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Urban sprawl processes characterize the landscape of the areas surrounding cities. These landscapes show different features according to the geographical area that cities belong to, though some common factors can be identified: land consumption, indifference to the peculiarities of the context, homogeneity of activities and building typologies, mobility needs exasperatedly delegated to private cars.

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Contents

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ENHANCING URBAN RESILIENCE IN FACE OF CLIMATE CHANGE[1].

A Methodological Approach

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ABSTRACT

Climate change can be considered as one of the main environmental topic of the 21st century (IPCC, 2011). It poses a serious challenge for cities all over the world (EEA, 2012): cities show, on the one hand a high level of vulnerability in face of climate change, on the other hand, they are responsible for 60% to 80% of global energy consumption and greenhouse gas (GHG) emissions, which represent the main causes of change in climate conditions. In 2011, the 73% of European population was living in urban areas and the level of urbanization is expected to be at 82% by 2050 (UN, 2012). Due to the evidence that in Europe the 69% of all GHG emissions are currently generated by cities, larger and larger is the attention devoted, by scientific literature and policy makers, to outline strategies for urban adaptation to climate change, both at European and local scale. Governments and scholars currently highlight the need for strengthening urban resilience in face of climate change and related consequences. By this perspective, some actions are already running, even though a clear identification of the features which make a city resilient in face of climate change is still missing. To fill this gap, this contribution is mainly addressed to:

- provide, by integrating different disciplinary perspectives, a conceptual model of the set of adaptive capacities and properties that characterize a resilient system;
- verify, starting from a snapshot of current strategies and actions for urban adaptation currently implemented at European level, the consistency between those strategies and the identified set of resilience capacities and properties.

KEYWORDS:
urban resilience, adaptation, climate change

1. CLIMATE CHANGE: RELEVANCE, FEATURES AND CONSEQUENCES

According to the numerous Intergovernmental Panel on Climate Change (IPCC) reports, set up from 1990 to 2007, the research projects and the large scientific literature focused on the topic, climate change is “one of the great challenges of the 21st century” (IPCC, 2011). To understand the importance assumed in the last decade by researches on climate change, it is worth mentioning that, since 2003, more than 130 research projects directly focused on climate change as well as other projects related to the effects of climate change in the areas of environment, energy, transport, agriculture, fisheries, natural hazards, have been supported by the European Community (EU, 2010). Moreover, the eligibility criteria of the last European Research Programme (FP7) allow partners from all over the world to participate in climate change research projects, according to the awareness that climate change represents a global threat. As stated by Rodríguez (2010) “the diversity of European research confirms that climate change is an encompassing matter touching on nearly every dimension of our society”.

Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity. This interpretation differs from the one provided by the United Nations Framework Convention on Climate Change, where climate change is referred to a change of climate directly or indirectly attributed to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods (IPCC, 2007).

Climate change induces a set of slow-moving phenomena, such as the increase in air and ocean average temperature and in the sea level, the decrease in snow and ice, the change in the global precipitation amount (with significant increases in some regions and declines in others). Furthermore, in the last decade an increase in the number of occurred natural hazards has been recorded: according to the Centre for Research on the Epidemiology of Disasters (CRED), the number of natural disasters in Europe rose from 59 disasters on average per year in the time-span 2000-2009, to 70 disasters in 2010. Such an increase is mostly due to a rise in the number of hydrological (avalanches and floods) and climatological (extreme temperatures, drought and wildfires) disasters (Guha-Sapir et al., 2011). Although these events cannot be directly linked to climate change, last IPCC Report (2007) has clearly highlighted that climate change contributes to the occurrence of more frequent, severe and unpredictable weather-related hazards, such as floods, droughts, tropical cyclones and heat waves. Hence, referring to climate change, both slow as well as quick-moving phenomena have to be taken into account. Moving to the causes of the mentioned phenomena, the GHGs emissions are widely recognized as the main contributors to climate change: carbon dioxide (CO_2) is the most important anthropogenic GHG and recent data confirm that consumption of fossil fuels accounts for the majority of global anthropogenic GHG emissions (IPCC, 2011).

Europe is responsible for approximately the 12% of the annual global anthropogenic direct GHG emissions (EU, 2011). According to the Kyoto Protocol, adopted in Kyoto in 1997 and entered into force in 2005, numerous efforts have been undertaken to curb emissions in Europe: total emissions had a significant decrease in the period 1990-2009 (more precisely from 2004 to 2009), going below the Kyoto target (8%), but an increase has been recorded in 2010 (Fig. 1) (EEA, 2012). Data provided by the Annual European Union GHG Inventory highlight that in EU 27, in 2010, the sectors that have mostly contributed to GHG

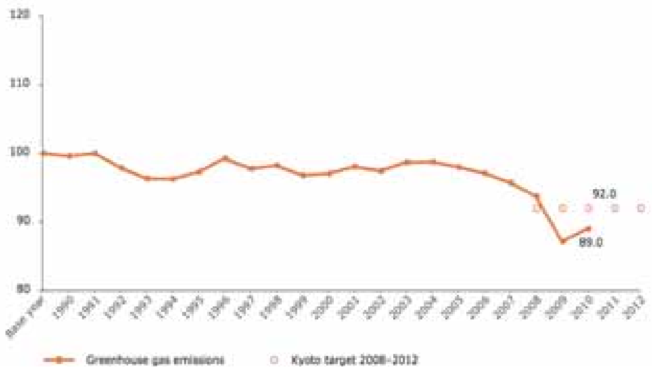

Fig. 1 GHG emissions in Europe (1990-2010) in respect to the Kyoto threshold.

emissions were Energy Production, Transport and Households Services (Fig. 2) (EEA, 2012). Broadly speaking, in respect to the heterogeneous phenomena induced by climate change, the most affected elements and systems can be identified in the coastal areas, exposed to increasing risks, including coastal erosion and sea level rise; natural ecosystems, which are threatened by the combination of climate change related disturbances (floods, drought, wildfires, etc.) and other global change drivers such as pollution, fragmentation of natural systems, etc..

