roofs. *Applied Energy.*

Brears, R. C., 2018. From Traditional Grey Infrastructure to Blue-Green Infrastructure. *Blue and Green Cities.*

Bush, J. & Doyon, A., 2019. Building urban resilience with nature-based solutions: How can urban planning contribute?. *Cities.*

Chui, T. F. M. & Ngai, W. Y., 2016. Willingness to pay for sustainable drainage systems in a highly urbanised city: a contingent valuation study in Hong Kong. *Water and Environment Journal.*

CIRIA, 2015. *The SuDS Manual.* s.l.:CIRIA.

Cloughton, I., 2021. Global Youth Activism on Climate Change. *Social Work & Policy Studies: Social Justice, Practice and Theory.*

Cohen-Shacham, E., Janzen, C., Maginnis, S. & Gretchen, W., 2016. *Nature-based Solutions to address global societal challenges.* s.l.:IUCN Publications.

Department of Economic and Social Affairs, 2014. World urbanization propects: the 2014 revision, Highlights.

Ellis, B. et al., 2004. *Urban drainage: a multilingual glossary.* London: IWA Publishing.

European Commission, 2011. *Natural water retention measures.* [Online]
Available at: https://ec.europa.eu/environment/water/adaptation/ecosystemstorage.htm
[Accessed 23 June 2021].

European Commission, 2020. *Nature-based solutions.* [Online]
Available at: https://ec.europa.eu/info/research-and-innovation/research-area/environment/nature-

based-solutions_en
[Accessed 23 June 2021].

European Forest Institute, 2018. *Aftermath of the "Vaia" storm in Italy.* [Online]
Available at: https://efi.int/news/aftermath-vaia-storm-italy-2018-12-17

Fletcher, T. D. et al., 2014. SUDS, LID, BMPs, WSUD and more – The evolution and application of terminology surrounding urban drainage. *Urban Water Journal.*

Foley, C. M., 2012. How socio-demographic factors and the physical environment shape resident attitudes towards green infrastructure in Syracuse, NY.

Galloway, A., 2005. Non-Probability Sampling. *Encyclopedia of Social Measurement.*

Grothmann, T. & Reusswing, F., 2006. People at Risk of Flooding: Why Some Residents Take Precautionary Action While Others do not. *Natural Hazards.*

Ignatieva, M., Haase, D., Dushkova, D. & Haase, A., 2020. Lawns in Cities: From a Globalised Urban Green Space Phenomenon to Sustainable Nature-Based Solutions. *Land,* 9(3).

ISPRA, 2018. Dissesto idrogeologico in Italia: pericolosità e indicatori di rischio.

ISPRA, 2020. Consumo di suolo, dinamiche territoriali e servizi ecosistemici. Edizione 2020.

ISTAT, 2021. *Popolazione residente al 1° gennaio.* [Online]
Available at: http://dati.istat.it/
[Accessed 18 april 2021].

Kabisch, N., Korn, H., Stadler, J. & Bonn, A., 2017. Nature-based Solutions to Climate Change Adaptation in Urban Areas. *Linkages between Science, Policy and Practice.*

Kam, C. D., Wilking, J. R. & Zechmeister, E. J., 2007. Beyond the ''Narrow Data Base'': Another Convenience Sample for Experimental Research. *Political Behavior.*

Lafortezza, R., Chen, J. & Konijnendijkvan den Bosch, C., 2018. Nature-based solutions for resilient landscapes and cities. *Environmental Research.*

Maes, J. & Jacobs, S., 2015. Nature-Based Solutions for Europe's Sustainable Development. *Conservation Letters.*

Mell, I. C., Henneberry, J., Hehl-Lange, S. & Keskin, B., 2013. Promoting urban greening: Valuing the development of green infrastructure investments in the urban core of Manchester, UK. *Urban Forestry & Urban Greening.*

MeteoWeb, 2021. [Online]
Available at: https://www.meteoweb.eu/tag/maltempo-veneto/
[Accessed June 2021].

Mondino, E. et al., 2020. Exploring changes in hydrogeological risk awareness and preparedness over time: a case study in northeastern Italy. *Hydrological Sciences Journal.*

Motta, R. et al., 2018. Selvicoltura e schianti da vento. Il caso della "tempesta Vaia". *Forest@.*

Panno, A. et al., 2017. Nature-based solutions to promote human resilience and wellbeing in cities during increasingly hot summers. *Environmental Research.*

R Core Team, 2020. *R: A language and environment for statistical computing..* Vienna: s.n.

