OUTLINING THE URBAN CS PLAYING FIELD – CS AND RISK MANAGEMENT AT URBAN LEVEL, THE INSTITUTIONAL STRUCTURES, AND THE OPTIONS FOR INFORMATION SHARING

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List of Abbreviations

Abbreviation	Full name and explanation
C3S	Copernicus Climate Change Service, part of COPERNICUS
COPERNICUS	Sub-programme in H2020 research programme oriented to earth observation and derived services, including C3S
CORDIS	Community Research and Development Information Service (European Commission)
CS	Climate Services
WTP	Willingness to pay
IPCC	Intergovernmental Panel on Climate Change
EEA	European Environment Agency
OECD	Organization for Economic Co-operation and Development
ERDF	European Regional Development Fund
NAP	National Adaptation Plan
NAS	National Adaptation Strategy
SEAP	Sustainable Energy Action Plan
BAP	Bologna Adaptation Plan
BLUE AP	Bologna Local Urban Environment Adaptation Plan for a Resilient City
ARPAE	Regional Agency for Environmental Protection of Emilia Romagna
EIB	European Investment Bank
TA	Technical Assistance
CRVA	Climate Risk and Vulnerability Assessments
HSY	Helsinki Region Environmental Services Authority
GFCS	Global Framework for Climate Services
ECMWF	European Centre for Medium-Range Weather Forecasts
CLIMATE-ADAPT	European Climate Adaptation Platform
AST	Adaptation Support Tool
EPA	United States Environmental Protection Agency
SWC	National Stormwater Calculator
SWMM	Storm Water Management Model
CURB	Climate Action for Urban Sustainability
CyPT	City Performance Tool
CRU	Climate Research Unit
UNISDR	United Nations Office for Disaster Risk Reduction
UKCIP	UK Climate Impacts Programme
ECV	Essential Climate Variables

Glossary of terms

Term	Explanation
climate service	The transformation of climate related data – often together with other relevant information - in to customized information products, offered as such or embedded in consultancy and/or education [condensed version of European Roadmap definition]
climate service: seasonal forecast	A prediction of weather tendencies (often expressed as probabilistic deviations from long term averages typical for the considered period and area) stretching from approx. 1 month to 6 months or more.

climate service: long term forecast	A prediction of climate conditions for a certain area and for typical time units (diurnal to annual) referring to decadal or multi-decadal averages several to many decades ahead
FCM	Fuzzy Cognitive Map – Graphical representation of the cause-effects network influencing the stakeholders' problem understanding.
ambiguity analysis	It refers to methodologies aiming at detecting and analysing differences and similarities among different actors' problem understandings.
social network analysis	Methodologies aiming at mapping and analysing the complex web of interactions among the main elements affecting a collective decision process, i.e. agent, resources, knowledge and tasks.
problem structuring methods	It refers to the methods aiming at eliciting and structuring the stakeholders' understanding of the issues to be addressed.

Contents

0. NON TECHNICAL SUMMARY

There is a mounting international interest about how to address the implications of climate change for urban areas. This is mainly due to two reasons. On the one hand, globally, over 50% of the population lives in cities. Urban population is projected to continue growing rapidly. AS major centers of consumption and production, cities are great energy consumers and, as a result, major greenhouse gas emitters. Cities appear to be responsible for 60-70% of global GHG emissions using a consumption-based criterion. The emissions produced stem primarily from building construction, cooling, heating and electrification, vehicle use, industry and manufacturing. The building sector alone sourced in 2010 (directly and indirectly through electricity and heath consumptions) the 18.4% of world GHG emissions. Urban planning could affect these emissions by influencing the way we arrange our cities (urban form), population densities (urban density), and how we move in and through the cities (urban mobility).

On the other hand, On the other hand, the high density of population, capital assets, key public and private services make cities, in the absence of adequate adaptation planning, potential "hot spots" for climatic risk.

There are some peculiar features characterizing the relation between cities, climate change impacts and accordingly, planning for impact reduction actions:

- Cities are mostly "artificial environments". Reducing climatic risk, or improving their climate resilience, thus needs human intervention.
- Cities present a high degree of heterogeneity, not only between, but also within them. This depends on the peculiar climatic, topographic, morphological, demographic, social and economic characteristics. This implies that impact assessment and adaptation actions become "context specific" at the highest degree.
- Cities' climate risks are often determined in – as well as effects of adaptation measures affect – areas wider than the city itself creating a complex interface between what is city/urban and what it is not. This requires impact assessment and adaptation planning to go often beyond the city boundaries.

All this underscores the importance of climate change adaptation planning in cities, but also stresses the complexities of this planning.

Starting from the results of WP1 concerning the identification of the main technical/scientific barriers hampering the actual use and the effectiveness of the climate services, this work aims at detecting, analyzing and overcoming the main barrier to the creation of a market for Climate Services in urban planning. Specifically, this deliverable focuses on the analysis of the institutional and organizational barriers occurring when urban planning institutions identify, specify, and acquire climate services and utilize the embedded information. This focus is motivated by three reasons. Firstly, the work done in Task 4.2 is meant to set the ground for the co-development of CS adopting a LivingLab approach, which was preselected in the study plan. Therefore, potential barriers hampering the cooperation among the different CS users – with specific reference to barriers hampering the interaction among users – were detected and analyzed in order to enable the participatory process. Secondly, our work is based on the assumption and observation that climate adaptation integrated in urban planning, is preferably to be considered as a collective decision making process. In this perspective, the lack of common understanding and the ineffective exchange of information are critical barriers hampering the actual adoption and, consequently, the effectiveness of CS for urban planning. Thirdly, the pre-selected case studies are carried out in climate change aware organisations, this makes several other obstacles largely irrelevant in this case.

Deliverable 4.1 starts with the description of the mainstreaming of urban planning for climate change adaptation, followed by a review of Bologna and Helsinki urban plans in relation to climate adaptation. This contextual sketch is important so as to better understand the actual needs of CS in a municipal planning process. Subsequently, a deep literature review of available urban CS, helped to identify the actual selection and matching challenges when alternative CS are offered, with a special attention to the two "front-runner" cities of EU-MACS project. The main technical reasons limiting the focus of CS on urban areas and their specific climate-related risks are then analyzed. Finally, Problem Structuring Methods and Social Network Analysis are implemented in order to analyze the main barrier due to the institutional structure. Besides the technical barriers, extensively described in D1.4, the activities carried out in the two EU-MACS case studies – i.e. Helsinki and Bologna – demonstrated that the institutional framework for urban adaptation could affect the usability of CS. Specifically, the analysis shows that roles and responsibilities of the different actors influence the individual problem understanding and, thus, the information needs. The explorations carried out in the case studies demonstrated that neglecting these differences could lead to an increasing gap between information producers – i.e. climate services producers – and information users – decision-making actors involved in urban planning.

Moreover, the mapping and analysis of the network of interaction among the different institutional actors allowed us to identify key elements and main vulnerabilities accounting for the three main elements in the organizational network, i.e. actors, knowledge and tasks.

1. BACKGROUND AND AIM

1.1 Background of EU-MACS

To support further product development and effective widespread uptake of climate services, as a means to boost mitigation of and adaptation to climate change as well as capabilities to cope with climate variability, the European Commission has included several actions in its current research programme Horizon 2020 (H2020). Essentially these actions follow from the logic to implement the European Research and Innovation Roadmap for Climate Services (cf. European Commission, 2015)

EU-MACS and it sister project MARCO deal with analysis of the climate services market. In addition demonstration calls were launched on the added value of climate services for supposedly high value added sectors with hitherto little uptake of climate services (SC5-01-2016-2017), while other actions focus more on networking activities interlinking to better connect relevant players (e.g. the ERA-NET for Climate Services (SC5-02-2015) and the project funded under the Coordination and Support Action (SC5-05b-2015) called Climateurope.

An extremely important sub-programme in H2020 is the COPERNICUS Climate Change Service (C3S) programme, which aims to generate a very comprehensive coherent and quality assured climate data set meant to support mitigation and adaptation planning, implementation and monitoring. In due course also coping capabilities of (current) climate variability are addressed.

In this framing, EU-MACS – European Market for Climate Services – will analyse market structures and drivers, obstacles and opportunities from scientific, technical, legal, ethical, governance and socioeconomic vantage points. The analysis is grounded in economic and social science embedded innovation theories on how service markets with public and private features can develop, and how innovations may succeed.

1.2 Aim of work package 4 and tasks 4.1 and 4.2

Identifying and removing barriers and enhancing enablers for climate services market uptake for urban planning requires acknowledgment of the complexities of this sector: i) adaptation and mitigation interactions – whereas climate proofing of the built environment associates in the first place with adaptation needs, sustainable urban planning has to absorb mitigation objectives, entailing energy efficient buildings, use of local renewable energy, and changes in the transport system; views on building densities, options for multiple use of space, and key technical choices are on the crossroads of both dimensions; ii) the time scale – urban planning interventions for climate change adaptation focus on medium- to long-term time scales, while various change and learning processes may have to start early enough; this strongly affects the level of uncertainty and the suitability of the information provided by climate services; furthermore, at operational level of urban services there can evolve a need for shorter term oriented climate & weather services; all in all, a shift from linear decision-making process towards a more adaptive-oriented approach is required in this multi-tiered multi-horizon planning environment; iii) the multi-actors dimension of the planning process – in order to better support planning for climate adaptation, climate services should be capable to facilitate the sharing of information within a community of decision-makers, characterized by different problem understanding and frames, that strongly influence the ways information is understood and used in the decision-making process.

WP4 aims at a stepwise analysis of barriers and enablers of CS use in urban planning, with the aim of exploring effective cooperative structures and processes that facilitate uptake of climate services in urban planning and fit the local socioeconomic, physical and technical circumstances. In this respect the following processes can be distinguished:

- Identification and specification of CS needs in urban planning & management
- CS acquisition, use and re-use processes in urban planning within and beyond the municipal organizational boundaries
- Budgeting, resourcing and willingness to pay (WTP) regarding acquisition and use of CS
- The interaction and evolution of these dimensions of CS use in relation to type of climate change challenges, city size, governance structure, etc.

Specific objectives are:

- Enhance the awareness of local decision-makers, stakeholders and communities concerning the role of climate services in the management of risks in urban areas which are exacerbated or created by climate change (valorization of CS)
- Improve the integration between urban planning activities and climate change adaptation and (where relevant) mitigation policies by means of climate services (mainstreaming of CS);
- Develop a durable creative environment for specification, tailoring, acquisition, use, and (local) dissemination of climate services in urban planning (tooling and sharing of CS). This is approached by means of Living Labs based networks and protocols.

It is worth mentioning that great part of the work done aimed at eliciting and structuring decision-makers' information needs. The key for advancing the CS market in urban planning is the co-creation of services. Instead of focusing on specific information, this work tried to develop and implement a methodological approach capable to fill the gaps between information providers and users in the CS domain. At the core of the adopted methodological approach we put the information needs elicitation and the co-creation process through LivingLab approach.

In order to achieve these objectives, primary stakeholders have been already recruited, i.e. the local authorities responsible for the urban planning processes. Other stakeholders to be involved in the co-creative process (task 4.3) will be identified in task 4.2.

As the urban planning context for CS use is crucially more complex than for the sectors of WP2 and WP3, the preparatory work preceding the CS explorations is divided in two Tasks. Task 4.1 deals with the – mainly – technical barriers and potentials related to the identification and specification of CS needs in relation to the physical climate change challenges to be faced in urban planning, as well as with actual selection and matching challenges when alternative CS are on offer. Task 4.2 on the other hand deals with the socio-institutional analysis of how and to what extent adaptation and mitigation policies are absorbed by urban planning strategies and their implementation and what are the (possible) roles of CS in that absorption process.

2. URBAN PLANNING FOR CLIMATE CHANGE ADAPTATION

The availability of "good" knowledge and information is a key prerequisite for a successful planning in cities. This applies also to the specific case of climate change adaptation, where it appears as a key feature, one of the enabling factor, but also a challenge to urban planning. This raises the importance of the availability/usability of good information on climate change pressures and impact in cities, and of proper "planner/user friendly" interfaces helping decision makers to interpret and translate this information into adaptation decisions.

This is exactly what climate services are asked to do. Reliable and actionable CS, either adaptation oriented or seasonal for better operational/tactical preparedness with respect to climate variability, are needed (Hirschnitz-Garbers & Drews, 2016).

This introductory section will offer a short overview of features, challenges and opportunities of urban planning for climate change adaptation to better focus on the actual CS needed by a municipality facing climate changes. The following subsections are therefore a functional opening to the subsequent treatment of CS at the urban level which link naturally to adaptation challenges being these the obvious source of CS demand.

In what follows, section 2.1 briefly introduces the urban dimension of climate change, presenting major climate stressors and impacts, with special reference to Bologna and Helsinki; section 2.2 revises the distinctive features of urban planning for climate change adaptation; section 2.3 focusses on the issue of multi-level governance. Section 2.4 describes the adaptation processes undertaken in Bologna and Helsinki. The last section (2.5) summarizes the general findings resulting from the case studies.

2.1 Climate change impacts in cities (what we have to plan for)

Being widespread and present in basically all areas of the world, cities are exposed to all kinds of climate change stressors and impacts. Among the first: average and extreme temperature changes, average and extreme precipitation changes, sea-level rise and changes in storm surges, can be listed. Among the second: heath waves, cold spells, hydrogeological risk, water scarcity, on their turn associated to direct and indirect health effects, stress on infrastructures, eventually affecting labor supply, economic activity in broad terms, the production and distribution of income and finally "welfare".

Interestingly, cities' exposure to climate risk is only partially determined by climatic conditions. Topography, morphology and also the adaptive capacity of the resident communities are equally important. Accordingly each city, or area within, needs to be considered with all its specificities.

Following World Bank (2011) and Un-Habitat (2014) the major climate change impacts affecting cities are:

Flooding: On their turn these can be a consequence of different climate and weather related phenomena. Namely:

Sea level rise and coastal inundation: related both to increase in average sea level and increased storminess. The first, results primarily from sea thermal expansion, and ice melting. According to the last IPCC report (IPCC 2015) average sea level is projected to rise between 15 and 33 cm by 2050. The second, is related to the increased frequency and magnitude of marine storms (e.g. cyclones, typhoons, and hurricanes), which are imposing high infrastructural, health and economic damages already today.

Increased rainfall: Climate change is likely to increase frequency and magnitude of rainfall events in some areas, thus increasing the episodes of "extreme precipitation" and the risk of urban floods. These phenomena are greatly facilitated by the usually high percentage of impermeable surfaces (roads, buildings, paved areas, parking lots) of urban areas, often coupled with inefficient sewage and drainage systems. Water outflows thus occur mainly on the surface cumulating on roads, low lying floors, metro stations etc.

Increased/intensified river flooding: These are a direct consequence of increased and intensified rainfalls which is particularly concerning for urban areas located in low-lying zones, flood plains, close to rivers or river deltas.

Both Bologna and Helsinki are facing different kinds of flooding risks. In particular, Helsinki, is already dealing with storm-water management problems during summer, while in winter, especially for the Greater Helsinki area, the so-called 'lake effect' (after the Great Lakes in the US) can occur, which means that, when the water surface is not yet frozen, large amounts of snowfall may occur along the coastal strip of such water bodies (The Finnish Gulf in the Helsinki case). Climate change seems to promote a longer period of open sea (in coastal regions) also when overland temperatures are predominantly below zero. Under certain weather conditions this set-up creates a kind of 'snow engine' and in a few days 20 – 30 centimeters can accumulate, which can be quite disruptive. On the other side, more than 50% of the Bologna municipality territory features a sub optimal (very poor or poor) surface water and groundwater flow regime, concentrated particularly in urbanized low-permeability areas that increases hydrological risk. In addition, 6.4 Km^2 (18.4%) of the hilly area characterizing the city and the neighboring countryside results landslide prone, while further 4.23 Km^2 are intrinsically unstable. According to climate projections, notwithstanding decreased summer precipitations, a slight increase in the number of days with intense precipitation is expected. This is going to put further stress on the hydrogeological stability of the whole area.

<u>Water scarcity</u>: Climate change is projected to reduce precipitation in most of Mediterranean areas which, coupled with increased temperatures, can lead to an exacerbation of droughts events and desertification processes. Urban areas can thus suffer from water scarcity. The issue is ampler than just water availability per se, but pertains to the access to safe drinking water and sanitation. These can be impaired for instance, also by flood events which contaminate freshwater resources. A first consequence of poor sanitation is the worsening of health conditions of the population with severe economic and social impacts. While Helsinki water supply relies on huge reserves, in Bologna, the water supply system is characterized by insufficient reservoirs and limited freshwater resources, and this risk already induces frequent problems especially during the summer period. More in detail, the Bologna area denotes an excess use of groundwater resources that, as further undesired effect causes subsidence, and an accelerated worsening of groundwater quality. Climatic changes which are projected to decrease summer precipitations, and potentially also increase water demand to contrast higher temperatures, will definitely exacerbates these problematics.

<u>Extreme heat, heat waves and air quality</u>: Climate change will likely increase temperatures and the occurrence/intensity of heat waves in most cities and towns all around Europe, in Bologna as well in Helsinki although with different levels of perception. Higher temperatures will be magnified in urban areas by the urban heat island phenomenon. The large quantity of reflecting surfaces, building and road material and design, relatively few green areas, absorb and trap heat. Eventually, a city can result 5 to 10°C hotter than the rural areas nearby. This will impact directly the health status of primarily very young and elderly population, and increase the burden on health care services. Furthermore, it is documented that climate conditions are linked to air pollution. Permanence, transportation, chemical transformation of pollutants emitted by cooling and heating appliances, power stations, road traffic are influenced by the amount of solar energy, precipitation and wind regimes (Hedegaard et al. 2012). Hotter climates and lower precipitation can thus increase the harming capacity of these pollutants (EEA 2013).

Beside the major climate change impacts just mentioned, it is important to remember that climate change may have crucial effects on ***environmental degradation and loss of socioeconomic potential*** related both to direct physical and human capital losses and to rehabilitation and recovery expenditure. Impacts of climate change can also have more long lasting and indirect effects on the economic potential of cities; extreme events as such or via environmental effects may reduce for example tourism potential, or reduce value of real estate, recurrent occurrence of heat waves reduces labour productivity; accumulation of negative effects may spur selective outmigration of the most talented and wealthy, significant rise in local public debts or local tax rates may also reduce the potential.

Against this background, climate change induced adverse distributional implication deserves a particular mention. Climate change will place unique burdens on the urban poor, residents of informal settlements, and other vulnerable groups, such as women, children, the elderly, disabled, and minority populations (World Bank 2011). Typically, weaker social groups are more exposed to climatic stressors as they tend to live in more degraded areas that often coincide with environmentally unsafe locations (e.g. at higher hydrogeological risk); and are less capable to adapt, for the lacking of basic resources, risk pooling/sharing instruments like insurances, or social safety nets.

Urban planners are thus involved in the preparation and implementation of local plans for the management, coherent and sustainable development of many areas/sectors affected by climate change, such as infrastructure, water, land use, health, transportation, disaster risk prevention/reduction, poverty reduction etc. A reliable and operational adaptation oriented CS should consequently respond to the complex multi-purpose needs that the climate change implies.

2.2 Areas, specific features and challenges of climate change adaptation planning at the urban level

Given the expected impacts of climate change on cities and urban areas, there is a clear need for cities to develop adaptation strategies, controlling for local climatic and biophysical conditions along with the risk of extreme events.

As noted, in cities mainstreaming climate policies into ongoing initiatives is one of the most effective ways to address climate change, since the impacts felt in cities are not necessarily new but rather changes in the frequency/intensity of exiting threats (Wilson 2006; Gleeson 2008; Condon, Cavens and Miller 2009; and Johnson and Breil 2012). Thus, climate change can be addressed in many of the existing sectors and through municipal management.

Still it is important to recognize that planning for climate change adaptation in cities has its own peculiarities with respect to the more standard city planning. Firstly, in many cases, it involves a broader group of stakeholders, including especially multi levels of government (e.g. state, county, regional, national, federal and provincial governments). Secondly, the planning horizon tends to be more long term as most projected to addressing future uncertainty and new risks rather than the current ones.

Urban policies commonly used to facilitate adaptations include land-use zoning, building and building codes, natural resource management, transportation, changes in the management of urban utilities such as waste and water (OECD 2009), and protection infrastructures such as dikes and erosion prevention. A review of the existing literature on urban adaptation strategies suggests that most adaptation strategies can be categorized as one of the following: (OECD 2009; Johnson and Breil 2012; EEA 2013a; and EEA 2015):

- Physical infrastructure and soft non-structural actions (IPCC 2007; Mueller and Rynne 2009)
- Land use planning (UN-Habitat 2011)
- Contingency planning
- Education and awareness raising (UN-HABITAT 2014)
- Research and monitoring
- Fiscal planning and financing (UN-HABITAT 2015)

At the same time, they need to respond to the following specific features:

- Ambitious vision
- Inclusiveness, comprehensiveness and integration (Carter 2011, EEA 2013b).
- Relevance at local and community level
- Evidence-based understanding of city specific climate change impacts
- Transparency and verifiability of the adopted strategy
- Long-term perspective (Lourenço et al., 2014)
- Good Governance(Moser and Luers 2008 and Birkmann et al. 2010; OECD 2010; Bulkeley et al. 2011; Garschagen and Kraas 2011; OECD 2014; OECD 2009)

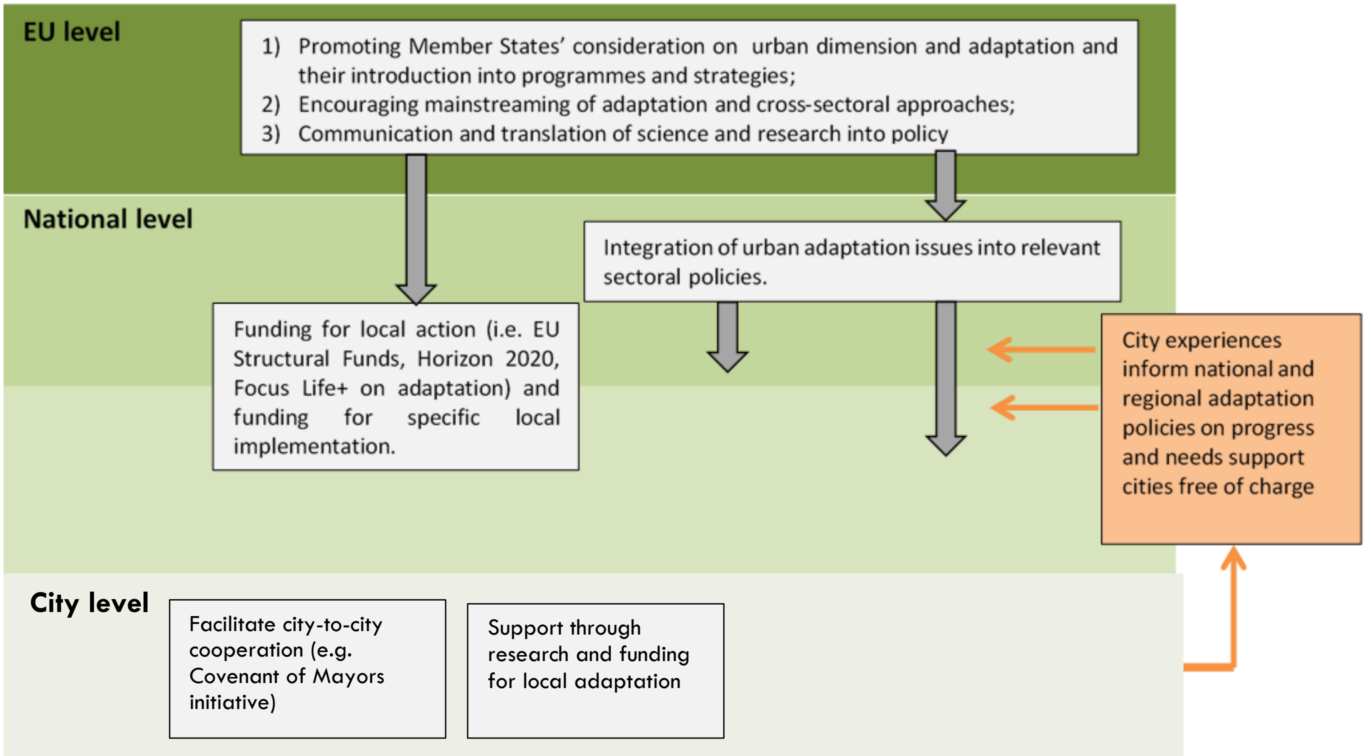
Although the climate change impacts felt in cities are not new and that many of the required actions are known, various challenges to adaptation planning and implementation remain. While part of these challenges can be addressed easily when considering climate change adaptation in the broader context of sustainable urban development planning, still the following major challenges need specific attention:

- Cooperation and coordination challenges (Grisel and van de Waart 2011)
- Integration challenges between institutions and their typical single-purpose solutions (Suzuki et al., 2010)
- Societal challenges
- Trade-offs between technological solutions and mitigation challenges
- Learning process (Chaum et al. 2011; Spearman and McGray 2012)
- Funding

2.3 Multi governance and urban planning in climate change adaptation

As already mentioned, mainstreaming adaptation measures into urban planning requires a multilevel governance approach. It involves higher-level coordination as cities are finally nested within a legal and institutional context established by national governments and the European Union (EU). These institutional setting and the interactions between different levels of government and other stakeholders are important in inhibiting or simplifying local adaptation.

At EU level, coordinated adaptation measures and trans-national connections provide a common strategic approach and a supportive policy framework. Moreover, the EU level provides financial instruments to urban adaptation mainly through it cohesion and structural funds, while the INTERREG and URBACT programs raise awareness about regional and local climate impacts.



Source: Adapted from EEA (2016)

FIG. 1: The multilevel governance structure for urban adaptation in the eu

To facilitate adaptation, the EU has provided advice and a framework for action through the 2013 EU Adaptation Strategy. It recognizes that the urban context is particularly vulnerable to climate change because "three quarters of the population of Europe live in urban areas, which are often ill-equipped for adaptation and are exposed to heat waves, flooding or rising sea levels" (EC 2013a). In order to achieve the strategic objective of 'Promoting action by Member States' at the city-level, the Commission is providing LIFE+ funding to support capacity building and step up adaptation, and introducing adaptation in the Covenant of Mayors framework as a direct incentive for cities to engage with adaptation. Lastly, the city level dimension is stressed in the 'Better informed decision-making' objective, (Blue AP project, ended in 2015, focused on Bologna, represents a good example of this financial instrument).

Another financial instrument provided by the European Commission to promote climate change adaptation, risk prevention and management, is the European Regional Development Fund (ERDF), that allowed Helsinki to carry out the Climate-Proof City project, ended in 2014.

