Article

Urban Resilience to Climate Change between the Strategic and Regulative Dimensions of Urban Planning. An Overview of the Italian Context

Carmela Mariano

[1] Department of Planning, Design, Architecture Technology, Sapienza University of Rome, carmela.mariano@uniroma1.it

Abstract: The paper addresses the concept of urban resilience to climate change-related degenerative processes understood "as the capacity of social, economic and ecosystems to cope with a hazardous event or trend or disturbance, responding or reorganising in ways that maintain their essential function, identity, and structure as well as biodiversity in case of ecosystems while also maintaining the capacity for adaptation, learning and transformation. Resilience is a positive attribute when it maintains such a capacity for adaptation, learning, and/or transformation' (IPCC, 2022). The paper provides a critical synthesis of analysis and evaluation of some case studies in the Italian national context, which allowed, through an inductive method, to assess, in terms of integration and coherence, the process of transposition of climate change adaptation contents, possibly already contained within a regional urban framework (Regional Urban Laws) or specific Regional Adaptation Strategies or Local Adaptation Plans, within the territorial and urban planning tools of metropolitan or local scale.

Keywords: resilience; climate change; urban planning; adaptation

1. Introduction

"Urban resilience refers to the ability of an urban system - and all its constituent socio-ecological and socio-technical networks across temporal and spatial scales - to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, and to quickly transform systems that limit current or future adaptive capacity" [1].

The resilience paradigm was introduced in the field of urban and territorial planning at the end of the last century [2] and refers to the possible actions capable of orienting, in a long-term vision and through an adaptive and co-evolutionary capacity [3], the ecological, social, cultural and economic dimensions of the transition processes taking place on cities and territories, directing them on new paths of sustainable growth [4].

The diffusion and progressive rooting of this concept in the scientific literature and the disciplinary field of urban planning have been determined by the polysemic meaning of the term. On the one hand, in close relation to the concept of the crisis of the city, it recalls the fragilities and vulnerabilities, from an environmental, social and economic point of view, that characterize the contemporary city. On the other hand, it expresses the perspective and strategy of action to respond to the crisis itself through new models of analysis and interpretation of territorial dynamics and new planning strategies to innovate public action [5, 6, 7].

In this context, the paper intends to focus on the concept of urban resilience to degenerative processes related to climate change understood "as the capacity of social, economic and ecosystems to cope with a hazardous event or trend or disturbance, responding or reorganising in ways that maintain their essential function, identity, and structure as well as biodiversity in case of ecosystems while also maintaining the capacity for

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adaptation, learning and transformation. Resilience is a positive attribute when it maintains such a capacity for adaptation, learning, and/or transformation" [8].

With the growing awareness by national and international bodies of the impact of climate change on the territory [9, 10] building urban resilience to climate change has become an important objective that is realised through a capacity-building process of the population, stakeholders, and all sectors that may be affected by adaptation actions. It implies the capacity to activate a conscious institutional governance, in which policymakers can elaborate a project of common actions for the protection and regeneration of the territorial heritage in an iterative and circular process between strategic visions and project spillovers [11, 12, 13, 14, 15].

This new approach presupposes an integrated and inter-scalar approach to the urban complexity of territories potentially exposed to climate change-related risk [16, 17] referable to the Ecosystem-Based Approach [18], as also advocated by the document *Guidelines for Ecosystem-based Approaches to Climate Change Adaptation and Disaster Risk Reduction* [19], that introduces and accompanies the construction of integrated climate-proof regeneration strategies in coherence with the objectives of the *European Strategy on adaptation to climate change* [20].

In this, by identifying policies, tools, programmes and projects that operationally articulate the directions of the 17 *Sustainable Development Goals of the 2030 Agenda for Sustainable Development* [14] and *the Climate Conference* [13] and, in particular, the need to "make cities and human settlements inclusive, safe, resilient and sustainable" (UN SDG no. 11) and identify "urgent measures to combat climate change and its impacts" (UN SDG no. 13), through the experimentation of forms of innovation for the improvement of citizens' living conditions and the cultural, economic and social growth of communities.

The transposition of the requests on climate change, promoted in Europe and addressed to the Member States, took shape in Italy, firstly, in the definition of the *National Strategy for Adaptation to Climate Change* [21], and, subsequently, of the *National Plan for Adaptation to Climate Change* [22], still in the process of approval, which envisages an articulation into *Regional Adaptation Strategies* and *Adaptation Strategies of Metropolitan Cities*, to be implemented through *local adaptation plans of the Unions of Municipalities/Municipalities*.

However, these policies do not include specific targets set or obligations for spatial government bodies to adopt specific planning instruments on this issue or to incorporate these contents in existing instruments.

Therefore, to date, the process of integrating and innovating the contents of regional urban planning laws and instruments appears to be rather slow, in some cases highlighting difficult coordination between territorial government bodies and a lack of multilevel governance and downscaling planning approach [23] capable of directly linking policies, strategies and actions with an explicit climate change mitigation or adaptation value [24].

Within the general framework of the research activities carried out by the author, the contribution returns a critical synthesis of a work of analysis and evaluation of some case studies of the Italian national context, which allowed, through an inductive method, to assess, in terms of integration and consistency the process of transposition of the contents on adaptation to climate change, possibly already contained within a regional urban planning framework (*Regional Urban Laws*) or specific *Regional Adaptation Strategies* or *Local Adaptation Plans*, within the territorial and urban planning tools of metropolitan or local scale.

The activity of analysis and critical in-depth analysis of the case studies analysed was based on the study of sources (regional laws, planning instruments, etc.) published in open data, of dossiers and reports produced by public administrations and published on institutional websites, and the study of scientific articles and proceedings produced on the subject [25, 26].

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2. Materials and method

The *Euro-Mediterranean Centre on Climate Change* (CMCC) foundation, in its CMCC report [27], has drawn up an integrated analysis of the risk related to rising temperatures, heat waves, and urban flooding, aimed at highlighting the expected scenarios for six of the ten Italian metropolitan cities (established under Reform Law 56/2014) (Bologna, Milan, Naples, Rome, Turin, and Venice) [28, 29, 30] through four filters comparing the different territorial realities.

