

9_Climate proof cities and resilient societies

Sensing the city: climate changes and advanced technologies

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Abstract For several years ecological and environmental issues have become a priority in all global political agendas. The transformations due to climate change oblige us to rethink our development model, stimulating us to look for new solutions able to decrease its negative effects. In these fields, urban planning plays an important role equipping itself with innovative tools, technologies and methods, which can contribute to increasing its effectiveness. The paper aims to report the studies that the interdisciplinary research group has conducted in this direction, with particular reference to the new technologies applied to mitigate climate change. In the first part of the paper we will outline a picture of the current regulatory framework, focusing on the Italian situation. In the second part, we will describe the methods and tools used today to acquire data, in order to outline a state of the art that highlights their strengths and weaknesses. Finally, we will describe the main concept of "Precision Environmental Planning", a methodology borrowed from agricultural sciences to analyse the ecological conditions of small portions of the city.

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Climate changes resulting from human activities.

Until a few decades ago climate change was considered the alarmist hypothesis of a small group of scientists, but now the sensitivity of public opinion on these issues has profoundly changed. Well over 90% of scientific publications agree in affirming the close correlation of these phenomena with the increase of CO₂ in the atmosphere, mainly due to the use of fossil fuels. Although the Earth has seen important climatic changes in its long history - just think of the several ice ages - however these changes have occurred on very large timescales, hundreds of thousands of years and they were due to external causes such as the orbital variations of the planet, or extensive volcanic eruptions on a large scale. Today we can observe very rapid climate changes measured in decades. Scientists no longer speak of reducing phenomena, as they did a few decades ago, but of stabilizing current levels. The effects of climate change are visible to everyone: extreme atmospheric phenomena, modified biodiversity, melting glaciers, rising sea levels, desertification of agricultural soils, etc. And health risks are therefore increasing, both because of the pollutants - in the air, in the water and in the soil - and because of the warmer temperatures that favour the hatching of the main vectors of infectious



diseases, such as the Anopheles mosquito¹. This situation was generated by many factors, but it is certain that most of them are attributable to the actions of man and above all to the way in which in the last two centuries he has organized his economic model and his lifestyle. The need for a change is therefore evident, a change on the awareness of phenomena, on the knowledge of the causes that determine them and on the identification of actions that can be put in place. From this point of view the city is a primary place to act on, due to the fact that it is the place where the world population is concentrated most and where the main environmental pollution processes take place.

The world climate summits.

The environmental issue was already introduced into the global political debate in the 1970s, but it is in the 1980s that the contours of the problems began to be more defined with the 1987 “Brundtland Report” and the “Intergovernmental Panel on Climate Change” of 1988. Although climate conferences have since taken place regularly, the results in terms of global agreements and commitments made by the signatory nations cannot be considered satisfactory. In the panorama of world climate summits we can mention: the 1992 “World Conference on the Environment and Development” of Rio de Janeiro, where it was outlined a global picture of the planet's problems, both from an environmental and social point of view; the “Kyoto Protocol” of 1997, which became enforceable only in 2004, when they ratified that 55 nations producing 55% of greenhouse gas emissions; the “Paris Climate Conference” (Cop21) of 2015, which provides indications regarding the energy transition from fossil fuels to renewable sources through a global action plan ratified by 195 countries. In these international summits, the subscriber states sign agreements that should then be translated into legislative acts. However the list of signatory states often excludes those most responsible for CO2 emissions - such as developing nations or USA. Moreover in many treaties the signing of the commitment is a voluntary act, which is not followed by any coercive action.

The Italian framework.

So what are the concrete measures that are being implemented in this direction? And what is the Italian situation? First of all, it should be emphasized that at the moment there are no legislative instruments that oblige institutions to apply the actions required by documents produced at European level. Nevertheless some documents on climate change are already available. The Ministry for the Environment Sea and Land (MATTM), together with the Euro-Mediterranean Centre on Climate Change (CMCC), produced in 2015 a "National Strategy for adaptation to climate change "(SNAC) whose main objective was « to elaborate a national vision on how to deal with the impacts of climate change, including climatic variations and extreme weather and climate events; to identify a set of actions and guidelines to deal with, so that through the implementation of these actions (or part of them) it will be possible to minimize the risks deriving from climate change, protect the health and well-being and the assets of the population and preserve the natural heritage, maintain or improve the adaptability of the natural, social and economic systems as well as taking advantage of any opportunities that may arise with the new climatic conditions " (MATTM, 2015: 10). This is a clear

