Design of urban services as a soft adaptation strategy to cope with climate change

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Abstract. Climate change is increasingly threatening anthropic systems, which are calibrated on climate parameters that have been mostly stable during the last millennium. Reducing its impact on urban centres is one of the most pressing global challenges of our time. This study develops the concept of soft-resilience, the ability of systems to absorb and recover from the impact of disruptive events without fundamental changes in their function or structural characteristics. Starting from this assumption, this paper explores the potential of the urban services field in a perspective of city adaptation to climate change, suggesting that measures based on ICTs applications and information exploitation represent one of the pillars of soft strategies.

Keywords: Climate change; Adaptation strategies; Local adaptation plans; Soft-resilience; Urban services design.

Possible approaches to the challenge of climate change

The phenomenon of global warming and the extreme weather events connected to it are increasingly threatening anthropic systems, which are calibrated on climate parameters that have been mostly stable during the last millennium.

The five direct and indirect effects of climate change on urban areas, identified in the Fifth Report published by the Intergovernmental Panel on Climate Change (IPCC, 2014) are: heat waves, drought, coastal flooding, internal flooding and human health problems. The same document also outlines the six most exposed urban sectors: water supply, energy supply, telecommunications, built environment, green infrastructure and ecosystem services, urban and social services.

Reducing the impacts of climate change on urban centres is one of the most pressing global challenges of our time.

Options for addressing risks related to climate change, and their consequent impact, are mitigation and adaptation (Fig. 1).

In common perception, mitigation strategies are increasingly recognised as a key issue, and scientific studies in this field are constantly increasing. Research on adaptation solutions is, on the contrary, still at an early stage and has neither consolidated experience nor shared practices (Araos, 2016); (Reckien, 2018).

It is important to underline that the effects of any mitigation action undertaken are normally only appreciable in the long term (after decades) (Füssel, 2007): even if CO_2 emissions were reduced to zero today, global warming and its consequences would continue to affect future generations with unprecedented magnitudes (WMO, 2016). Therefore, while waiting for the desirable benefits of mitigation measures, the scientific community and politicians should focus on adaptation too, as a transition strategy. Since the climate is changing, anthropic systems must be prepared from now to cope with the multiple effects of global warming in the short and medium term.

At present, there are multiple obstacles to the implementation of adaptation actions by stakeholders and these can be essentially referred to: the high degree of uncertainty that characterises climate projections and impact scenarios, the resulting erroneous perception of the unlikelihood of consequences of global warming, the intrinsic complexity of anthropic systems and the absence of legislative provisions (Fig. 1).

The World Energy Council (WEC, 2018) has expressed the idea that overcoming these barriers would require a soft-approach to the climate issue: the integration of soft measures in the proposal of adaptation solutions for the built environment would offer several advantages in this context, considering their flexibility, reversibility and effectiveness in terms of costs (Tab. 1). Besides, it poses new questions for planning, design and management of urban spaces and artefacts.

Hard adaptation strategies regard tangible infrastructures. They generally require large investments of resources and may lack both flexibility and adaptability to sudden potential changes in climate projections.

Adaptation to climate change based on the adoption of non-structural or soft solutions, on the contrary, mainly deals with the operational, management and organisational aspects of systems and intangible infrastructures (Sovacool, 2011), in particular:

- it is closely linked to information and process management, supported by ICTs (Information and Communication Technologies), and to the implementation of political, legal, social and financial measures;
- it makes changes that are reversible in the short and medium term, which do not limit other future choices;
- it requires relatively low and short-to-medium-term investments
- it allows coexistence and synergy with other measures;
- it contributes to increase the well-being of residents and the attractiveness of public spaces in cities.

The study presented in this paper develops the concept of soft-resilience, which is the ability of systems to absorb and recover from the impact of disruptive events without fundamental changes in their function or structural characteristics (Proag, 2014).

Based on this assumption, this paper explores the potential of the urban services sector in the process of adapting cities to climate change, advancing the hypothesis that the implementation of measures based on the application of ICTs and the exploitation of information are one of the pillars of soft strategies and represent interesting options thanks also to the cost-benefit ratio.