- Climate past and future, in which an analysis is proposed on how the climate of cities might change in the coming decades, also based on the phenomena recorded over the last 30 years in each city;
- Climate impacts, in which changes in the frequency and intensity of temperature and precipitation are analysed about the effects of climate change on the territory;
- Risk assessment, in which a detailed analysis of how each city deals with the assessment of risk from climate change affecting its territory is proposed;
- Adaptation Tools, which offers a summary of the main instruments deployed by each city to cope with climate risks.

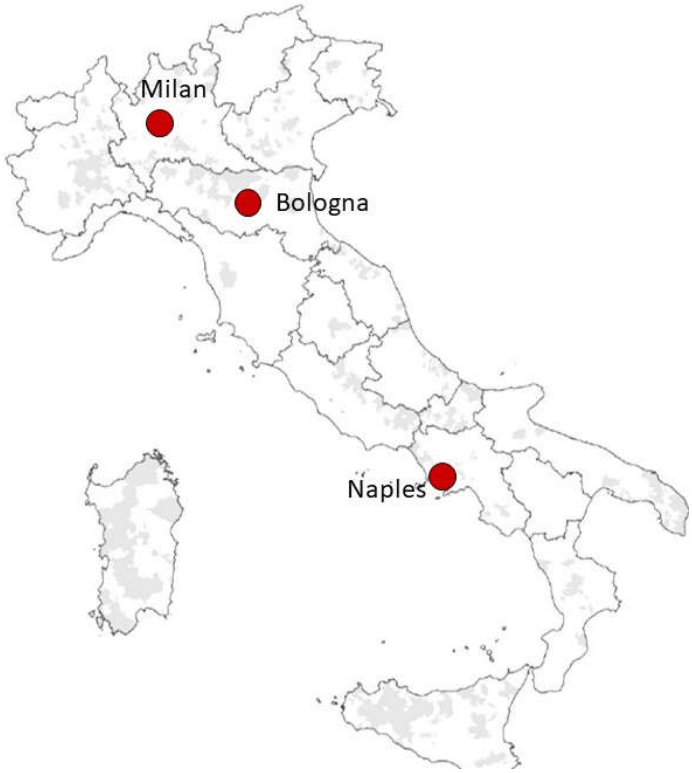

Figure 1. Map of Italy and localization of the three case studies.

With particular reference to this fourth filter "Adaptation Tools", the paper proposes the results of a study conducted on three case studies (Tab. 1) (Bologna, Milan and Naples) that provides a comparative assessment of the state of the art of spatial and urban planning instrumentation with particular reference to the contents on adaptation to climate change.

The comparative analysis (Tab. 2) contains an evaluation concerning:

- contents of the Regional Urban Regulatory Framework (LUR), the Adaptation Strategy and/or Plan (prepared in coherence with the National Climate Change Adaptation Plan [21];
- evidence of adaptation objectives referring to the supra-municipal level of the Plan (implicit or explicit);

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- evidence of adaptation measures referred to the local level of the Plan (implicit or explicit);
- measurability of expected impacts of adaptation measures;
- updating of the Plan's territorial cognitive framework about climate analysis and identification of territories potentially at risk;
- assessment of the level of coherence between supra-municipal and local levels of the Plans with a view to more effective coordination between the contents of the individual instruments.

These criteria make it possible to check whether:

- The instruments refer to regional urban laws, regional climate change adaptation strategies and/or adaptation plans, which provide a framework for defining adaptation goals and actions at the regional and local levels;
- Adaptation objectives and measures or actions, as defined by the instruments, are either explicit (defined specifically in response to climate change) or implicit (not specifically defined as a response to climate change, but also useful for adaptation);
- the tools identify parameters/indicators/standards for measuring the expected impacts of the implementation of objectives and actions;
- the tool is supported by a thematically elaborated Knowledge Framework prepared from climate data and analyses based on time series and/or future projections;
- there is full/partial/no consistency between the contents of instruments at the supra-municipal and local levels.

Table 1. The framework of instruments for the three case studies.

	The regional frame		**The metropolitan level**	**The local level**	
Cities	**Regional Urban Planning Law (LUR)**	**Regional climate change adaptation strategy**	**Supra-municipal level planning**	**Climate Change Adaptation Plan**	**The local level of planning**
Bologna	LUR No. 24/2017	Climate Change Mitigation and Adaptation Strategy (2018)	PTM - Metropolitan Territorial Plan (2021)	Adaptation Plan Municipality of Bologna (2015)	PUG - General Urban Plan (2021)
Milan	LUR No. 12/2005 and subsequent supplements and amendments (No. 31/2015 and 9/2019)	Regional Action Document for Adaptation to Climate Change (2016)	PTM - Metropolitan Territorial Plan (2021)	Adaptation Guidelines to climate change of the city of Milan (2019)	PGT - Territorial Government Plan (2019)
Naples	LUR No. 22/2004 and subsequent supplements and amendments (No. 16/2009 and No. 1/2011)	-	Provincial Coordination Territorial Plan (2016 update)	-	PUC - Municipal Urban Plan (2019)

3. Case studies

3.1. The case of Bologna

The Regional Framework

The Regional Town Planning Law

The LUR of the Emilia-Romagna Region no. 24/2017 "Regional regulation on the protection and use of the territory" [31]contains explicit references (art. 1 and 21) to the need

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to combat soil consumption and enhance the territory in its environmental and landscape characteristics through ecological and environmental endowments that translate into the:

- reduction of climate-changing emissions responsible for global warming
- the restoration of air and water quality
- proper management of the water cycle
- reduction of noise and electromagnetic pollution
- permeability of soils
- an ecological rebalancing of the urban environment
- mitigation of the effects of global warming
- seismic, hydrogeological, hydraulic and flood risk reduction.

Article 34 'Strategy for urban and ecological-environmental quality' sanctions the need for '[...] adaptation to climate change, the defence or relocation of built-up areas and infrastructures at risk and the improvement of the healthiness of the urban environment, also through the implementation of environmental and territorial compensation and re-balancing measures and the realisation and enhancement of ecological and environmental endowments [...]'.