Rajczak, J., Pall, P. & Schär, C., 2013. Projections of extreme precipitation events in regional climatesimulations for Europe and the Alpine Region. *Journal of Geophysical Research: Atmospheres,* Volume 118, pp. 3610-3626.

Recantesi, F. & Petroselli, A., 2020. Land Cover Change and Flood Risk in a Peri-Urban Environment of the Metropolitan Area of Rome (Italy). *Water Resources Management.*

Regione Veneto, 2021. *Opere infrastrutturali per la sicurezza dal rischio idraulico.* [Online]
Available at: https://www.regione.veneto.it/web/ambiente-e-territorio/opere-infrastrutturali-per-la-sicurezza-dal-rischio-idraulico
[Accessed June 2021].

Sañudo-Fontaneda, L. A. & Robina-Ramírez, R., 2019. Bringing community perceptions into sustainable urban drainage systems: The experience of Extremadura, Spain. *Land Use Policy.*

Scolobig, A., De Marchi, B. & Borga, M., 2012. The missing link between flood risk awareness and preparedness: findings from case studies in an Alpine Region. *Natural Hazards.*

Semmler, T. & Jacob, D., 2004. Modeling extreme precipitation events—a climate change simulation for Europe. *Global and Planetary Change,* 44(1-4), pp. 119-127.

Sharma, A. K. et al., 2016. Water Sensitive Urban Design: An Investigation of Current Systems, Implementation Drivers, Community Perceptions and Potential to Supplement Urban Water Services. *Water,* Volume 8.

Strollo, A. et al., 2020. Land consumption in Italy. *Journal of Maps.*

Thorne, C. R. et al., 2015. Overcoming uncertainty and barriers to adoption of Blue-Green Infrastructure for urban flood risk management. *Journal of Flood Risk Management.*

Ugolini, F., Massetti, L., Sanesi, G. & Pearlmutter, D., 2015. Knowledge transfer between stakeholders in the field of urban forestry and green infrastructure: Results of a European survey. *Land Use Policy.*

Walsh, K. & Pittock, A., 1998. Potential Changes in Tropical Storms, Hurricanes, and Extreme Rainfall Events as a Result of Climate Change. *Climatic Change,* Issue 39, pp. 199-213.

Williams, J. B. et al., 2019. Residents' perceptions of sustainable drainage systems as highly functional blue green infrastructure. *Landscape and Urban Planning.*

Worldometer, 2021. *Coronavirus Cases: Italy.* [Online]
Available at: https://www.worldometers.info/coronavirus/country/italy/

Yilmaz, A. G., Hossain, I. & Perera, B. J., 2014. Effect of climate change and variability on extreme rainfall intensity–frequency–duration relationships: a case study of Melbourne. *Hydrol. Earth Syst. Sci.,* 18(10).

8. Appendix

8.1. Survey

I. CARATTERI TERRITORIALI

1. Qual è la tua provincia di residenza?
   Belluno
   Padova
   Rovigo
   Treviso
   Venezia
   Verona
   Vicenza
   Altro: ______________

2. In che comune vivi attualmente? ______________________________________

3. CAP

4. Da quanti anni?
   Meno di 1 anno
   1-5 anni
   6-10 anni
   11-20 anni
   Più di 20 anni

5. Zona di residenza
   Centro urbano
   Periferia urbana
   Centro rurale
   Zona agricola

II. SENSO DI SICUREZZA E PERCEZIONE DEL RISCHIO

6. In che misura vivere nel tuo comune ti fa sentire sicuro/a?

Minima sicurezza				Massima sicurezza	Non so
1	2	3	4	5	0

7. Puoi indicare in che misura ritieni che ognuno degli eventi riportati qui sotto possa rappresentare un pericolo per te personalmente o per l'abitazione in cui vivi?

	Nessun pericolo				Pericolo serio	Non so
Terremoto	1	2	3	4	5	0
Furto	1	2	3	4	5	0
Siccità	1	2	3	4	5	0
Incendio	1	2	3	4	5	0
Vento forte	1	2	3	4	5	0
Cambiamento climatico	1	2	3	4	5	0
Epidemia sanitaria	1	2	3	4	5	0
Animali selvatici	1	2	3	4	5	0

8. Quanto pensi che le alluvioni siano un rischio per:

	Minimo				Molto elevato	Non so
La tua abitazione	1	2	3	4	5	0
Te personalmente	1	2	3	4	5	0
Per il paese in cui vivi	1	2	3	4	5	0

III. CONOSCENZA DEI SISTEMI DI MITIGAZIONE DEL RISCHIO

Paratie mobili

Le paratie mobili sono delle barriere che possono essere installate sui punti di potenziale ingresso dell'acqua all'interno degli edifici. Possono essere dei semplici sacchi di sabbia o paratie rigide costruite su misura per una porta o un cancello. Evitano che l'acqua entri nell'abitazione, se questa non supera l'altezza della paratia.