As a matter of fact, the overall European framework gives to local authorities an "implementing" role of "place-based" adaptation measures; while at the European level is given only a "supporting" role (EEA 2012). In other words, while cities and regional administrations establish grey and green infrastructures and soft local measures, national and European policy frameworks enable or speed up local adaptation, making it more efficient (RICARDO-AEA 2013). Although this general framework at the EU level, actions are mainly at the national level and eventually at the very local level. Each EU country should set up a National Adaptation Plan (NAP) and Strategy (NAS) to frame the issue of adaptation to climate change;

however, there is no uniform behaviour in terms of which national strategies governments have put in place to adapt at the urban level.
While nearly all EU Member States adopted a NAP, the inclusion of urban adaptation into countries' legal framework is scattered among countries. No legally binding framework is in place in Austria, Italy and Spain. Each of these countries does not translate the prescriptions of the NAP into a specific binding law but they mainly rely on the existing legal framework. On the other hand, in the last few years many countries, such as Czech Republic, Denmark, Finland, Ireland, and Sweden, adopted specific Spatial Plans which address, among other issues, climate change adaptation at the urban level. Most of these plans directly consider specific sectors. For instance the Finnish Plan remarks the role of local communities with respect to storm-water.
National governments are the crucial link between the city level and the EU. They provide a strategic framework where to frame local actions and strategies. Moreover, the national level provides a climate-proof national legislation ensuring that national policies are also coherent and supportive for local adaptation. Finally, it supports and enables local and regional actions, providing background information and regional climate data, scenarios and assessments.
Despite this collaborative multilevel governance in the EU, adaptation in the urban context involves other stakeholders. National City Networks (i.e. in Denmark, Finland, Hungary, Italy, Romania, Spain, Sweden and UK) coordinate and promote local actions, providing technical advises, case studies, tools and information to cities about climate change risk and vulnerabilities and impacts for public services and local communities. But also the private sector could be involved in the local adaptation initiatives as well. There are few cases. The Austrian energy association of the region of Oberosterreich provides suggestions and information on how to deal with heat waves and increasing temperatures. Several non-governmental organizations, market players and their association participate to the London Climate Change Partnership, which gathers institutional actors with the private sector to support the city planning (VATI 2011).
In the next section, a focus on how Bologna and Helsinki developed their own adaptation planning strategies is provided.

2.4 Bologna and Helsinki Climate Change Adaptation and Resiliency planning

Bologna

As many European cities, the City of Bologna1 has already started to tackle climate change through a systematic multi-level process. The city drafted its strategy to adapt to climate change starting from a deep analysis of its multi-decadal climate observations.
Through this analysis, the City of Bologna has reported a series of impacts of climate change at the local scale. The urban area appeared located in a vulnerable climatic area and its major critical elements are (i) draught and water shortage, (ii) heat waves, and (iii) extreme hydro-climatic events and related flood risk.
According to the climate change assessment, the intensity and duration of summer draught spells will be exacerbated, thus worsening the water problems already registered today. Indeed the aqueduct, the old channels and the reclamation network are fed by a single river, the Reno, whose natural flow in the summer is quite limited.

[1] http://www.urbancenterbologna.it/en/climate-change

Concerning heat waves in urban areas, future scenarios points to an average temperature increase by 2°C, with stronger anomalies during the summer and a consequent increase of heat waves. The urban built density was found as a main determinant of heat waves in large urban areas which can be contrasted through strategies to increase the number of green areas available to the population, from large sub-urban parks to trees in the streets and small green buffer spaces.

Concerning the hydro-geological risks due to extreme weather events, the analysis for the period 1951-2011 highlighted an increase in the number of days with intense precipitations, also predicting this trend to continue in the coming years. Because of the geographical and topographical characteristics of the Bologna area, the adopted local projections show that climate changes will increase the vulnerability of the drainage systems in the city and the surrounding hills, thus increasing the already existing risk of floods and landslides. An element of disadvantage, which causes the system to be quite vulnerable, is the low permeability characterizing 50% of the municipal territory that prevent rainwater to infiltrate the soil. Even for this type of climate-related risk, the creation of green infrastructures meant to retain rainwater is envisaged to enhance the role of natural bio-systems by increasing the urban and sub-urban hydrological response.

The frequency and increasing intensity of anomalous climate phenomena experienced in the recent years convinced the city government to undertake strategic policies on prevention. This has been pursued with the development of a comprehensive climate strategy organized in two integrated climate plans dealing with mitigation and adaptation.

Between 2011 and 2015, the Bologna Municipality designed two main tools to define and coordinate viable environmental policies.

The Sustainable Energy Action Plan (SEAP) was approved at the beginning of 2013, followed by Bologna's early adoption of Covenant of Mayor in 2014 and Bologna Adaptation Plan (BAP) approved by the City Council in October 2015. The BAP is the result of the LIFE+ project (LIFE11 ENV/IT/119) named BLUE AP (Bologna Local Urban Environment Adaptation Plan for a Resilient City) funded by the European Commission, and also came as a concrete output of the commitment approved by the City Council on June 2014 for the Mayors Adapt initiative.

In the lack of any national or regional adaptation action plan in place, the City of Bologna undertook its own adaptation route by drafting an Adaptation strategy directly based on the European guidance documents.

The plan focused on the development of innovative, locally tangible measures targeted to make the city less vulnerable to the consequences of climate change. These measures were defined as part of the BLUE AP project in partnership with Kyoto Club, Ambiente-Italia and ARPAE Emilia Romagna (Regional Agency for Environmental Protection). Therefore a package of integrated actions, defined "pilot actions", have been launched: drinking water saving and water treatment; collection and storage of rainwater; targeted use of plant species to improve the microclimate and reduce air pollution; pre-emptive insurance against risks.

The Plan consists of a local Strategy and an Action Plan that translates these strategies into measures. Strategy and Plan make reference to a medium-term frame that takes 2025 as the year of achieving goals.

Since the very design of the Strategic Document2, a high focus was devoted to detecting actions tasked to the local administration and those that must be taken care of at metropolitan, regional or even national level. Therefore, the Adaptation Plan was built with a participatory process of collaboration with actors of plan strategies. The various pares involved in the path belong to public bodies, public and participative

[2] http://www.urbancenterbologna.it/collane-editoriali-urban-center-bologna

enterprises, universities, facilities managers, multi-utilities, consortia, trade associations, consumer associations, environmental associations and the protection of land, businesses, foundations.
The results have been assessed together with the Scientific Board of the BLUE AP project and validated by the Board. The Scientific Board was coordinated by CMCC and composed by representatives of scientific and research institutions and universities.
The BAP can be considered a good practice for results achieved not only as planning instrument, but also as a concrete collaborative action plan of the City which represent an example for the cities sharing with Bologna climate conditions, urban and social environment. As such, the structure of the plan can be replied in other medium-size cities, as well as some actions which are more suitable to their uses and needs.
As next step, the actual implementation of the BAP measures has been undertaken involving the European Investment Bank (EIB). As the EU Bank, the EIB supports the transition to a low-carbon and climate-resilient economy. In its Climate Strategy (approved in 2015) the EIB committed to ensuring that at least 25% of total annual lending goes towards Climate Action (35% outside the EU by 2020). As part of a pilot initiative, the EIB is providing funding for Technical Assistance (TA) to support Climate Change Adaptation and Resilient Cities. The City of Bologna together with Newcastle upon Tyne (UK) have been selected within the scope of the TA funding for their active commitment on climate change resilience.
Starting from the relevant projects already identified within their urban development plans, the TA provided by the EIB aimed to better address these projects in targeting the unavoidable climate impacts and their economic, environmental and social cost.
For the Bologna pilot case the EIB commissioned the ATKINS consultancy and its local partner (the Italian sme IRIDRA) to work closely with the Municipality to identify viable climate change adaptation options to enhance the resilience of the cities. Since November 2016, ATKINS has been supporting the Municipality in reviewing existing strategies, masterplans, feasibility studies and Climate Risk and Vulnerability Assessments (CRVA) with the objective of identifying viable climate adaptation options.
Two selected options have been proved by the TA team to be targeted solutions to existing climate risks and to have a high potential for effectively improving the resilience to climate change adaptation. In March 2017 the TA team presented to the local stakeholders the progress of the work done with the Municipality of Bologna, discussing the potential climate change adaptation measures/solutions for the two selected projects in the City (e.g. Water Channel network and Lazzaretto new urban development). One of the aims of this workshop was to discuss how to prioritize the solutions and developed guidelines and design criteria. After the workshop, a new “call to action” was launched for the implementation of “Bologna resilient city” and more than fifty new proposals were submitted and shown during thematic round tables. Some the proposed actions are going to be inserted in the plan after an evaluation about their consistency with the goals set in the BAP.

Helsinki

The Finnish capital region consists of four cities: Helsinki, the capital of Finland, Espoo, Vantaa and Kauniainen. They are distinct municipal and political entities; but collaborate in certain issues, most notably in waste and water resources management through a joint municipal body called Helsinki Region Environmental Services Authority (HSY). The case study city in EU-MACS is Helsinki, not the entire capital region, although some climate change adaptation aspects, such as commissioning of studies, is coordinated by HSY. HSY published a climate change adaptation strategy for the entire Helsinki metropolitan area in 2012. The strategy was prepared in close cooperation with the region’s cities, regional authorities and other regional actors. The strategy was backed up by studies on regional climate and sea level scenarios, modelling of river flood risks and a survey of climate change impacts in the area. The strategy concentrates on the adaptation of the built and urban environment to the changing climate.

The city of Helsinki has also been active in developing its climate change adaptation guidelines and measures, which are based on the adaptation vision, describing what a climate-proof Helsinki will look like in 2050. The vision 2050 states that

"Helsinki is a climate-proof and safe city. Helsinki has adapted to the changing climate well in advance, and is prepared for extreme weather events and global impacts of climate change. Helsinki has integrated climate change adaptation into city planning and is continuously developing its adaptation activities. Economically most advantageous measures in the long run are evaluated. The city promotes adaptation business opportunities by providing an environment where it is easy to experiment and implement solutions that promote adaptation. Helsinki is known as an international leader in adaptation."

Adaptation related plans and programmes throughout the years have been:

- Storm water strategy 2007, Storm water risk areas report
- Flood strategy 2008
- Guidelines for maintenance of forests and green areas 2009
- Helsinki metropolitan area adaptation strategy 2012
- Contingency plans to secure the energy supply system 2010
- Action plan for a sudden deterioration of air quality in the Helsinki Metropolitan Area 2010
- Survey of adaptation measures in building and maintaining public spaces 2010
- Green roof strategy 2016

In 2017, Helsinki adopted so called adaptation guidelines, which act as the official strategy document of the city in guiding adaptation. The four adaptation themes in the guidelines are preparedness, integration, development, as well as economic advantage and business opportunities.

Each theme includes priorities for the next two four-year city council terms, and concrete actions for the current council for 2017-2021. The priorities for the four themes are as follows:

Theme 1. Preparedness For Extreme Weather Events

- Risk mapping
- Planning and construction
- Instruments
- Management of abnormal situations
- Preparedness and awareness of global impacts

Theme 2. Integration

- Adaptation is integrated into Helsinki's activities and management system
- Integrated stormwater management in planning
- Mitigation of undesired impacts of land use change

THEME 3. Development and know-how

- Adaptation to climate change as part of management in the city of Helsinki
- Education and communication
- Helsinki leading the way
- Research & Development

- Collaboration

Theme 4. Economic Efficiency And Business Opportunities

- Adaptation is part of the city's development and business collaboration
- Helsinki acts as a testbed for experiments and innovations for Smart & Clean solutions
- Developing the assessment of economically most advantageous measures in investments

2.5 Final remarks

The experiences reported for Bologna and Helsinki demonstrate that no single, easily generalizable approach to urban adaptation planning does exist, thus, this magnifies the central role of local governments to addressing the challenges of adaptation planning and implementation in close partnership with the public, low-income groups, civic and private sectors.

From the analysis of the two case studies, as well as demonstrated in many examples of cities that have adopted ambitious policy agendas (EEA, 2017), it appears evident that the key elements to reach an effective climate change policymaking actions at the local scale have been identified as:

- good governance;
- presence of national programs facilitating local action;
- democratic and participatory nature of institutions;
- cities' competences and authority to regulate climate-relevant issues;
- the commitment of cities to take climate action, including the presence of a local champion;
- availability of economic resources, and
- knowledge and information, for example via the involvement of cities in national and transnational networks facilitating the exchange of experience (Alber and Kern 2008 and Martins and Ferreira 2011).

These key elements are mostly interdependent and follow good politics principles. Therefore the weakness of one of these key elements, often brings to the vulnerability of the entire process involving a complex system, lowering performances, reducing adaptability or information gathering (e.g. Carley, 2005). Section 4 describes the results of a detailed institutional analysis carried out in the two EU-MACS case studies. The main aim of this analysis was to better understand how the different actors perceived their roles in the above mentioned adaptation planning framework. It also analyses the way the different elements forming the collective process at the basis of the urban adaptation interact each other. Key vulnerabilities of the interaction network are then addressed.

It is also important to notice that the main issue with climate change adaptation planning in cities remains more about implementation.
According to Cortekar (Cortekar et al. 2016), the implementation stages in the adaptation process can be identified as in the following scheme:

- Understanding of possible impacts caused by climate change:
  - Detect problem
  - Gather/Use information
  - (Re)Define problem

- Planning:
- Develop options
  - Assess options
  - Select options
- Implementing and evaluating selected options
  - Implement options
  - Monitor option and environment
  - Evaluate.

Climate services should support the involved actors in most of the above mentioned adaptation stages. In next section, a proper use of CS, supported by successful examples, is shown.

3. CLIMATE SERVICE FOR URBAN PLANNING

As an outcome of the previous analysis, in order to be effective, climate services require appropriate engagement along with an active access mechanism and must respond to user needs. Such services involve high-quality data on temperature, rainfall, wind, soil moisture and ocean conditions, as well as maps, risk and vulnerability analyses, assessments, and long-term projections and scenarios. These data and information products, due to the complex multi-purpose needs that an urban planner has to consider, may be combined with non-meteorological data.

It is thus evident that a comprehensive review of existing CS would be far about the purpose of the present study.

The following subsections, based on the analysis of white and grey literature, not intended to be exhaustive, will review the major providers of CS and the typologies of available CS for urban planning, showing successful examples of applications. In subsection 3.1 a top-down approach is described, leading the reader to a proper use of CS. Subsection 3.2 describes CS for the awareness, since this is a crosscutting need during all the implementation stages. Subsection 3.3 reports examples of tailored CS highlighting Bologna and Helsinki cases. Finally, subsection 3.4 focuses on technical barriers hampering the mainstreaming of CS in urban climate change adaptation.

3.1 Preparing the ground for adaptation through CS

As described in section 2, in order to undertake any best practice to adapt cities to climate change, urban planners have to manage a very complex system: understanding CC projections, gather and use climate information, CC possible impacts, define the problem. This can be supported by the use of CS.

Such a multifaceted knowledge can be reached starting from the understanding of what to expect from a CS and how to tailor it to specific needs, also looking at what has been done worldwide.

As initial step, it can be useful for urban planners to understand how climate service works and how coordinating bodies support the uptake of climate information suggesting ad hoc solutions and providing successful examples of their application.

The **Global Framework for Climate Services** (GFCS)3 provides a worldwide mechanism for coordinated actions to enhance the quality, quantity and application of climate services. It focuses in five priority areas, among which '*Disaster risk reduction*' *and* '*Health*' can better address the needs of urban planning. GFCS has five main components:

- A User Interface Platform to provide a means for users, user representatives, climate researchers and climate service providers to interact;
- A Climate Services Information System to protect and distribute climate data and information according to the procedures agreed by governments and other data providers;
- An Observations and Monitoring component to ensure that the climate observations necessary to meet the needs of climate services are generated;
- A Research, Modelling and Prediction component will assess and promote the needs of climate services within research agendas;

[3] https://www.wmo.int/gfcs/

- A Capacity Building component to support systematic development of the necessary institutions, infrastructure and human resources.

Several platforms have thus been created to sharing learning and opinions on challenges, opportunities and innovations; identifying and mapping current activities, stakeholders and information needs; fostering links and collaborations at research and project level and beyond, including internationally; tackling barriers and disconnects; supporting capacity building and growing capacities.

The Climate Services Partnership4 is an example where to find, among others, case studies focused on urban adaptation measures.

At European level, the Copernicus Climate Change Service (C3S)5 is one of the six thematic services provided by the European Union's Copernicus Programme. The Copernicus Programme is managed by the European Commission and the C3S is implemented by the European Centre for Medium-Range Weather Forecasts (ECMWF) and is expected to become operational in 2018.

The objective of the Copernicus Climate Change Service is to build an EU knowledge base in support of mitigation and adaptation policies for Climate Change and Global Warming. The goal of the operational Climate Change service is to provide reliable information about the current and past state of the climate, the forecasts on a seasonal time scale, and the more likely projections in the coming decades for various scenarios of greenhouse gas emissions and other Climate Change contributors. It arranges its services in Sectoral Information, where 'Health + Infrastructure' is the one addressed to urban planning. At the moment one proof of concept project (Urban SIS6, with Bologna as one of the case studies) is working with this sector to develop the C3S so that it meets the needs of these users.

The Copernicus Climate Change Service is still in the development phase and, in addition to national capabilities, will capitalize on a series of earth observation projects.

In the near future, the service will be also be supported by data and products from the Sentinel satellites. All missions will contribute to building comprehensive, long-term datasets of some of the essential climate variables.

Policy makers will gain a wealth of reliable information to help them better quantify the risks and opportunities linked to climate change and thereby better plan future climate policies supporting improved quality of life for European citizens. As example, a conceptual list of indicators for Urban Planning and Management is well described by (Chrysoulakis et al., 2014).

Within the European scenario, a very useful climate service platform is Climate-Adapt7. The European Climate Adaptation Platform (CLIMATE-ADAPT) is a partnership between the European Commission (DG CLIMA, DG Joint Research Centre and other DGs) and the European Environment Agency.

CLIMATE-ADAPT aims to support Europe in adapting to climate change. It is an initiative of the European Commission and helps users to access and share data and information on:

- Expected climate change in Europe
- Current and future vulnerability of regions and sectors
- EU, national and transnational adaptation strategies and actions

[4] http://www.climate-services.org/
[5] https://climate.copernicus.eu/
[6] https://climate.copernicus.eu/urbansis-climate-information-european-cities
[7] http://climate-adapt.eea.europa.eu/

- Adaptation case studies and potential adaptation options
- Tools that support adaptation planning

FIG. 1: European Climate Adaptation Platform

CLIMATE-ADAPT organizes information under the following main entry points:

- Adaptation information (Observations and scenarios, Vulnerabilities and risks, Adaptation measures, National adaptation strategies, Research projects)
- EU sector policies (Agriculture and forestry, Biodiversity, Coastal areas, Disaster risk reduction, Financial, Health, Infrastructure, Marine and fisheries, Water management)
- Transnational regions, Countries and Urban areas
- Tools (Adaptation Support Tool, Case Study Search Tool, Map Viewer)

Its section dedicated to urban adaptation is full of indicators, publications & report, and tools. It supports user to identify needs, measures and stakeholders involvements to be considered, especially in the adaptation that is a complex, multi-issue and multi-level decision-making area and as such requires a certain set-up to ensure success, consistency and continuity. Several case studies show how climate services have been used or created ad hoc for specific municipalities, providing interesting clues to identify adaptation options.

All the most important climate service providers are at least mentioned in the Climate-Adapt platform, since their climate services are the first key to assess risks and vulnerabilities to climate change. Nowadays it is possible to find in all of the major National Climate, Meteorological and Hydrological Service Centers a good starting point for a first survey of available CS. The majority of the entities (public and private) dealing with climate changes, have a specific section dedicated to Climate Services, organized, for instance, for typology of hazard.

In 2012, a first effort to review some of the most relevant activities carried out by the existing Climate Services Center and Consulting Agencies and of their main products and services, was conducted by CMCC (Medri, Banos de Guisasola, & Gualdi, 2012), in the framework of GEMINA project. The encompassed activities range between observations and research, generation and provision of information systems, maps, guidance and management tools (based on past, present and future climate and its impacts on natural and human systems) and advice on climate change related issues (for managing the risks and making use of opportunities for mitigation and adaptation).

For instance, the ECMWF8 provides a rich catalogue with operational, climate reanalysis and real-time data specialized on atmosphere and oceans. The MET Office UK9, as well as the Finnish Meteorological Institute10 have their own CS products, providing climate projections and impact research on several topics, such as transport, energy, water, public sector, rural and coastline. The American Association of State Climatologists11, lists 91 products (mainly thematic maps), categorized by the region that the item is relevant for.

Within these providers websites, the concept of climate services is mostly used to refer to the provision of and accessibility to climate information (Goosen et al., 2014); (Hewitt, Mason, & Walland, 2012); (Vaughan & Dessai, 2014), while not all of them provide climate impacts contingent on various societal and geographical factors (i.e. vulnerability and exposure), which vary significantly across locations (IPCC, 2014). In order to support municipalities, several private companies offer their consultancy, also developing tools to assess adaptation measures effectiveness, or to analyze the cost-benefit ratio of the adopted actions.

The Urban Climate Service Centre12, as well as the Climate-Expert Website13, or Atkins group14 are independent research and technology organization in the areas of cleantech and sustainable development, elaborating solutions for the large societal challenges of today. This kind of consultancy agencies help cities to cope with the challenges by means of various urban climate services, such as urban climate assessments; short-term forecasts; future climate projections; adaptation scenarios and impact assessments. The Atkins group, for example, is providing Bologna municipality technical assistance to support climate change adaptation measures. Deltares, for instance, developed an Adaptation Support Tool (AST) to support the collaborative planning of such adaptation measures for a more resilient and attractive environment. The AST can be used in design workshops by urban planners, landscape architects, water managers, civil engineers, local stakeholders and other experts to create conceptual designs.

[8] https://www.ecmwf.int/en/forecasts/datasets
[9] http://www.metoffice.gov.uk/services/climate-services/climate-service-uk
[10] http://en.ilmatieteenlaitos.fi/climate-service-centre
[11] https://www.stateclimate.org/climate_services_catalog
[12] http://www.urban-climate.be/
[13] http://www.climate-expert.org/en/home/
[14] http://www.atkinsglobal.com/

FIG. 2: Adaptation support tool by Deltares

The U.S. Climate Resilience Toolkit provides several tools, as a guide to assessing green infrastructure cost and benefits for flood reduction, as well as an adaptation toolkit to sea level rise.

The United States Environmental Protection Agency (EPA)15 has developed an entire bucket of tools related to Climate Change and Water, such as the National Stormwater Calculator (SWC) that is a desktop application estimating the annual amount of rainwater and frequency of runoff from a specific site anywhere in the United States. Or the Storm Water Management Model (SWMM), used throughout the world for planning, analysis, and design related to stormwater runoff, combined and sanitary sewers, and other drainage systems in urban areas, designed to be used by anyone interested in reducing runoff from a property, including site developers, landscape architects, urban planners, and homeowners.

The STAR tools16 allow users to assess the potential of green infrastructure in adapting their areas to climate change. They include a surface temperature tool and a surface runoff tool. Outputs of the STAR tools can be used to inform policy, strategy, and development. They are of use to a range of professionals and organizations with an interest in understanding more about the influence of urban greening on their local climate. This includes planners, developers, master-planners, local authorities, urban forestry initiatives, NGOs and academics.

Again, the Green Infrastructure Valuation Toolkit, provides a set of calculator tools, to help assess an existing green asset or proposed green investment and translate findings into a business case:

- in monetary terms - applying economic valuation techniques where possible;
- quantitatively - for example with reference to jobs, hectares of land, visitors;
- qualitatively – referencing case studies or important research where there appears to be a link between green infrastructure and economic, societal or environmental benefit.

Climate services can be provided also by reinsurance companies, or entities not really specialized in the research or urban planning sector. WilliRe17 helps reinsurance companies to anticipate how their market will evolve in response to climate change, and specifically provides risk modeling expertise, capital market

[15] https://www.epa.gov/climate-change-water-sector/climate-change-and-water-tools
[16] http://maps.merseyforest.org.uk/grabs/
[17] http://www.willisre.com/

solutions, actuarial services, and reinsurance design. World Bank18 has a section on urban risk assessment that brings convergence to related work undertaken across the World Bank and key partner organizations. On this website the CURB Tool (Climate Action for Urban Sustainability) is available. The City Performance Tool (CyPT), by Siemens19 is an interactive and comprehensive tool, adopted, among several cities, also in Helsinki giving a guidance to a city on how to achieve their environmental targets while providing an indication on how each infrastructure-related decision will influence job creation and the infrastructure sector growth.

3.2 CS for the awareness of citizens

Awareness raising for behavioral changes, together with knowledge creation, supports all other capacity-building activities, as well as planning, implementing and monitoring adaptation. CS can also address this need since not all stakeholders are aware and informed about their vulnerability and the measures they can take to pro-actively adapt to climate change. Awareness raising is therefore an important component of the adaptation process to manage the impacts of climate change, enhance adaptive capacity, and reduce overall vulnerability.

Although awareness raising is often considered to be important at the first stages of the adaptation process, research shows that levels of awareness fluctuate through time under the influence of external variables20. For example, the Al Gore movie ‘An Inconvenient truth’ (2006) and IPCC Nobel Peace Prize has a positive effect on the public awareness whilst the 2011/2010 cold winters in Europe, the minor IPCC errors and CRU (Climate Research Unit) emails have negatively influenced public acceptance of climate change and increased public skepticism. Therefore, raising awareness is not only important at the first stages of the process but is integral throughout the process to maintain and increase the general level of awareness.

Local adaptation policies and planning should create conditions that foster autonomous adaptation at private household level and provide public adaptation when autonomous adaptation is insufficient or fails to take place (IPCC, 2001; Stern, 2007; Wamsler, 2016). Consistent with this idea, distributed risk governance systems and city–citizen collaborations are attracting increasing interest (IPCC, 2014; UNISDR, 2015). The basic tenet is that citizens (either as individuals or in groups) can, and should, play an important part in assessing and managing environmental risks to increase resilience (Gausset and Hoff, 2013; Kuhlicke et al., 2011; Tompkins and Eakin, 2012; UNISDR, 2015). This is based on the understanding that no single actor has the capacity to control everything, and all actors need each other to support their actions (Gausset and Hoff, 2013). This is notably the case in the context of climate change, where the effectiveness of institutional responses to ‘common’ hazards is being increasingly undermined. Furthermore, it is not clear to what degree citizens’ needs and their capacity for climate change adaptation have already been taken into account in urban planning practice and policy frameworks, and what are the drivers or barriers to change.

There are various forms of media, through which specific messages can be communicated as well as different target audience to reach. Besides traditional media such as television and journals, internet, and connected social media, constitutes, nowadays, the most efficient tool to disseminate knowledge and information and, at the same time, to intercept citizens expectations.