Concerning the 'cognitive framework' the importance of updating is declared (art. 22) as a constitutive element of the territorial and urban planning tools for an organic representation and evaluation of the state of the territory and of the evolutionary processes that characterise it, with particular attention to the effects linked to climate change, and as a necessary reference for the definition of the objectives and contents of the plan.

The Regional Climate Change Mitigation and Adaptation Strategy

The Strategy for Mitigation and Adaptation to Climate Change (D.C.R. 187 of 20.12.2018), which is not binding concerning regional plans and programmes, identifies fifteen reference sectors, which correspond to the main regional areas of competence and intervention, divided between physical-biological and socio-economic sectors, and divides the regional territory into five 'homogeneous territorial areas' concerning which it highlights the risk analysis according to value classes [32, 33].

The strategy formulates proposals and 'suggested actions to complement/adapt existing programming (where possible) or to be introduced in the definition of future sectoral Plan and Programme documents', divided between those of 'mitigation and adaptation' and divided between those 'useful for standardisation/planning/incentivisation', 'useful for improving emergency management and 'necessary for research and development.

The supra-municipal level of planning

The Metropolitan Territorial Plan of the Metropolitan City of Bologna (PTM), approved by DCM no. 16 of 12/05/2021 [34], outlines 5 main strategies that it calls 'challenges' articulated in 10 strategic policy objectives:

Challenge 1: Protect the soil.

Challenge 2: Ensure security (about the effects of the climate crisis and urban metabolism)

Challenge 3: Ensure inclusiveness and liveability (through regeneration processes of the urbanised territory);

Challenge 4: Attract sustainable investment;

Challenge 5: Apennines, Via Emilia and the plains: a single territory

Implicit structural objectives of climate change mitigation and adaptation can be found in some of the Challenges. In particular, Challenge 1 identifies the fight against settlement dispersion through the preservation and protection of natural ecosystems and the reduction of land consumption by a maximum of 3% of the current urbanised land, and Challenge 4 the promotion of attractiveness and accessibility by strengthening and qualifying metropolitan networks and nodes sustainably.

Explicit objectives are instead identified in Challenge 2:

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- recover usable space for cycling and pedestrian mobility, as well as permeable and vegetated surfaces, reducing (where necessary and possible) the size of the road section

- transforming parking areas with re-waterproofing and vegetation to avoid flooding and reduce 'heat island' phenomena

- create 'green and blue infrastructure by including protected areas, wetlands, forests, wooded areas and parks, with an overall review of ecological corridors that includes uncultivated land and areas that can be reclaimed and naturalised (the PTM endorses the objective of increasing the average urban green area per inhabitant by 50 per cent to 45 square metres)

- recovering 'space for water, with alternative landscaping solutions to the emergence of reservoirs

- 'territorialising' a strategy for local energy production from renewable sources

- identification of areas subject to different forms of 'risk' (hydrogeological, seismic, due to climate change, pollution by dust, infiltrating substances, noise) to exclude them from possible new urbanisation;

- Encourage all types of intervention to counteract the 'heat island' phenomenon and promote the absorption of rainwater.

The Local Level of Planning

Adaptation Plan to Climate Change Municipality of Bologna

The plan was created in 2015 thanks to the LIFE+ BLUEAP (Bologna local urban adaptation plan for a resilient city) [35, 36, 37] project and analyses vulnerabilities related to three areas:

1. combating heat waves in urban areas;
2. extreme events and hydrogeological risk;
3. combating droughts and water shortages.

In an attempt to limit the rise in temperatures in the urban area during the summer season, an increase in green areas is planned, from large peri-urban parks and street trees to smaller interstitial spaces in more structured urban areas. The Adaptation Plan aims to act and implement green infrastructures that retain water, rather than accelerate its runoff, and enhance the role of natural ecosystems. One of the measures is to make pavements permeable and to encourage rainwater storage through green roofs or the creation of storage volumes and to encourage the reduction of sealing. The Plan's measures aim to reduce water withdrawals, both by further limiting losses from the distribution network and by reducing consumption, particularly civil and agricultural, and by using alternative water resources and recovering rainwater for non-drinking uses.

The Plan was drawn up through a participatory process involving public and private bodies, businesses and citizens and includes several challenges, for each of which objectives and actions are identified to increase the safety and resilience of the territory, which are fully effective when integrated into municipal planning tools.

The General Urban Plan

The General Urban Plan [38] approved by DCC No. 342648 of 2021, synthesises the 5 challenges of the into 3 prevailing 'urban strategies' that constitute the vision of the Plan:

1. Resilience and the environment
2. Habitability and inclusion
3. Attractiveness and work

These are then broken down into 24 'Local Strategies' using fiches containing the individual local actions to achieve the strategy.

In particular, in Strategy No. 1 the Plan identifies, in coherence with the contents of the PTM, implicit and explicit structural objectives and actions to counter territorial fragilities related to climate change:

- rehabilitation and upgrading of the existing building stock

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- interventions for the reuse and urban regeneration of built-up areas and man-made land

- de-sealing and de-paving of soils to restore hydraulic functionality and ecological corridor function

- urban blue infrastructure and improvement of the urban tree balance through urban forestation at different scales, urban greening

- regular water flow in the mouths of tombed streams and ditches and the network for the adduction, distribution and storage of rainwater for compatible uses inside or outside buildings

- Mitigation of heat island effect in urban areas and introduction of measures for climate adaptation in buildings.