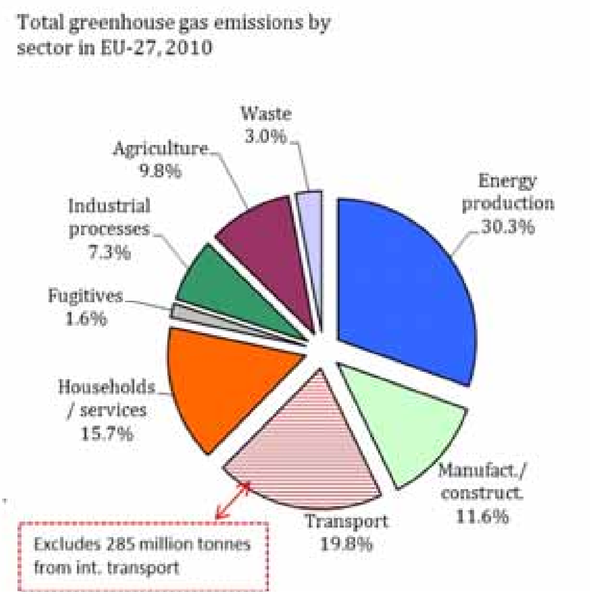

Fig. 2 Sectors contributing to total GHG Emission in 2010 (EU27).

Crop productivity can be also positively (in some regions) or negatively (in others) affected by change in local temperatures, whereas impacts on water availability would be a critical issue all over the world. In Europe, especially in the northern area, referring to IPCC (2007) scenarios, negative impacts of climate change can be referred to the increased risk of inland flash floods and to more frequent coastal flooding and increased erosion (due to storminess and sea level rise). In southern Europe, climate change could worsen livability, due to high temperatures and drought and reduce water availability, hydropower potential, summer tourism and crop productivity. Moreover, it is also expected to increase health risks due to heat waves and frequency of wildfires.

2. EUROPEAN STRATEGIES FOR TACKLING CLIMATE CHANGE

According to the features and the potential consequences of climate change shortly described above, two are the main typologies of strategies that at global, European and local level are currently put in place:

- mitigation measures, aimed at reducing GHG emissions;
- adaptation measures, aimed at adjusting natural or human systems in response to actual or expected climatic stimuli or their effects (UNISDR, 2009).

The two types of strategies also differ one from each other, both from a temporal and a spatial perspective. Mitigation measures are generally the result of international strategies, although applied at national or local levels, and are referred to a long-term perspective.

Adaptation measures are strongly characterized as site-specific measures; they generally refer to the scale of the impacted system and are undertaken at local level, although based in some cases on a wider common platform at national or upper level (Walsh, 2010; EEA, 2012a)

Focusing on strategies for tackling climate change, in 2007 the European Council adopted ambitious energy and climate change objectives for 2020 consisting in:

- a reduction in European GHG emissions of at least 20% below 1990 levels (12% less than the Kyoto target);
- an increase in the share of renewable energy up to 20%;
- an improvement of 20% in energy efficiency.

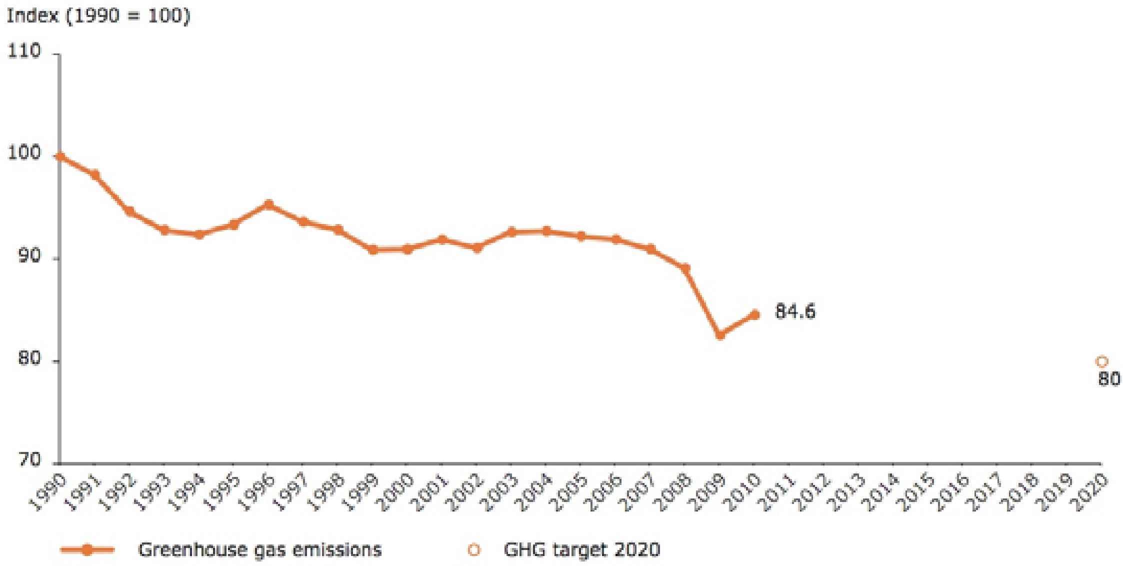

Fig. 3 Trend in total GHG emissions in Europe (1990-2010) in respect to the EU 20-20-20 Strategy threshold.

Currently EU is on track to meet the first of the mentioned targets (fig. 3), despite the increase in GHG emissions registered in 2010; good results have been recorded also in respect to the second target, but it is still far from achieving the third one, the energy efficiency target.

Hence, the priority remains, on the one hand, to achieve all the targets already set for 2020 (EC, 2011); on the other hand, to define new targets for further reducing GHG emissions. In order to keep climate change below 2°C, in February 2011, Europe has established new targets, related to a long term temporal scenario. In detail, the main aim is to reduce GHG emissions by 80-95% by 2050 compared to 1990, in the context of the necessary reductions that, according to the Intergovernmental Panel on Climate Change, have to be pursued by developed countries. A Roadmap fixing the actions that, by 2050, could enable Europe to deliver GHG reductions, in line with the agreed 80 to 95% target (EC, 2011), has been also established. The pathway towards an 80% reduction by 2050 is shown in fig. 4; in detail, it highlights how emissions due to different sectors could evolve, if additional policies were put in place, taking into account technological options available over time. To achieve these goals, EU has defined the main strategies to be followed in each sector. In detail in the power sector, the key role of renewable energies is largely emphasized and investments in smart grids are defined as crucial for a low carbon electricity system.