This was done by applying the following methodology:

1. analysis of barriers to climate change adaptation actions through a systematic bibliography search, an in-depth literature review and collaborations with regional and local governments;
2. conceptualisation of soft-resilience and soft-approach solutions through a systematic bibliography search and an in-depth literature review;

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Tab. 01 | Example of characteristics of soft and hard adaptation measures

3. search and analysis of the available Italian, European and international regulations and standards on urban adaptation, urban facility management and urban services;
4. review and analysis of recent international publications (2015-2019) (Fig. 2), selected among the most representative of the advancements in comparative studies in the field of climate policy;
5. definition of criteria to select a sample of European cities provided with a Local Adaptation Plan: a) capital cities of European states that are the forerunners in adaptation to climate change planning at the national scale, that is to say among the first countries to adopt a National Adaptation Strategy (then transposed into a National Adaptation Plan); b) capital cities of European states that have made it mandatory to adopt local climate plans (Denmark, France, United Kingdom, Slovakia); c) Covenant of Mayors signatories and members of the C40 cities network;
6. in-depth qualitative comparative analysis of the selected Local Adaptation Plans and adaptation initiatives on a local scale;
7. proposal and application of a novel method for the classification of adaptation measures;
8. selection of examples of inefficient and ineffective investments in structural, hard adaptation solutions (defensive structures, such as sea walls, dams, desalination plants, drainage systems, etc); selection of examples of successful soft measures; analysis of case studies;
9. identification of the main enabling technologies for soft-approach solutions, distinguished in: technologies to improve situational awareness (basically regarding sensors), technologies to support decision making (related to data gathering) and sector-specific applications; detection of recurring aspects of interest and trends in the use of ICTs.

Climate adaptation planning: trends and innovation in policy tools and in the design of adaptation measures

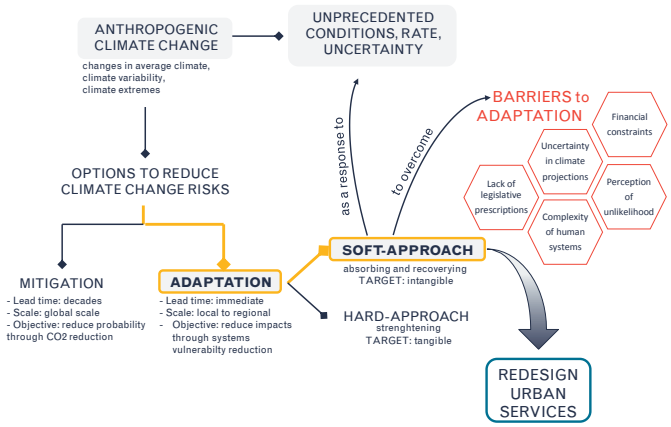
The adoption of the European Strategy on Adaptation to Climate Change - COM (2013) 216 - by the European Commission in 2013 is a lever for the adaptation of cities. It sets out the framework and mechanisms for improving EU actions in relation to current and future climate impacts.

Climate policy tools can be distinguished in strategies and plans at all the different scales:

- strategies address general issues and identify objectives and guidelines, outline the need to implement planning at different scales, are useful to raise awareness of the issue of climate adaptation and the involvement of stakeholders, provide risk and vulnerability assessments;
- plans aim at implementing climate strategies and at identifying measures to achieve their objectives, report a more detailed assessment of the risks and the vulnerabilities, facilitate coordina-

Tab. 01 |

Attribute	Soft – approach adaptation strategies	Hard – approach adaptation strategies
Flexibility	Flexible, adaptable to sudden changes in climate conditions or projections	Inflexible in the short-term, not adaptable to sudden changes in climate conditions or projections
Reversibility	Reversible in the short term without adverse effects; does not narrow future choices	Reversible in the long time with impact; narrows future choices
Simplicity	Rely on simple, low nimpact technologies and intangible infrastructures	Rely on complex technologies and human-built infrastructures
Implementability	Short-medium term investments	Long-term investments
Scalability	Small scale measures	Large scale measures; large scale disturbances
Compatibility	Allow coexistence and synergies with other measures	Trade-offs with other measures; narrow future choices
Cost-effectiveness	Resource-saving; cost-effective	Resource-consuming; usually capital intensive
Intangibility	Deal mainly with organisational, operational and institutional capacity	Mainly provide for physical interventions
Adjustability	Adjustable to stakeholders needs	Hard to define proportions on the basis of uncertain data
Environmental sustainability	No environmental drawbacks	Medium to high environmental drawbacks



tion between stakeholders, establish priorities between interventions, identify adaptation options and implementable actions, conduct assessments of the identified options and actions, and outline procedures for monitoring adaptation actions.