Awareness raising CS can be thus developed as simple dissemination webpages, social media groups (newsletters, Facebook, Twitter, ect.), webgis, webseries, as well as board games.

[18] http://www.worldbank.org/en/topic/urbandevelopment/publication/urban-risk-assessments

[19] https://www.siemens.com/global/en/home/company/topic-areas/intelligent-infrastructure/city-performance-tool.html

[20] http://climate-adapt.eea.europa.eu/metadata/adaptation-options/awareness-campaigns-for-behavioural-change

Besides classical websites based on the dissemination of climate information21,22, in order to promote an active participation from citizens, Inhabitat23 can be considered an interesting CS. It is a weblog devoted to the future of design, tracking the innovations in technology, practices and materials that are pushing architecture and home design towards a smarter and more sustainable future. Interesting hints can be found for citizens, urban planners, landscape architects and building companies, providing examples of smart adaptation and sustainable measures around the world. Among several news, it is possible to find useful climate services, as the Chicago Green Roof initiative24, a tool for building green roof in Chicago that helps user to choose the best option for its own green roof, with a cost-benefit analysis, a list of providers, a list of plants, and a direct link to obtain a permit from the Department of Construction and Permits.

An example of webgis CS is DisasterAWARE25 that continually 'listens' to trusted hazard data sources, and integrates impact modelling, risk exposure and a host of other information to deliver web- and mobile-accessible mapping and geographical information service capabilities to the public and disaster managers worldwide. One significant application of this CS has been made for the urban risk assessment in Marikina City, Philippines, where, by working with the city's Mayor and numerous stakeholders, it was possible to identify and map areas most susceptible to flood and earthquake hazards.

FIG. 3: Disaster-aware web-based GIS interface

21 https://weather-and-climate.com
22 www.actionclimate.today
23 http://inhabitat.com/
24 http://www.saic.edu/webspaces/greeninitiatives/greenroofs/main.htm
25 http://www.pdc.org/solutions/products/disasteraware/

Climate City26, a global system dedicated to devising strategies for coping with local climate risks in the world's major cities has developed a web series to help raise awareness of urban climate change issues.

In addition, several tools have been developed to increase decision makers' awareness (see for examples the online tools on the UKCIP27 website) and public awareness.

As example, Keep Cool28, created by two scientists from the Potsdam Institute for Climate Impact Research, is a board game that promotes players to influential representatives of superpowers, continents or developing nations. The players must balance their own economic interests with the needs of the environment in a game of negotiation. Similarly, Plan it Green29, where gamers act as the planners of a city to revitalize it to become a greener town through energy retrofits, clean energy jobs, and green building.

Large climate change awareness raising campaigns are often a mixture of mitigation, energy efficiency, and sustainability measures rather than adaptation measures. For example, the campaign 'You Control Climate Change ' (2006) of the European Commission aims to inform individuals about climate change, initiate pro-active dialogues, and aims for (small) behavioral changes without affecting individuals' everyday life by giving them a sense of empowerment and personal responsibility.

3.3 Tailored Climate Services

The majority of CS reviewed can be immediately used by city planners for a preliminary assessment. Nevertheless, there are no one-size-fits-all-solutions since cities are complex networks with very specific framework conditions in many aspects such as location, urban climate, population density, financial and human resources, and stakeholder interests. To transfer a measure or strategy that was specifically designed for a given framework to another city, much meta-information is needed. Moreover, adaptation measures that result from research projects often receive funding for the development, which other cities may not have. Thus, developed measures are only rarely implemented due to limited project durations and financial constraints.

A good example of support to adaptation in urban areas is the EcoCities30 project, an interdisciplinary research focused on the concept of building adaptive capacity to help cities to develop skills, knowledge and expertise necessary to adapt to the impacts of climate change. During the project a spatial portal has been implemented to assess Greater Manchester's (UK) vulnerability.

In New Zealand, the collaboration between Westcoast Regional Council, Buller District Council, Wellington City Council, Greater Wellington Regional Council, Auckland Council, Christchurch City Council, and Environment Canterbury Regional Council ended up with the development of the Urban Impact Toolbox31, showing, in Westport, how physically-based climate, hydrological and hydrodynamic models can be used together to simulate changes in meteorological and hydrological processes under future climates, and how the effect of those changes on projections of flood inundation and risks to people and assets can be evaluated.

Within the Future-Cities project32, the Adaptation Compass toolkit has been developed. It applies a pre-structured assessment and documentation layout, enabling the user to plan the stages to create climate

[26] http://www.climatecityoperator.com/
[27] http://www.ukcip.org.uk/
[28] http://www.climate-game.net/?lang=en
[29] http://www.nationalgeographic.com/plan-it-green/
[30] http://www.ppgis.manchester.ac.uk/ecocities/
[31] https://www.niwa.co.nz/climate/urban-impacts-toolbox
[32] http://www.future-cities.eu/

proof cities with a vulnerability check; a module to understand climate change effects; an assessment of risks and opportunities method; a module to explore adaptation options; a need for action module; and examples for monitoring the results of measures. Nevertheless, Adaptation Compass, as well as the Adaptation Wizard tool from UK Climate Impacts Programme (UKCIP)33 or the BalticClimate toolkit34 need several local information that can be obtained only by an interdisciplinary approach, in order to produce a tailor-made climate services to support adaptation strategy.

Within this framework, Bologna and Helsinki are very active cities in terms of climate change adaptation. This is demonstrated by the numerous initiatives promoted by the two municipalities. Both of them are spending much attention to raising the awareness of citizens through public workshops, calls to action, websites to share information, and involve actively the population in the decision process with reference to climate changes (visit www.urbancenterbologna.it and www.hel.fi, where it is possible to find news on planned events, maps and other kind of useful data).

The main CS providers for Bologna and Helsinki are, respectively, ARPA Emilia Romagna35 and Finnish Meteorological Institute36. They are the key actors in developing local climate scenarios and participating in almost all climate driven projects.

In particular, in Bologna, local climate condition data and future scenarios have been collected and processed by ARPA in the Local Climatic Profile (PCL), a tool which analyses climatic variability in great detail in order to define and implement the adaptation strategies for the City of Bologna, by interpreting the impact scenarios as risks and opportunities alike.

For the purposes of heatwave risk prevention, for example, the City of Bologna in bundle with ASL, ARPA, the Civil Defence, Social and Healthcare Services, associations and volunteers, created a prediction and local warning service mainly targeted at the elderly, either living alone or in groups, and other particularly exposed demographics. One of the main strategies to mitigate the effects of heat waves in large urban areas is to increase the number of green areas available to the population, from large periurban parks to trees in the streets and small green buffer spaces, which became the target of the follow up GAIA initiative. GAIA is a project financed by the Life+09 European Fund, and coordinated by the Municipality of Bologna, that, among other projects, contributes in the mitigation of heat island effect and the reduction of greenhouse gas emissions at the local level through the creation of a partnership between Municipality and companies to plant trees throughout the municipal area. The realization of this partnership will also make possible the implementation of an innovative system of environmental governance that links companies and Municipality to improve the global quality of the urban environment.

More focusing on the creation of more effective CS, the ongoing project Urban SIS (Climate Information for European Cities) is funded by Copernicus which has Bologna as case study. The goal of the project is to provide a proof-of-concept of a service offering Essential Climate Variables (ECV) and impact indicators based on temperature and other climatic variables together with air pollutant concentrations. Related to urban heat risk, impact indicators of relevance for the health sector will be analyzed in comparison to the expected changes in the infrastructure of Bologna and the evolution of its population. ARPA will assess the impact of local climate changes on health sector by calculating specific indices such as heat wave duration and Thom index. The Urban SIS data and those provided by the statistical downscaling models developed

[33] http://www.ukcip.org.uk/wizard/
[34] http://www.balticclimate.org/en/project/toolkit
[35] www.arpae.it
[36] En.ilmatieteenlaitos.fi

by ARPA will be taken into account. In addition, the model ENVIMET will be applied to identify synergic effects of heat waves and heat island phenomena in test areas over the town of Bologna.

In Helsinki, adapting to climate change, is mainly carried out through local operations and most of the adaptation measures are covered by cities' jurisdiction. Helsinki has been active in developing innovative measures to reduce the impacts of extreme weather events and climate change. For instance, the use of green infrastructure and particularly an innovation in the Finnish context, green roofs, has been promoted as an adaptation measure in an increasingly densely populated city. Helsinki has developed a Green Factor Tool37 to be used in urban planning, which calculates the ratio of the scored green area to lot area. The idea behind the use of the factor is to "mitigate the effects of construction by maintaining a sufficient level of green infrastructure while enhancing the quality of the remaining vegetation". The Tool is excel-based and it is based on compiling best practices of existing international green factor approaches and tailoring the tool for Helsinki.

A new development area Kuninkaantammi in northwestern Helsinki acts as a pilot project for the Helsinki Storm Water Strategy38. The solutions planned to be used are relatively new in Helsinki. For instance when planning the Kuninkaantammi residential area, various solutions will be presented for utilizing, absorbing and delaying storm waters, before leading them to the two rivers through ditches.

The Climate-Proof City (ILKKA) Project, funded by ERDF, was coordinated by the City of Helsinki and other members of the consortium were Cities of Lahti, Turku and Vantaa, Helsinki Region Environmental Services Authority (HSY), Finnish Meteorological Institute and the University of Turku. The goal of the project was to create planning tools and instructions about climate-proof planning for urban planners and construction and landscape industries.

In addition to the planning tools best adaptation practices in Finland and abroad were surveyed. The results are presented in the planner's workbook and in Climate Guide– web portal. The long-term goal of the project was the development of climate-proof planning procedures and growing knowledge of city officials and decision-makers.

BaltCICA – Climate Change: Impacts, Costs and Adaptation in the Baltic Sea Region project, ended in 2012, was designed to focus on changes in precipitation and flood patterns as well rising sea level affecting not only the built environment but also water availability and quality. In this context HSY developed adaptation to climate change options for the Helsinki Metropolitan Area carrying out climate change scenarios, possible impacts of climate change with a focus on built area, urban environment and coastal areas and possible adaptation options.

This brief review of tailored CS reveals how a clear objective in the decision making strategy contributes to develop an effective and useful service. Moreover, it is also clear the key role that the European Union covers funding projects that, for their own interdisciplinary character, produce locally targeted results also addressing CS development to actual community needs.

3.4 Barriers

Barriers to adaptation are deeply explored in the literature from the context of social actors and, more specifically, from the context of actors from government agencies (Eisenack et al., 2014). In particular, based on the definition proposed by Eisenack et al., (2014), barriers to adaptation are defined as obstacles to specified adaptations for specified actors in their given context that emerge in the adaption

[37] http://ilmastotyokalut.fi/developing-a-green-factor-tool-for-city-of-helsinki/

[38] http://ilmastotyokalut.fi/kuninkaantammi-the-pilot-of-the-helsinki-storm-water-strategy/

process from climate and non-climate factors and conditions (which are the actor, the system of concern and the larger context). The focus lies on barriers that have a social dimension, which can be dynamic, interdependent and valued differently according to the actors. Finally, a barrier is malleable and can be overcome.

Regarding the urban sector, the literature review revealed that barriers related to the adaptation process are the dominant topics (Cortekar et al. 2016; Reckien et al., 2015; Doherty et al., 2016; etc.). Focusing more on climate services for urban adaptation, the analysis on barriers revealed only a limited attention from the literature. As reported in the EU-MACS deliverable D1.1[39], research on barriers occurring in development, provision and use of climate services is in a very premature phase. Only few reports and scientific papers directly analyze the barriers that impede the use of CS in urban planning process (Hirschnitz-Garbers & Drews, 2016; Räsänen et al., 2017).

Starting from the analysis of CS reported in D1.1, better detailed in deliverable D1.2[40] with regard to business models and in D1.3 for data policy issues, the existing barriers can be divided into 6 dominant categories, political, economic, social, technological/scientific, ethical, and legal, with 20 sub-categories.

The identified categories and sub-categories of barriers are related to the development and use of CS in general and they can be definitively applied to the urban planning sector. Nevertheless, in this specific context, barriers can be found throughout the entire adaptation process, (Cortekar et al. 2016).

Focusing on the recent literature concerning CS for urban planning, the findings were analyzed in terms of the highlighted barriers, classifying more than 50 statements. Table 1 is organized as Table 12 of D1.1, introducing four new sub-categories and reporting scientific references specific for the urban context.

Type of Barriers	Sub-categories	References
Political	*Tailored CS is hindered by the short term political cycles*	(Carter et al., 2015)
	Political focus on mitigation rather than on adaptation	(Bedsworth et al., 2010)
Economic	Insufficient human or financial resources	(Gret-Regamey et al., 2016); (Bedsworth et al., 2010); (Clements, Ray, & Anderson, 2013); (Jörg Cortekar, Bender, Brune, & Groth, 2016); (Räsänen et al., 2017); (Hirschnitz-Garbers & Drews, 2016)
	Added-value of CS often unclear / difficult to measure	(Clements et al., 2013); (Hirschnitz-Garbers & Drews, 2016); (Räsänen et al., 2017); (Robrecht & Birgit, 2014)
	Organizational setting, practices and routines	(Clements et al., 2013); (Räsänen et al., 2017)
	Dysfunctional definition or distribution of competencies and responsibilities	(EEA report No 2, 2012)
	Business models	(Hirschnitz-Garbers & Drews, 2016)
Social	Language in science and practice	(Carter et al., 2015); (Hirschnitz-Garbers & Drews, 2016); (Bedsworth et al., 2010)
	Difficulties involving different stakeholders	(Jörg Cortekar et al., 2016)

[39] See Chapter 3.5, Deliverable D1.1
[40] See chapter 2.3, Deliverable D1.2

	Differences in attitudes, priorities and expectations between providers and users	(Eliasson, 2000); (Räsänen et al., 2017)
	Understanding targeted users and their regulatory setting	(EEA report No 2, 2012)
Technological/scientific	Technical capacity	(Carter et al., 2015); (Clements et al., 2013); (Gret-Regamey et al., 2016)
	Accuracy and reliability of information	(Masson et al., 2014); (Clements et al., 2013); (Hirschnitz-Garbers & Drews, 2016)
	Inappropriate format of CS	(Clements et al., 2013); (Bedsworth et al., 2010)
	Missing standardization of information (forecast type, verification type, layout, terminologies)	(Bedsworth et al., 2010); (Carter et al., 2015); (Clements et al., 2013)
	Availability and accessibility	(Bedsworth et al., 2010); (Hirschnitz-Garbers & Drews, 2016); (Räsänen et al., 2017)
	Difficulties in transferability of tailored CS	(Räsänen et al., 2017); (Jörg Cortekar et al., 2016); (Gret-Regamey et al., 2016)
	Lack of risk assessment and decision-support tools	(Räsänen et al., 2017); (Carter et al., 2015); (Hirschnitz-Garbers & Drews, 2016); (Jörg Cortekar et al., 2016); (Robrecht & Birgit, 2014)
Ethical	Missing or limited collaboration between providers and users (co-design)	(Eliasson, 2000); (Hirschnitz-Garbers & Drews, 2016)
	Missing metadata information on data sources, methods etc. used to develop services	(Bedsworth et al., 2010); (Hirschnitz-Garbers & Drews, 2016)
	Provision is corrupted by personnel / institutional interests	(Hirschnitz-Garbers & Drews, 2016)
Legal/regulation	Reliance and/or dependence upon national policies and regulations	(Clements et al., 2013); (Jörg Cortekar et al., 2016)
Others	Conflict time-scales or priorities (short-term interventions based on a long-term vision)	(Masson et al., 2014); (Räsänen et al., 2017)

Table 1: Summary of barriers relevant to cs development, provision and use reported in urban planning literature review

Overall, this urban-specific review revealed that more than 40% of barriers belongs to the technological sector followed by the economic barriers (25%). This kind of result, which of course is not unexpected, synthesizes the main difficulty in the relationship between the CS supply and the real needs for the urban planning sector. In particular, findings on Economic aspects such as 'Insufficient human or financial resources', 'Organizational setting, practices and routines' and all the sub-categories related to Social impacts, confirm what already reported in D1.1. Moreover, the lack of accounting for user needs and capabilities in CS design and narrow conception of quality of CS, leads to a difficulty in measuring the added-value of CS itself and, as a consequence, cost-benefit analysis is hard to perform, as demonstrated similarly in D1.1 and D1.2. The main barriers, as it is possible to read in D1.1, D1.2 and D1.3, are related to technical issues, that prevents the efficient flow from science to decision-making. Even if less represented in literature, ethical and legal aspects, as well exemplified in D1.2 - Ch. 7, constitute an important part preventing from a plain development of CS implementation.

It has been noticed that, from the political point of view, municipalities are focused on mitigation measures rather than adaptation actions, implying a limited use of available CS (Carter et al., 2015). Most knowledge seems concentrated in the area of awareness raising rather than in physical adaptation planning and design, and there is a difficulty from urban planners to use climate data especially for the mismatch of time and spatial scales respect to the standard planning horizon (Dhar & Khirfan, 2017). Moreover, it has been underlined by several authors (Hirschnitz-Garbers & Drews, 2016), that municipalities need tailored CS, due to their uniqueness. Moreover, the planning system's connection to short term political cycles constrains its development for achieving longer term progressive goals (Bedsworth et al., 2010). Only few cities have adopted long term adaptation guidelines. Helsinki did this in 2017, including priorities for the next two four-year term city council.

Furthermore, developing tailored CS is a goal mostly reached by nationally and internationally funded projects, see Bologna and Helsinki cases, and only rarely implemented due to limited project durations. Since limited financial resources are a major topic for many cities, a lack of funding opportunities may prevent the next city from using CS (Cortekar et al., 2016). By the way, even if specific projects may have a strong impact in developing new and innovative CS, a tangible risk, experienced for example in Helsinki in the ILKKA project, is the difficulty of the capitalization of the results, which can be hardly integrated into existing tools that planners use (derived from interviews).

The usefulness of integrated cost-effectiveness and cost-benefit analyses to facilitate improved decision-making is often questioned (Robrecht & Birgit, 2014). A lack of international methodological consensus on how to carry out such analyses feeding into CS reduces the validity and legitimacy of possible decisions and solutions. This poses a challenge to decision-makers for credibly and robustly identifying the most cost-effective adaptation solutions at the urban scale. Even though several tools have been reviewed in previous chapters, these particular CS are not really known or are difficult to be applied due to the variety of information they require.

This introduces the last but not less important challenge for useful urban climate services: a multilevel governance in urban adaptation to climate change, which has been strongly underlined by the European Parliament and the Committee of the Regions (2017). They noted the need and urgency of new relationships between different levels of governance and different actors, as private actors, citizens and diverse stakeholders to widen answers to urban climate change adaptation. In essence, policies have to operate in a multiscale governance framework where European, national, regional and local policies need to be articulated, while accounting for other levels. Specifically within national and regional climate services, an interesting institutional model would be to host within the same climate expert centre a diversity of staff representing different disciplines and sensitivities: (1) experts in climate science able to perform, analyse, and synthesize model simulations and representing the culture of the climate science community; (2) specialists in impact, adaptation, and vulnerability, specifically economists, representing not only the academic culture but also the approaches adopted by consulting firms; (3) representatives of the corporate world with good knowledge of the culture of business in the private world; (4) representatives of public services, understanding the culture of the political world and public administration, specifically urban planners, and finally (5) social managers and communication specialists with a strategic vision and a good understanding of the specificity of the different communities involved (Brasseur & Gallardo, 2016).

The overall analysis on the two front-runner cities enables to conclude that most of the CS already developed are centred on raising the awareness of citizens, reaching their goal. Even though some of the Helsinki region municipalities have also acquired specific planning oriented CS. Nevertheless, most of the mentioned barriers where clearly detected also in both Bologna and Helsinki, especially regarding economic and technological aspects.

Apart from the study based on literature review and adaptation activities undertaken by Bologna and Helsinki municipalities, a stakeholders interview has been conducted during the workshop held in Helsinki, on June the 20th 2017.

The participants, representing the main actors involved in Helsinki adaptation process, were asked to indicate the relevance of 6 categories related to CS implementation in urban planning.

The rank was from 1 – most relevant to 6 – less relevant. Table 2 describes the obtained results

Categories of CS	Order of relevance
Awareness of climate change risks	1
Thematic maps on urban planning/climate change risk assessment	2
Assessing adaptation measures effectiveness	3
Building construction techniques	4
Cost-benefit analysis	4
Awareness of available Climate Services, new technologies, examples	5

Table 2: Order of relevance from Helsinki stakeholders analysis during 20th June 2017 workshop

Even if no explicit reference to barriers has been done during the question time, it is evident that where a need is expressed, a difficulty is intrinsically foreseen. It is interesting to notice that almost all the interviews agree that the awareness of climate change risks is the most important category to emphasize, while at the last place they choose the awareness of the available CS. This is probably due to the good work done by the municipality concerning the involvement of citizen in the climate change issue, while some ambiguity exists in the perception of what a CS is and what is its aim. A more detailed analysis on Helsinki case study will be provided in the following chapters.

A similar workshop was organized in Bologna involving the most important actors dealing with urban planning. The results of these meetings are described further in the text.

4. INSTITUTIONAL ANALYSIS AND INFORMATION SHARING FOR CS IN URBAN PLANNING: AMBIGUITY AND COMPLEXITY OF INTERACTION

4.1 Introduction

Governing urban processes aiming at adapting the urban system - i.e. a system in which four main categories of processes, such as infrastructure, built environment/planning, administration and human services, interact each other – to the effects of climate change claims for approaches capable to deal with both complexity and uncertainty. There is complexity due to the densely interconnected networks in which decision-actors operate, which span between and across ecological, economic and socio-political domains. There is also uncertainty because what other decision-actors involved in the network are going to do is largely unknown, making difficult to predict whether the choices pay off or not (Rosenhead and Mingers, 2001).

In these complex and uncertain environments, it is very difficult to determine how effective a policy will be. Part of the difficulty resides in the fact that even when a policy is targeted to regulate the behaviour of individual, actors are interdependent in performing their tasks, so any action choice will influence and be influenced by the actions choices of the other actors (Brock and Durlauf 2001).

The governance structures allowing the mainstreaming of climate change adaptation in urban planning have been extensively investigated in the scientific literature. Evidences demonstrated that, in order to be effective, strategies for coping with climate change at urban level require not only a deep understanding of the main phenomena to be addressed, but also an unprecedented level of cooperation between different levels of institutional government and the private sector. Non-state actors – i.e. corporations, NGOs, community groups – are increasingly involved in responding to climate change. This means that the urban adaptation to climate change is no longer a matter for public institutions.

Although, local governments still play a prominent role in leading urban climate change adaptation, private and civil society actors are increasingly important in the whole process. Key actors in the policy process typically fall into four key categories: state actors (governments or related institutions, including local governments), market actors (business and business institutions), scientific actors (including other expert domains such as economics), and civil society, which encompasses the media as well as social movement organizations (Cochran & Teasdale, 2011). Moreover, the boundaries between the public and the private sector are increasingly blurred, with a mutual exchange of roles and responsibilities (Castán Broto & Bulkeley, 2013). Public-private partnerships at different governance levels are quite common in the urban adaptation. These partnerships can be either vertical – that is, involving private and public actors at different governance levels – or horizontal – e.g. partnerships between governments, civil society organizations and private actors.

Governmental institutions condition the way that agents and systems interact to respond to climate stress (Tyler & Moench, 2012). Adaptation processes involve the interdependence of agents through their relationships with each other, with the institutions in which they reside (organizational structures), the knowledge they use and the resources based on which they depend (Adger, 2003; Castán Broto & Bulkeley, 2013). Many potential risks related to climate change necessarily involve intervention and planning by the institutional actors, yet adaptation strategies are equally dependent on the ability of individuals and communities to act collectively (Adger, 2003). Collective decision making is a central feature in the policy process for urban adaptation (Cochran & Teasdale, 2011).

Thus, the way different actors relate each other play a fundamental role. Trust, information sharing and cooperation, which are at the basis of the collective actions, are developed through the relational network in which the actor are involved. These relationships form the social capital, which is increasingly considered as fundamental in addressing the climate-related risks at urban level and enabling the local adaptation to climate change (Adger, 2003). The social capital is expressed through trust, social norms, obligation and information sharing that characterize the social networks. That is, social networks are considered as crucial embodiment of social capital (Islam and Walkerden, 2014). Strong social networks have been proved to improve collaborative governance processes by facilitating the the generation, acquisition and diffusion of different types of knowledge and information (Cunningham et al., 2015). In urban planning for adaptation, as well as for other decision-making processes, interaction among different decision actors are formalized (prescribed) by regulations. Nevertheless, exeperiences demonstrate the inadequacy of the official protocols to fully describe the complexity of the interactions. Most of the time, the actual networks are far less hierarchical and accounts for informal interactions taking place among decision actors. That is, besides the official interactions, the institutional actors activated personal relationships to gather important information and to performed tasks (Giordano et al., 2017).

The structure of the networks helps determine both the availability of expertise and the potential level of conflicts to which one is exposed in the network. Moreover, the structure of the network, in terms both of the patter of connections and the way in which individuals are distributed across them, alters aggregated outcomes (Siegel, 2003). Finally, the structure of the network of interaction strongly affects the effectiveness of the information sharing processes (Giordano et al., 2017).

Institutional and non-institutional actors who have access to timely, understandable and reliable information are better able to respond to climate threats. Households, enterprises, community organizations and other decision-making agents should have ready access to credible and meaningful information to enable judgments about risk and vulnerability, and to assess adaptation options (Cochran & Teasdale, 2011). Using social networks to engage the community in climate policy should prove advantageous as the information being disseminated is likely to be trusted and accepted by individuals within the network, prompting individual and collective action (Cunningham et al., 2015).

Enhancing the information sharing processes within the interaction network in which the different actors are embedded could be not enough for enabling an effective collective action for climate change adaptation. Decision-makers need to cope with uncertainty due to ambiguity in problem understanding. Action choices are not neutral, but commensurate with the perspectives and frames held by the actors making the decisions. The group decision frame explicitly incorporates each member's frame, so it is broader than any member's decision frame (Keeney, 2015). The problem is that when these frames do not overlap or are incompatible, they lead to a situation of ambiguity (Brugnach and Ingram, 2012).

Ambiguity refers to the degree of confusion that exists among actors in a group for attributing different meaning to a problem that is of concern to all (Weick 1995). In a management situation, it indicates that there are discrepancies in the way in which the situation is interpreted. It originates from differences in interests, values, beliefs, background, previous experiences and societal position among the actors (Van den Hoek et al., 2013). Under the presence of ambiguity it may not be clear if a situation is problematic or not, or if there is a problem what the problem is, or whose problem it is, or what actions path should be taken to deal with it (Brugnach et al., 2011; Brugnach and Ingram, 2012 for reviews and details)

In multi-actors setting the presence of ambiguity is unavoidable. This is particulalry true in an institutional decision environment, where the different roles played by the decision-actors affect the lens through which they give a meaning to a certain situation. Ambiguity in problem framing may have diverse implications.