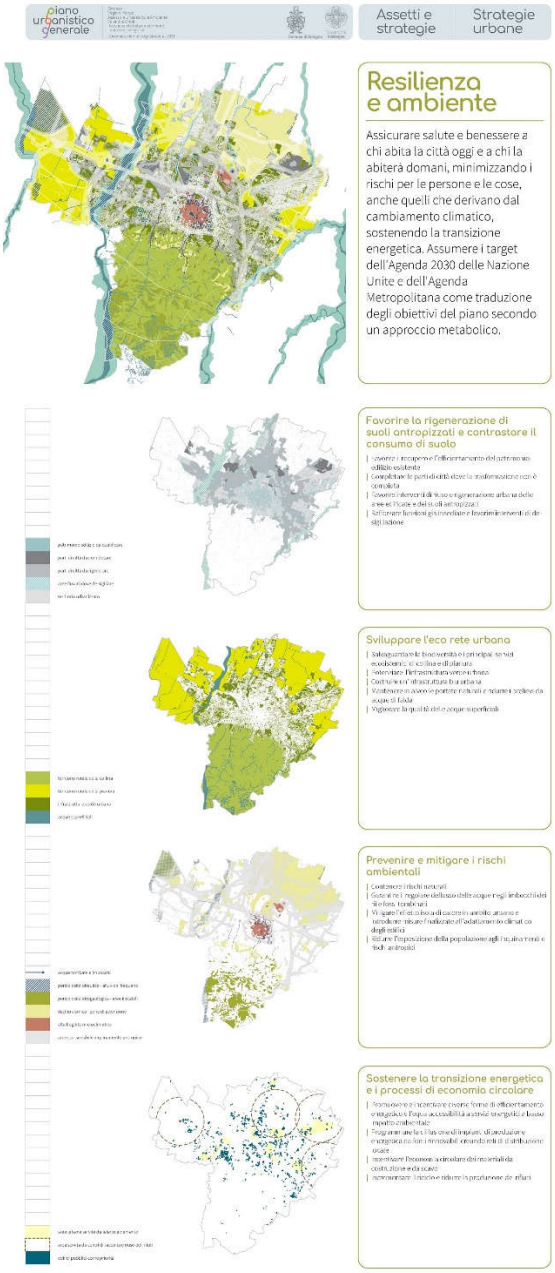

Figure 2. Fig. 1 Bologna General Urban Plan (2021). Structure and strategies. Urban strategies.

Concerning the territorial cognitive framework, the Plan has elaborated a microclimate map, which identifies a series of microclimate fragilities, based on climate scenarios

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for the Bologna area elaborated by ARPAE - Emilia-Romagna Climate Observatory, in collaboration with the University of Bologna, Department of Civil, Environmental, Chemical and Materials Engineering (DICAM).

The Plan also identifies significant indicators about the objectives and strategies and their association with a target value for the purpose of evaluating the Plan's implementation actions and monitoring the effects by annually updating the set of indicators that make up the environmental framework.

3.2. The case of Milan

The Regional Framework

The Regional Town Planning Law

The LUR of the Lombardy Region no. 12/2005 [39] and its supplements L. no. 31/2014 and L. no. 9/2019 [40, 41], do not contain direct references to the issue of adaptation to climate change except for a few references to the need for sustainable stormwater management and the need to adopt an ecological approach to urban development in spatial governance tools, through the objectives of reducing soil consumption and urban and territorial regeneration of already urbanised areas, which take the form of directing urban-planning and building transformation activities towards areas that are already urbanised, degraded or disused, to be redeveloped or regenerated', with a particular focus on the objective of increasing the safety of buildings about seismic risk [42].

The Regional Strategy for Climate Change Adaptation

The Regional Action Document for Adaptation to Climate Change (DRACC) [43], approved by the Regional Council with DGR n. 6028 of 19 December 2016, which constitutes the final evolution of the 2015 Regional Strategy for Adaptation to Climate Change, defines the priority areas concerning the effects produced by the climate and identifies interventions to minimise risks and impacts on the population, materials and natural resources and to increase the resilience of society, the economy and the environment. The Document includes analyses of current and expected climate trends, impacts and targets. In addition, the Document proposes an analysis of the vulnerability and risk elements of the main targets on which climate change is expected to impact, in tone basic functions for Actions. Elaborating on these elements, and identifying priorities, the Document finally proposes for each section Adaptive Challenges and Adaptation Guidelines and finally Actions. Each Action is then accompanied by some elements of analysis for further specification.

By applying the principle of mainstreaming economic and instrumental resources for the implementation of interventions to the different sectors, and integrating adaptation into the various sectoral policies, some 30 measures were identified for the identified priority areas of human health and air quality, soil and land protection, water management and quality, agriculture and biodiversity, tourism and sport.

The supra-municipal level of planning

The PTM, the Metropolitan Territorial Plan, approved by DCM no. 16/2021 [44], takes up the legacy of the Provincial Coordination Territorial Plan, extending its competencies, and introduces rules and actions for the territory of the Metropolitan City concerning the environment, landscape, infrastructures, services, settlement development, territorial regeneration.

Alongside the mechanisms for reducing soil consumption to zero, the PTM sets out an articulated system of actions and policies to mitigate and adapt to climate change with the priority objective of decreasing the vulnerability of natural and socio-economic systems and strengthening, especially for territories characterised by high levels of soil sealing and high urban density, the resilience of the territory in the face of the inevitable impacts of a changing climate, also by fostering cooperation between public, private and citizen actors in pursuing concrete actions. In particular, the PTM devotes an entire title

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to climate change, in line with the objectives of the European LIFE project "*METRO ADAPT: enhancing climate change adaptation strategies and measures in the Metropolitan City of Milan"*, delving in particular into the themes of hydraulic invariance, containment of drinking water consumption and heat island, and preventive strategies and actions.

The PTM has developed the Metropolitan Green Network (RVM) project as a general strategy for adaptation to climate change, with a focus on stormwater management and heat island mitigation, and as a supporting element for the qualification of non-urbanised territory.

For the definition of the draft RVM, the entire metropolitan territory was divided into individual Environmental Landscape Units (UPA) based on the specific characteristics of the different landscapes, their structure and their function.

For each UPA, specific project planning priorities were identified and articulated in actions to be implemented preferably through Nature-based solutions (NBS) selected according to the different territorial characteristics.

The Local Level of Planning

The Guidelines for Adaptation to Climate Change

The guidelines (2019) [45] define the adaptation strategy, objectives and measures within the framework of the *Air Climate Sector Plan* [46], integrating them with mitigation policies and measures and air quality improvement measures.