¹ These topics were studied in depth during a series of interdisciplinary lessons on climate change held at the Architecture Department of Pescara (D'dA) in 2019. More on: <http://www.paolofusero.it/didattica/>

document which could be used immediately as a standard to coordinate the actions at the local level, in order to make them mandatory. Unfortunately nowadays it is just a *vademecum* for the most virtuous regions or municipalities. Then we can consider the "Covenant of Mayors for climate and energy", a more stringent document but still not mandatory: here the signatory mayors undertake to face the challenges linked to climate change (Covenant of Mayors, 2008). Specifically, they commit themselves to act concretely:

1. to reduce CO₂ emissions - and possibly other greenhouse gases - in the city by at least 40% by 2030, specifically through energy efficiency improvements and greater use of renewable resources;
2. to increase city's resilience by adapting them to the effects of climate change;
3. to pool visions, results, experience and know-how with other local and regional authorities of the EU and beyond the Union through direct cooperation and peer exchange.

The objective of these actions is to obtain in 2050 decarbonized, resilient, safe and sustainable territories, striving to maintain the promise made during the Paris COP to keep the global temperature below 2 ° C. To date in Europe there are about 7,000 signatories of the pact, more than 3,000 are from Italy. These municipalities have taken the commitment to deal concretely with climate change, implementing what has been called the "Sustainable Energy and Climate Action Plan": a series of guidelines to help the municipalities to put into practice climate strategies, through a process that alternates operational phases with monitoring phase (Bertoldi *et al.*, 2018). We can therefore consider the "Covenant of Mayors for climate and energy" a first document adequately structured, albeit general, to implement mitigation and adaptation actions. However it does not seem to get the desired results. A few years after the first signature, the general level of Italy's commitment to these issues still seems to be highly inadequate. And the causes could be twofold, linked on the one hand to the fact that adhering to the pact is not mandatory - while to obtain concrete results we would need a complete and widespread mobilization throughout the national territory - on the other hand that there are no rewards or sanctions for the work done, repercussions that would be necessary to spur concrete actions, especially in this first start-up phase.

The availability of environmental indicators.

To draw up environmental planning tools such as "Plans for Adaptation to Climate Change", Strategic Environmental Assessment (VAS), Environmental Impact Assessments (VIA) or simply to monitor the environmental conditions of a specific urban environment, the first problem is to find the right environmental data. The indicators can be referred to the atmosphere (air quality, temperature, dryness index, carbon dioxide emissions, acid gases...), to the soil (permeability, presence of chemical products...), to water (surface water and groundwater quality...), to noise, etc. Unfortunately these indicators are not always available and, even when they are, they almost never have the level of definition expected for a punctual investigation. The missing data must be first integrated with specific detectors necessary to complete the information framework, then compared with the national data and with the sub-regional ones - if they exist. Furthermore, the environmental databases are collected on areas that do not necessarily coincide with the project scale, and they are not easily scalable by interpolation operations. To measure the achievement or non-achievement of specific objectives is therefore not always guaranteed. However, we live in an age in which technology

provides us with sophisticated detection tools, great computing and archiving capabilities, which can help us to remedy this problem.

The sensors network.

Our cities are very complex organisms and it's quite difficult to monitor their climate features. Just think of the different landscape that we can find there: historic centres, peri-urban agricultural landscapes, industrial areas, residential areas, etc. It is difficult to outline an accurate picture of the urban scenario using traditional environmental analyses. Take for example the surveys on air quality: authorities in charge collect the data using fixed machines able to detect the different substances present in the air. The costs of these stations are high, as well as the necessary calibration and maintenance operations. Consequently the number of control units in a medium-sized city rarely reaches ten units. In order to have a complete mapping of the territory it is therefore necessary to use sophisticated calculation models that estimate by interpolation the parameters in the missing areas. So, even considering the high capacity of these models, the result of the operation don't give us a degree of precision satisfactory if we want to operate at the neighbourhood scale. Let's think of the air quality index (IQA), and consider all the series of parameters that can have negative effects on human health: nitrogen dioxide, ozone, sulphur dioxide, PM10 particulates and PM2.5. The data may have substantial differences if we measured it close to a major road or in a peri-urban agricultural area, or in a central urban park. The Euro-Mediterranean Centre on Climate Change (CMCC) has recently created the "CLIME" platform, which offers to users the possibility of conducting climate analyses by their own, using the research centre's databases. Although this platform is at the forefront, the maximum data resolution is 12 km², evidently still insufficient for a precision analysis on a specific neighbourhood. Therefore, the control units currently used allow us to have accurate information but at a low resolution. They also have high costs that do not encourage their spread throughout the territory. It is necessary to looking for alternative methodologies for the detection of environmental data, methodologies that allow us to obtain a level of precision of the surveys at least at the neighbourhood scale.