On the one hand, a diversity in frames can offer opportunities for innovation and the development of creative solutions (Brugnach and Ingram, 2012). From this point of view, a certain degree of ambiguity is desirable to foster the collaborative work needed to enable urban adaptation. On the other hand, the presence of ambiguity can be a source of discrepancies or conflict in a group. When this happens, ambiguity can result in a polarization of viewpoints and the incapacity of a group to create a joint basis for communication and action, conditions that can greatly interfere with the development of collective actions (e.g., Brugnach et al. 2011). The extent to which the lack of shared meaning alters the implementation of a policy is largely dependent on the behavioural repertoires actors use to interact with one another (Donnellon et al. 1986). It has been suggested that divergent frames can still yield organized collective action when the interaction frames (i.e., communication behaviours actors use) are sufficiently aligned (Dewulf et al. 2009). Evidences demonstrate that making the decision actors aware of the existence of ambigous problem framing is the key to enable creative and collaborative decision-making processes (e.g. Giordano, Brugnach, & Pluchinotta, 2016). Ambiguity in problem understanding could represent a barrier to the actual use of climate services in urban adaptation, because it could lead to different information needs (Bosch et al., 1996). The information needs is the link between monitoring and decision process. Specification of information needs is a means to make a translation from a policy problem into an information management issue; the water policy and management objectives are translated into information expectations that in turn form the basis for an information production network.

4.2 Methodology: Problem Structuring Methods for Ambiguity analysis

Starting from the premises described in the previous section, this task aims at detecting and analizying potential barriers to collective actions for climate change adaptation by addressing two main issues: i) the ambiguity in problem understanding; ii) the complexity of the interaction network involving the different decision-actors. To this aim, two main approaches were implemented in EU-MACS, i.e. Problem Structuring Methods (PSM) for ambiguity analysis and Social Network Analysis (SNA) for unravelling the complexity of the interaction networks involving the different stakeholders.

The implementation of the PSM in this work aims at assessing to what extent divergencies in problem framing could also lead to barriers hampering the adoption of climate services. To this aim, we firstly related the stakeholders' information needs (i.e. what kind of information each stakeholder needs in order to solve a certain problem and/or take a decision) to the problem framing. Secondly, we analyzed in which condition discordance over adaptaiton-related information may result in discordance over climate services.

PSM are based on the assumption according to which the most demanding and troublesome task in problem solving often consists in defining the nature of the problem, rather than its solutions (Rosenhead and Mingers, 2001). PSMs support the elicitation of the different perceptions of the problematic situation and facilitate the debate in which assumptions about the world are teased out, challenged, tested and discussed (Checkland, 2001). During the debate, par-ticipants become aware of each other's perspectives and key interests. The objective of the debate is the establishment of a common understanding, which supports information exchange and co-operation.

PSMs do not aim to create a linear process through which an unstructured problem becomes structured. PSMs aim to identify, confront and integrate different views with respect to a given problem situation (Hommes et al., 2009). PSMs recognize and integrate participants' subjective perspectives, the importance of mutual learning, iterative process design and adaptive decision making. Given the main scope of this work, here we assume that the stakeholders involved in the different phases of the analysis were describing their problem understanding as member of a specific institution, rather than their own personal perspective.

Among the different PSMs, this work focuses on cognitive mapping methodologies, and specifically on Fuzzy Congitive Mapping. Fuzzy Cognitive Map (FCM) can be considered as a model which is as close as possible to the cognitive representation made by decision makers. Thus the model can be considered as a "mirror" of the causes and effects that are inside the mind of decision makers (Montibeller et al., 2001; Kok, 2009). FCMs can simulate the cause – effect relationships between the main variables in the model. The FCM comprises concepts representing the key elements of the system, joined by directional edges or connections representing causal relationships between concepts. Each edge is assigned a weight which quantifies the strenght of the causal relationship between two concept (Kosko, 1986). The tool is said to be semi-quantitative because the quantification of the variables and connections can be interpreted in relative terms only (Kok, 2009).

FCM is a flexible tool that has been succesfully applied in a large number of discipline. The FCM have been largely used to analyze system dynamics in the business domain (e.g. Xirogiannis and Glycas, 2007; Glykas and Xirogiannis, 2004). The FCM are increasingly applied in spatial and environmental planning. Ozesmi and Ozesmi (2004) used FCM to analyze the perceptions about an ecosystem held by people in different stakeholder groups. De Kok et al. (2000) adopted a FCM approach qualitative to integrate social science concepts in a quantitative modeling for water management scenarios development. Xirogiannis et al. (2004) proposed an FCM – based approach to model experts' decision mechanisms in the field of urban area management.

The implementation of FCM to support urban adaptation is based on the analysis of the two main phases of a decision process, i.e. the divergent and the convergent thinking phases (Montibeller et al., 2001). From decision analysis point of view, during the divergent thinking stage, the issue is disclosed, different views are encouraged and proposed, alternatives are generated, objectives are defined and the boundaries of the problem definition are discussed during the debate among the decision makers. Thus, FCM can be useful during divergent thinking phase because it supports creative definition of the problem's characteristics and the identification of alternatives. It can be used to clarify what interests are involved in the discussion and to facilitate the debate. For what concerns the urban planning for adaptation and the role of climate services, FCM can support the divergent thinking phase by making explicit the existence of different concerns and interests related to climate change adaptation. As described further in the text, these elements were used to define the individual information needs, that is, the information that a decision actor needs in order to take some decision.

During the convergent thinking phase, criteria are defined to measure the performances of alternatives on the objectives, data about these performances are gathered, compensations between criteria are stated, alternatives are ranked, and the 'best' alternative is selected and implemented (Montibeller et al., 2001). The convergent thinking phase in this work aimed at reducing the differences among decision-actors' information needs and to get to a consensual definition of climate services. To this aim, FCM's potentialities to simulate qualitative decision scenarios were considered as crucial (Kok, 2009).

The divergent thinking phase: constructing the Fuzzy Cognitive Map and ambiguity analysis

The first phase in the implementation of the FCM to support the maintreaming of climate service in urban planning was meant to elicit and structure the different stakeholders' problem understanding. As already stated, the basic assumption of this work is that different problem undestandings could lead to different information needs. In order to make ambiguity a source of creativity in the development of climate services, decision-makers need to be aware of the existence of different, and equally valid, problem understandings.

The first issue to be addressed concerned the selection of the experts to be involved in this phase. In order to minimise the selection bias and the marginalization of stakeholders (Ananda & Herath, 2003; Reed et al., 2009) a top-down stakeholder identification practice, which is referred as ”snowballing” or ”referral sampling”, was implemented (Harrison & Qureshi, 2000; Prell et al., 2008; Reed et al., 2009). The selection process started with the actors mentioned in the offical protocol of interaction for urban planning, i.e. the decision actors whose main responsibility is to develop urban strategies and plan for adaptation. The preliminary interviews carried out with these agents allowed us to widen the set of stakeholders to be involved.

The individual FCM were developed through semi-structured interviews. The framework for the interviews is described in the annex. The interviews aimed at collecting the stakeholders' perceptions about the cause-effects chains affecting the impacts of climate change at urban level, and the potential solutions. In order to use the results of interviews for the FCM development, a “means-ends” hierachical approach was adopted in this phase. The interviewees were, thus, required to describe the main climate change impacts at urban level in terms of risks. Then, they described the primary (direct) and secondary (indirect) impacts of those risks. The main causes of the system vulnerability were also descibed by the involved stakeholders. Finally, the interviewees were required to describe potential and/or existing strategies to facilitate the adaptation of the urban system to climate change. The role of climate-related information was discussed as well.

The interviews were analyzed in order to detect the keywords in the stakeholders' argumentation – i.e. the variables in the FCM – and the causal connections among them – i.e. the links in the FCM. The results of the interviews were structured as in the following figure:

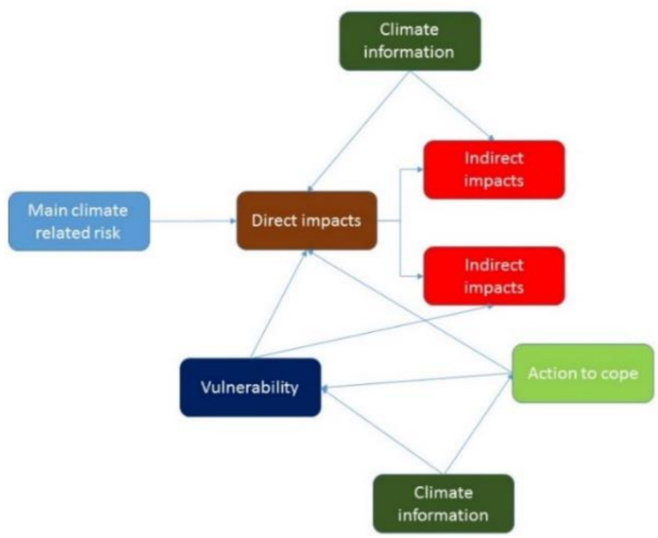


FIG. 5: FCM structure starting from the interviews' results

Figure 5 shows the framework adopted in our approach for structuring the narratives collected through the individual interviews. This framework is meant to define stakeholders' information needs, starting from their own personal problem understanding. Following Slegers (2008), the interviews were aimed at collecting actors' experiences about both direct and indirect impacts of climate changes. Participants were required to specify elements which can either increase or decrease those impacts. They were also required to specify both the information used to support the selection, implementation and assessment of the actions needed to cope with the risks related to climate changes.

As shown in fig. 6, an element of vulnerability can affect both direct and indirect impacts. The actions to be implemented could aim at reducing vulnerability and/or reducing direct and indirect impacts. Finally, climate-related information could allow decision-makers to better comprehend the main impacts, the causes of the impacts (vulnerability), facilitate the implementation of the actions. The following figure shows how the stakeholders' narratives, collected during the interviews, were translated into FCM variables and relationships.

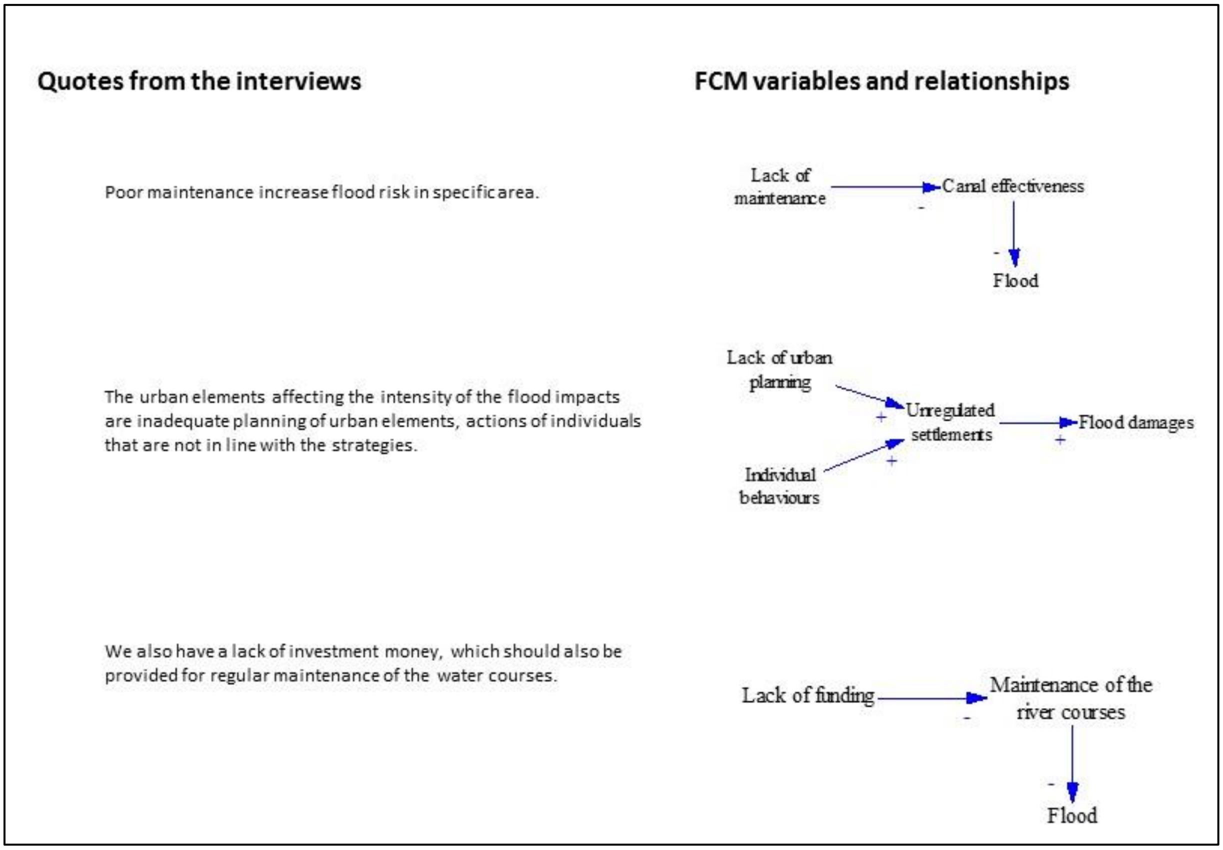


FIG. 6: Translating quotes from the stakeholders' interviews into variables and relationships of FCM

The links (i.e. relationships) in a FCM can be either positive or negative. The existence of a positive link between "A" and "B" means that if A increases then B increases. If the link is negative, then an increase in A implies a decrease in B. Once all the concepts and links were identified, the analysts were required to define the strength of the links accounting for the stakeholders' perception. The strength of a link between two concepts indicates the intensity of the relationship between them, that is to say, how strong is the influence of one concept over the other. The strength can assume values in the interval [-1; 1]. The relationships between variables can be represented in an adjacency matrix. In the FCM, this matrix allows the overall effects of an action on the elements in the map to be inferred qualitatively, as described below.

The FCM developed referring to the stakeholders' interviews were used to infer the users' information needs. For a more detailed description of the FCM developed in the EU-MACS case studies, please, refer to the following sections. Two sequential analysis were carried out. Firstly, the FCM were analysed in order to detect the most important elements in the stakeholders' problem understanding, the so called "nub of the issue" (Eden, 2004). Secondly, the FCM capability to simulate qualitative scenarios were used to assess the expected impacts of climate related information on the stakeholders' problem understanding.

Concerning the first analysis, FCM centrality degree was assessed. The basic assumption in assessing the centrality degree of the variables contained in the FCM is that the more central the variables, the more important the concept is in the stakeholder's perception. Taking into account that the meaning of a variable in a FCM depends on its explanations and consequences (Eden, 2004), the centrality of each concept can be assessed analyzing the complexity of the surrounding perceived causal chains. The following equation was used in this phase of the analysis:

$$CI = td(vi) = od(vi)+id(vi)$$

$$\mathrm{od}(v_i) = \sum_{k=1}^{N} \bar{a}_{ik}$$

Out-degree shows the cumulative weight of connections (aij) exiting the variable, where N is the total number of variables.

$$\mathrm{od}(v_i) = \sum_{k=1}^{N} \bar{a}_{ik}$$

In-degree shows the cumulative weight of variables entering the variable.

The centrality degree was the first element used in this work to identifying the most important element in the stakeholders' problem understandings.

The individual FCM were then used to define the stakeholders' information needs. To this aim, different scenarios were simulated using the individual FCM. The Business-As-Usual scenario (BAU) was simulated running a FCM process ((Kok, 2009) with an initial state vector A0, with all variables set to 0, besides those related to Climate change (fig. 3).

			C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21
C1	Climate change	1,00	**1,00**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
C2	Rainfall intensity	0,00	1,00	**0,00**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
C3	Seal level rise	0,00	0,70	0,00	**0,00**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
C4	Heat waves	0,00	0,30	0,00	0,00	**0,00**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
C5	Urban flooding	0,00	0,00	1,00	0,30	0,00	**0,00**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-1,00	-0,70	0,00	0,00	0,00	0,00	0,00	0,00
C6	Increasing temperature	0,00	0,00	0,00	0,00	1,00	0,00	**0,00**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
C7	Health problems	0,00	0,00	0,00	0,00	0,00	0,00	0,70	**0,00**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
C8	Cooling systems	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,70	**0,00**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
C9	Energy infrastructures reliab.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-0,30	**0,00**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
C10	Building damages	0,00	0,00	0,00	0,00	0,00	1,00	0,00	0,00	0,00	0,00	**0,00**	0,00	0,00	0,70	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
C11	Infrastructure damages	0,00	0,00	0,00	0,00	0,00	0,70	0,00	0,00	0,00	0,00	0,00	**0,00**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
C12	Insurance sector	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-0,30	-0,30	**0,00**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
C13	Social vulnerability	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	**0,00**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
C14	Adaptation measures effect.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	**0,00**	0,00	0,00	0,00	0,00	0,00	0,00	-1,00
C15	Water infrastr. Effectiveness	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	**0,00**	0,00	0,00	0,00	0,00	0,00	-0,30
C16	Lack of coordination among depts	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	**1,00**	0,00	0,00	0,00	0,00	0,00
C17	Monitoring measure effectiv.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	**0,00**	0,00	0,00	0,00	0,00
C18	Understanding costs	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	**0,00**	0,00	0,00	0,00
C19	Understanding benefits	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,70	0,00	**0,00**	0,00	0,00
C20	Understanding measures impacts	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,70	**0,00**	0,00
C21	Conflicting goals	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	0,00	0,00	-1,00	**0,00**

Table 3: Adjacency matrix and initial state vector A0 for the BAU scenario simulation.

The table 3 shows the list of variables forming the stakeholder's FCM, the initial state vector, and the weight of the connections among the different variables. In order to simulate the BAU scenario, the variables "climate change" and "lack of coordination among depts" were activated. That is, their initial state was set to 1. In order to reiterate the pulse of the drivers until the state of the variables reach a stabel state, we need to set the diagonal values of the drivers to 1 as well. Individual adjacency matrixes were developed for each interviewed stakeholder.

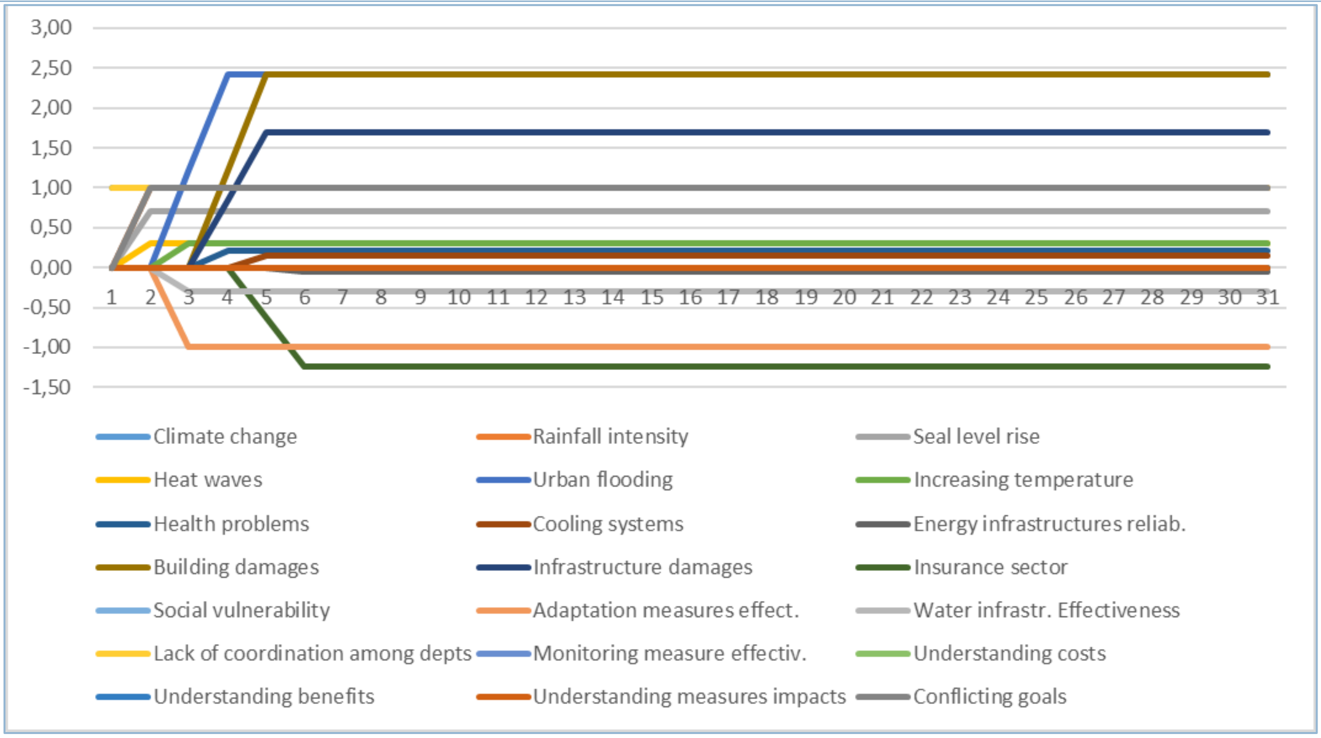


FIG. 7: Chart representing the state of the FCM variables in the "No-information" scenario. The x-axis represents the number of vector x matrix iterations before the variables reached a stable state. The y-axis measure the change in the variable state.

In order to assess the impacts of information availability on the stakeholder's problem understanding, the value of the connected variable is changed in the initial state vector, and the change of values of the most important elements (i.e. centrality degree) was evaluated (fig. 7). The information-related variables (e.g. "understanding benefits" in the previous example) can assume two values, i.e. 0.5 if it is partially available, or 1 if it is fully available.

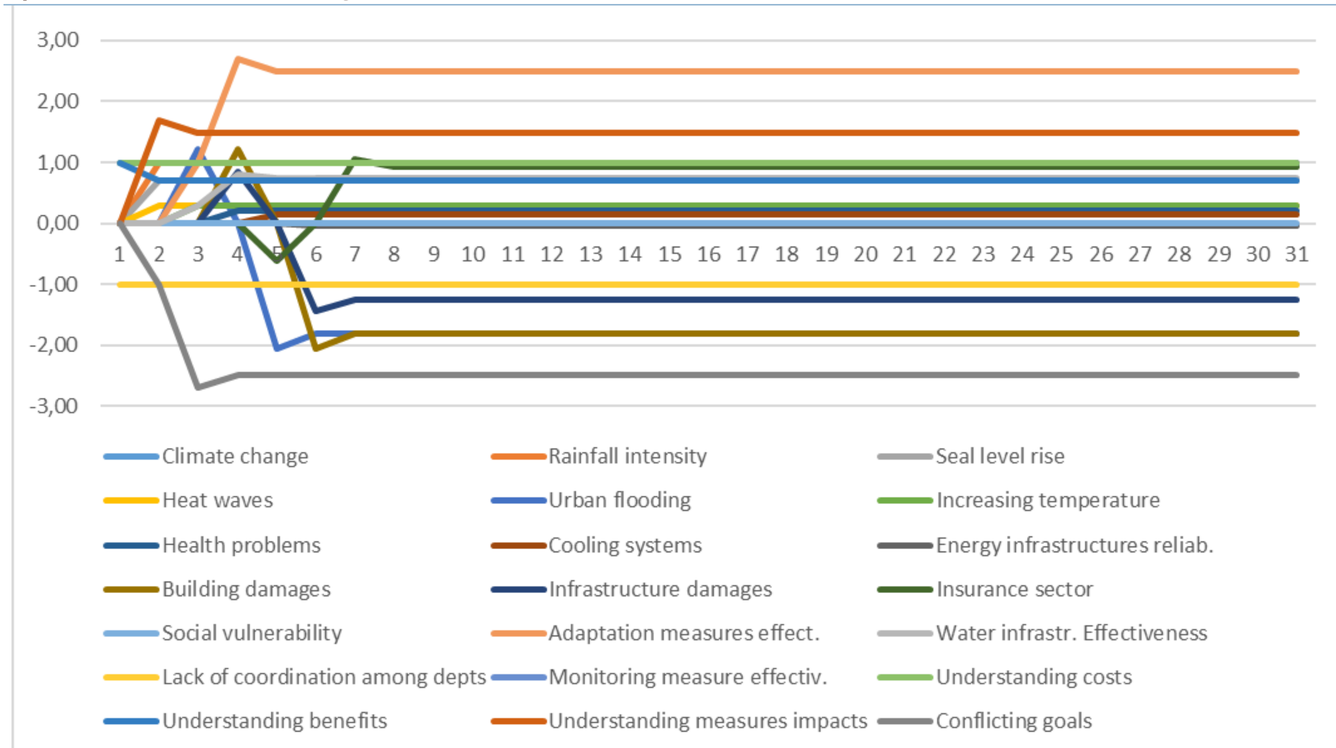


FIG. 8: State the FCM variables in the "information-available" scenario.

The graph in fig. 8 shows that the availability of information "Understanding measures impacts" enhanced the effectiveness of adaptation measure effectiveness and, thus, reduced the value of "conflicting goals", "building damages", and "infrastructure damages". The degree of change for the most important element in the FCM due to the beginning of the drought phenomenon was assessed using the fuzzy linguistic variable shown in fig. 9.

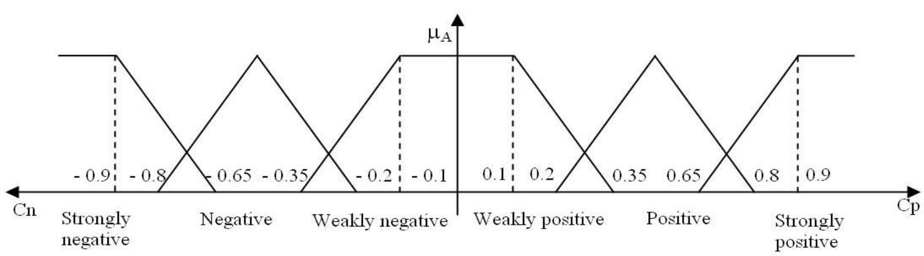


FIG. 9: fuzzy linguistic function representing the information impact degree

The basic assumption is that the higher the impacts of information availability on the most central variables in the stakeholder's problem understanding, the more crucial the information for addressing climate adaptation measures (information needs).

We have carried out individual analysis in order to elicit and compare the stakeholders' individual information needs. This analysis allowed us to identify complementarities in information needs, and differences that could lead to barriers to CS mainstreaming in urban planning. The results of the information needs elicitation in the two EU-MACS case studies are described further in the text.

The convergent thinking phase: the social FCM and the scenario analysis

The results of the individual problem structuring approach were used to facilitate the discussion among the different stakeholders and to support the creation of consensus over the most suitable CS. This does not mean that all the decision-actors need to refer to the same category of CS. Information needs are affected by the institutional roles played by the different actors within the urban planning framework. Neverthless, in order to facilitate the maistreaming of CS in urban planning, a consensus is required among the decision-actors concerning the categories of CS to be used to address the different issues due to the climate-related risks.