The document identifies a series of objectives aimed both at solving strictly physical-environmental problems, and thus with direct effects on the microclimate and urban drainage, and at improving the socio-economic conditions of Milan's citizens:

- Reducing Environmental Impacts in City Time Management, which addresses the relationship between city pace, travel, and environmental transition;
- Implement the circular economy, aiming at systemic management of urban metabolism, minimisation of environmental impact and valorisation of resources;
- Resilient emergency management, ensuring the widest possible dissemination of information on extreme weather events, such as floods and heat waves, to enable the population to act in a manner that is aware of both where it is best to go and what to do;
- Analysis and monitoring of local climate variability by updating the local climate knowledge framework to recognise and quantify problems for their resolution;
- Urban cooling and reduction of the heat island phenomenon, coping with rising temperatures and its consequences on the territorial system;
- Milan 'sponge city', which expresses the need to make the city more resilient in water management by preventing rainwater from being channelled into the drainage network. This objective helps to improve the management of a particularly important resource for the urban plant heritage, which is set to expand considerably thanks to the ForestaMi metropolitan forestation programme [47].

The Urban Government Plan

The Piano di Governo del Territorio (PGT 2030) of the Municipality of Milan [48], approved with DCC n. 34 of 14/10/2019, outlines the development of the city towards 2030, through 5 macro-objectives:

1. A connected, metropolitan and global city,
2. A city of opportunity, attractive and inclusive,
3. A green, liveable and resilient city,
4. One city, 88 neighbourhoods to call by name
5. A city that regenerates itself.

The objective most explicit to climate change adaptation content is number 3 'A green, liveable and resilient city', which envisages reducing land consumption by 4 per cent compared to the pre-existing Plan, by scaling down settlement forecasts and through some pilot actions:

- realisation of the large Metropolitan Park, making it possible to reunite the North Milan Park and the South Agricultural Park,

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- 'Environmental Regeneration Areas' consisting of degraded or fragmented public and private spaces to be transformed into ecological corridors that connect and consolidate existing parks,

- improvement of energy performance, creation of new permeable areas, including through 'green roofs', and certification of CO2 reduction.

These forecasts contribute to the achievement of adaptation goals, both in terms of cooling the urban system and in terms of de-impermeabilisation and sustainable management of urban drainage, crucial aspects in the adaptation measures proposed by these guidelines.

Of particular interest is the content of art. 10 "Environmental sustainability and urban resilience" of the Implementation Rules of the Regulatory Plan", which defines new sustainability standards, both for new construction and for the regeneration of the existing heritage through the introduction of a "Climate Impact Reduction Index - RIC", intended as the ratio between green areas and the territorial area of the intervention, diversified according to the type of area on which the intervention is carried out.

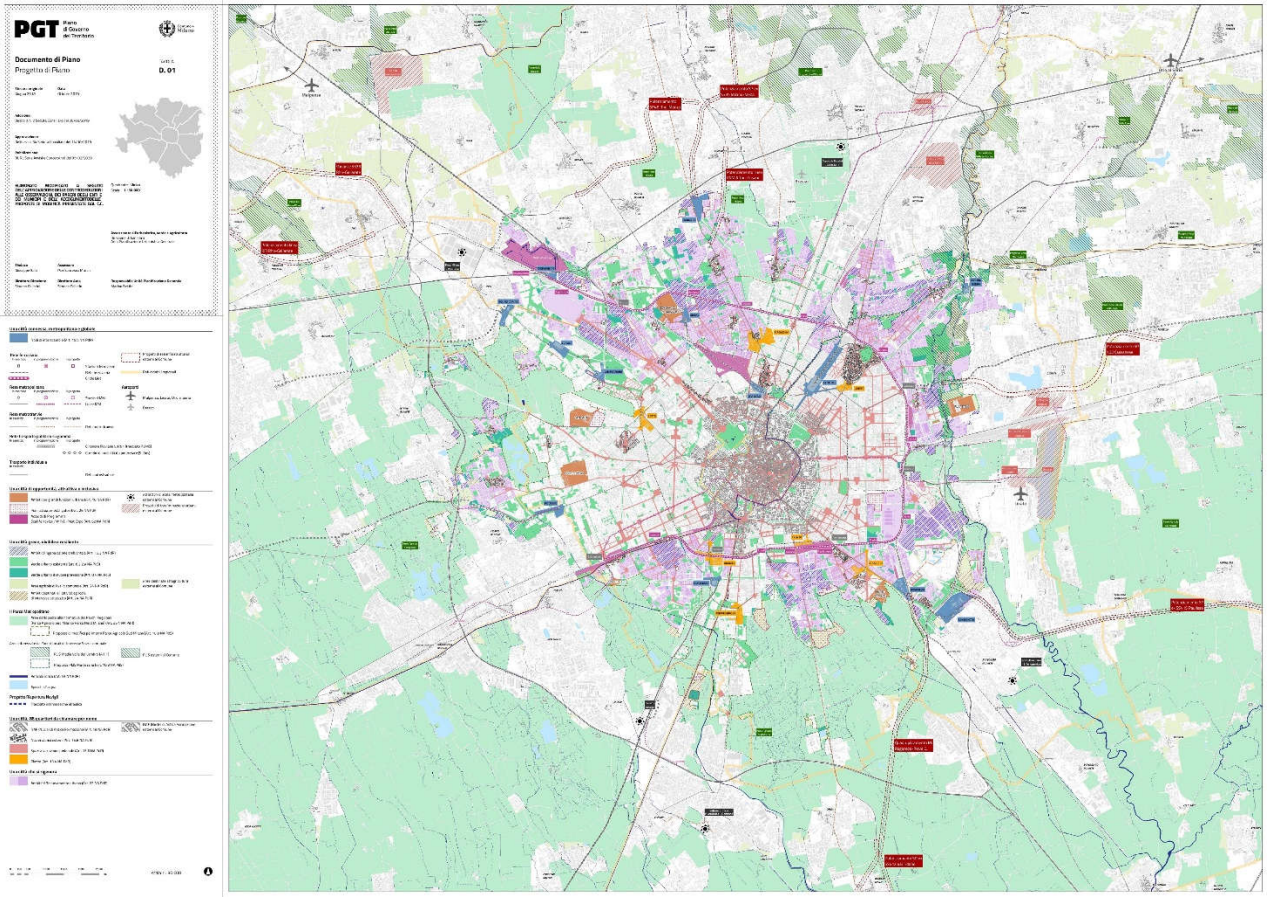

Figure 3. Land use plan 2030 Milan (2019). Draft D01 Plan Document. Draft Plan.

The article provides that, if these parameters are not attainable, it is possible to proceed through monetisation of the interventions, in favour of depaving and forestation works and for the benefit of the construction of the metropolitan park.