In respect to transport sector, technological innovation is defined as the key tool for “a more efficient and sustainable European transport system by acting on 3 main factors: vehicle efficiency through new engines, materials and design; cleaner energy use through new fuels and propulsion systems; better use of networks and safer and more secure operation through information and communication systems. According to the Roadmap, “emissions from road, rail and inland waterways could be brought back to below 1990 levels in 2030, in combination with measures such as pricing schemes to tackle congestion and air pollution, infrastructure charging, intelligent city planning and improving public transport” (EC, 2011). In respect to the built environment a significant improvement of the energy performance of buildings could be achieved thanks to the prescriptions included in the Energy Performance of Buildings Directive (EU, 2010).

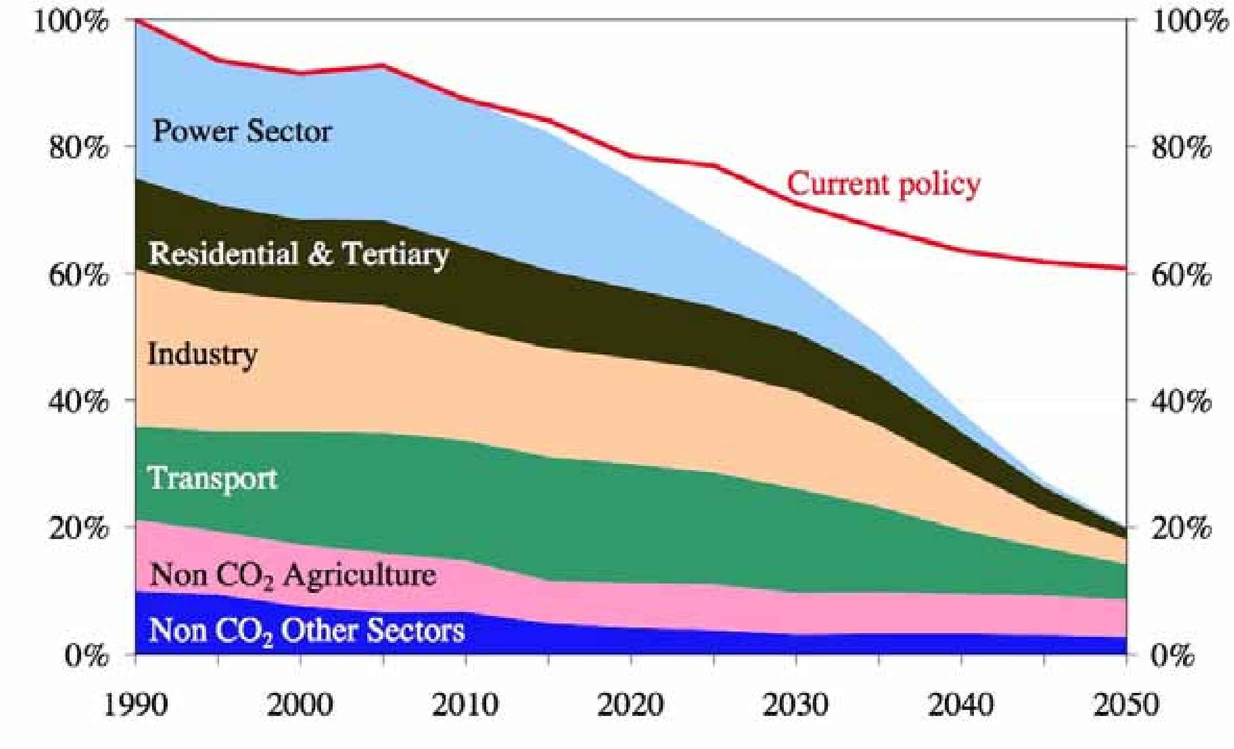

Fig. 4 Sectoral emissions pathway towards an 80% reduction by 2050.

Referring to the industrial sector, it is expected to achieve positive results from the application of more advanced resources and energy efficient industrial processes and equipment, increased recycling, as well as abatement technologies for non-CO^2 emissions for reducing related emissions (EC, 2011).

Finally, in the sector of agriculture "non-CO_2 emissions could be reduced through policies focused on options such as further sustainable efficiency gains, efficient fertilizer use, bio-gasification of organic manure, improved manure management, better fodder, local diversification and commercialization of production and improved livestock productivity, as well as maximizing the benefits of extensive farming" (EC, 2011).

The need for addressing climate change is more and more significant, when moving from individual sectors towards urban areas. The awareness that climate change poses a serious challenge for cities all over the world (EEA, 2012) –being cities highly vulnerable to the consequences of climate change and, in the meanwhile, important contributors to global GHG emissions and to global energy use– is more and more widespread at present.

Therefore, European Commission has recently published a report focused on Urban Adaptation to Climate Change (EEA, 2012a). It provides a range of adaptation measures classified, according to the White Paper "Adapting to climate change: Towards a European framework for action" (EC, 2009), as follows:

- "grey infrastructure", related to physical interventions or construction measures and using engineering services to make buildings and infrastructure essential for the social and economic well-being of society more capable of withstanding extreme events;
- "green infrastructure", devoted to the increase of ecosystems resilience and to the reduction of biodiversity loss, waste of water and degradation of ecosystem.
- "soft measures", consisting in policies, plans, programs and procedures implemented for achieving behavioral changes that can be very relevant in contexts characterized by high levels of uncertainty, due to the fact they contribute to increase adaptive capacity (UNECE, 2009).

Therefore, cities seem to play a crucial role in all the European strategies for tackling climate change, in terms both of mitigation, being relevant to all measures related to the sectors of power, transport and built environment, and of adaption measures, specifically tailored on urban areas.