For some time the use of low-cost sensors is spreading. The price of this kind of sensors is around hundreds of euros, and this make suitable to widespread them above the territory. In this way we can considerably increase the number of surveys, obtaining detailed information that, for example, allows to identify with precision the critical points of the city on which to intervene with punctual environmental recovery actions. A further advantage of these low-cost technologies is precisely the minimum value of the investment, which allows a broad diffusion of these sensors even outside the professional scientific context. Greater diffusion of detection systems means more data available in open source mode, but above all it means greater involvement of citizens on environmental issues. Experiences of this kind are already underway, such as community of citizens who monitor the pollution levels of their neighbourhood through their own low-cost equipment. It must be said, for scientific correctness, that not all scholars agree on a systematic use of low-cost sensors, expressing perplexity on the accuracy of the surveys. Among the most discussed devices there are precisely those for measuring air quality. In an article published on Nature, Lewis and Edwards express their scepticism in this regard and urge us to consider them as valid tools exclusively for educational or informative purposes, avoiding using them to guide decisions that may affect the future of the city (Lewis and Edwards, 2016). A similar position is expressed by the Senseable Lab which in 2017 conducted a specific research on this theme, placing low-cost sensors in Nairobi to measure the quantity of pollutants in the air (De Souza *et al.*, 2017). If on the one hand this approach has allowed to obtain relevant evidence - e.g. to identify some causes of pollution, as well as their location and

peak periods - on the other hand the study showed how the data obtained were influenced by external environmental conditions, and therefore low accurate. The problem of the low reliability of low-cost devices gets worse if we consider that they are used to a large extent by non-experts. Therefore, disseminating low-cost sensors on the territory seems not to be the most effective solution at the moment. Just as the opposite strategy does not seem feasible: to invest in a few very high-performance instruments.

Precision Environmental Planning.

The term *Precision Environmental Planning* refers to the possibility of using ICT technologies to carry out surveys on the health status of restricted urban areas (a neighbourhood, a street, or even a single building), in order to identify the “suffering” areas and the actions to rehabilitate them. The contribution of new digital technologies to monitor the environmental performance of a city can be tested through the experimentation of an easy installation low-cost tool composed of:

1. a system of sensors to detect environmental index
2. a hardware/software platform to process data
3. an adequate system to visualize maps.

Compared to what is already present on the market, the environmental data acquired through such a tool have the characteristic of being customizable by the user who will have to carry out the environmental remediation actions. Moreover data are collected through punctual surveys carried out on site and not through interpolation of existing data obtained from monitoring stations kilometres away from the place of analysis.

An "ordinary" cheap sensor system that is easily available on the market can easily measure:

- temperature, humidity, pressure;
- wind direction and speed;
- solar radiation;
- air pollution;
- electromagnetic fields;
- noise;
- pollen / allergens;
- water permeability;
- urban canopy (covering canopy of trees);
- state of health of the vegetation.

The database acquired in this way could be processed through a dedicated hardware/software platform that compares the data collected by our sensors, those collected from the institutional control units and the open data supplied by users on the various existing platforms. Data could be visualized using parametric representation methods in order to provide dynamic maps. The maps could be of two types: a) "measurement" maps, which show the state of affairs for each measured parameter; b) "parametric" maps, in which the measured parameters are related to threshold values, in order to show the risk level of that area. Once we know all the environmental features of the area, we can design actions that depend on the objectives chosen: from the diversion of traffic flows, if the problem is the reduction of atmospheric pollutants in a given neighbourhood; natural shading or reflective materials,

if you want to counter urban heat islands; usage of sound-absorbing materials or micro barriers, if we want to reduce the sources of noise emissions; etc. The project of a tool for environmental monitoring could be developed within a university spin-off. The innovative idea behind the project consists in making a kit of sensors + hardware / software platform for data processing + maps of parametric representation which, in addition to monitoring the "state of health" of an urban environment, indicate the solutions to improve the area from an environmental point of view, showing, through appropriate communication techniques, how the performance of a neighbourhood can be improved through punctual and targeted actions.

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Note

1st, 2nd, 3rd paragraphs must be attributed to Paolo Fusero; 4th, 5th, 6th to Lorenzo Massimiano.

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