Important is the possibility, in the Services Plan, to count among the territorial endowments the eco-systemic services produced about building and urban land transformation interventions, by their benefits for the environment and the community, as well as about their function of mitigation and adaptation to climate change.

Finally, to increase environmental and ecological quality as well as achieve mitigating effects of climate change and air and noise pollution, the Services Plan identifies a multifunctional network of Green and Blue Infrastructure that also fulfils the functions of

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a Municipal Ecological Network for the implementation of cooling actions through urban forestation and sustainable urban drainage.

Concerning the territorial cognitive framework, the Plan is provided with a Local Climate Profile for the city of Milan to 2050 and 2100 elaborated with the support of the Regional Agency for Prevention, Environment and Energy of Emilia-Romagna (Arpae) and the Regional Agency for Environmental Protection of Lombardy (Arpa Lombardia).

3.3. The case of Naples

The Regional Framework

The Regional Town Planning Law

The Campania Region's Regional Law is Law No 22/2004 *Norme sul Governo del territorio* [49], subsequently supplemented and amended by Law No 19/2009 *Misure urgenti per il rilancio economico, per la riqualificazione del patrimonio esistente, per la prevenzione del rischio sismico e per la semplificazione amministrativa* e dalla n.1/2011 Modifiche alla legge regionale 28 dicembre 2009, n. 19 (*Misure urgenti per il rilancio economico, per la riqualificazione del patrimonio esistente, per la prevenzione del rischio sismico e per la semplificazione amministrativa*) e alla legge regionale 22 dicembre 2004, n. 16 (*Norme sul governo del territorio*) [50, 51].

An analysis of the regional spatial government regulations does not reveal any references to explicit climate change adaptation measures, in this case, unlike in Lombardy, not even references to the need to limit land consumption [52].

The Regional Strategy for Climate Change Adaptation

The Campania Region has not yet approved the Regional Climate Change Adaptation Strategy, implementing the 2015 National Strategy. However, in the framework of the Call for the Promotion of Research Projects to Support the Implementation of the National Strategy for Sustainable Development of the Ministry for the Environment, Land and Sea (2017), the Campania Region presented the project '*Green City Strategy for Sustainable Development in Urban and Metropolitan Areas in Campania Municipalities* (2021)', which identifies some guidelines and objectives for climate change adaptation [53].

The reference grid adopted to focus on measures for the sustainability of cities is the one identified in the Green City Network Guidelines, which are divided into three priority addresses (with measures for each address):

1. Ecological quality (with measures for urban and architectural quality, the provision of green infrastructure, air quality and sustainable urban mobility);

2. Efficiency and circularity in the use of resources (with measures for urban regeneration and soil protection, rehabilitation of existing heritage, waste prevention and recycling, water saving and protection);

3. Combating the climate crisis (with measures to cut greenhouse gas emissions, reduce energy consumption, develop renewable energy sources and adapt to climate change).

The Strategy includes:

- Develop studies on the city's vulnerability to climate change about the impacts of extreme weather events (heat waves, heat islands, droughts, heavy rainfall, floods) with a focus on sea level rise for coastal cities.

- Define plans and projects for resilience and adaptation to climate change aimed at prevention, reduction of vulnerability and exposure to short-term and long-term risks - with priority for key buildings and infrastructure - concerning extreme weather events of an occasional and/or long-lasting nature.

- To develop analyses and assessments of adaptive capacities to heat waves and increasing heat islands using advanced sensor and diagnostic tools and effective design, technical and management solutions in urban regeneration and redevelopment of buildings, open or connected spaces and green infrastructure.

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- Promote tools and processes to inform, educate and involve citizens and adopt warning systems for extreme weather phenomena.

Stop sealing and consumption of new soil and increase de-impermeabilisation of urban areas to reduce vulnerability and risks to heavy rainfall.

The supra-municipal level of planning

The Metropolitan City of Naples has not yet drawn up the Metropolitan Territorial Plan, according to the Statute. Currently, the Provincial-Territorial Coordination Plan [54] is in force, drafted according to the provisions of Article 20 of Legislative Decree 267/2000 and updated in 2016, which accepts and reaffirms the indication of the International Panel on Climate Change for the United Nations Framework Convention on Climate Change (UNFCCC) to adopt a dual strategy of action of mitigation and adaptation to climate change.

The CTP is designed with a set of standards that are particularly attentive to soil permeability:

- containment of urbanisation through the technique of densification;
- preservation of open spaces within urbanised areas;

the obligation of percentages of permeable surfaces in building interventions.

Municipalities are encouraged to adopt every instrument in favour of permeability, such as:

- the creation of urban parks and green areas;
- the creation of permeable surfaces, car parks or yards;
- the collection of rainwater in whitewater networks separated from dark water;
- conveyance to ponds, marshes and marshlands where absorption and filtration towards the water table are accompanied by phyto-purification processes.

Concerning the objective of reducing urban heat islands, the CTP recommends:

- creating widespread urban green spaces within the fabric of cities, especially in residential areas and possibly connected to ecological networks in continuity with open and natural spaces;
- provide shade with trees and cool with the presence of water surfaces; alternatively, irrigation systems can be considered to ensure an adequate supply of water to the vegetation during hot periods;
- external cooling of buildings such as sunshades, ventilated walls, etc.
- make cities more permeable by increasing green areas, garden roofs, and permeable pavements to increase the cooling obtained from evaporation (and thus achieve the reduction of the heat island effect).

The Local Level of Planning

Climate Change Adaptation Plan

The Naples Municipality's Climate Change Adaptation Plan has not been drafted.

The Municipal Urban Plan

The preliminary Municipal Urban Plan (PUC) [55], approved by resolution no. 12/2020, is articulated in the Strategic Document (DS) (Municipality of Naples, 2019), the Preliminary Environmental Report (RAP), the cartographic documents that constitute the cognitive framework and the territorial regeneration table.

The *Naples Strategic Document 2019-2030. City, environment, rights and common goods* outline 5 strategies and qualitative and quantitative objectives of the PUC actions, in line with the Axes and Actions of the First Strategic Plan of the Metropolitan City of Naples (2020):

1. Accessible, multi-scalar city;
2. Safe and sustainable city;
3. Welcoming and collective city;
4. Productive and habitable city;
5. Attractive and regenerated city.