3. URBAN ADAPTATION TO CLIMATE CHANGE: A CRITICAL ISSUE FOR THE NEXT FUTURE

At present, more than half of the world population lives in urban areas and it will further increase by 2050 (UN, 2012) (fig. 5). Europe is one of the less urbanized area in the context of developed countries; nevertheless, in 2011, 73% of its population was living in urban areas and its level of urbanization is expected to be at 82% by 2050 (UN, 2012). Hence, cities currently represent a crucial issue for addressing climate change: looking at global scale, cities are responsible for 60% to 80% of global energy consumption and of all global emissions; in Europe, 69% of all greenhouse gas emissions are generated by towns and cities (EU, 2011).

According to the trends of population growth, these data could significantly worsen in the next future.

In cities both causes and impacts of climate change are highly concentrated: here, indeed, the demand for energy and associated services to meet basic human needs (e.g., lighting, cooking, space comfort, mobility and communication) is constantly increasing, whereas “at the very same time, densely built-in urban spaces allow for less air displacement and thereby less natural cross-ventilation. (....) Potential risks related to climate change - such as natural disasters, shortage of food or increase of food prices, etc. – threaten more intensively urbanized areas, where more people are influenced by certain impacts” (EU, , 2011a).

Thus, being cities, namely, the urban way of life, part both of the problem and of the solution (EU, 2011), in addition to reduce emissions, the issue of adapting them to a changing climate is becoming more and more prominent as well and larger and larger attention is currently devoted both by scientific literature and by decision makers at European and local scales to outline strategies for urban adaptation to climate change. Grounding on the awareness of the role played by cities, a reflection on “how we create our built environment is” indeed “critical in lessening our dependence on oil and minimizing our carbon footprint” (Newman et al., 2009). In order to analyze current strategies and actions for urban adaptation, it is worth firstly classifying them according to the main sectors which may influence or which may be affected by climate change in urban areas. These sectors can be identified as follows:

- energy;
- transportation;
- water management;
- natural hazards;
- waste management;
- planning;
- governance.

In respect to these sectors, a snapshot of the strategies and measures which are currently the most widespread ones in the European cities is provided in table 1.

Within this list, settlements have been not included as specific sectors, although almost all mentioned measures directly or indirectly affect them. Nevertheless, long term strategies specifically related to the re-shaping of urban areas with the aim to create a climate-friendly urban structure would be required; among them, for example, strategies addressed to the promotion of “compact-city” models at local scale and polycentric urban patterns at regional level, able to counterbalance urban sprawl phenomena, and the reduction of transport needs, favoring mixed land uses.

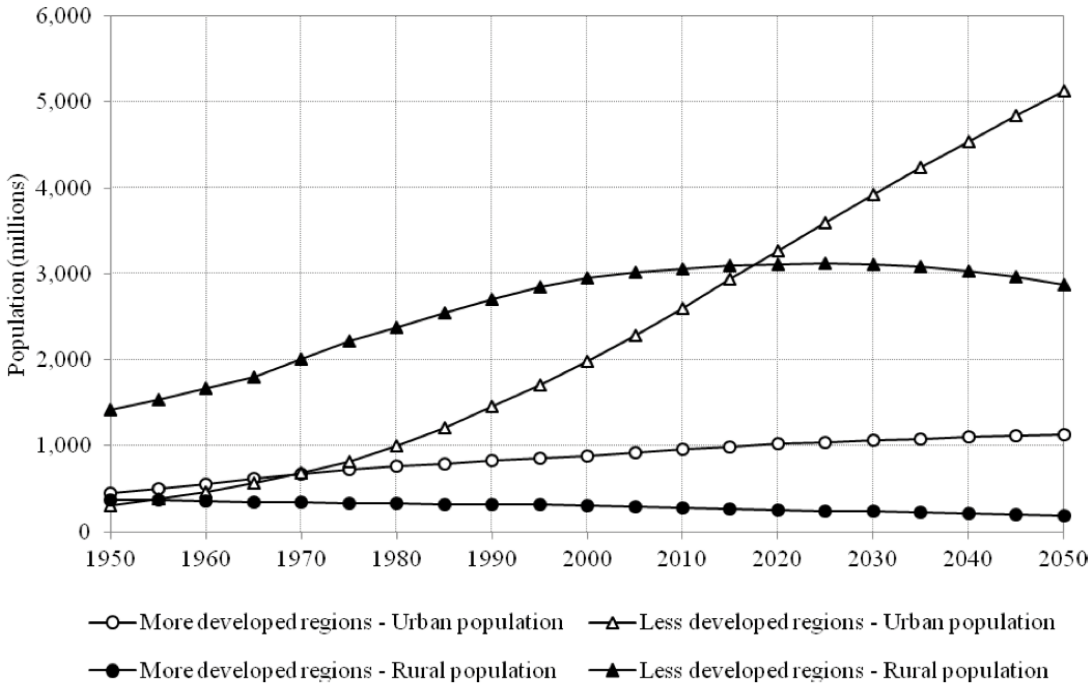

Fig. 5 Urban and rural population trends (1950-2050) in developed and less developed regions.

In detail, energy sector includes strategies and actions aimed at improving energy efficiency and saving. Among them: retrofitting of existing buildings and criteria and rules for guaranteeing high energy performances of new buildings, according to the 2002/91/EC and 2010/31/EU Directives; promotion of renewable energies (solar, geothermal) for supplying domestic hot water; promotion of building automation for energy saving. Moreover, large attention is devoted to improve urban infrastructures for energy distribution, such as smart grids or district heating, and to increase the spread of renewable energy sources (photovoltaic roofs, wind plants, biogas). These are mainly “grey measures”, essentially engineering solutions exploiting innovative technologies, although in many cases they require soft measures to be effectively implemented (e.g. rules or plans which may favor the rehabilitation of building stock according to energy efficiency principles).

Due to the relevance of transportation sector for addressing climate change, a common framework for European cities is represented by recommendations and actions included in the Action Plan on Urban Mobility carried out in 2009. Transportation sector includes both grey and soft measures; among them: increase of a low emission vehicles in public transport, promotion of environment friendly modes (rail networks, bicycles, pedestrian), development of Intelligent Transport Systems (ITS) for urban mobility, introduction of traffic reducing/calming measures (pedestrian areas, car sharing/carpooling, congestion charge, parking charge, etc.).