Adaptation strategies and plans at European, national and regional levels are difficult to translate into measures that can actually be implemented on a local level due to territorial specificities such as different degrees of exposure to the impact of climate change, different tangible and intangible assets, different physical, structural and organisational dimensions of each city, etc.

Indeed, National Adaptation Strategies and Plans (NAS[1] and NAP[2]) guide local administrations by outlining climate policy objectives. Furthermore, they provide climate scenarios, approaches and methodologies for risk and vulnerability assessments, as well as procedures for monitoring adaptation initiatives. However, the local level seems to be the most suitable scale for translating policy tools into practical actions by avoiding the undifferentiated transfer of solutions and best practices, which Cortekar (2016), like many other sources (Cortekar, 2016) (Aguiar, 2018) (Preston, 2016), identifies as the cause of the ineffectiveness that has characterised adaptation processes so far. An analysis of recent international publications (2015-2019) (Fig. 02), selected among the most representative of the advancements in comparative studies in the field of climate policy, highlights that the available literature:

- does not propose a classification of the strategies presented in the analysed climate plans similar to the distinction of adaptation measures in hard and soft measures; to date, neither a shared categorisation of adaptation measures nor a settled and unambiguous definition of hard and soft measures are available;
- does not consider the integration of ICTs in climate change adaptation processes as a key issue to take into consideration in the analysis of plans.

The following considerations can be made, based on this review of comparative studies and on a further analysis of three climate plans (Tab. 2), chosen among the most representative of advanced ap-

| 02

YEAR	AUTHORS	TITLE	KEYWORDS
2018	Aguiar, F. et al.	Adaptation to climate change at local level in Europe: An overview	Adaptation; Climate change; Europe; Land planning; Municipalities; Strategies
2015	Araos, M. et al.	Climate change adaptation planning in large cities: A systematic global assessment	Adaptation; Cities; Climate change; Monitoring and evaluation; Systematic assessment
2017	Campos, I. et al.	Understanding climate change policy and action in Portuguese municipalities : A survey	Adaptation; Cities; Climate change; Monitoring and evaluation; Systematic assessment
2019	Grafakos, S. et al.	Integration of mitigation and adaptation in urban climate change action plans in Europe : A systematic assessment	Co-benefits; European cities; Evaluation; Interrelationships; Planning; Scoring; Synergies
2015	Huges, S. et al.	A meta-analysis of urban climate change adaptation planning in the U. S.	Institutional capacity; Governance; Adaptation; Meta-analysis; Networks
2020	Lioubimtseva, E. et al.	Local climate change adaptation plans in the US and France: Comparison and lessons learned in 2007-2017	Climate adaptation plan; Community; Small city; Mid-sized city; United States; France
2019	Pietrapertosa, F. et al.	Urban climate change mitigation and adaptation planning : Are Italian cities ready?	Climate change; Urban adaptation; Urban mitigation; Italy
2018	Reckien, D. et al.	How are cities planning to respond to climate change ? Assessment of local climate plans from 885 cities in the EU-28	Climate change; Paris agreement; Local climate plans; Cities; Urban areas; Urban audit cities; Europe; Adaptation; Mitigation; SEAP/SECAP
2019	Reckien, D. et al.	Dedicated versus mainstreaming approaches in local climate plans in Europe	Local climate policy/ planning; Mitigation; Adaptation; Urban areas/ cities; Urban audit; Mainstreaming; Mitigation/ adaptation tracking
2019	Woodruf, S. et al.	Quality of national adaptation plans and opportunities for improvement	Climate change; Adaptation; Adaptation plan; UNFCCC; Plan evaluation

Tab. 02 | Synthesis of the climate plans analysis of Copenhagen, London, Paris[4]

proaches (based on the criteria specified in note[3]):