9. Prima di questo sondaggio, qual era la tua conoscenza personale delle paratie mobili?

Nessuna conoscenza				Conoscenza elevata	Non so
1	2	3	4	5	0

10. Quanto pensi siano efficaci le paratie mobili per ridurre i danni provocati da alluvioni nella zona dove vivi?

Per nulla efficaci				Molto efficaci	Non so
1	2	3	4	5	0

11. Perché?

Bacini di espansione

I bacini di espansione sono zone inondabili in cui una parte dell'acqua di un fiume/torrente in piena può essere accumulata in modo da evitare l'esondazione nelle zone a valle del bacino. Si tratta di solito di zone agricole nelle vicinanze di corsi d'acqua delimitate da argini.

12. Prima di questo sondaggio, qual era la tua conoscenza personale dei bacini di espansione?

Nessuna conoscenza				Conoscenza elevata	Non so
1	2	3	4	5	0

13. Quanto pensi siano efficaci i bacini di espansione per ridurre i danni provocati da alluvioni nella zona dove vivi?

Per nulla efficaci				Molto efficaci	Non so
1	2	3	4	5	0

14. Perché?

Canali di diversione

I canali di diversione sono canali artificiali che, durante un evento di piena, permettono di indirizzare una parte dell'acqua di un corso a rischio di esondazione in un altro corso o bacino idrico in grado di gestire l'acqua in eccesso.

15. Prima di questo sondaggio, qual era la tua conoscenza personale dei canali di diversione?

Nessuna conoscenza				Conoscenza elevata	Non so
1	2	3	4	5	0

16. Quanto pensi siano efficaci i canali di diversione per ridurre i danni provocati da alluvioni nella zona dove vivi?

Per nulla efficaci				Molto efficaci	Non so
1	2	3	4	5	0

17. Perché?

____

Pozzi disperdenti

I pozzi disperdenti sono strutture sotterranee permeabili che permettono all'acqua che vi si accumula durante un evento di pioggia di infiltrarsi nel terreno. Evitano, quindi, che l'acqua di pioggia vada a sovraccaricare la rete di drenaggio urbana.

18. Prima di questo sondaggio, qual era la tua conoscenza personale dei pozzi disperdenti?

Nessuna conoscenza				Conoscenza elevata	Non so
1	2	3	4	5	0

19. Quanto pensi siano efficaci i pozzi disperdenti per ridurre i danni provocati da alluvioni nella zona dove vivi?

Per nulla efficaci				Molto efficaci	Non so
1	2	3	4	5	0

20. Perché?

____

Sistemi di accumulo dell'acqua piovana (cisterne, laghetti, ecc.)

Rientrano in questa categoria tutti i sistemi che permettono di raccogliere e accumulare l'acqua di pioggia proveniente da una superficie impermeabile. L'acqua può essere successivamente riutilizzata. Riducono la quantità di acqua che deve essere gestita dalla rete di drenaggio urbano.

21. Prima di questo sondaggio, qual era la tua conoscenza personale dei sistemi di accumulo dell'acqua piovana?

Nessuna conoscenza				Conoscenza elevata	Non so
1	2	3	4	5	

22. Quanto pensi siano efficaci i sistemi di accumulo dell'acqua piovana per ridurre i danni provocati da alluvioni nella zona dove vivi?

Per nulla efficaci				Molto efficaci	Non so
1	2	3	4	5	0

23. Perché?

____

Pavimentazioni permeabili

Si tratta di pavimentazioni costruite con materiali e/o metodi che permettono all'acqua di infiltrarsi sotto la pavimentazione e nel terreno. Riducono la quantità di acqua che defluisce sul suolo e di conseguenza quella che deve essere allontanata dalla rete di drenaggio urbano.

24. Prima di questo sondaggio, qual era la tua conoscenza personale delle pavimentazioni permeabili?

Nessuna conoscenza				Conoscenza elevata	Non so
1	2	3	4	5	0

25. Quanto pensi siano efficaci le pavimentazioni permeabili per ridurre i danni provocati da alluvioni nella zona dove vivi?