Water management is an important sector for dealing with some of the long term consequences of climate change which are very likely in some regions, such as drought. Therefore, in areas where water scarcity is going to become a priority, strategies addressed to water saving are currently in progress (e.g. systems and devices for collecting rainwater or recycling grey-waters in individual buildings or in dense urban areas).

Another important sector is related to the prevention and mitigation of the main climate related hazards, such as floods or heat waves. Current strategies for flood prevention mainly refer to structural measures (dams, dikes and diversion channels) or to regulative approaches (land use planning, flood proof buildings or infrastructures). Nevertheless, large attention is also devoted to the maintenance of urban drainage systems and to the role of urban green networks: the cooling effect of green areas through evaporation may reduce both the threat related to heat waves and may have significant effects in reducing pressure on urban drainage.

Waste management might play a significant role in climate change mitigation effects, mainly in respect to the disposal of the collected waste. Some cities are testing new solutions for waste management, combining recycling and composting, or creating complex waste treatment plants, in which recycling facilities, biogas power plant as well as landfill sites with a landfill gas collecting system are combined. In respect to planning sector, it is worth noting that numerous cities are currently engaged in carrying out planning tools specifically addressed to mitigate climate change effects, such as Energy Local Plan and Urban Mobility Plans specifically addressed to reduce GHG emissions. Despite these efforts, the main challenge that should be faced in this sector is the development of an integrated approach (unfortunately still missing) to land use, mobility and environmental planning which seems to be, at present, a key-requirement for an effective urban adaptation to climate change.

SECTORS	STRATEGIES
Energy	Retrofitting of existing buildings (insulation of roof and walls, replacement of windows, replacement of light bulbs) Energy performance criteria for new buildings Solar thermal systems Production of energy from RES (Renewable Energy Sources) Improvement of power and heat generation (cogeneration, heat pump) Building automation (sensors, timers) Public Lightening Smart grids District heating
Transportation	Substitution of public vehicles (e.g. electric vehicles) Car sharing/car pooling Promotion of cycling and pedestrians paths Mobility Management Development of ITS and cleaner emission technology
Water management	Water saving devices Grey water recycling systems Rain water harvesting systems
Natural Hazard (floods and heat waves)	Urban green networks (useful both for reducing pressure on urban drainage and for counterbalancing heat waves) Maintenance of drainage systems Temporary water storage in basins Dams, flood defense Forecasting and early warning systems Adapting building and planning codes in respect to floods Flood risk management plans
Waste management	Promotion of recycling Solution for reducing the amount of CH_4 emitted from landfills
Planning	Updating of local Master Plan codes (by an energy perspective) Urban Mobility Plan City Energy Plan Sustainable Action Energy Plan (SEAP)
Governance	Climate Action Plan City Networks (e.g. Climate Action Network-Europe) European Programmes (e.g. INTERREG, URBACT) Training courses for Public Administration Green Points Observatories for Energy Green Public Procurement (GPP) Fiscal incentives Promotion of ESCO's role

Tab.1 The main strategies for urban adaptation to climate change in European cities.

A first step towards such an integrated approach might be represented by the Sustainable Energy Action Plan (SEAP), which is the main outcome of the voluntary European initiative "Covenant of Mayors", involving local and regional authorities committed to increase energy efficiency and use of renewable energy sources on their territories in order to meet the 20-20-20 targets.

The last sector to be considered is related to governance; it is a cross-cutting sector and it is particularly important since urban adaption to climate change requires a multi-level governance cooperation. In Europe, some steps towards a better cooperation among cities have been currently undertaken through the establishment of global, European or national city networks (e.g. Climate Action Network-Europe, Association of Finnish Local and Regional Authorities-ALFRA), networks of experts (e.g. Energie Cités), or through European programmes devoted to transfer knowledge and experiences in different fields, including climate change (e.g. INTERREG, URBACT). Besides these initiatives, the sector concerns all the strategies addressed to inform people, for increasing climate change awareness both at institutional and at community levels (e.g. creation of green points or observatories on energy, implementation of training courses for public administrations), and to the establishment of regulations, for improving energy efficiency (e.g. introduction of energy efficiency criteria in public spending or fiscal incentives, establishment of Energy Service Companies (ESCO), providing financial support to the realization of energy efficiency projects.

Summing up, despite the large efforts currently underway, policies at city level are still fragmented and effective tools to support decision-making processes are still lacking (Corfee-Morlot et al. 2011).

On the opposite, looking at the theoretical and methodological approaches provided by scientific literature as well as by institutional documents, it has to be noticed that the awareness that urban adaptation to climate change requires a multi-level, integrated and participatory approach is at present widely recognized (EEA, 2012a) (fig. 6).

Most of recent studies and researches seem to converge towards the idea that urban adaptation strategies have to be addressed to increase the resilience of natural and human systems in face of current and future impacts of climate change and that, according to the variability of climate change effects on different contexts, they have to be highly site-specific (EEA/JRC/WHO, 2008).

Although the reference to the need for strengthening urban resilience in face of climate change is becoming more and more widespread both in scientific literature and in institutional documents and numerous related initiatives at European, national and local scale are already running, a clear identification of the features able to make a city resilient in face of a threat, such as climate change, is still missing.

Fig. 6 The pillar model of the climate friendly city

Thus, in the following paragraph, the concept of resilience will be deepened and -based on the review, from a multi-disciplinary perspective, of current scientific literature- the main features of a resilient system will be outlined.

4. RESILIENCE, CLIMATE CHANGE AND UNCERTAINTY

The concept of resilience has been developing since the Fifties through different disciplinary fields, from physics to psychology, from ecology to management science, although it is hard to find out a shared interpretation of the concept in the different domains.