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Concerning measures to combat climate change, in compliance with the UN recommendations that envisage zero land consumption by 2050, the plan identifies the following directions:

- To help combat climate change, envisage alternative, diffuse and zero-kilometre forms of energy production instead of traditional centralised systems based on the exploitation of fossil fuels;
- give priority to the reclamation processes of industrial sites, with particular regard to East Naples, starting with the location of oil deposits, on the one hand, and of land subject to illegal waste spills over the years, on the other, as well as the recovery and reconversion of landfill areas, with the Administration carrying out a punctual check on the effectiveness of reclamation;
- implement urban forestation actions starting with large paved areas to reduce the heat island phenomenon, also recovering the possibility of sustainable use by citizens;
- to encourage greater protection of the characteristics of the Unesco historic centre, to counter, through the town planning instrument, phenomena that distort the social and economic fabric of the centre, as well as processes of progressive expulsion of inhabitants, causing the gentrification currently underway;
- work to ensure that the protection of the right to live also translates into the guarantee of healthy living conditions in compliance with the relevant regulatory indices;
- work to ensure that sustainable mobility contributes, through adequate and integrated infrastructure systems that are compatible with territories, to improving the environmental conditions of the entire city, development and growth, and quality of life for citizens.

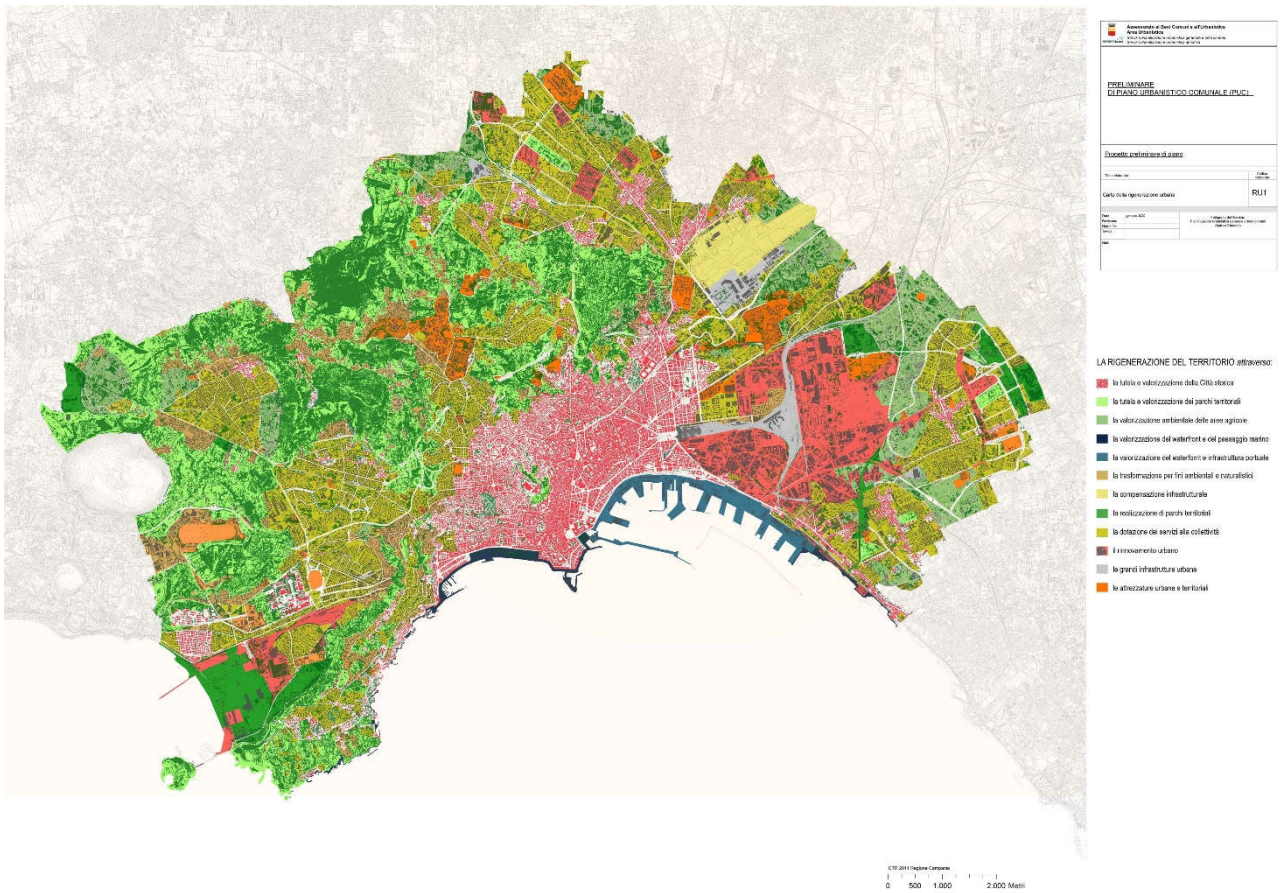

Figure 4. Preliminary Municipal Urban Plan Naples (2020). Urban regeneration map.

Also noteworthy is the updating of the knowledge framework of the territory concerning the issues of the effects of climate change on the territory.

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The State of the Environment Factsheet reports the fragilities of the territory and the most innovative part related to the in-depth studies carried out within the CLARITY project (a Horizon 2020 programme that produced information and graphs on the expected effects of the risks induced and amplified by climate change on the urban territory in terms of risk, vulnerability and impact) [56]. In particular, two main phenomena related to climate change were analysed, namely heat waves and extreme weather events.

In this sense, the paper QC-a - Fragility of the territory highlights the areas of particular hydrogeological and hydraulic danger taken from the planning tools of the Basin Authority of the Southern Apennines; the paper QC-b - Average radiant temperature reports the variation of thermal stresses in the different areas of the city, simulated through an indicator, the Average Radiant Temperature (TMRT), widely validated in literature as representative of the comfort perceived by people (data taken from three groups of main information: Air temperature; Surface temperature; Urban morphology and surface characteristics of buildings and open spaces).