1. the absence of European regulations and standards capable of harmonising the structure of climate policy tools entails difficulties in systematic comparative analysis of strategies and plans in different countries and cities (Reckien, 2018) (Woodruff, 2019) (Pietrapertosa, 2019);
2. most of Europe's local climate plans have not been updated since their first publication (see Copenhagen and London); due to the rapid evolution of climate parameters and scientific studies, the planning documents are generally not aligned with the most recent advances in this field;
3. no distinction between hard and soft measures can be found in the plans. A shared categorisation of adaptation measures in the literature is not available yet;
4. looking at adaptation plans, the approach to climate adaptation is predominantly of the hard type. The only measures definable as soft solutions in the climate plans analysed are the provision of warning systems, the reallocation of vulnerable functions and the proposal of training initiatives to increase the degree of awareness of urban communities.

However, plans published in more recent years (as in the case of Paris) suggest, alongside hard options, the implementation of some measures based on the integration of ICTs in adaptation processes and on efficient information management.

Tab. 02 |

Number of inhabitants	603,000	8,500,000	2,270,000
Area	86 km^2	1,595 km^2	105 km^2
National climate policy tools	Denmark: NAS (2008), NAP (2012)	United Kingdom: NAS (2007), NAP (2013)	France: NAS (2006), NAP (2011)
Provisions for the adoption of climate plans	Mandatory adoption of a Local Adaptation Plan	Mandatory adoption of a local climate plan	Mandatory adoption of a local climate plan
Membership in networks	Covenant of Mayors; C40	Covenant of Mayors; C40	Covenant of Mayors; C40
Awards	C40 awards finalist in 2015; C40 Innovator city	C40 awards finalist in 2015; C40 Megacity	C40 awards finalist in 2015; C40 Megacity
Analysed documents	River flooding, heat waves, flooding, drought, coastal flooding	River flooding, heat waves, flooding, drought, coastal flooding	River flooding, heat waves, flooding, drought, coastal flooding
Documents update	2011	2011	2018
Type of risks (order of decreasing seriousness)	Heavy rainfall, flooding, heat waves, coastal flooding	River flooding, heat waves, flooding, drought, coastal flooding	Heat waves, river flooding, cold waves, strong winds, flooding, land slides
Focus of the plan	Adaptation	Adaptation/mitigation	Adaptation/mitigation
Adaptation strategies	Co-benefit strategies	Differentiated strategies by sector	Co-benefit strategies Integration of soft and hard strategies
***Hard* adaptation measures**	Green-infrastructures	Green-infrastructures; building retrofitting; adoption of new building standards	Green-infrastructures; building retrofitting
***Soft* adaptation measures**	Reallocation of vulnerable functions in areas with a low-level of flooding risk	Installation of early warning systems	Use of 3D GIS and BIM for the creation of digital models of buildings and neighbourhoods; monitoring of adaptation initiatives through web platforms; differentiation and decentralisation of climate information (*climate services*); awareness campaigns; training programmes

Local climate plans often turn out to be no more than guidance tools and do not go into more detail than strategies. They fail to specify adaptation measures that can be implemented in practice (Cortekar, 2016; Aguiar, 2018; Preston, 2016; Pietrapertosa, 2019).
In order to track soft solutions, aimed at raising the degree of resilience of the built environment, it is necessary to investigate specific initiatives and experiences at local or sub-local scale. Although these are not included in the official planning documents, they may represent an important response to the potential impact of climate change (EC, 2013). An example is the exploration of the urban services offered by local governments: the potential of this sector in the perspective of adaptation, lies in its correspondence to the characteristics of low-regret measures, defined by the IPCC as «measures that would generate net social and/or economic benefits under both current climate and a number of future climate change scenarios» (IPCC, 2014).