The term found wide room in Ecology in the Seventies, although it was probably embedded in this field since the Fifties (Kelman, 2008). At the beginning of the Seventies, Resilience was defined by Holling (1973) as a "measure of the persistence of systems and their ability to absorb changes and disturbance and still maintain the same relationships between populations or state variables". The aspects related to the capacity to resist and absorb change and disturbance were later more properly included in the "stability" concept by Berkes and Folke (1998), underlining that resilience concept mainly refers to the opportunity for the recombination of modified structures and processes in face of a disturbance. This aspect became preeminent when discussion on resilience moved from the ecological to the socio-ecological field. The importance of "adaptation" within the resilience concept has been largely emphasized also in the field of psychology (Masten et al., 1990).

Resilience was officially introduced in the disaster field in 1994; in the Guidelines for the World Conference on Natural Disaster reduction the need for strengthening "resilience and self-confidence of local communities to cope with natural disasters through recognition and propagation of their traditional knowledge, practices and values as a part of development activities" (UN, 1994) was largely emphasized. A lot of documents published under the umbrella of relevant international institutions and NGOs followed the 1994 one.

Resilience was firstly introduced into the 2004 UNISDR Glossary on Disaster Risk Reduction and defined as "the capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure". Therefore, such a definition embodies both the concept of stability and the opportunity for change in face of a given threat.

In the last updating of the UNISDR Glossary on Disaster Risk Reduction the definition of resilience was re-defined as follows: "The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions" (UNISDR, 2009). It is worth noting that in the latest definition of Resilience provided by the UNISDR, the relevance attributed in the first one to the change has been significantly revised, putting more emphasis on the ability to resist and to recover.

Nevertheless, the importance of adaption and transformation in face of a disturbance is also stressed by CRSI (2011) that defines resilience as the capability of a community to anticipate risk, to limit impact, and to recover rapidly through survival, adaptation, evolution, and growth in the face of turbulent change.

Despite the difficulty in finding out a shared definition, Resilience is nowadays largely recognized as a key concept for a "shift in thinking" in the field of disaster analysis and management, due to the opportunity that it provides for dealing with concepts like uncertainty, cross-scale effects, non-linear dynamics, etc. which are very important mainly in face of urban disasters, showing a higher and higher level of complexity (Ensure, 2010).

These concepts seem to be crucial also for addressing the set of slow-moving and instantaneous phenomena related to climate change, from the increase in average temperatures to the numerous "climate related hazards" such as heat waves, storms, hurricanes, floods, drought, forest fires, and so on, which are largely characterized by uncertainty, cross-scale effects and so on. From this point of view, the resilience perspective appears significant in order to improve the capacity of social as well as territorial systems to cope with, adapt to, and shape change (Folke, 2006; Bahadur et al. 2010).

According to Fiksel (2003), indeed, where the conditions are stable and where projections about the future are generally clear, the concept of anticipation works better, although it must be employed judiciously; but where uncertainties are large, the resilience concept is probably most suitable.

What it is worth emphasizing to our aims is that, according to the large scientific literature on the resilience concept (Handmer and Dovers, 1996; Wildavsky, 1988; Folke, 2006; Berkes, 2007) and namely on its importance for coping with uncertainty, resilience can be an useful concept for driving strategies addressed to urban adaptation in face of climate change, mainly due to the following aspects:

- resilience is conceived as a conceptual approach to deal with uncertainty and future change with respect to traditional approaches mainly focused on system's control;
- resilience represents a premise for a proactive response to disasters as it embodies the concept of adaptive and learning capacity, which is typical of living systems;
- resilience gives room to the emergence of new configurations of the system (even more desirable than the previous ones) after a disturbance, as a result of the self-organization capacity that is typical of complex systems.

5. CAPACITIES AND PROPERTIES OF A RESILIENT SYSTEM

"Coping with ongoing trouble immediately raises the questions of (…) capabilities. A tank or a battleship is resilient because it has armor. A football team is resilient because its players are tough and its moves are well coordinated. (…) organizations are resilient because they can respond quickly or even redesign themselves in the midst of trouble. (…) organization's flexibility is often a key factor in organizing to fight the problem. They are thus 'adaptive' rather than 'tough.' This is true, for instance, of learning during conflict or protracted crisis. Many examples of such learning are apparent from the history of warfare. There are many aspects to such learning. One aspect is learning from experience" (Hollnagel, Woods, 2006).

This long quotation highlights some of the numerous capabilities that may contribute to make an element or an organization resilient in face of a trouble or a crisis.

Researches and studies seem currently to converge towards an interpretation of resilience as a set of interrelated adaptive capacities (Norris et al. 2008; Paton, 2008; Chapin et al. 2009; Gibson and Tarrant, 2010). Nevertheless, although the large debate on the capabilities making a system resilient developed in the last decade, a consensus on which capacities/properties make a territory or a community resilient is still missing. As a consequence, it is also difficult to understand how and on which elements or components of a systems to act in order to increase resilience. An effort in this line has been carried out in the ENSURE project (2010), mainly addressed to enhance resilience of communities and territories in face of natural and na-tech hazards. The similarities existing between natural hazards and climate change - since both of them represent a relevant "threat" for settled communities- allow to extend the main findings of this project to the topic at stake. Grounding on the review of institutional documents and scientific literature, carried out according to a multi-disciplinary perspective, the main capacities and properties contributing to make a system resilient in face of disturbances have been singled out and arranged into a conceptual framework (Fig. 7). In such a framework, Resilience, meant as the final aim of a continuous process, is placed in the core of the framework and is progressively specified, in operational terms, through a set of interrelated capacities/properties, which have been sorted according to a hierarchical structure -widely applied in planning- linking goals, objectives and actions.

Such a structure allows to compare current policies and actions aimed at enhancing urban resilience in face of climate change and capacities and properties of a resilient system, checking their mutual compliance.

Fig. 7 The set of interrelated capacities/properties/ of a resilient system (Adapted from ENSURE, 2010)

Robustness, adaptability and transformability have been recognized as three distinct components of resilience and, as a consequence, identified as the three main goals to pursue for enhancing systems' resilience.