To this aim, participatory processes were designed and organized by WP4 in the two urban case studies. Different approaches were implemented, according to the different issues to be addressed and the different socio-institutional contects. The two approaches are described in the following sections.

4.3 Methodology: Social Network Analysis for climate change adaptation

Decision-making actors do not operate in a vacuum. Social interactions can alter choices. The main scope of this phase is to analyse the way the different stakeholders interact each other an exchange information, knowledge, resources in order to carry out shared adaptation tasks.

According to the scientific literature (i.e. Joshi and Aoki, 2014; Islam and Walkerdem, 2014), three kind of networks can be identified in a community of decision agents, i.e. bonding, bridging and linking. Bonding social networks refer to the relations within the same community. Bonding relationships are, broadly speaking, inward looking. They are particularly closed relationships. Bridging social networks connect members of the group to external networks. They could be considered as horizontal relationships with similar entities. Linking relationships are considered as networks of trusting relationships between people who are interacting across explicit, formal or institutionalized power. Linking relationships are vertical relationships. The following figure shows the different kind of social networks influencing the social capital:

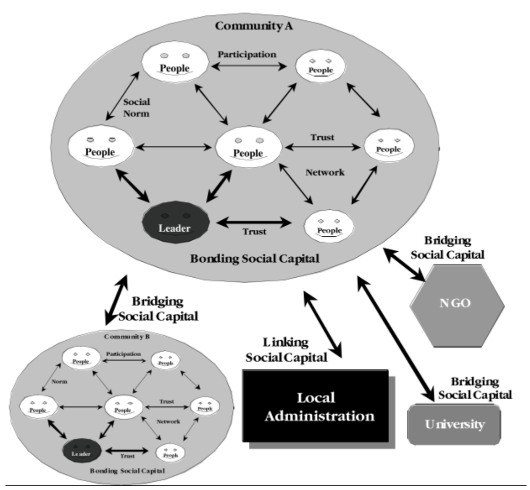


FIG. 10: Bonding, bridging and linking social networks.

Most of the relationships in the context of urban planning are defined by the official protocol of interactions. Nevertheless, experienced demonstrated that besides the "formal" relationships, informal network of connections is activated in order to make the decision process more effective.

Social network analysis (SNA) can help understanding how and why the actors behave the way they do, through the analysis of structural patterns of relations. Moreover, it provides valuable insights to ambiguity in problem understanding and framing, and how uncertainty is dealt with. The basic assumption behind the role of social network analysis in climate change adaptation is that the structural patterns of relations in networks influence the social processes (Borgatti, 2006). Social network mapping can support the identification and analysis of barriers to cooperation and collaboration (Bodin and Crona, 2009).

Networks topologies can be analyzed at the node-level focusing on institutions or actors. The centrality of an actor allows analysis of the role she/he can play in the network as a bridge that connects the others. These actors facilitate the flow of knowledge and information within the network. Central actors can be potential agents of change, facilitating the adaptation to emergence situations.

Although the literature on SNA is well developed, there are few examples of SNA application in climate change adaptation. Nevertheless, there is consensus on the role that SNA could play in revolutionizing the way organizations and communities prepare and respond to climate-related risks. SNA allows to analyse the impacts of information and activities on individuals and the network as a whole for different scenarios and options. In this work, SNA was implemented to map and analyse the dense network of interactions, both formal and informal, affecting the sharing of climate-related information and knowledge, and, thus, having an impact on the effectiveness of the urban planning for climate adaptation.

Mapping the social interactions

The Social Network Analysis (SNA) method was implemented in this phase. SNA investigates the social relationships of a large number of actors between different groups of organizations and provides a mathematical approach for measuring the strength of ties (Furht, 2010). In this work, SNA phase focused on structural patterns between actors involved in urban planning and climate-related risk management, allowing the understanding of roles, interdependencies, tasks, and information flows, through specific measures.

Specifically, SNA has been implemented to make explicit the informal networks of interactions, allowing urban planners and risk managers to better comprehend its complexity and enhance their capabilities to enable collective decision processes. Among the different methods available in the scientific literature for modelling and analysing the social networks (e.g. Borgatti, 2006; Ingold, 2011; Lienert et al., 2013), the Organizational Risk Analysis (ORA) approach has been implemented in this work (Carley, 2002). The underlying assumption in ORA is that an organization could be conceived as a set of interlocked networks connecting entities such agents, knowledge, tasks and resources (Carley, 2005). The adopted approach is also capable to detect or simulate changes in the organizational framework. This will require the adoption of a dynamic perspective in mapping the interaction (Carley, 2005). At this stage of the project implementation, we have no enough information in the two EU-MACS case studies for adopting a dynamic approach. The results of the SNA described in this work are based on the assumption of static organizational framework. We are aware that Helsinki municipality is defining a strategy to change the organizational structure. An analysis of the impacts on climate-related information sharing process due to the changes in the Helsinki organizational structure will be described in the D4.3.

In order to implement the ORA approach, we considered the whole set of actors involved in urban planning and climate-related risk management as one heterogeneous organization (Leskens, Brugnach, Hoekstra, & Schuurmans, 2014). The interlocked networks can be represented using the meta-matrix conceptual framework, as shown in the following table 5.

	Agent	**Knowledge**	**Tasks**
Agent	*Social network:* map of the interactions among the different institutional actors in the different urban planning phases	*Knowledge network:* identifies the relationships among actors and information (Who does manage which information? Who does own which expertise?)	*Assignment network:* defines the role played by each actor in the urban planning phases
Knowledge		*Information network:* map the connections among different pieces of knowledge	*Knowledge requirements network:* identifies the information used, or needed, to perform a certain task in the urban planning.
Tasks			*Dependencies network:* identifies the work flow. (Which tasks are related to which)

Table 5: Meta-matrix framework showing the connections among the key entities of social network (adapted from (Carley, 2005))

The ORA method theorizes that the effectiveness of a social network is not limited to the way the different actors interact with the others. The meta-matrix framework allows to analyse the complexity of the interaction network accounting for the role of knowledge and tasks, and of the interconnections among the key elements – i.e. agent, knowledge and tasks. The *Agent x Agent* matrix is shown in the table 6.

	A_1	A_2	A_3	$\cdots$	A_n
A_1	0	W_{12}	W_{13}	$\cdots$	W_{1n}
A_2	W_{21}	0	W_{23}	$\cdots$	W_{2n}
A_3	W_{31}	W_{32}	0	$\cdots$	W_{3n}
$\cdots$	$\cdots$	$\cdots$	$\cdots$	0	$\cdots$
A_n	W_{n1}	W_{n2}	W_{n3}	$\cdots$	0

Table 6: *Agent x Agent* matrix

In the previous matrix, W_{ij} represents the strength of the interaction between the agent A_i and the agent A_j. Different methods are available to define the strength of the connections – e.g. based on the number of interaction per day, emails exchanged during an urban planning process, etc. In this work, we refer to the stakeholders' opinion concerning the importance of the connections during the urban planning process. In this work the interaction network was developed using stakeholders' experience as expert knowledge. Therefore, W_{ji} represents the strength of the connection as perceived by the agent A_i. A fuzzy linguistic variable was developed to this aim. For a more detailed explanation of the procedure, a reader may refer to (Giordano et al., 2017). Similarly, the value of W_{ji} refers to the strength of the interaction between the agent A_i and the agent A_j as perceived by the agent A_j. The weights were calculated referring to the results of the stakeholders' interviews. We assumed that the extent to which A_i considered important the interaction with A_j depends on the information A_j could provide in order to allow A_i to perform the allocated tasks and achieve the specific goal. Among the different properties of information in a decision-making process – i.e. volume, accuracy, indispensability, conditionality and dependency, usability, etc.. – we explicitly asked to the stakeholders in the two case studies to define the importance of the connection accounting for the accuracy and the usability of the shared information.

The individual FCMs were also used to define the other matrices. For instance, the individual i-th *Agent x Knowledge* matrix was obtained considering the weights assigned by the i-th actor to the different *agent-information* connections. The *Agent x Knowledge* matrix for the i-th agent is represented in the table 7.

	$\boldsymbol{I_1}$	$\boldsymbol{I_2}$	$\boldsymbol{I_3}$	$\cdots$	$\boldsymbol{I_n}$
$\boldsymbol{A_1}$	${K^i}_{11}$	${K^i}_{12}$	${K^i}_{13}$	$\cdots$	${K^i}_{1n}$
$\boldsymbol{A_2}$	${K^i}_{21}$	${K^i}_{22}$	${K^i}_{23}$	$\cdots$	${K^i}_{2n}$
$\boldsymbol{A_3}$	${K^i}_{31}$	${K^i}_{32}$	${K^i}_{33}$	$\cdots$	${K^i}_{3n}$
$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$
$\boldsymbol{A_n}$	${K^i}_{n1}$	${K^i}_{n2}$	${K^i}_{n3}$	$\cdots$	${K^i}_{nn}$

Table 7: Knowledge network matrix for the i-th agent.

The overall *Agent x Knowledge* matrix was obtained as the sum of the individual matrices. Similar processes were implemented to develop the *Agent x Tasks*, *Knowledge x Knowledge*, *Knowledge x Tasks* and *Tasks x Task* matrices.

Similarly, the stakeholders' narratives were used to develop the *Agent x Task* matrix.

	$\boldsymbol{T_1}$	$\boldsymbol{T_2}$	$\boldsymbol{T_3}$	$\cdots$	$\boldsymbol{T_n}$
$\boldsymbol{A_1}$	Y_{11}	Y_{12}	Y_{13}	$\cdots$	Y_{1n}
$\boldsymbol{A_2}$	Y_{21}	Y_{22}	Y_{23}	$\cdots$	Y_{2n}
$\boldsymbol{A_3}$	Y_{31}	Y_{32}	Y_{33}	$\cdots$	Y_{3n}
$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$
$\boldsymbol{A_n}$	Y_{n1}	Y_{n2}	Y_{n3}	$\cdots$	Y_{nn}

Table 8: Agent x Task matrix

The interviews were used to define the weight for each agent-task connection. That is, Y_{11} represents the degree of importance of the task T_1 for the agent A_1. Fuzzy linguistic variables were used to this aim. If the actor did not carried out a specific task, the weight was set to 0. Finally, the *Knowledge x Task* matrix was developed accounting for the perceived importance of the information for performing the tasks.

Analysing the network of interactions: the graph theory measures for vulnerability assessment

The overlapping of the different interaction maps allowed us to obtain the meta-matrix and, thus, the map of the interactions taking place during a decision making process in urban planning, and connecting agents, knowledge and tasks. The map was developed using the ORA© software (Carley, 2005), developed by the Centre for Computational Analysis of Social and Organizational Systems of the Carnegie Mellon University. Following the graph theory, the weights in the matrixes were used to represents the strength of graph edges, while rows and columns were labelled by graph vertices. Indeed, a graph $G =< V, E >$ consisting of a set of vertices (nodes) V and a set of edges (arcs) E, can be represented by an adjacency matrix $A = |V| \times |V|$.

In this work, the map of the network was used to analyse and unravel the complexity of interactions, allowing the identification of the key elements in the network and the main vulnerabilities. To this aim, graph theory measures were implemented. Table 9 describes the measures adopted for the identification of the key actors, their definition according to the graph theory and the meaning in urban planning for climate change adaptaation. For a detailed description of the graph theory measures for the analysis of the networks, a reader could refer to (Freeman, 1978; Carley et al., 2007)

Network	Network measure	Assessment	Meaning in Urban adaptation
Agent x Agent	Total degree Centrality	Those who are ranked high on this metrics have more connections to others in the same network.	Individuals or organizations who are 'in the know' are those who are linked to many others and so, by virtue of their position have access to the ideas, thoughts, beliefs of many others.
	Betweenness centrality	The betweenness centrality of node v in a network is defined as: across all node pairs that have a shortest path containing v, the percentage that pass through v.	Individuals or organizations that are potentially influential are positioned to broker connections between groups and to bring to bear the influence of one group on another or serve as a gatekeeper between groups.
Agent x Knowledge	Most knowledge	Assess the number of links between a certain agent and the different pieces of knowledge in the network.	An agent with a high value of most knowledge has access to a great variety of knowledge to be used in case of disaster.
Agent x Task	Most task	Assess the number of links between a certain agent and the different task that need to be carried out.	An agent with a high degree of most task plays a crucial role in the network due to her/his capability in performing different tasks.
Knowledge x Knowledge	Total degree of centrality	It calculates the importance of a certain piece of information according to the number of connected links.	The most central pieces of knowledge are those whose availability is crucial to make the other pieces of knowledge accessible.

	Betweennes centrality	The Betweenness Centrality of node v in a network is defined as: across all node pairs that have a shortest path containing v, the percentage that pass through v.	The betweennes centrality measure allows us to identify the information that could facilitate the process of information sharing.
Knowledge x Task	Most task	Assess the number of links between a certain piece of knowledge and the different task that need to be carried out.	The pieces of knowledge with a high value for this measure are fundamental for the effectiveness of the network, since without them a high number of tasks will be not carried out.
Task x Task	Total degree of centrality	It analyses the complexity of the connections within the task X task network.	Tasks with high degree of centrality are those that have to be carried out in order to allow the executions of the other tasks.

Table 9: Graph Theory measures for key elements detection

Different measures are mentioned in the scientific literature for the assessment of the network vulnerability, that is, those elements that could lead to failures of the network, lower performance, reduced adaptability, reduced information gathering, etc. (e.g. Carley, 2005). Considering the complexity of the emergency network, in this work the vulnerability elements were identified though the combination of different measures, as described in the table 10.

Network	Network measures	Meaning in emergency management
Agent x Agent **Agent x Knowledge**	Total centrality degree Most knowledge	An actor with a high degree of centrality and a low most knowledge degree represents a vulnerability because, although she/he a central position in the network, she/he has a limited capability to enable information sharing.
Agent x Agent **Agent x Knowledge**	Betweennes centrality Most knowledge	An actor with a high degree of most knowledge and a low betweennes degree represents a vulnerability because she/he is not capable to share with the others the pieces of knowledge she/he has access to.
Agent x Agent **Agent x Task**	Total centrality degree Most task	An actor with a high degree of most task and a low centrality degree represents a vulnerability because, although she/he is required to carry out important tasks, she/he is quite isolated and cannot be supported by the others during an emergency.
Agent x Knowledge **Knowledge x Task**	Most knowledge Most task	A piece of knowledge poorly shared within the network (low most knowledge) represents a vulnerability if its access is crucial to carry out important task (high most task).
Agent x Knowledge **Knowledge x Knowledge**	Most knowledge Closeness centrality	A piece of knowledge with a high degree of closeness but poorly shared (low degree of most knowledge) represents a vulnerability since it could hamper the process of information sharing.

Agent x Task **Task x Task**	Most task Centrality degree	A task with a high centrality degree and with low ost task degree represents a vulnerability because, although its importance, there is no, or very limited cooperation to guarantee its effectiveness.

Table 10: Measures for the detection and analysis of key vulnerability in the Urban planning and CCA network

5. RESULTS FOR HELSINKI AND BOLOGNA CASE STUDIES

5.1 The multi-steps process for the barriers to CS due to the governance framework

In order to test the suitability of the methodologies described in the previous sections for detecting and analysing potential barriers hampering the market uptake of climate services in urban planning, they were implemented in the two EU-MACS front-running cities, i.e. Helsinki and Bologna. Two multi-steps processes were implemented in the urban case studies, as shown in the following figure:

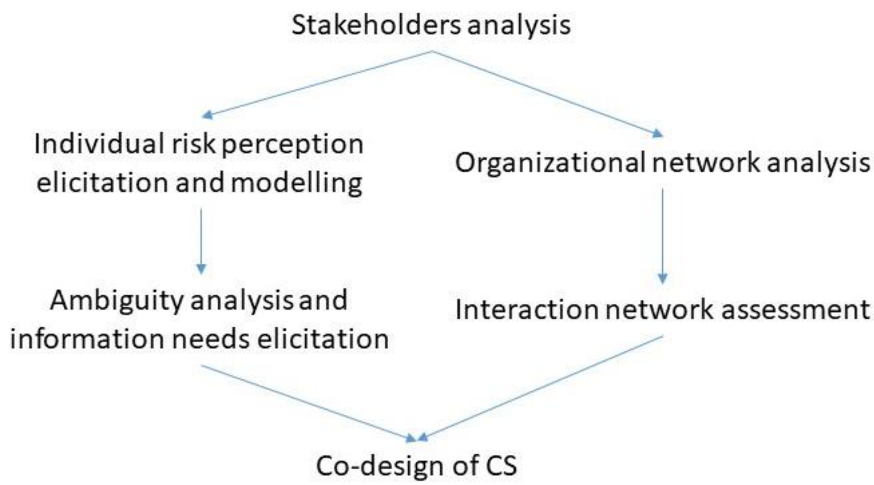


FIG. 11: Multi-steps process implemented in Helsinki and Bologna

As shown in figure 11, the most important phase of the process implemented in the EU MACS urban case studies was the co-design of climate services. That is, the results of the analysis carried out implementing Problem Structuring Methods and Social Network Analysis were used to inform the debate among different climate services users in the two case studies.

The involvement of stakeholders played an important role throughout the whole process. Different participatory approaches were implemented in the different phases of the process:

- Individual interviews: risk perception elicitation; organizational network mapping;
- Group discussion: consensus achievement over the main information needs;
- Living Lab approaches: co-design of CS.

5.2 The Helsinki case study

The stakeholders risk perception, the ambiguity analysis and information needs elicitation

The following institutional actors were involved in the first round of interviews:

ORGANISATION
HSY - Helsinki Region Environmental Services Authority
Helsinki - Public Works Department
Helsinki - City executive office

Helsinki - Environment Centre
Helsinki - City Planning Department
Ramboll Consulting
Helsinki University Student Union
Finnish Meteorological Institute
CNC Construction

Table 11: Institutional actors involved in the first round of interviews.

Unfortunately, we weren't capable to involve other actors in the knowledge elicitation phase. Nevertheless, information were collected concerning the other institutional actors, as described further in the text.

A round of semi-structured interviews was carried out, aiming at collecting the individual perception of the main climate-related risk in the local area, the potential impacts – both direct and indirect – the adaptation strategies and, finally, the potential role of climate services. The interviewees were also required to provide information about the flow of climate-related information among the different institutional and non-institutional actors. The latter data were used for the social network analysis.

Following the FCM methodology, the results of the interviews were analysed in order to identify the keywords in the stakeholders' argumentation, and to define the perceived cause-effects links connecting the different keywords (variables) and their strength. FCM were developed for each of the interviewed actors. See annex 2 for the FCM developed in the Helsinki case study.

The figure 12(a and b) shows two examples of the FCM developed using the Helsinki interviews.

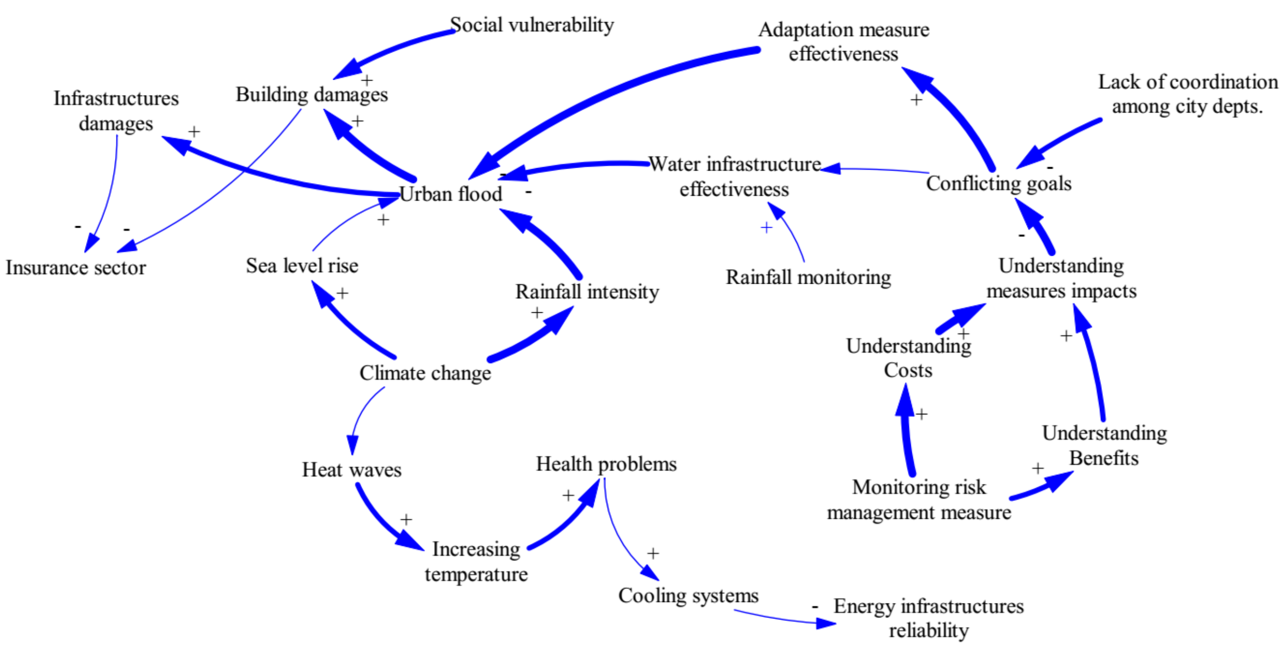


FIG. 12(a): FCM representing the Helsinki Environmental Centre problem understanding.

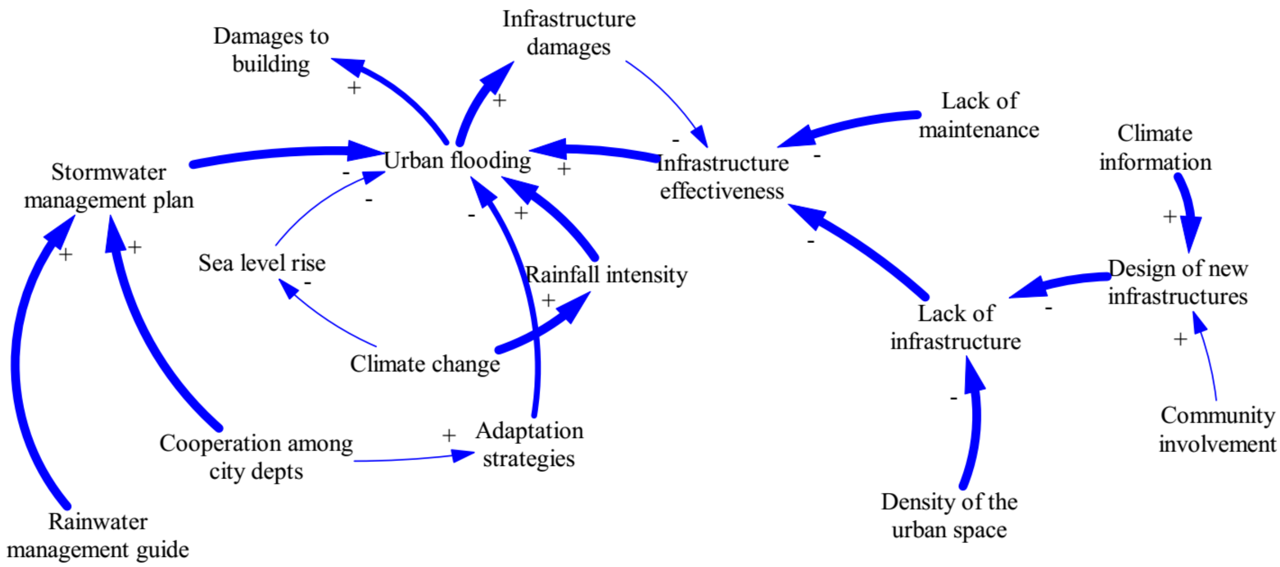


FIG. 12(b): FCM representing the Public Work Dept. – Design office problem understanding.

The centrality degree measure was implemented in order to identify the key elements in the stakeholders' problem understanding. The following table summarizes the results of the centrality analysis for the interviewed stakeholders. It is worth mentioning that the results refer to the actors' perception. Therefore, the described results cannot be treated as a validated representation of the real organizational complexity

Decision actor	Type of variable	Variable	Centrality degree (value)	Centrality degree (index)
Building control Dept.	Main effects	Urban flooding	2,00	High
		Increasing temperature	1,73	Medium
	Primary impacts	Storm water	5,53	Very high
		Heat island	1,31	Medium
	Secondary impacts	Building damages	3,63	High
		Energy consumption	1,70	Medium
		Building costs	0,61	Low
City Executive Office	Main effects	Urban flooding	1,00	Medium
	Primary impacts	Storm water	5,48	Very high
	Secondary impacts	Infrastructure effectiveness	1,92	Medium
Urban Planning consultancy	Main effects	Coastal flooding	3,28	High
		Sea level rise	2,00	High
	Primary impacts	Storm water	3,75	High
	Secondary impacts	Tourisms	0,78	Low
		Migration	0,75	Low
Helsinki Environ. Centre	Main effects	Urban flooding	5,68	Very high
		Increasing temperature	1,78	Medium
	Primary impacts	Storm water	1,64	Medium
		Heat island	2,28	High
	Secondary impacts	Economic development	2.42	High
		Building sectors	1.75	Medium
		Social vulnerability	1.69	Medium
		Urban infrastructures	1.67	Medium
Public Work Dept.	Main effects	Urban flooding	2,67	High
		Sea level rise	1,03	Medium
		Increasing temperature	0,75	Low
	Primary impacts	Storm water	1,78	Medium
		Heat waves	1,33	Medium
	Secondary impacts	Infrastructure effectiveness	0,97	Low
		Building damages	0,69	Low

Table 12: Main elements in the stakeholders' problem understanding (centrality degree)

These elements were used to support the elicitation of the information needs for each of the above mentioned decision-actors. To this aim, the capability of the FCM to simulate qualitative scenarios were used. In order to elicit the decision-actors' information needs, the impacts of climate-related information on the effectiveness of the risk management actions were calculated. The basic assumption here is that an information could be considered important for a decision-actor if its availability positively affects the values of the main elements in the decision-actor's problem understanding. That is, if the information availability allows the decision-makers to select and implement the most suitable actions for enhancing the climate-change adaptation of the urban system.