4. Results

The comparative analysis of the three case studies made it possible to identify two different approaches to the instruments promoted by territorial government bodies from a climate-proof perspective [57].

A strategic dimension is related to the supra-municipal planning level (metropolitan city), which identifies the main strategies for adaptive and resilient cities to climate change, and a regulatory dimension, mainly referred to the local planning level, which highlights a gradual process of integration of the plan contents, both in terms of implementation of the cognitive framework of territorial vulnerability with the preparation of management works that give back the consistency of the areas affected by the risk phenomenon, differentiated by level of hazard and about any time horizons analysed (heat islands, floods, alluvial phenomena, subsidence, etc.), and in terms of the identification of possible mitigation and adaptation actions on target areas identified by the Plan, from which quantitative and qualitative indicators/requirements/standards can be identified, referring to the measures adopted [58].

Table 2 highlights, for each case study, the presence or absence of an up-to-date regional urban regulatory framework concerning climate change adaptation content, the presence or absence of a regional and/or local framework (Adaptation Strategy or Plan) of instruments drafted in coherence with the National Climate Change Adaptation Strategy [21].

Furthermore, it summarises and evaluates in comparative terms the contents of spatial and urban planning instruments, declined in the two dimensions that emerged during the analysis (strategic and regulatory) by verifying:

- the nature (explicit or implicit) of the adaptation objectives of the supra-municipal strategic dimension;
- the nature (explicit or implicit) of the actions to adapt to the local regulatory dimension;
- the measurability of the expected impacts and the possible presence of parameters/indicators/performance standards useful also for the monitoring phase;
- the updating of the territorial knowledge framework about the expected impacts in territories at risk;
- the level of coherence of the contents of planning instruments concerning the double dimension (strategic and regulatory).

The case of Bologna is certainly the most interesting one in the national panorama, both from the point of view of the integration of 'explicit' climate change adaptation measures within the local level instrumentation and in terms of coherence between policies, strategies and plan instruments. A consequentiality emerges between the regional regulatory apparatus, reformed with Law no. 24 of 2017, the contents of the Regional Strategy and the Adaptation Plan, the strategic objectives of the NMCP and the regulatory

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addresses of the WYP, adapted and modulated from the regional/over-municipal scale down to the local scale.

The case of Milan also shows a good innovation of the instruments and a good level of coherence between their contents. However, the absence of an updated regional urban planning reference framework concerning climate change adaptation issues should be noted [59].

Both Bologna and Milan identify in the regulatory dimension of the Local Plan parameters/indicators useful for the measurability of the impacts expected from the implementation of adaptation actions, and also useful for the innovation of the concept of the territorial endowment.

Table 2. Consistency check of the contents of the instruments related to the three case studies.

	Regional urban regulatory framework	**Regional and local adaptation framework**		**Spatial and urban planning instruments**						**Verification of Planning Instrument Coherence**		
Cities	Regional town planning law	Adaptation strategy	Adaptation Plan	Supra-municipal strategic dimension Adaptation objectives		Local regulatory dimension Adaptation actions		Measurability expected impacts Parameters/Indicators	Spatial knowledge framework			
				implicit	explicit	implicit	explicit			None	Partial	Full
Bologna	●	●	●	●	●	●	●	●	●			√
Milan		●	●	●	●	●	●	●	●			√
Naples		●		●	●	●	●		●		√	

The analysis of the Naples case study shows how there is a good degree of integration between the 'strategic' and 'regulatory' dimensions that, in the close relationship between the Preliminary Strategic Document (PSP) and the PUC, has the ambition of guaranteeing the implementation of strategies and objectives, including those related to the territory's adaptation to climate change, in what will be the new local planning tool.

However, two weaknesses emerge: on the one hand, a regional urban planning framework (LUR) that is completely obsolete concerning climate change adaptation issues, which also records the lack of approval of the Regional Climate Change Adaptation Strategy and a regulatory dimension that remains on the level of the explicitation of actions but does not yet translate into the identification of parameters/indicators to measure the impacts expected from adaptation actions.

5. Conclusions

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The analysis conducted on the three case studies allows new theoretical-methodological references to be outlined and operational for an innovative planning system capable of supporting regeneration strategies for urban and environmental issues according to the specificities of territorial contexts. This makes it possible to pursue, through urban planning instruments, actions that have significant effects on mitigation and adaptation to the effects of climate change, developing a model of urban sustainability centred on the ecological regeneration of the city that envisages:

- assumption of the strategic dimension as a flexible feature of the plan form capable of adapting to the changing urban dynamics and constantly evolving socio-economic scenarios;
- Identification of the local plan as the optimal planning level and territorial dimension for testing site-specific measures/actions on target areas;
- the need for a process of updating and modernising the concept of territorial endowment as a consequence of major environmental and socio-economic changes that require the prefiguration of new cognitive references, new integrated approaches hinged on adaptive and resilient strategies, new types of standards, multifunctional and reversible, that also stimulate the development of innovative lines of research and experimentation.
- the need for a constant updating of the territory's cognitive framework, using innovative elaborations and databases capable of managing and sharing environmental, climatic, urban and economic information, and a periodic evaluation of the results obtained through the implementation of climate-proof strategies and site-specific actions, which would allow, about new instances and monitoring results, to initiate a constant process of updating and adaptation of the Plan.

However, the analysis carried out shows that, even though in all three cities analysed there is an attempt to transpose contents specifically oriented towards adaptation to climate change into spatial government tools, there is no univocal 'regulatory dimension' at a national level, such as to standardise and homogenise these attempts, both within the same municipal context, which sees initiatives of good quality, but often uncoordinated with each other (thus representing isolated cases), and at the national level (there is no coordination between the various cities), a factor that determines different speeds of progress and advancement on the transposition of climate change issues.

The recent very serious news events of Ischia (2022), linked to the hydrogeological risk of the island, urgently call for the approval of the National Climate Change Adaptation Plan pending since 2018, and, at the same time, highlight the need to reform the national urban planning regulatory framework [60], still anchored to the National Urban Planning Law (LUN) no. 1150 of 1942, incorporating the innovations introduced by the Regional Urban Planning Laws and the experiments underway in the most advanced planning tools concerning the issue of climate change adaptation.

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