Robustness, in the field of climate change, has been defined as "the ability of a system to continue to perform satisfactorily under load" (UKCIP, 2003); *adaptability* represents the capacity of a system to adapt in face of the consequences of a given threat or perturbation; *transformability* represents the capacity of a system to turn a threat, a disaster into an opportunity, by creating new conditions, different and sometimes more desirable in respect to the previous ones.

Following the hierarchical structure, the three facets of resilience have been specified through six capacities or properties, related to one or more facets, which represent the main objectives to be pursued for strengthen them.

Resistance, closely related to the concept of robustness, is generally meant as the ability of systems to withstand the stress, maintaining its features in face of a given stress. According to numerous authors, resistance is related to the capacity to absorb, without being damaged, disturbance (Folke, 2006; Berkes and Folke, 1998). *Learning capacity*, typical of living systems such as communities, refers to the ability of learning from past event in order to foresee and cope with the future. It has been recognized as part of the resilience concept by Resilience Alliance (Folke et al., 2002) and plays a key role for improving both robustness and adaptability. The concepts of *Flexibility* and *Redundancy* are closely related to adaptability. In detail, the former is a key aspect of adaptive capacity (Godshalk, 2003) and is proper of adaptive systems which are able to learn from experience, process information and adapt accordingly (Bankoff et al., 2004). Redundancy can be interpreted as the presence within a system of several actors or elements performing the same function, so to assure the function may continue if one actor/element fails (Chuvarajan et al., 2006). Therefore, it is a relevant concept in order to cope with uncertainty. *Resourcefulness* is related both to adaptability and to transformability and refers to the availability of resources and skills and to the capacity to mobilize and apply material and human resources to achieve goals in case of adverse events (Bruneau et al., 2003). It is a key ability for improving preparedness and planning in face of a threat or in case of emergency (Buckle et al., 2000). *Innovation,* directly linked to transformability, refers to capacity of change and innovation of a system, which makes it able to re-think and re-organize previous social, economic, ecological conditions (Walker et al., 2004).

The last group of capacities/properties further specifies the previous ones and each of them is related to one or more of the previous mentioned one. *Individual capacity* and *self-reliance* represent the main properties that might be improved for enhancing resistance. Self-reliance refers to the ability of satisfying basic needs locally with the aim to eliminate dependence on imported resources (Chuvarajan, 2006). In economy, self-reliance has the advantage of strengthening local economies, decreasing energy consumption for transportation (Ekins, 1986), and makes local economy stronger and less vulnerable to global economy fluctuations (James and Torbjorn, 2004). Individual capacity is related both to resistance and to learning capacity, since it refers to the capacity of the individual actors to cope with external stresses which depends both on the livelihoods but also on the learning capacity, which is crucial for enhancing preparedness.

The success of a learning process depends on the interrelated aspects of *experience*, *memory*, *knowledge* and *cohesion*.

Memory and experience are relevant both for preventing future events and for the re-organization of a system after a disturbance. Furthermore, they largely contribute to increase knowledge (of events, damages, mitigation measure, best practices, etc.) which is crucial for an effective learning process too. Finally, learning capacity is also influenced by the level of cohesion existing within the community: in case of a good cohesion level, indeed, experience is more easily communicated and memory more easily preserved.

Redundancy can be specified in terms of *transferability* and *substitutability* (Van der Veen et al., 2005), which refer to the availability of elements or systems which can replace or substitute another one if the need arises (Van der Veen et al., 2005).

Flexibility can be enhanced through different properties or mechanisms aimed at overcoming dependency. Among them, *spatial and organizational network patterns* - designed or spontaneous - which can be singled out as properties ensuring a higher flexibility in respect to the hierarchical ones; *cooperation* among the different actors within a system, especially by an institutional perspective. It is worth noting that cooperation can also enhance redundancy, in that it provides a multiplicity of opportunities that are very useful, especially in face of a threat.

Other key-properties to improve resourcefulness can be recognized in *rapidity*, viewed from an organizational perspective, and *efficiency*, aimed at optimizing the available resources, making a rational use of them.

Diversity is another property to strengthen for enhancing resourcefulness; it supports the richness and the variety of available resources. Diversity has been widely recognized as a crucial property of a system for coping with uncertainty and surprise, facilitating redevelopment and innovation following a crisis (Folke et al., 2002). Therefore, diversity has been also linked to the innovation capacity. The latter depends also on another intangible resource, *creativity*, which is a crucial property to cope with surprise or, in other words, with threatening events that can't be easily foreseen. It is extremely important also for developing future scenarios taking into account less likely threats and can be defined as the ability to achieve a higher level of functioning by adapting to new circumstances and learning from the experience (Maguire and Hagan, 2007).

6. CURRENT POLICIES FOR URBAN ADAPTATION TO CLIMATE CHANGE AND RESILIENCE CAPACITIES: ARE THEY CONSISTENT?

In this paragraph the consistency between strategies and actions currently implemented in European cities for adapting them to climate change and the capacities/properties which characterize a resilient systems will be discussed.

In the Table 2, a first attempt to verify such a consistency has been provided. In detail, each strategy/action may contribute to strengthen one or more of the identified capacities/properties. The consistency has been investigated in respect to the group of resilience capacities/properties placed at the lower level of the hierarchical structure: they represent, indeed, a specification of the previous “levels”; hence these capacities/ properties are those which have to be strengthen through specific measures in order to increase resilience.

Only strategies included in “planning” sector have been left aside from this consistency exercise: referring to this sector, indeed, the match with resilience capacities should make no sense, due to the fact that the former includes, in turn, multiple strategies and actions. Thus, the consistency should be sought between the measures included in each planning tool and the resilience capacities. Therefore, in this case, the resilience model should represent an useful tool guiding planning tools in enhancing urban resilience.

At a first glance, current strategies seem to be mainly addressed to enforce some resilience capacities (such as efficiency, knowledge) more than others (e.g. cohesion, memory). This might have a double meaning: on the one side, we should consider that a large effort in defining capacities and properties that make a system resilient has been done in the ecological domain as well as in the field of natural hazards, in which some capacities, such as memory, play a relevant role, being less relevant to climate change; on the other side, one could argue that current policies are more addressed to improve some aspects of resilience, namely flexibility, resourcefulness and resistance, than others.