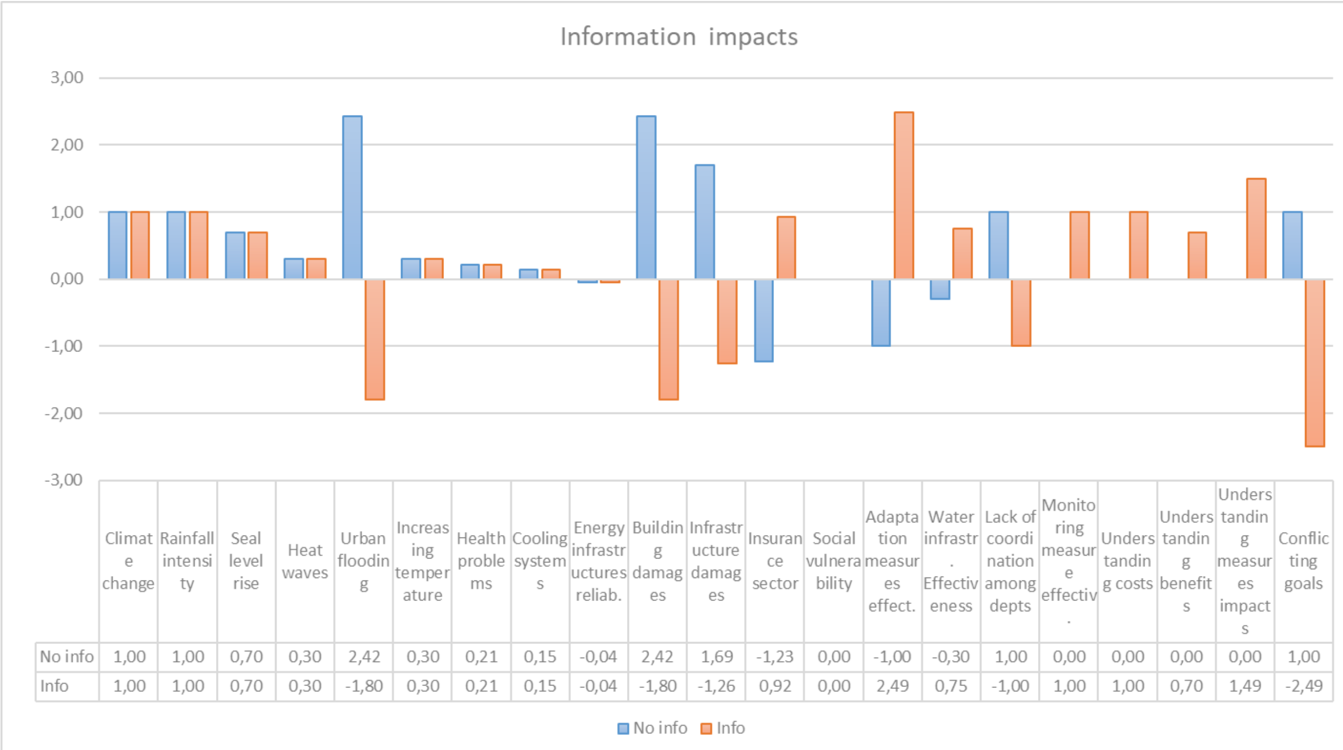


FIG. 13: The graph shows the state of the variables in the Helsinki Environmental Centre in two scenarios: without climate-related information and with information.

The graph allowed us to assess the impacts of the availability of the climate-related information. According to the Helsinki Environmental Centre problem understanding, the availability of the following information – "Monitoring adaptation measures effects"; "understanding costs", "Understanding benefits" – allows to drastically reduce the probability of having conflicting goals among the different city departments. Consequently, the increased effectiveness of adaptation measures provoked a reduction of the urban flood intensity (primary impact), and the damages to buildings and infrastructures (secondary impacts).

The fuzzy linguistic function in figure 9 was used to assess the information impacts, as shown in the following table:

		Information availability impacts	
Main element	**Centrality degree**	**Monitoring the measure effect**	**Understanding cost/benefits**
Urban flooding	Very high	Positive	Highly positive
Increasing temperature	Medium	No change	No change
Storm water	Medium	Positive	Highly positive
Heat island	High	No change	No change
Economi developm.	High	Weakly positive	Weakly positive
Building sectors	Medium	Weakly positive	Positive
Social vulnerability	Medium	No change	Weakly positive
Urban infrastructures	Medium	Weakly positive	Highly positive

Table 13: Elicitation of the Helsinki Environmental Centre information needs.

The fuzzy AND operator was adopted in order to aggregate the impact of the information availability on the main elements of the stakeholder's problem understanding. The degree of centrality was accounted for as a weight in the aggregation phase.

Different scenarios were simulated introducing the climate adaptation related information in the FCM. Table 14 shows the list of the available information, which was defined accounting for the information mentioned by the stakeholders during the interviews, either as an already used information or as a desirable one.

Information	**Acronym**
Land use regulations	IP1
Rainfall modelling	IC1
Rainfall monitoring	IC2
Temperature data monitoring	IC3
Temperature modelling	IC4
Construction requirements	IG1
Storm water management requirements	IG2
Urban zoning	IP2
Green adaptation guidelines	IG3
Climate scenarios	IC5
Sea water level monitoring	IC6
Sea water level modelling	IC7
Building costs	IT1
Wind monitoring	IT2
Adaptation measures benefit assessment	IT3
Adaptation measures cost assessment	IT4
Green areas state assessment	IT5
Monitoring measure effects	IT6

Tab. 14: Type of information for climate change adaptation. IP "planning information"; IC "climate-related information"; IG "guidelines information"; IT "technical information".

This list of information was then used to simulate different information scenarios – i.e. changing the state of the information variable in the stakeholders' FCM (see section 4.1) – allowing us to assess the impacts of the information on the individual problem understanding, as described in the table 15.

Information	Land use regulations	Rainfall modelling	Rainfall monitoring	Temperature data monitoring	Temperature modelling	Construction requirements	Storm water management requirements	Urban zoning	Adaptation guidelines	Climate scenarios	Sea water level monitoring	Sea water level modelling	Building costs	Wind monitoring	Adaptation measures benefit assessment	Adaptation measures cost assessment	Green areas state assessment	Monitorin g measure effects
City Executive Office	Medium	High	Medium	Low	Low	Low	Medium	Medium	High	High	Low	Low	Low	Low	High	High	Low	Low
FMI	Low	High	High	High	High	Low	Low	Low	Low	High	Medium	Medium	Low	Low	Low	Low	Low	Low
City Planning Dept.	High	Low	Low	Low	Low	Low	High	High	High	Low	Low	Low	Low	Low	High	High	Medium	Medium
Public Work Dept.	Low	Medium	High	Low	Low	Low	High	Medium	Low	Medium	Low	Low	Low	Low	High	High	High	Low
Real Estate Dept.	High	Low	Low	Low	Low	High	Medium	High	High	Medium	Medium	Medium	High	Low	Medium	High	Low	Low
Building Control Dept.	Low	Low	Medium	Low	Low	High	Medium	Low	High	Low	Low	Low	Medium	High	High	High	Low	High
Helsinki Environm. Centre	Medium	Low	Low	Low	Low	Low	Medium	Medium	High	Medium	Low	Low	Low	Low	High	High	High	High
Private consultants	Low	High	High	Medium	Medium	Low	Low	Low	Low	High	Medium	Medium	High	Medium	Medium	Medium	Low	Low
Regional Environm. Service	High	Low	Medium	Medium	Low	Low	High	Low	High	High	Medium	Low	Low	Low	Low	Low	Low	Low
Construction companies	Medium	Low	Low	Low	Low	High	Low	High	High	Low	Low	Low	High	Low	Medium	High	Low	Low
Building designer	Medium	Low	Low	Low	Low	High	Medium	High	High	Low	Low	Low	High	Low	Medium	Medium	Low	Medium
Planning agency	High	Medium	Medium	Low	Low	Low	High	Medium	High	High	Low	Low	Low	Low	Medium	Medium	Low	Low
Social Media	Low	Low	Medium	Low	Low	Low	High	Low	Low	High	Low	Low	Low	Low	High	High	Medium	Low
National Gov.	Low	Medium	Medium	Medium	Medium	Low	Medium	Low	Low	High	Medium	Medium	Low	Low	Low	Low	Low	Low
Practitioners association	High	Low	Low	Low	Low	High	High	High	High	Medium	Low	Low	High	Low	Medium	Medium	Low	Low
Local community	Medium	Low	Low	Low	Low	High	Medium	Low	High	Medium	Low	Low	High	Low	High	High	Medium	High
Int. Organizations	Low	High	Low	Low	High	Low	Low	Low	Medium	High	Low	High	Low	Medium	Low	Low	Low	Low

Tab 15: Elicitation of the information needs for the different stakeholders in the Helsinki case study. Each row describe the information scenario for each institutional actor.

Table 15 shows the differences in stakeholders' preferences concerning the suitability of the information related to climate change adaptation. As expected, the role played by the different agents in the urban planning process had a strong impact on their preferences over the available information. Differences in problem understanding resulted in different preferences over information. Accounting for these differences could facilitate the mainstreaming of the CS in urban planning for adaptation, as described in the next section.

The results of the table 15 were used to select the most important climate-related information, to be used in the convergent thinking phase, as discussed in the next section.

The convergent thinking phase: selection of the most suitable CS for Helsinki case study

The divergent thinking phase allowed us to assess to which extent differences in problem understanding could lead to different information needs. Table 15 shows the differences in information needs among the institutional actors. As already discussed in the introductory sections of this part of the deliverable, ambiguity could be either a source of creativity in the collective decision-making processes, or the cause of the polarization of the viewpoints. Experiences demonstrated that the key to change ambiguity in problem understanding from a barrier to an enabling factor for the collective decision-making processes is the decision-actors awareness of the existence of different, and equally valid, problem framings (Giordano et al., 2016).

Starting from these premises, the results of the ambiguity analysis were used as basis for the convergent thinking phase, i.e. the achievement of a consensus on the most suitable categories of climate services for enabling the urban adaptation in Helsinki. The stakeholders' preferences over the different categories of CS were aggregated, in order to detect the most preferred choices, i.e. the categories of CS with high preference for most of the stakeholders.

A stakeholders workshop was organized in the Helsinki case study. Three main phases were designed in order to facilitate the discussion among the stakeholders, i.e. the selection of the most suitable adaptation strategies, the usability of CS for supporting the selection and implementation of adaptation strategies, and the selection of the most suitable CS according to the participants' opinions. The results of the FCM analysis (see previous section) were then used to inform the debate. Specifically, we referred to the FCM analysis for identifying the most suitable adaptation strategies, and the most consensual categories of CS – i.e. those categories with a high information need score for most of the actors.

Adaptation measure	Description
Building techniques	Improving the design of the building and the use of construction materials.
Green roofs	Reducing the temperature in the building and contribute to manage the storm water.
Green areas for storm water retention	Reduce the runoff and contribute to reduce the flood risk.
Grey infrastructures	Reduce the runoff.
Awareness raising	Training courses, awareness campaigns. The scope is to increase the social acceptability of adaptation measures.
Stormwater management	Reduce the flood risk.
Institutional cooperation	Facilitate the flow of information and the communication among the different institutional actors.

Urban density	Reduce urban density in order to have more space for the green infrastructures.
Maintenance of green areas	Enhance the capability of existing urban areas to reduce runoff and flood risk.

Table 16: List of adaptation measures mentioned by the stakeholders during the FCM development phase.

Participants were required to provide a score to each of the mentioned measure. They were also allowed to add other measures not mentioned in the list. At the end of the discussion, a ranking of the adaptation measures was agreed on by the participants (Table 17).

	S1	S2	S3	S4	S5	S6	S7	Score
Building techniques	4,00	4,00	5,00	4,00	3,00	4,00	4,00	**4,00**
Green roofs	3,00	2,00	3,00	3,00	1,00	3,00	2,00	**2,43**
Green areas for stormwater retention	5,00	4,00	3,00	4,00	4,00	4,00	4,00	**4,00**
Grey infrastructures	3,00	3,00	3,00	4,00	4,00	4,00	4,00	**3,57**
Awareness raising	3,00	5,00	4,00	4,00	5,00	4,00	5,00	**4,29**
Stormwater management	5,00	5,00	3,00	4,00	4,00	5,00	5,00	**4,43**
Institutional cooperation	3,00	3,00	2,00	5,00	4,00	5,00	4,00	**3,71**
Urban density	1,00	2,00	3,00	4,00	4,00	5,00	3,00	**3,14**
Maintenance of green areas	4,00	1,00	3,00	3,00	4,00	4,00	4,00	**3,29**

Table 17: Ranking of the climate adaptation measures according to the stakeholders opinions (S1:S7).

The ranking was used to enable the discussion concerning the selection of the most suitable categories of CS. The results of the individual information needs elicitation were used to identify the most consensual categories of CS. Then, participants were required to describe how, according to their opinion, the CS could facilitate the selection and implementation of the climate adaptation measures (Table 18). The discussion leaded the participants in defining a ranking of the available CS.

	Rainfall modelling	Rainfall monitoring	Construction requirements	Storm water management requirements	Urban zoning	Adaptation guidelines	Climate scenarios	Building costs	Adaptation measures benefit assessment	Adaptation measures cost assessment	Monitoring measure effects
Building techniques			X			X		X			
Green roofs	X	X	X	X		X	X	X	X	X	X
Green areas for stormwater retention					X	X	X		X	X	X
Grey infrastructures	X	X		X	X		X		X	X	X
Awareness raising			X	X		X	X	X	X	X	
Stormwater management	X			X	X	X	X		X	X	X
Institutional cooperation						X	X		X	X	X
Urban density					X	X	X				
Maintenance of green areas					X	X	X				

Table 18: Climate-related information – Adaptation measures connections according to the participants' opinions.

The table 18 allows us to identify the information with the highest impacts on the effectiveness of climate adaptation measures, according to the participants' opinion. These results will be used in Task 4.3 for supporting the co-creation of suitable climate services.

It is worth mentioning that most of the interviewed stakeholders required to have easily access to guidelines and detailed descriptions of the measures to be implemented in order to enable the Helsinki adaptation. This means that, beside the development of reliable and understandable climate scenarios, efforts are required in order to enhance the transformation of climate-related data into adaptation measures. Stakeholders were specifically interested in having access to information for the monitoring and assessment of the measures' effectiveness – i.e. benefits assessment. This is an important gap in the climate and adaptation information sharing process in Helsinki.

The Organizational Network Analysis in Helsinki

In order to analyse the way the different actors interact during a decision-making process for the implementation of adaptation measures, the SNA methodology previously described was implemented. As already explained, the implementation of EU-MACS in Bologna is experiencing some delays due to difficulties in organizing the stakeholders meetings and workshops. Therefore, there is still missing information concerning the interaction among the different decision agents in urban planning for climate change adaptation. The social network analysis for Bologna case will be discussed in the deliverable 4.3. This section describes the results of the SNA for the Helsinki case.

The framework for the stakeholders' interviews was meant to collect individual experiences concerning the interactions, both formal and informal, activated during urban planning processes for climate change adaptation. The analysis is limited to the Helsinki municipal area.

List of actors

Actors	**Acronym**
City Executive Office	CEO
Climate-related research centres (FMI and SYKE)	RES
City Planning Dept.	CPT
Public Work Dept.	PWD
Real Estate Dept.	RED
Building Control Dept.	BCD
Helsinki Environmental Centre	HEC
Private consultants	CONS
Regional Environmental Service	RES
Construction companies	CC
Building designer	BD
Planning agency	PLAN
Social Media	SM
National Government (min. of Environment and min. of Finance)	NGOV
Practitioners association	ASSPR
Local community	LC
International Organizations	INT

List of information

Information	Acronym
Land use regulations	IP1
Rainfall modelling	IC1
Rainfall monitoring	IC2
Temperature data monitoring	IC3
Temperature modelling	IC4
Construction requirements	IG1
Storm water management requirements	IG2
Urban zoning	IP2
Green adaptation guidelines	IG3
Climate scenarios	IC5
Sea water level monitoring	IC6
Sea water level modelling	IC7
Building costs	IT1
Wind monitoring	IT2
Green solutions benefit assessment	IT3
Green areas state assessment	IT4

Clusters of information

IP → planning information
IC → climate-related information
IG → guidelines information
IT → technical information

List of tasks

Tasks	Acronym
Public investments	T1
Storm water strategy	T2
Construction guidelines	T3
Land use planning	T4
Water quality assessment	T5
Climate modelling	T6
Building activities control	T7
Training activities	T8
Awareness raising	T9
Designing public spaces	T10
Infrastructures development	T11
Maintenance of public areas	T12
Adaptation advises	T13
Risk analysis	T14

Using the results of the stakeholders interviews, the following Agent x Agent matrix was developed:

	CEO	RES	CPT	PWD	RED	BCD	HEC	CONS	RES	CC	BD	PLAN	SM	NGOV	ASSPR	LC	INT
CEO	0	0	10	8	10	8	6	8	0	0	0	0	0	0	0	0	0
RES	0	0	8	5	5	5	5	10	0	0	0	0	0	0	0	0	10
CPT	8	0	0	8	8	8	5	10	5	0	0	0	0	0	0	0	0
PWD	0	8	8	0	0	8	10	8	0	0	0	10	0	0	8	8	0
RED	10	0	0	0	0	8	0	0	0	0	5	0	0	0	0	0	0
BCD	0	0	8	5	0	0	5	8	0	10	2	0	0	0	5	0	0
HEC	0	0	0	0	0	0	0	0	0	0	0	0	8	6	0	0	0
CONS	0	10	10	10	8	0	0	0	0	0	0	8	0	0	5	0	0
RES	0	0	0	0	0	8	8	0	0	0	0	0	0	0	0	0	0
CC	0	0	0	0	0	10	0	0	0	0	10	5	0	0	5	8	0
BD	0	0	5	5	5	10	0	0	0	10	0	0	0	0	10	0	0
PLAN	0	0	10	0	8	0	0	0	0	5	5	0	0	0	5	0	0
SM	5	8	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NGOV	5	0	0	10	0	0	8	5	0	0	0	0	0	0	0	0	0
ASSPR	0	0	0	0	0	0	0	8	0	8	10	0	0	0	0	0	0
LC	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0
INT	5	10	0	5	0	0	0	0	0	0	0	0	0	8	0	0	0

This matrix was used for the development of the map of interactions among agents (fig. 16)

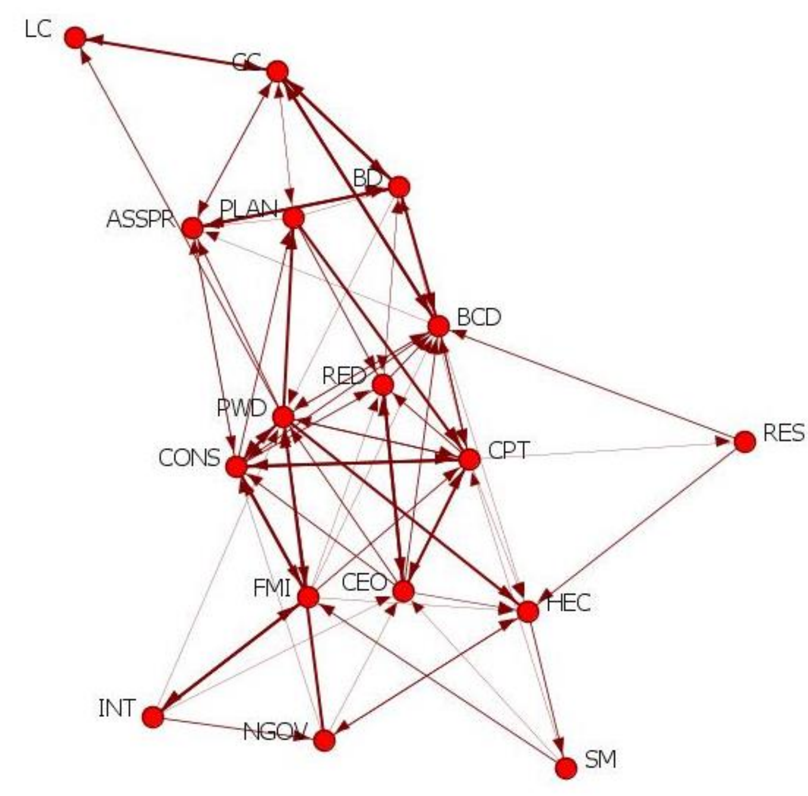


FIG. 14: Map of the *Agent x Agent* interactions taking place during urban planning for adaptation. The thickness of the links represents the degree of importance according to the stakeholders' opinion.

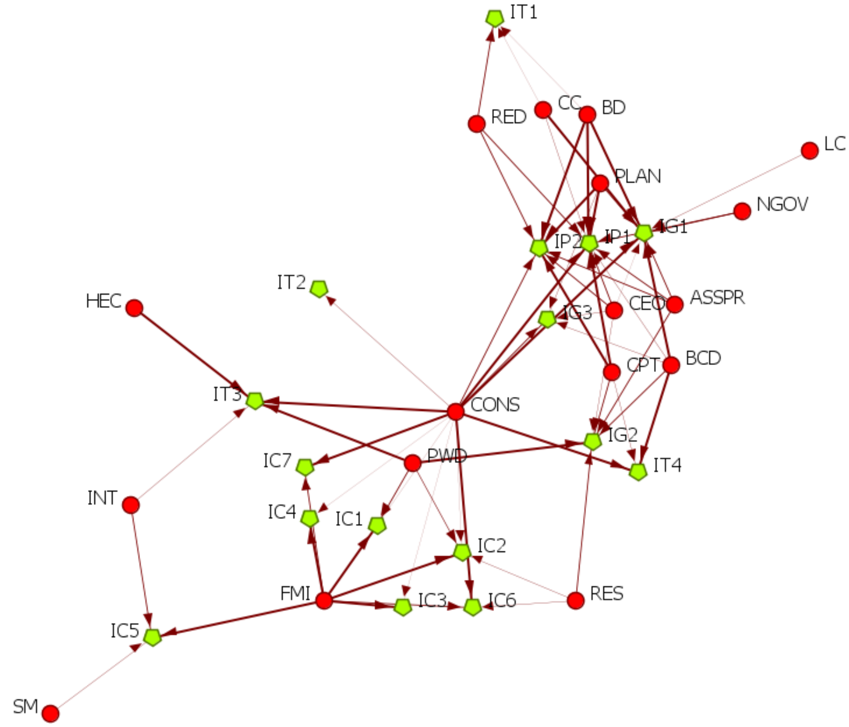


FIG. 15 Map of the *Agent x Knowledge* interactions taking place during urban planning for adaptation.

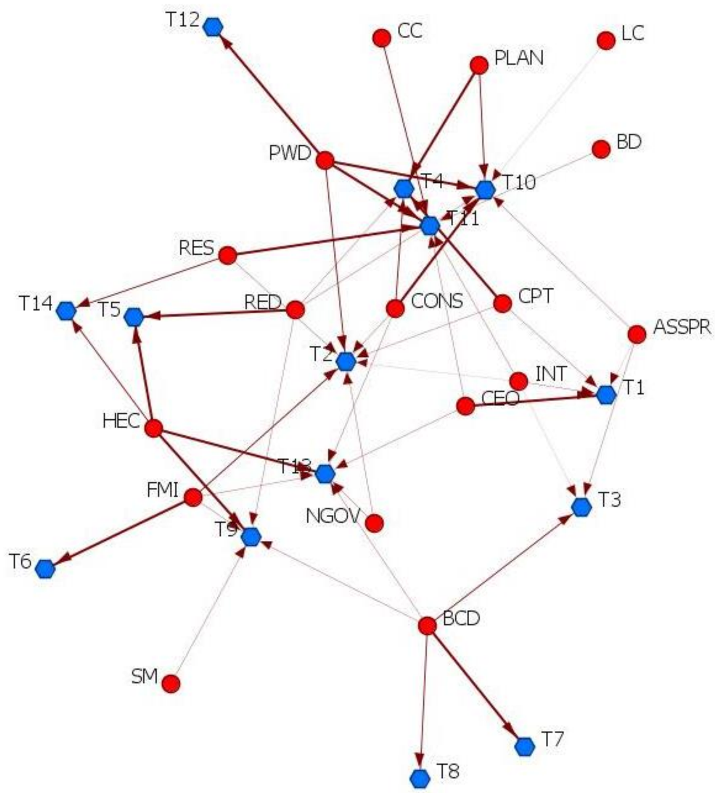


FIG. 16: Map of the *Agent x Tasks* interactions taking place during urban planning for adaptation.

The analysis of the different maps of interactions allowed us to identify the key elements in the collective decision-making process for urban adaptation.

Entity	Measure	Nodes
Agent	Total degree of centrality	PWD – Public Work Dept. CPT – City Planning Dept. BCD – Building Control Dept.
	Betweeness centrality	PWD – Public Work Dept. BCD – Building Control Dept. CPT – City Planning Dept. BD – Building designer
	Most knowledge	CONS - Consultancy agencies RES – Public research centres (FMI & SYKE)
	Most Task	BCD – Building control dept RES – Public research centres (FMI & SYKE) PWD – Public Work Dept.
Knowledge	Total centrality degree	IG2 – Storm water management requirements IG1 – Construction requirements IT3 – Green solution benefits ass. IP1 – Land use regulation
	Closeness centrality	IP1 – Land use regulations IG3 – Green adaptation guidelines IT3 – Green solution benefits ass.
	Most task	IG1 – Construction requirements IT3 – Green solution benefits ass IP1 – Land use regulation
Task	Total centrality degree	T2 – Storm water strategy development T3 – Construction guidelines T7 – Building activities control

Table 19: Key elements in the network of interactions according to the Graph Theory measures

The Graph Theory measures were also implemented in order to detect potential vulnerable point in the network. That is, those elements whose failure could provoke a failure or a reduction of the functionality of the entire network. The two actors with high specialization in knowledge production and use, i.e. the **RES** and the **consultancy agencies** have a quite low **centrality degree** and **betweennes centrality**. This strongly reduce their capability to enabling an effective information sharing process. This does not mean that these actors do not have and/or produce useful information for enabling the climate adaptation process. A lot of the produced information is public (and often belongs to open data platforms) or would be available under certain conditions. The centrality and betweennes measures have been implemented in this work to assess to which degree the available knowledge and information put these actors at the centre of the adaptation process. These measures show that efforts are required in order to enhance the usability of the available information. These results will be used as a starting point for the co-creative process involving the local stakeholders, and aiming at enhancing the usability of climate-related information in the urban planning processes (task 4.2).

For the same reasons, the **RES** could represents a vulnerable point in the network because it has a high most task degree, but a low level of centrality. It is worth mentioning that the centrality degree describes the capability of a specific actor to interact with the others and, thus, to share important information with them. The low degree of centrality of RES means that only few institutional actors are capable to use the scientific information for performing their tasks.

Furthermore, some of the actors with the most task degree have a limited access to crucial information. This could be due to their limited capability to comprehend and use the available scientific information. That is, they have a low most knowledge degree. Specifically, PWD, BCD have limited access to climate-related information.

Concerning the knowledge, the Green solution benefits assessment seems to have an important role both for facilitating the implementation of tasks and for enabling the information sharing process.

Concerning the tasks, the three most important ones, i.e. T4 T3 and T2 have a very limited degree of sharing among the agents. That is, although these tasks play a crucial role in the urban adaptation process, they seem to be poorly cooperative. This could represent a barrier to the effectiveness of the process.