Per nulla efficaci				Molto efficaci	Non so
1	2	3	4	5	0

26. Perché?

____

Tetti verdi

Includono tutti i sistemi che permettono di creare uno strato di vegetazione sopra un edificio. Possono anche diventare delle aree verdi fruibili. Aumentano il tempo che l'acqua impiega per arrivare alla rete di drenaggio urbano, riducendo il picco di piena.

27. Prima di questo sondaggio, qual era la tua conoscenza personale dei tetti verdi?

Nessuna conoscenza				Conoscenza elevata	Non so
1	2	3	4	5	0

28. Quanto pensi siano efficaci i tetti verdi per ridurre i danni provocati da alluvioni nella zona dove vivi?

Per nulla efficaci				Molto efficaci	Non so
1	2	3	4	5	0

29. Perché?

____

Aree di bioritenzione (giardini pluviali, trincee di infiltrazione, ecc.)

Si tratta di aree verdi, anche fruibili, molto permeabili in cui l'acqua viene indirizzata durante un evento piovoso. Qui l'acqua si accumula per brevi periodi e si infiltra nel terreno. Queste aree possono anche avere un notevole effetto estetico.

30. Prima di questo sondaggio, qual era la tua conoscenza personale delle aree di bioritenzione?

Nessuna conoscenza				Conoscenza elevata	Non so
1	2	3	4	5	0

31. Quanto pensi siano efficaci le aree di bioritenzione per ridurre i danni provocati da alluvioni nella zona dove vivi?

Per nulla efficaci				Molto efficaci	Non so
1	2	3	4	5	0

32. Perché?

____

IV. PERCEZIONE DI UTILITÀ E ADOZIONE DEI SISTEMI DI RIDUZIONE DEL RISCHIO

33. Nella tua opinione, in che ambito sarebbe più utile adottare questi sistemi di mitigazione del rischio alluvionale? (sono possibili più risposte)

	Privato (singola abitazione)	Pubblico locale (quartiere, comune)	Pubblico su ampia scala (provincia, regione)
Paratie mobili	☐	☐	☐
Bacini di espansione	☐	☐	☐
Canali di diversione	☐	☐	☐
Pozzi disperdenti	☐	☐	☐
Sistemi di accumulo	☐	☐	☐
Pavimentazioni permeabili	☐	☐	☐
Tetti verdi	☐	☐	☐
Aree di bioritenzione	☐	☐	☐

34. Per le sole misure di ritenzione realizzabili in ambito domestico, in che misura saresti disposto ad adottarle presso la tua abitazione (indipendentemente dalla reale fattibilità tecnica)?

	Per nulla				Moltissimo	Non so
Paratie mobili	1	2	3	4	5	0
Pozzi disperdenti	1	2	3	4	5	0
Sistemi di accumulo	1	2	3	4	5	0
Pavimentazioni permeabili	1	2	3	4	5	0
Tetti verdi	1	2	3	4	5	0
Aree di bioritenzione	1	2	3	4	5	0

35. Per un'abitazione con 200 metri quadrati complessivi di superficie impermeabile (tetto, viabilità, passaggi pedonali, ecc.), un'ipotesi funzionale di gestione sostenibile dell'acqua piovana prevede la realizzazione di una zona di bioritenzione di 20 metri quadrati e l'installazione di una cisterna di accumulo dell'acqua (che può essere impiegata per l'irrigazione del giardino) con una spesa complessiva di € 1000,00. Questo intervento è in grado di gestire in loco più del 90% dell'acqua piovana caduta in un anno e, se adottato dalla maggior parte delle abitazioni, sarebbe in grado di contribuire alla riduzione significativa del rischio di alluvione della comunità locale.

Saresti disponibile ad intraprendere un intervento di questo tipo presso la tua abitazione? (nel caso di villette a schiera o condomini considera che l'intervento sia realizzato in accordo con i condomini)

Sì
No

36. Puoi motivare la risposta?

____

37. Quali di questi fattori potrebbero essere un incentivo alla realizzazione dell'intervento descritto in precedenza? (sono possibili più risposte)

Migliore conoscenza dei benefici per il territorio
Migliore conoscenza dei diversi sistemi e delle tecniche di realizzazione
Contributi economici per la realizzazione
Verifica dell'effettiva utilità tramite progetti pilota realizzati in zona
Modifica del regolamento edilizio a favore della gestione sostenibile dell'acqua piovana
Bassi costi di realizzazione e manutenzione