Urban services and possible applications of ICTs for the adaptation of urban systems to climate change

The Fifth Report of the IPCC (AR5) suggests that, at a local scale, infrastructures associated with the provision of basic services - such as water supply, sanitation, waste disposal, energy, rainwater and road management and public transport - are an essential element to increase adaptation capacity, and that "the provision of services includes a diverse range of specific activities" (IPCC, 2014). Taking this statement into account, the vision introduced in the AR5 can be broadened, investigating the potential of smart urban services (supported by the application of ICTs) for the enhancement of the resilience level of the built environment (Cortekar, 2016).
Recent ICT innovations introduce new optimisation and innovation scenarios for urban service management processes, related to the climate adaptation capacity of urban centres. While intervening on organisational and managerial aspects of systems (in line with the definition of soft-approach), ICTs facilitate:

1. the sharing of information and knowledge; the accessibility and distribution of information is an important element for supporting decision-making processes at different levels (strategic, operational) for municipalities and residents;
2. the integration of data from heterogeneous sources; the interpolation of data from different sources and fields can generate diversified information, which is useful for the development of innovative services
3. the improvement of the quality of future projections, the optimisation of weather and climate forecasts and the detection of extreme events; the application of ICTs allows to acquire, process, analyse and manage large amounts of data (Big Data) in order to predict future events and interpret the behaviour of cities (e.g., identifying areas at risk, available resources on the territory, etc.) to improve their response capacity;
4. the accurate assessment of risks, vulnerabilities, potential impacts and damages from extreme events;
5. the sharing of early warnings, emergency management instructions and remote assistance in the organisation of operations and coordination of on-field activities.

These functions are mainly implemented through the application of innovative enabling technologies, such as the Internet of Things and Big Data management.
In the light of these ICT-enabled functions, it is possible to outline optimisation scenarios of some actions that enhance the resilience of urban systems and their capacity to adapt to climate change such as:

1. the improvement of residents' behaviour. This category includes services aimed at optimising the management of resources (e.g. water, energy, etc.) through the use of ICTs, to outline consumption profiles of urban areas and users, and to provide solutions for waste reduction and efficiency improvement. The London datastore, for example, collects and stores data for the development of an inventory of air emissions, energy consumption, water use profiles, etc. Another example is the city of Santander which, thanks to the implementation of dynamic and shared dashboards, promotes the interaction between administration and residents to share data about energy consumption;
2. the improvement of organisational capacities in case of extreme events through the development of: condition-based services along with the definition of acceptance levels of critical parameters to be monitored in real-time (Paganin, 2018); real-time resource management services based on the integration of monitoring systems, dashboards and applications (web and mobile) capable of providing geo-referenced data about deployed/available resources on the territory; communication and alert systems to alert critical infrastructure managers to activate emergency services (firefighters, mobile teams, etc.). In Thailand, for example, the Department of disaster prevention and mitigation is equipped with a combined monitoring system (of data concerning as sea level, time, climate change, etc.) and multi-hazard early warning to improve preparedness and disaster management (e.g. tsunami).

Conclusions

The adoption of a soft approach to the issue of climate adaptation for urban systems is an effective strategy to overcome the main barriers to the implementation of adaptation-measures, opening up to solutions characterised by their flexibility, reversibility and cost effectiveness. The most up-to-date local climate plans include, alongside hard adaptation solutions, measures with characteristics that correspond to the definition of soft measures, revealing a growing interest in this approach.

The exploration of the urban services sector, in a perspective of climate change adaptation, opens up to several optimisation scenarios of the organisational and management practices of human systems, with the support of ICT applications to ensure the smartness of services.

The design of smart services for management and maintenance of urban facilities, understood as a strategy of adaptation to climate change, also gives back, as co-benefit, the enhancement of urban well-being and the attractiveness of public spaces in cities.

Research on soft adaptation solutions requires urgent advancements to encourage the adoption of this approach in planning the adaptation of urban systems to the potential impacts of climate change.

Lastly, it should be stressed that mitigation and adaptation are not alternatives, but complementary actions, and climate plans are the regulatory tools intended to ensure consistency and compatibility between the selected adaptation and mitigation measures.

NOTES

[1] National Adaptation Strategy

[2] National Adaptation Plan

[3] Criteria: 1) Capital cities of European states that are the forerunners in adaptation to climate change planning at a national scale, that is to say among the first countries to adopt a NAS (later transposed into a NAP); 2) Capital cities of European states that have made it mandatory to adopt local climate plans (Denmark, France, United Kingdom, Slovakia); 3) Covenant of Mayors signatories and members of the C40 cities network.

[4] Sources: Covenant of Mayors; EU scoreboard adaptation preparedness country fiches; ClimateADAPT; C40.

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