Type of elements	Vulnerable elements	Meaning
Agent	FMI – Finnish Meteorological Institute CONS - Consultancy agencies	These agents have a high specialization in knowledge but a low centrality degree
	PWD – Public Work Dept. BCD – Building control dept.	These actors have a high most task degree and a limited access to crucial information.
Knowledge	IT3 – Green solution benefits ass.	It has a high centrality degree but it is poorly shared.
Task	T2 –Storm water strategy development T3 – Construction guidelines T4 - Land use planning	These tasks are central in the process but have a very limited degree of sharing among the agents

Table 20: Elements affecting the vulnerability of the interaction network in Helsinki.

The element of vulnerability could lead to failures in the collective decision-making process for urban adaptation, and, thus, they could represent barriers to the actual use of climate services. A debate involving the institutional actors was organized in order to define strategies aiming at overcoming the above mentioned barriers. To this aim a prototype of collaborative planning platform, based on climate-related information, was tested in Helsinki.

Testing a collaborative climate-related planning platform in Helsinki

The results of the SNA allowed us to demonstrate that one of the main drawbacks hampering the actual implementation of CS in urban planning was the shortfall in cooperation and information sharing among the different decision-makers. Therefore, in order to be effective a CS has to be capable not only to provide climate-related information, but also to enhance the cooperation and information sharing. In order to address this issue, a stakeholders' WS was organized in order to define the characteristics of a CS conceived as a collaborative planning platform.

The main scope of the workshop was to test and evaluate the suitability of a collaborative planning process, involving the different institutional actors, and based on the use and sharing of climate-related information. Given a specific urban policy issue, the process allows decision-makers to identify other actors that need to be involved to develop a consensual and affective solution to the problem at stage. The process will be referred for developing a collaborative planning platform for supporting decisions related to urban planning for climate adaptation, enabling collaboration among stakeholders.

Stakeholders have been involved in a group exercise aiming at developing a consensual solution to the following problem: how to design the most climate smart urban district in Helsinki? How to integrate the new urban area in the existing city structure? (Haaga, Pitäjänmäki). The “Vihdintien bulevardikaupunginosa” (Boulevard district of Vihdintie street) was introduced as case study.

In order to facilitate the discussion, participants were provided with a box containing initial information on the case. This box was named “initial knowledge-base”, and it represented the initial set of available concepts on the issues to be addressed during the decision-making process. Participants were also provided with a folder containing all the basic information concerning their role in the decision process, i.e. main objectives, tasks to be performed, information owned and used. The results of the previous interviews were used to this aim. The workshop was structured in “time-boxed” interactions. Participants had a limited time slot for contributing to specific topics of the discussion. In order to simulate a real collective decision-making process, the following phases were identified:

- Initial and collective problem formulation: The opening team introduces the initial problem formulation, based on the case study area, and the specific objectives to be achieved (e.g. reducing flood risk, increasing the urban areas, reducing the energy consumption, etc.). The other participants are required to add new specific objectives and/or challenge the ones cited by the opening team.
- Task list co-development: At this stage, the participants are required to define the list of tasks that, according to their own experiences, need to be carried in order to achieve the objectives defined in the previous step. The opening team submits in the platform the initial list of tasks (e.g. climate scenario modelling, risk analysis, transportation planning, public space design, etc.). The other participants could add and or challenge the initial list of tasks. The list is defined when a consensus is achieved.
- Information to be used in the process: Participants are required to specify the information needed in order to achieve the specific objectives and related tasks. To this aim, the platform provides two information panels/boards: the first contains information available in the interaction network (i.e. owned by the other actors), the second contains the supplementary information that can be gathered using available climate services. Participants are required to add information to the central panel, either using the owned information or referring to the two supplementary boxes.

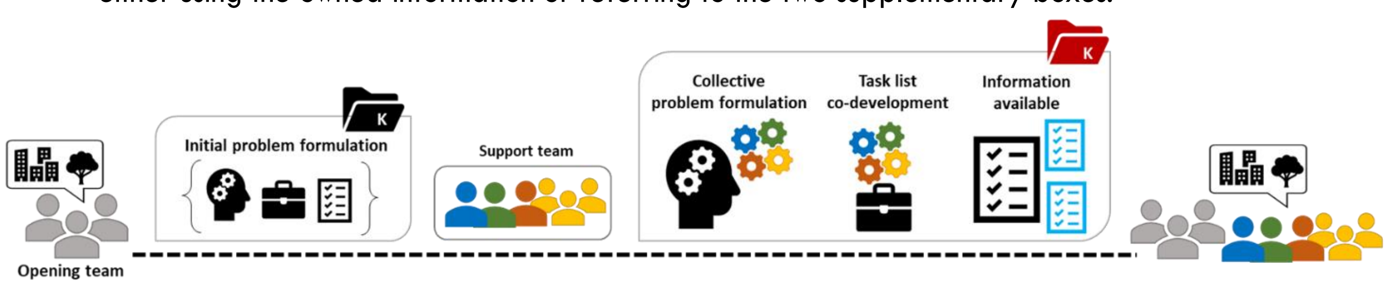


FIG. 17: Prototype for a collaborative planning process for climate change adaptation

The observation of the process and the collection of the stakeholders' feedbacks allowed us to define the characteristics of a collaborative planning platform in Helsinki, based on climate-related information:

- In order to facilitate the active involvement of different actors, the platform should be focused on specific problem. Generic issues could lead the participants toward endless discussion without the capability of achieving a solution.
- The structure of initial problem formulation need to be improved, facilitating the information retrieval by the other participants. The information – including the climate-related info – to be provided in the problem formulation needs to be clustered in easily identifiable and understandable classes of information.
- The development of the initial knowledge-base requires several improvement. Firstly, it should contain exclusively information and data that need to be used to solve the specific problem at stage. Generic information could be misleading. Participants should have access to this knowledge-base well in advance, in order to get familiar with the information contained and, thus, actively participate in the discussion. Finally, the way data and information are structured in the knowledge-base has to be clear and easily understandable for the participants.
- In order to facilitate the interaction among different actors, the profiles of the participants need to be well structured and shared. That is, every participant needs to know who is participating in the discussion, what are the roles, the tasks and the objectives around the table. The availability of this information could positively affect the creation of the "supporting team".
- The task list expansion phase has to be structured accounting for the different phases of the urban planning decision process, ranging from the strategy definition, to the actual action selection and implementation. The actors need to be involved in the phases of the process according to their role and responsibility. This will enhance the task list expansion.

The availability of an information dashboard, where all the participants can find out who-is-owning-what information is of utmost importance. This dashboard will allow participants to gather all the information needed for performing their tasks.

5.2 The Bologna case study

The stakeholders risk perception, the ambiguity analysis and information needs elicitation

The following actors were involved in the first phase of the analysis aiming at collecting and structuring individual problem understandings about climate change adaptation and the role of climate services.

Actors
European Invest. Bank
Regional Environmental Protection Agency
Private consultants
Water utility
Bologna University
Municipality - Urban regeneration dept.
Municipality – Environmental Protection and Energy dept.

Municipality – Urban transportation dept.
Municipality – Civil protection dept.
Municipality – Urban planning dept.
Municipality – Public work dept.
Private financial investors
Water drainage network management company
Regional Authority for water resources management

Table 21: List of actors involved in the Bologna case study.

Following the protocol of stakeholders' activities, individual semi-structured interviews were carried out, and the results were structured in FCM.

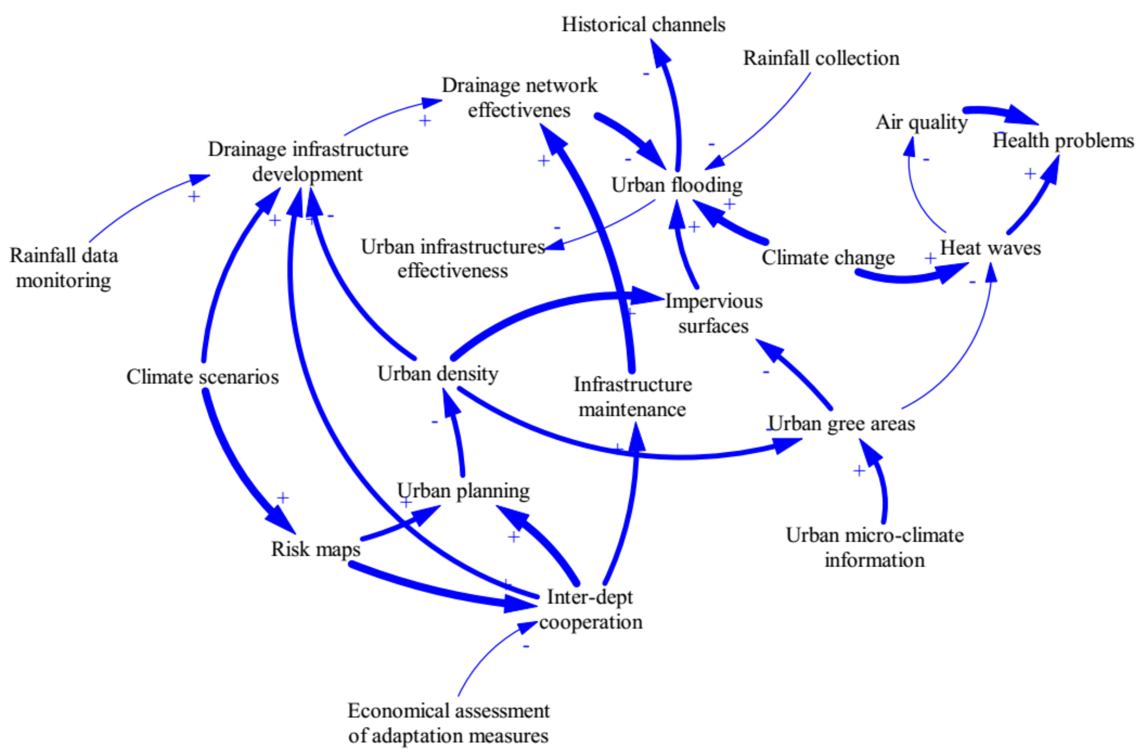


FIG. 18: FCM Municipality – Environmental Protection and Energy dept.

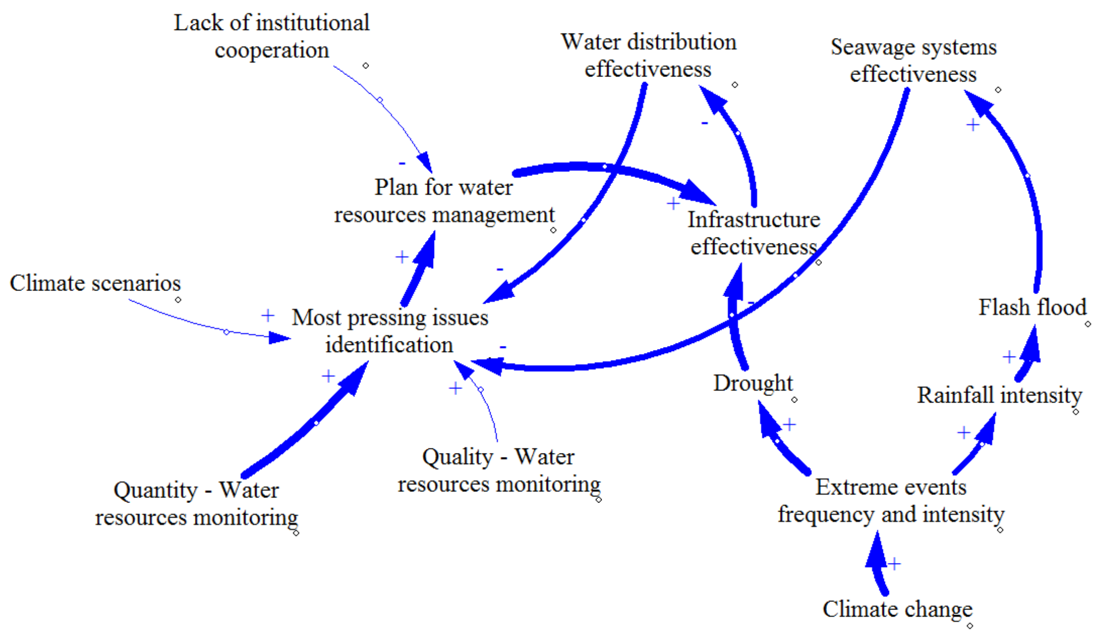


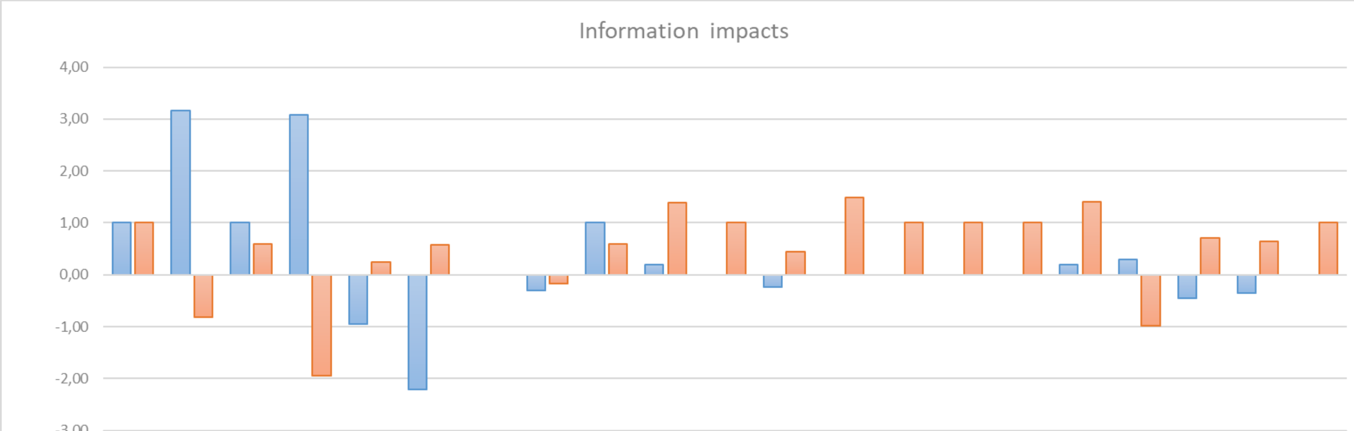
FIG. 19: FCM for the Regional Authority for water resources management.

Table 22 shows the results of the centrality degree analysis.

Decision actor	Type of variable	Variable	Centrality degree (value)	Centrality degree (index)
European Invest. Bank	Main effects	Rainfall intensity	2,34	Medium
	Primary impacts	Urban flooding	2,67	Medium
	Secondary impacts	Building damages	0,89	Low
		Infrastructure damages	5,37	High
		Social vulnerability	4,86	High
Regional Environmental Protection Agency	Main effects	Ranifall intensity	2,56	Medium
	Primary impacts	Air quality	4,76	High
		Urban flooding	3,98	Medium
	Secondary impacts	Building damages	2,45	Medium
		State of the urban environm.	5,87	High
Private consultants	Main effects	Rainfall intensity	1,65	Medium
		Increasing temperature	4,45	High
	Primary impacts	Urban flooding	2,43	Medium
		Heat waves	3,67	Medium
	Secondary impacts	Infrastructure damages	0,73	Low
		Building damages	2,34	Medium
		Helath problems	5,69	High
		Green areas state	4,73	High
		Historical heritage	5,32	High
Municipality - Urban regeneration dept.	Main effects	Rainfall intensity	3,32	Medium
		Increasing temperature	0,75	Low
	Primary impacts	Urban flooding	4,78	High
	Secondary impacts	Building damages	1,83	Medium
		Historical heritage	5,63	High
		Infrastructure damages	5,32	High
		Green areas state	4,65	High
Municipality – Environmental Protection and Energy dept.	Main effects	Ranfall intensity	2,34	Medium
		Increasing temperature	2,76	Medium
	Primary impacts	Urban flooding	4,32	High
		Air quality	5,45	High
		Health problems	4,32	High
	Secondary impacts	Infrastructure effectiveness	4,21	High
		Historical heritage	5,32	High
Municipality – Public transportation dept.	Main effects	Ranfall intensity	3,21	Medium
	Primary impacts	Urban flooding	2,56	Medium
		Air quality	0,57	Low
	Secondary impacts	Infrastructure effectiveness	5,65	High
Regional Authority for water resources management	Main effects	Extreme events intensity	4,35	High
	Primary impacts	Drought	5,37	High
		Flash flood	3,67	Medium
	Secondary impacts	Water distribution effect.	4,65	High
		Seawage infrastr. Effect.	3,83	Medium

Table 22: Main elements of Bologna stakeholders' risk perception.

Figure 20 shows the change in the variable states of the Environmental Protection and Energy department because of the availability of the information "climate scenarios", "rainfall monitoring", and "urban micro-climate".



	Climate change	Urban flooding	Heat waves	Impervious surfaces	Urban infrastructure effect.	Historical channels	Rainfall collection	Air quality	Health problems	Urban green areas	Urban micro-climate inform.	Drainage network effect.	Drainage infrastr. Developm.	Rainfall data monitoring	Climate scenarios	Risk maps	Urban planning	Urban density	Inter-dept. Cooperation	Infrastructure maintenance	Economic assessment
No Info	1,00	3,16	1,00	3,09	-0,95	-2,21	0,00	-0,30	1,00	0,20	0,00	-0,23	0,00	0,00	0,00	0,00	0,20	0,30	-0,45	-0,35	0,00
Info	1,00	-0,81	0,58	-1,95	0,24	0,57	0,00	-0,18	0,58	1,39	1,00	0,45	1,49	1,00	1,00	1,00	1,40	-0,98	0,70	0,65	1,00

No Info   Info

Fig. 20: FCM variable states before (a) and after (b) the availability of the climate-related information.

Table 23 shows the stakeholders' preferences over the available information.

Information	Land use regulations	Rainfall modelling	Rainfall monitoring	Temperature data monitoring	Temperature modelling	Construction requirements	Storm water management requirements	Urban zoning	Urban climate assessment	Adaptation guidelines	Climate scenarios	Building costs	Adaptation measures benefit assessment	Adaptation measures cost assessment	Green areas state assessment	Monitoring measure effects
European Invest. Bank	Low	High	Medium	Low	Low	Low	Low	Medium	Low	Medium	High	Low	High	High	Medium	High
Regional Environmental Protection Agency	Medium	High	High	High	High	Low	Low	Low	High	High	High	Low	Low	Low	High	Low
Regional Auth. Water resources manag.	Low	High	High	Low	Low	Low	High	Low	Medium	Medium	High	Low	High	High	Low	Medium
Private consultants	High	High	High	High	High	Low	High	High	High	High	High	Low	High	High	Low	Low
Water utility	Low	High	High	Low	Low	Low	High	Medium	Low	Low	Medium	Low	High	High	Low	High
Municipality - Urban regeneration dept.	Medium	High	Medium	High	High	Low	Medium	Medium	High	High	Medium	Low	High	High	High	High
Municipality – Environmental Protection and Energy dept.	Medium	Medium	Medium	Medium	Medium	Low	Low	Medium	High	High	Medium	Low	High	High	High	High
Municipality – Urban transportation dept.	Low	Low	Low	Low	Low	Low	Medium	Low	Low	High	High	Low	Medium	Medium	Low	High
Municipality – Civil protection dept.	Low	Low	High	High	Low	Low	Low	Low	Medium	Low	Low	Low	Low	Low	Low	High
Municipality – Urban planning dept.	High	Medium	Low	Low	Medium	Low	Medium	High	High	High	Medium	Low	Medium	High	High	Medium
Municipality – Public work dept.	Medium	Low	Low	Low	Low	Low	High	High	Low	High	Medium	Low	Medium	Medium	High	Medium
Private financial investors	Low	High	Medium	Medium	High	Low	Medium	Low	Medium	High	High	Low	High	High	Low	High
Public research centres	Low	High	High	High	High	Low	Low	Low	High	Low	High	Low	High	High	Low	Low
Water drainage network management company	Low	Medium	High	Low	Low	Low	High	Low	Low	High	High	Low	High	High	Low	Low
Practitioners association	High	Low	Low	Low	Low	High	High	High	Medium	High	Medium	High	High	High	Low	Low
Local community	Low	Low	Medium	Medium	Low	High	Medium	Low	Low	Low	Low	High	Medium	Medium	Medium	Low

Table 23: Stakeholders' information needs in the Bologna case study.

The convergent thinking phase: selection of the most suitable CS for Bologna case study.

Starting from the results of the information needs analysis, two CS users WS were organized in the Bologna demo. The first one focused on the development of a common definition of the role of CS in supporting the Urban planning for adaptation in the city. The attendees were required to describe the main characteristics of the CS according to their own understanding. ENoLL designed and led the WS. The results of the WS are summarized in the following table:

Stakeholders	Services
Planners	Spatial location of main problems Identifying both, the main (common) issues but also (location) specific issues; Information database for training technicians & citizens Processed & aggregated information for a scenario simulation, to evaluate response based on adopted practice
Public administration	Training in the use of CS Scenarios & Indices Software tool to evaluate microclimatic response based on the adopted practices
Business	Data collection & management as a business Understanding future evolution of a system Deciding the location of important businesses
Citizen	Warning users about climate related issues (eg. Heat waves) Risk maps (short & long-term scenarios, evaluation of risks & investments) Web portal presenting a range of possible intervention alternatives Representation of climate extremes

Table 24: Results of first stakeholders WS in Bologna

The integration between the services descriptions and the results of the information needs elicitation process allowed us to define the role of the CS in supporting the urban planning for adaptation. That is, providing reliable and understandable information for facilitating the communication among the different stakeholders for what concerns the costs and benefits due to the implementation of adaptation measures.

To address this issue, a second stakeholders' WS was organized in Bologna. The main scope of this WS was to collect the stakeholders' understandings about the information that should be provided by a CS in order to assess adaptation measures costs and benefits. To enable the discussion a real example related to the design of a parking area was used. Participants were firstly required to describe the specific objectives to be achieved through the design of the area, accounting for both the maximization of the benefits and the minimization of the costs. This allowed us to co-develop the cost/benefits definition. Secondly, participants were required to describe how costs and benefits could be evaluated (indicators) and the kinds of information needed for the evaluation. The following table shows the results of the stakeholders' WS for what concerns the information needed for the cost/benefits assessment.

Objectives	Information required
Sustainable management of the water cycle	Extreme events scenarios Hydraulic modelling (sewage network) Flood risk maps Sewage network assessment maps
Improving air quality	Urban downscaling of the air pollution scenarios Wind monitoring
Enhancing micro-climatic conditions	Temperature Wind monitoring Scenarios development Local climate scenarios
Reducing health problems	Socio-economic indicators Social vulnerability assessment Locally-based health data

Table 25: Information needs for the cost-benefits analysis of the adaptation measures in Bologna.

5.3 Concluding remarks.

This section was aiming at detecting and analyzing potential barriers due to the public policy and administration structure that could hamper the creation of a market for the climate services. Specifically, two different kind of barriers were analyzed in this work, i.e. the ambiguity in problem understanding and the vulnerability in the network of interactions taking place during a collective decision-making process. These two elements could reduce the effectiveness of the adaptation process as collective decision-making process and, thus, the usability of the climate services for urban planning.

On the one hand, the ambiguity in problem understanding could provoke conflicts among the different stakeholders and, hence, hamper the implementation of adaptation measures. Previous works (i.e. Giordano et al., 2016) demonstrated that, if neglected, ambiguity could provoke a polarization of the viewpoints, impeding the definition of socially accepted policies. In this situation, climate related information seems not be useful. Therefore, the methodology described in this work aims at making ambiguity explicit and to allow decision-makers to better comprehend the main reasons of ambiguity. In this work, the ambiguity analysis was used to facilitate the elicitation of the decision-actors information needs. The analysis of the individual problem understanding allowed to making the differences in information needs explicit. Moreover, the experiences carried out in Helsinki allowed to demonstrate the usability of the ambiguity analysis as a mean to inform and enable the debate among the decision-makers – that is, the users of the climate-related information.

On the other hand, the organizational approach to Social Network Analysis allowed us to unravel the complexity of the network of interactions at the basis of the urban planning process. The adopted methodology was capable to identify key elements and main vulnerabilities accounting for the three main elements in the organizational network, i.e. actors, knowledge and tasks. The basic assumption of the adopted methodology is that the more effective and reliable is the network of interaction, and the more effective is the collective process for urban adaptation. In order to be effective, climate services need to be based on a reliable and effective network of interactions.

The results of the analysis were used to organize stakeholders' WS in both Helsinki and Bologna. Specifically, the Helsinki WS was focused in co-developing a collaborative planning platform, based on climate-related information, capable to overcome the main barriers hampering the flow of information among the different decision-makers involved in the urban adaptation. The Bologna WS aimed at overcoming the barriers hampering the actual use of climate services due to a lack of common understanding about the information that needs to be used as basis for the planning process.

6. CONCLUSIONS

The main scope of this work was to analyse the main barriers, both technical and institutional, hampering the actual mainstreaming of climate services in urban planning for climate adaptation. To this aim, three main activities have been carried out in WP4:

- Analysis of the main urban planning tools for climate change adaptation: starting from a general review of the urban planning process for CCA, the analysis has been focused on the current situation in the two EU-MACS urban case studies, i.e. Helsinki and Bologna. Scientific and grey literature has been used to collect information about previous and ongoing experiences related to CCA. The experiences reported in Bologna and Helsinki demonstrated the unsuccessfulness of centralized, institutional-oriented approaches. A strong cooperation with local communities and private actors is required. It is also important to notice that the main issue that need to be addressed in climate change adaptation planning concerns the implementation phase. Specifically, the difficulties in monitoring and evaluating cost and benefits due to CCA measures is negatively affecting their implementation.
- Analysis of the existing climate services for urban planning: a deep literature review has been carried out aiming at developing a catalogue of existing, and already used, CS for urban planning. These tools have been clustered in categories, facilitating the discussion with the stakeholders in the two case studies. The analysis carried out in the phase allowed to integrate the list of the main barriers hampering the usability of CS (D1.1), by introducing urban planning-related barriers. Specifically, this task allowed to barriers related to the policy making field. Policy makers seem more interested to mitigation policies, rather than adaptation. Moreover, the short terms policy-makers' attitude negatively affects the willingness to implement long-term adaptation measures. Finally the lack of tools for assessing the effectiveness of adaptation strategies is having a negative impact on the public awareness about the role of adaptation measures in order to reduce climate-related risks.
- Analysis of institutional and information sharing framework for CS: this phase aimed at detecting barriers to CS usability due to some drawbacks in the interactions among the different institutional actors involved in urban planning for adaptation. Referring to the literature in this field, two different kinds of barrier were analised: i) the barriers due to the lack of common understandings about climate-related issues and measures; ii) the barriers hampering the flow of information among the different institutional and non-institutional actors. The activities carried out in the two EU-macs urban case studies allowed us to emphasize the need to account for the different actors' information needs. This is a fundamental initial step to fill the gaps between information users and producers in climate change adaptation. Moreover, the analysis showed how the lack of information sharing and willingness to cooperate among the different actors – and specifically the different municipal departments – could represent a strong barrier to the actual use of CS for urban planning.