38. Come vedi l’introduzione delle misure di ritenzione naturale delle acque in spazi pubblici urbani?

	Molto negativa				Molto positiva	Non so
Pozzi disperdenti	1	2	3	4	5	0
Sistemi di accumulo	1	2	3	4	5	0
Pavimentazioni permeabili	1	2	3	4	5	0
Tetti verdi	1	2	3	4	5	0
Aree di bioritenzione	1	2	3	4	5	0

V. RELAZIONE CON IL TERRITORIO

39. Puoi indicare in che misura sei d’accordo con ognuna delle seguenti affermazioni?

a. La gestione del rischio alluvionale è compito delle Amministrazioni Pubbliche

Per nulla d’accordo				Totalmente d’accordo	Non so
1	2	3	4	5	0

b. Adottando i sistemi di gestione sostenibile dell’acqua piovana presso la mia abitazione, posso contribuire a ridurre il rischio alluvionale della comunità in cui vivo

Per nulla d’accordo				Totalmente d’accordo	Non so
1	2	3	4	5	0

c. La gestione del rischio alluvionale non è compito mio

Per nulla d’accordo				Totalmente d’accordo	Non so
1	2	3	4	5	0

d. Il verde urbano contribuisce ad aumentare il benessere delle persone

Per nulla d’accordo				Totalmente d’accordo	Non so
1	2	3	4	5	0

e. Ci sono troppe piante in città

Per nulla d’accordo				Totalmente d’accordo	Non so
1	2	3	4	5	0

f. Vivo in una zona soggetta ad alluvioni

Per nulla d’accordo				Totalmente d’accordo	Non so
1	2	3	4	5	0

g. Sono a conoscenza di come le Amministrazioni locali gestiscono il rischio alluvionale nella zona dove vivo

Per nulla d’accordo				Totalmente d’accordo	Non so
1	2	3	4	5	0

h. Il cambiamento climatico è un problema serio che va affrontato il prima possibile

Per nulla d’accordo				Totalmente d’accordo	Non so
1	2	3	4	5	0

i. L’adozione di sistemi naturali di gestione dell’acqua nel caso di interventi urbanistici dovrebbe essere obbligatoria

Per nulla d’accordo				Totalmente d’accordo	Non so
1	2	3	4	5	0

j. Le infrastrutture grigie (bacini di espansione, canali di diversione, paratie mobili, ecc.) sono la soluzione migliore per mitigare il rischio alluvionale

Per nulla d'accordo				Totalmente d'accordo	Non so
1	2	3	4	5	0

k. Mi fido delle altre persone della comunità in cui vivo

Per nulla d'accordo				Totalmente d'accordo	Non so
1	2	3	4	5	0

l. Nella comunità dove vivo ci sono già abbastanza sistemi per la gestione del rischio di alluvione

Per nulla d'accordo				Totalmente d'accordo	Non so
1	2	3	4	5	0

m. Mi piace fare giardinaggio e/o coltivare l'orto

Per nulla d'accordo				Totalmente d'accordo	Non so
1	2	3	4	5	0

VI. CARATTERI SOCIO-DEMOGRAFICI E TERRITORIALI

40. Età:

41. Genere
    - Uomo
    - Donna
    - Altro

42. Tipologia dell'abitazione di residenza:
    - Casa singola
    - Villetta a schiera
    - Piccola palazzina (max 4 unità abitative)
    - Condominio (più di 4 unità abitative)

43. L'abitazione dove vivi è:
    - Di tua proprietà o di proprietà della famiglia
    - In affitto
    - Altro: ___________________

44. Titolo di studio più alto conseguito:
    - Licenza elementare
    - Licenza media inferiore
    - Diploma di scuola superiore
    - Laurea, dottorato

45. Nel caso di diploma, laurea o dottorato, specificare la disciplina: ______________________________

46. Occupazione:
    - Settore agricolo
    - Industria, artigianato
    - Pubblica Amministrazione
    - Servizi (commercio, turismo, istruzione, sanità, ecc.)
    - Studente
    - Pensionato/a

Non occupato/a
Altro: _______________

47. Nel caso tu sia occupato/a in un'Amministrazione Pubblica, puoi indicare che ruolo ricopri?
____

48. Nel caso tu sia uno/a studente/studentessa, puoi indicare che indirizzo scolastico o facoltà frequenti? ______________________________

49. Fai parte di un gruppo di Protezione civile?
Sì
No

50. Sostieni e/o fai parte di un'associazione ambientalista?
Sì
No

51. Il tuo impiego ti porta ad essere a contatto con l'ambiente e il territorio?

Mai				Molto spesso
1	2	3	4	5