In detail, current actions in almost all the considered sectors seem to be mainly addressed to improve efficiency that, as mentioned above, aims at optimizing available resources, making a rational use of them, contributing to increase the amount of available resources (resourcefulness) of a system in case of disturbance.

Action addressed to improve cooperation and knowledge seems to be also very relevant, mainly in the field of governance, even due to the fact that the different kinds of solutions (grey, green and soft measures) ground on knowledge.

On the opposite, in the future initiative to be undertaken for tackling climate change, the key role of diversity and self-reliance should be further stressed, being them key-properties for enhancing resistance, innovation and resourcefulness and, through them, robustness, adaptability and transformability, which are the three main sides of resilience.

Other capacities which should play a more significant role are those related to redundancy (substitutability and transferability): in face of uncertainty, indeed, the presence within a system of several actors or elements performing the same function, so to assure the function may continue if one actor/element fails is obviously crucial.

Rapidity seems currently to play a secondary role, although it is relevant for all measures related both to deal with climate-related hazards and to monitor the effectiveness of strategies and actions undertaken in each sector. Moreover, creativity should be further encouraged, by investing firstly in the field of research and IT in order to provide spurs for innovate cities in face of a changing climate but also by rethinking cities, even in their shape and structure, according to old common practices adopted for preventing some climate related events, such as heat waves.

Finally, in respect to memory and cohesion, which seems to be not affected by current policies, it is worth noting that the former could play a key role if interpreted as the capacity to recover traditional rules for building construction and settlements organization able to guarantee a better defense from climate conditions, without a broad use of air-conditioning; the latter is crucial for improving self-reliant communities addressed to be sustainable and resilient.

SECTORS	STRATEGIES	RESILIENCE CAPACITIES
Energy	Refurbishment/rehabilitation of old buildings (insulation of roof and walls, replacement of windows, replacement light bulbs) Energy performance in new buildings Solar thermal systems Production of energy from RES (Renewable Energy Sources) Improvement of power and heat generation (cogeneration, heat pump) Building automation (sensors, timers) Public Lightening Smart grids District heating	**Efficiency** **Efficiency** Diversity/Substitutability Diversity/Substitutability Diversity/Substitutability **Efficiency**/Rapidity **Efficiency** Network pattern/Self-reliance Network pattern/Self-reliance
Transportation	Substitution of public vehicles (e.g. electric vehicles) Car sharing/car pooling Promotion of cycling and pedestrians paths Mobility Management Development of ITS and cleaner emission technology	**Efficiency** **Efficiency** Diversity **Efficiency**/**Knowledge** Creativity/**Efficiency**
Water management	Water saving devices Grey water recycling systems Rain water harvesting systems	**Efficiency** **Efficiency** Self-reliance
Natural Hazard (flood and heat waves)	Urban green networks (useful both for reducing pressure on urban drainage and for counterbalancing heat waves) Maintenance of drainage systems Temporary water storage in basins Dams, flood defense Forecasting and early warning systems Adapting building and planning codes in respect to floods Flood risk management plans	Network patterns **Efficiency** **Efficiency** Resistance Rapidity Resistance **Knowledge**
Waste management	Solutions for reducing the amount of CH_4 emitted from landfills Promotion of recycling	Creativity **Efficiency**
Planning	Updating of local Master Plan codes (by an energy perspective) Urban Mobility Plan City Energy Plan Sustainable Action Energy Plan (SEAP)	Cooperation
Governance	City Networks (e.g. Climate Action Network-Europe) European Programmes (eg. INTERREG, URBACT) Training courses for Public Administration Green Points Observatories for Energy Green Public Procurement (GPP) Fiscal incentives Promotion of ESCO's role	Cooperation **Knowledge**/Cooperation **Knowledge** **Knowledge**/Individual Capacity **Knowledge** Individual Capacity Rapidity

Tab.2 The resilience capacities affected by current strategies for urban adaptation. In detail, in bold violet the main affected ones, in blue all the others.

7. CONCLUSION

Summing up, in this paper the main reasons that make climate change a serious challenge for the world population in the next future and the key role of cities being, in the meanwhile, hotspots of vulnerability to climate change and responsible for a large amount of GHG emissions, have been discussed.

Then, a snapshot of the most widespread strategies and measures currently undertaken both at European and local scale for addressing climate change has been provided: what clearly arises is that, despite the large efforts currently underway, policies at city level are still fragmented and effective tools to support decision-making processes are still lacking. On the opposite, focusing on the theoretical and methodological approaches provided by scientific literature as well as by institutional documents, the need for an integrated approach for developing an urban adaption strategy addressed to increase the resilience of natural and human systems in face of current and future impacts of climate change is more and more emphasized.

Hence, being the resilience concept still so vague that it "is in danger of becoming a vacuous buzzword from overuse and ambiguity" (Rose, 2007), a resilience model has been carried out, grounding on an interpretation of resilience as a set of interrelated adaptive capacities and on the review of the resilience capacities/properties developed from a multi-disciplinary perspective. The resilience model is characterized by a hierarchical structure in that, moving from the core towards the outer side, a progressive specification, in operational terms, of the resilience concept and of the capacities and properties that characterize a resilient system has been provided.

Finally, the consistency of the strategies and actions currently implemented in European cities for adapting to climate change with the capacities/properties characterizing a resilient system has been investigated. The analysis shows how current strategies seem to be mainly focused on some capacities/properties (such as efficiency or knowledge), neglecting others, which could also be very significant in enhancing urban resilience.

It is worth stressing that this contribution has to be interpreted as a first stage of a wider research work addressed to deepen the resilience model, even by refining it from a climate change perspective. Indeed, the resilience model might represent a key tool for supporting a multi-level, integrated and participatory approach, extremely welcomed towards such kind of issues and for enhancing urban resilience in face of climate change by driving future strategies at local scale.

Notes

1 Although this paper is the result of a common research work, paragraphs 1, 4, 5, 6 and 7 have been written by A. Galderisi and paragraphs 2, 3 have been written by F.F. Ferrara.

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