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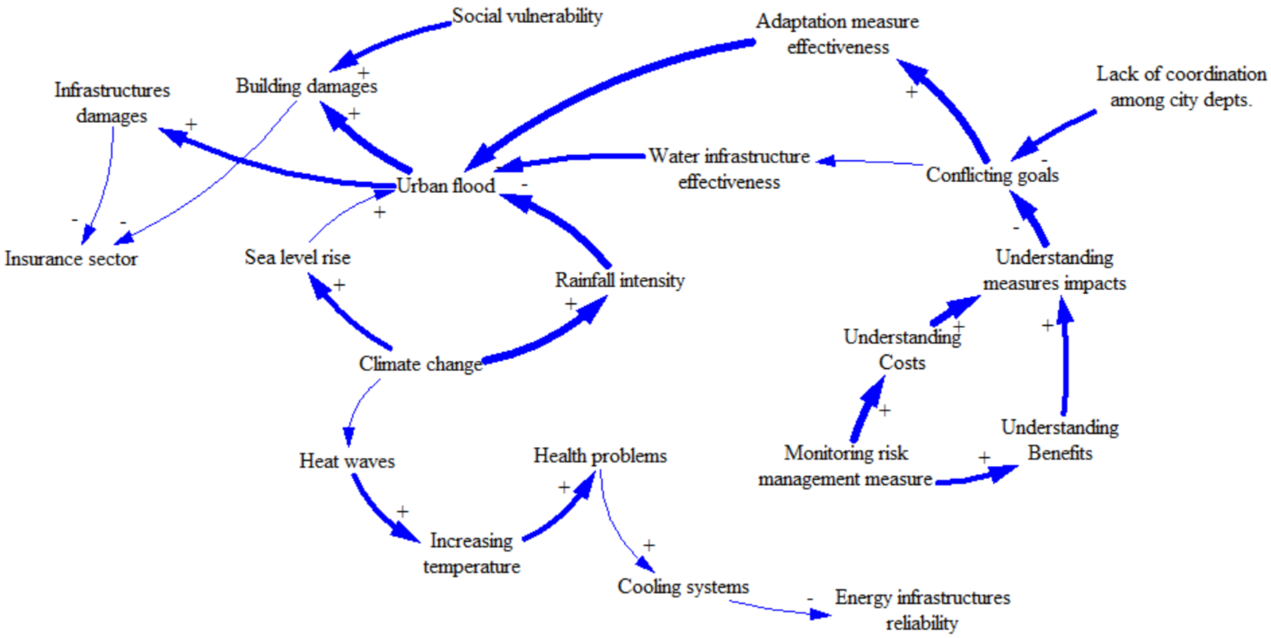
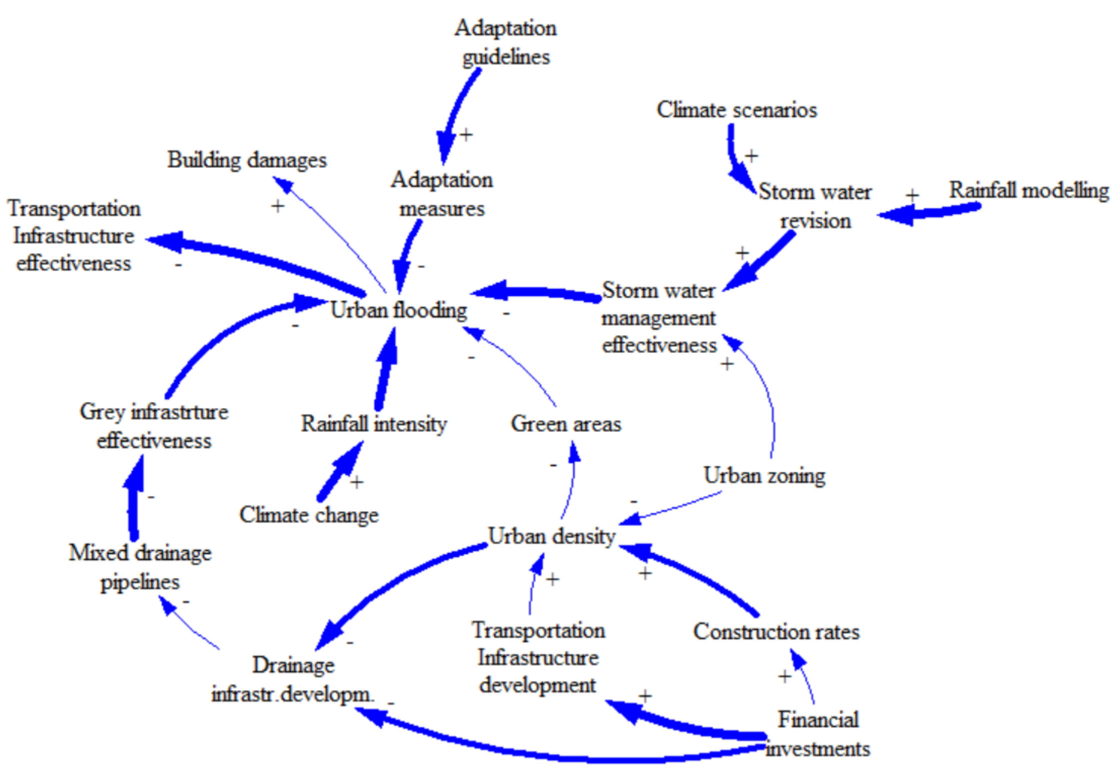
ANNEX 1 – FRAMEWORK FOR THE STAKEHOLDERS INTERVIEWS

1. Could you, please, describe your role in urban planning process and, specifically, in urban adaptation to climate change?
2. According to your best knowledge, could you briefly describe how climate changes are going to affect Helsinki area? (e.g. increasing risks, etc.)
3. Could you describe the main sectors that could be impacted by the climate change effects (i.e. transportation infrastructures, energy consumption, etc.);
4. For each of the above mentioned sectors, could you describe the expected climate change impacts?
5. Are you already experiencing these impacts?
6. What are the urban elements affecting the intensity of these impacts (i.e. vulnerability)?
7. What are the main strategies (plan) that Helsinki municipality is (or will) implement in order to deal with the above mentioned impacts? What's your opinion about the effectiveness of these strategies? Are they effective/sufficient?
8. Which information was used to define these strategies/plan? (e.g. scenarios of climate-related risks; etc.). What was the format of this information (e.g. model, decision support system, map of risk, etc.)?
9. Who was the provider of this information?
10. What kind of decision were taken using this information? Was this information easily understandable and accessible?
11. How much internal/external resources did you use prior to use the climate information in the decision process?
12. Could you, please, list the actors (both institutional and non-institutional) with whom you interact for the definition/implementation of strategies/plans for the adaptation to climate change?
13. For each of the above mentioned actors could you describe the kind of interaction you had (e.g. information providers, information receivers, cooperative task performance, etc.)? Could you assess the importance of these interactions?
14. Among the above mentioned actors, could you list those with whom you exchanged climate information?
15. Are these interactions formally defined by the internal regulations? Do you activate some informal interactions (e.g. to have access to important information)? Could you explain why informal interactions needed to be activated?
16. According to your experience/opinion, could you describe some limits/drawbacks of the current interaction network hampering the process for the adaptation to climate change (e.g. lack of information sharing, few actors involved in the process, few actors owning too much information, etc.)?
17. What was the role of the local community in the definition/implementation of the strategies for the adaptation to climate change? Are members of the community involved in the process? In which phase?
18. Do you think that the involvement of the local could positively affect the process for adaptation to climate change? How?

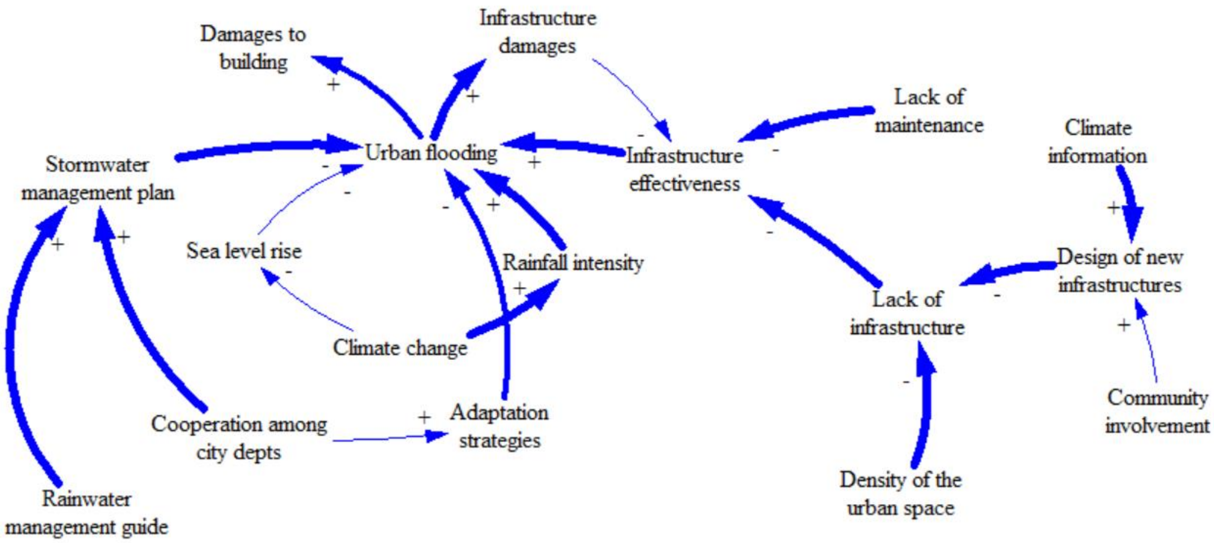
ANNEX 2 – FCM EXAMPLES: HELSINKI CASE STUDY



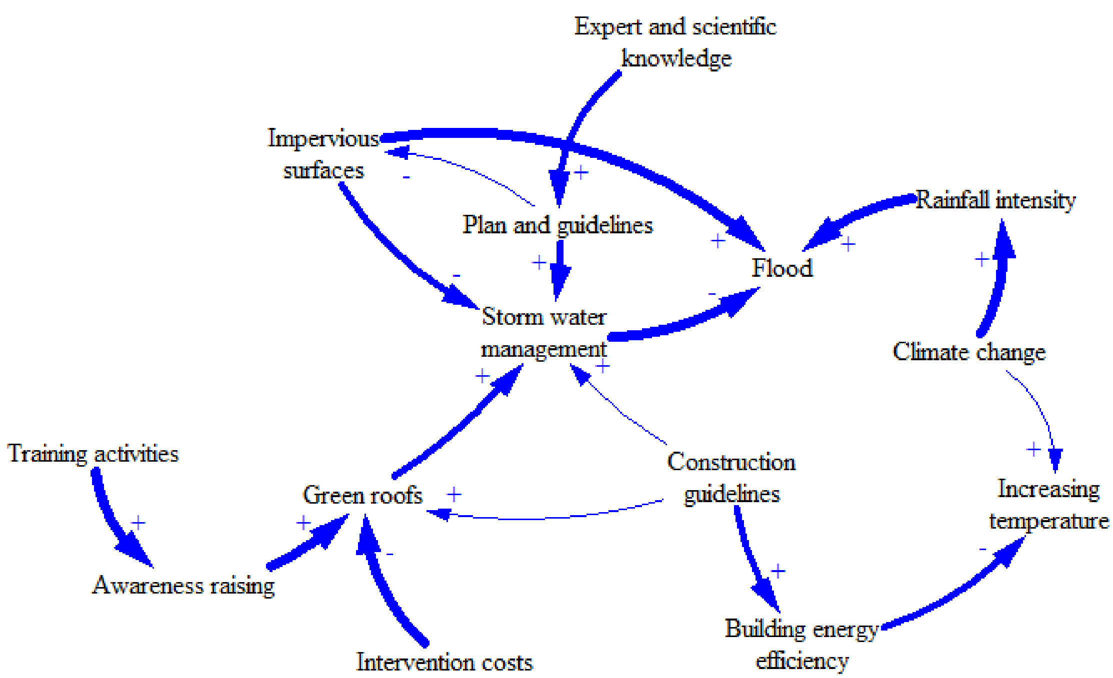
Helsinki Environmental Centre



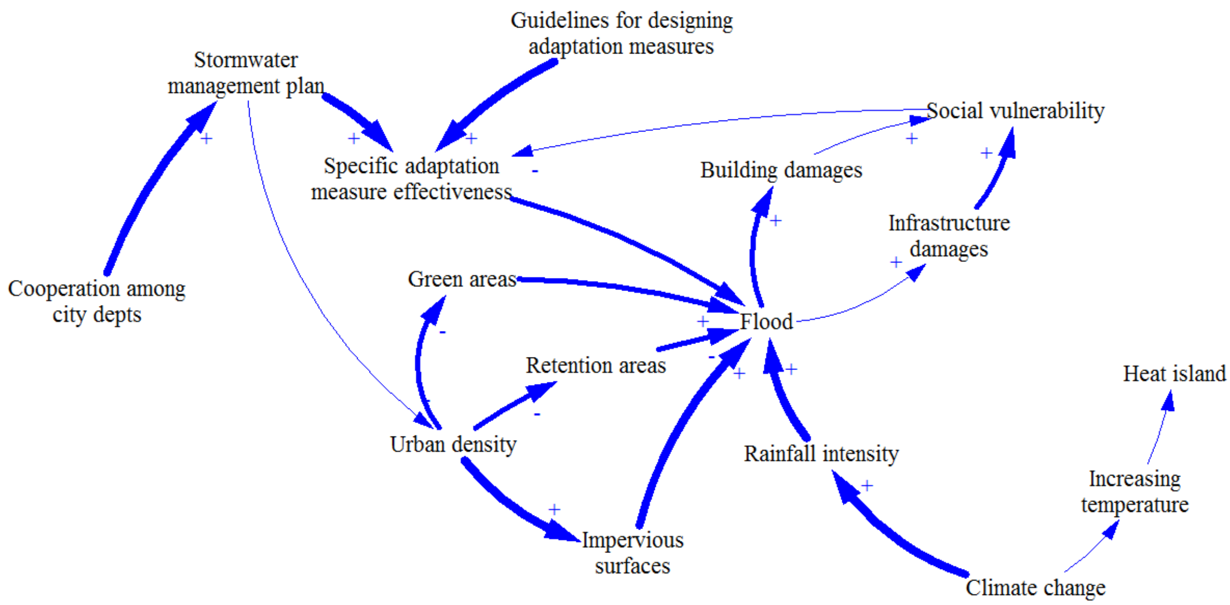
Helsinki City Executive Office



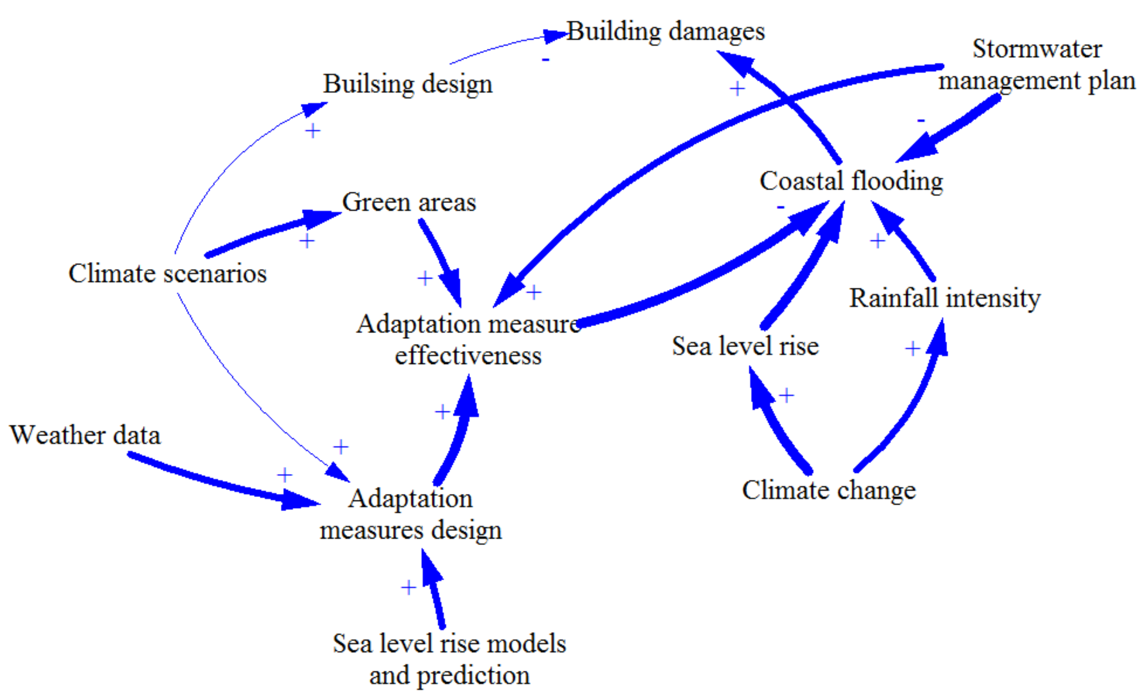
Public work department



Building control committee

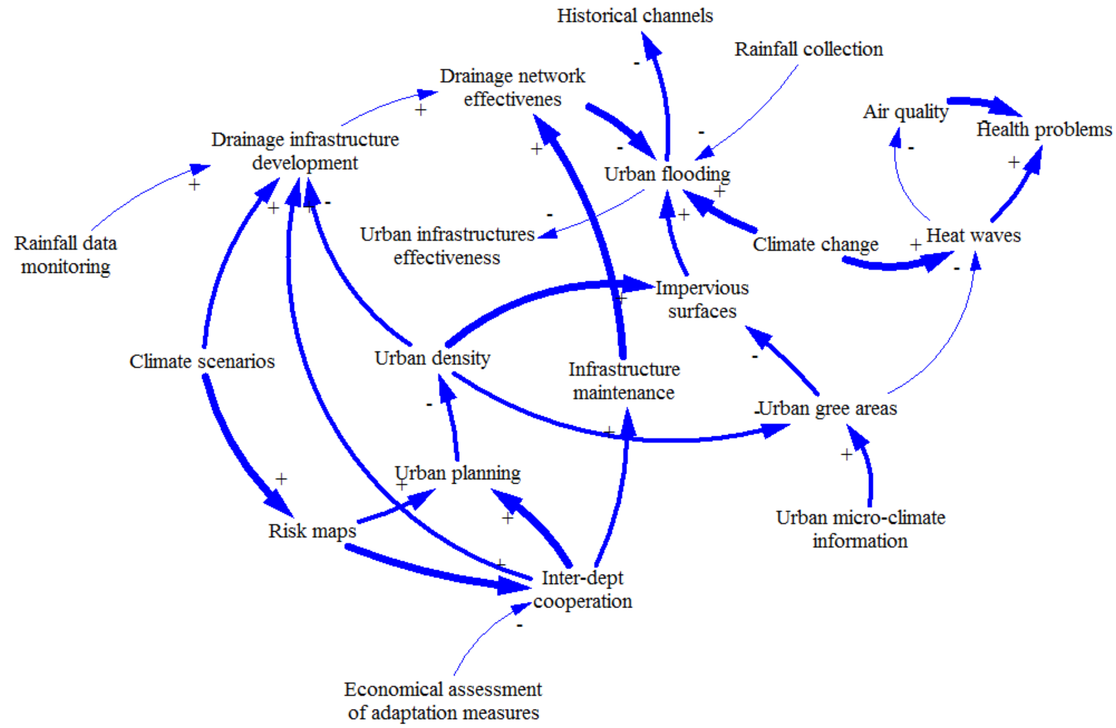


Helsinki Regional Environmental Centre

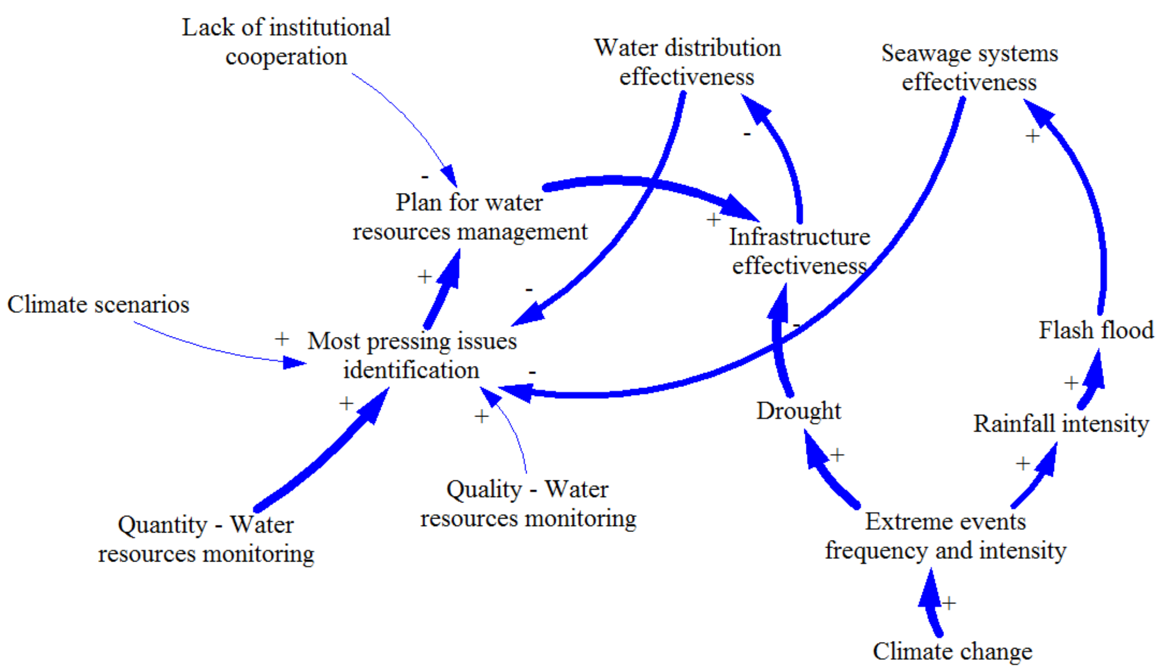


Consultancy Agency

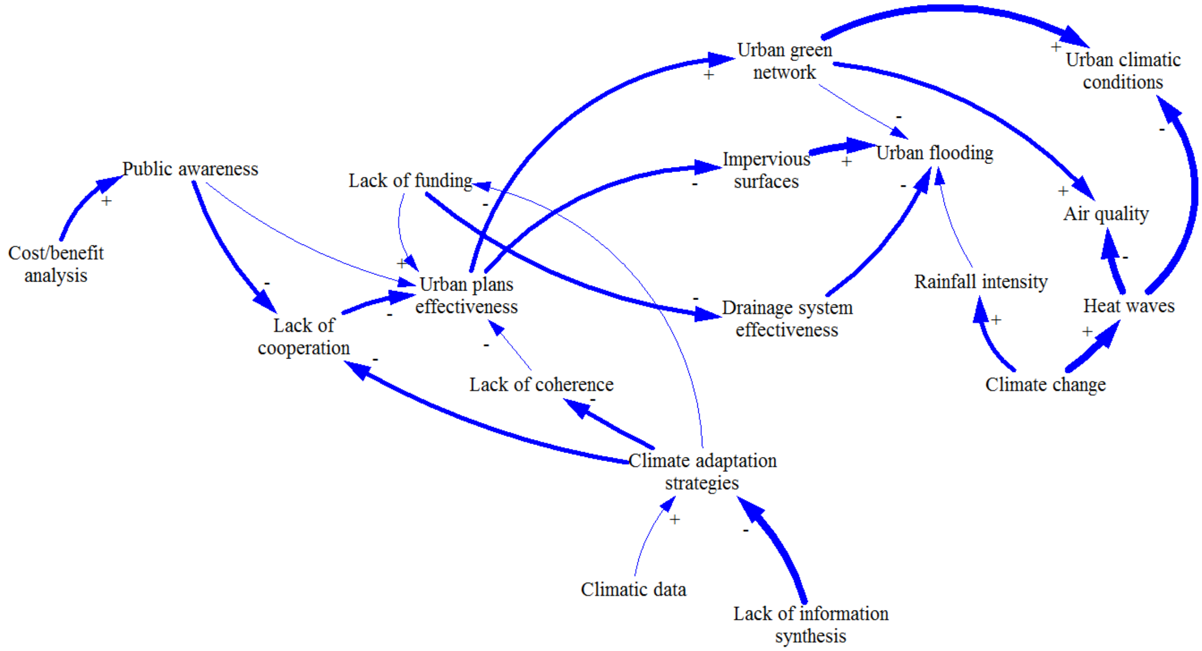
ANNEX 3 – FCM EXAMPLES: BOLOGNA CASE STUDY



Bologna Municipality: Environment and Energy saving dept.



Regional authority for water resources management



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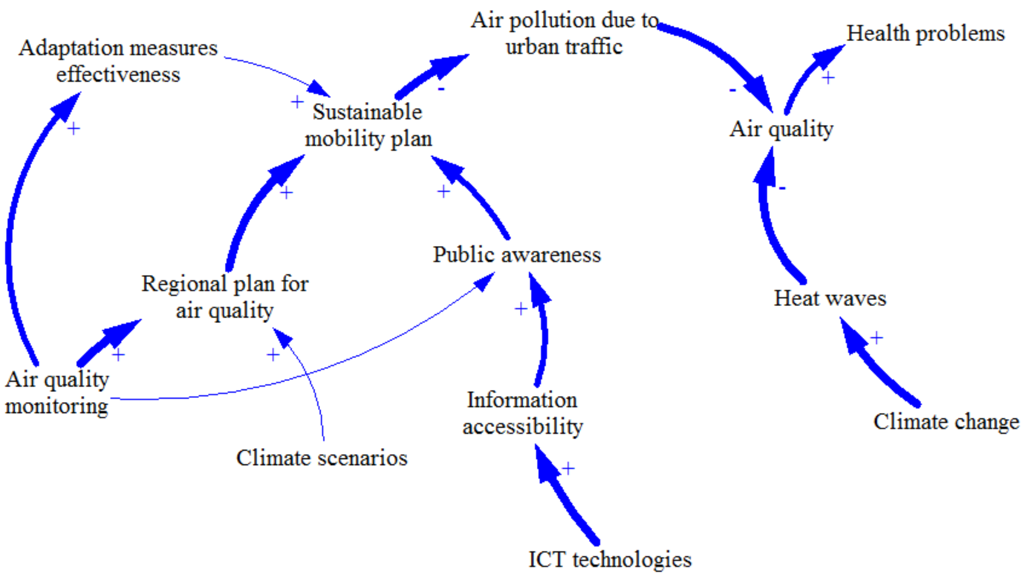

Bologna municipality: Transportation planning dept.