A Possible Circular Approach for Social Perception of Climate Adaptation Action Planning in Metropolitan Cities

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Abstract One of the factors that will affect the livability of cities and the overall citizens' quality of life in the future is certainly climate change. Urban areas will play a fundamental role in the commitment against climate change and will have to develop appropriate adaptation actions, in accordance with the European Strategy against climate change, including the planning and implementation of Green Infrastructures (GIs). They produce various environmental and social benefits in the urban context. Various studies have shown that citizenship involvement at all levels is necessary for the evaluation of the sharing of the proposed projects. The research proposes an innovative methodological model to support administrations in the strategic planning choice of GIs according to a shared and circular approach. To perform a multi-layer assessment, the multi-criteria evaluation will be combined with the circular evaluation model called Green City Circle. The evaluation is set up as a circular process, followed by a first investigative phase, followed by a proactive phase of solutions and an implementation phase up to a final stage of evaluation of the results and strategies for long-term sustainability. The study was carried out in the city of Catania to test a planning and management tool for GIs envisaged by the administration as win–win climate adaptation measures.

Keywords Green infrastructure · Social perceptions · Green public management · Participatory decision support systems · Green city circle

1 Introduction

Climate change is both a threat and a new challenge for twenty-first-century cities, projected into a scenario of uncertainty, with repercussions from the complex environmental system perspective (Haaland and van Den Bosch 2015; Hunt and Watkiss

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2011). In this arena, the management of city areas could contribute both in terms of developing proposals to reduce emissions and in terms of integrating adaptation actions aimed at specific territorial contexts (Gill et al. 2007; Matthews et al. 2015). It is now widely acknowledged by the international scientific community that the cyclical natural changes in environmental systems that have always been happening have been superimposed by the decisive and invasive contribution of human activity (Evans and Schiller 1996; Werguin et al. 2005). Human activities have impacted both in terms of an increase in emissions and of a lack of, and, above all ineffective, territorial planning (Alpert et al. 2017; Wei et al. 2018). Over recent years, there has been an increase in temperature, with an upheaval of the rainfall regime and a rise in sea level, as well as an increase in the frequency and intensity of extreme weather events that multiply numerous risks at the local level, for the territories and cities (Bulkeley 2010; Moughtin et al. 2009; Tzoulas et al. 2007).

In this scenario of possible changes, there are urban systems in which the negative effects of the climate are more impactful on the prevalence of the human influence over the natural one (Oke 2006). The identification of the risks to which the inhabitants are exposed, the assessment of the urban vulnerability as a whole and the formulation of strategies to counteract the problem of local impacts of external events represent an important test for planning oriented to the growing consideration of climate change (Gómez-Baggethun and Barton 2013).

Cities play a central role as motors of the global economy, and they could be uniquely positioned to drive a global transition from a linear economy (based on the linear 'take-make-dispose' model) towards a circular economy (Ellen MacArthur Foundation 2017; Lindner et al. 2017). Local governments have a large and direct influence on urban planning (from mobility to grey and green infrastructure planning, labor policy, business, and social and inclusion policies). Therefore, local governments can play an important and active role by developing the principles of the circular economy across a coordinated set of policies and instruments (C40 2017; Petit-Boix and Leipold 2018; UNEP 2017).

Italian institutions have shown interest in the new orientation, as evidenced by the broad adherence to the Covenant of Mayors and the definition of the recent National Strategy for Adaptation to Climate Change (SNAC) and the consequent adoption of the Adaptation Plans (De Gregorio Hurtado et al. 2015; Spanò et al. 2017; Sturiale and Scuderi 2018).

By placing climate change and the related policies to counteract it at the center of urban policies, a scenario opens up that must question the disciplines of territorial governance with respect to its role, the way in which the city is designed and managed, and its ability to adapt to the changing climate scenario. In this context, cities will be called upon to use innovative urban planning tools capable of responding to the uncertainty imposed by climate change. Nevertheless, the involvement of stakeholders and citizens will be necessary to verify, on the one hand, the degree of perception of climate change issues and, on the other hand, to undertake participatory planning of adaptation measures to be taken.

As several studies have shown, it is now necessary to test innovative tools that can support local governments in the process of acquiring in-depth knowledge of

the territory, from economic, environmental, and social points of view, according to a vision of a sustainable, resilient, inclusive and circular city. In particular, among many aspects, the following (Caspersen and Olafsson 2010; Langemeyerab et al. 2016) deserves in-depth analysis (Demuzerea et al. 2014; Kabisch 2015):

- sociality, including inclusion, multiculturalism, the presence of cultural-creative districts and innovative services;
- resilience and adaptation to climate change, i.e., the energy and environmental performance of the city and climate adaptation strategies;
- technological innovation, which, on the one hand, provides tools to achieve energy and resource savings and, on the other hand, enables reaching more citizens and ensuring better, customizable, and more attentive services to individual needs.

These are the main questions to which the public administrations should try to respond in the immediate future, using innovative and participatory methodologies. In this work, a methodological approach is proposed aimed at implementing bottom-up planning considering the needs of the environment and the local community, as well as economic activities.

2 The Role of Nature-Based Solutions in Urban Planning

The climate protection planning in Europe is absolutely heterogeneous (COM 2013). Each country has developed national mitigation plans and strategies and local initiatives in terms of climate plans and local authority instruments (DG 2013).

The different urban contexts are subject to very different consequences, resulting from the various combinations of the structure of the territory, resulting from climate change with specific dimensional, localizing, social and productive characteristics (European Commission 2016). For the definition of exposure, the downscaling of climate forecasts and analyses is of central importance. The current climate models operate mostly on a large scale, offering several indications but, for planning on a local scale, it is fundamental to use specific indicators for the understanding of local impacts and vulnerabilities and supporting tools for formulating strategies (Hunt and Watkiss 2011; Sturiale and Scuderi 2019).

The scientific scenario and international relations (IPCC—Intergovernmental Panel on Climate Change; EEA—European Environmental Agency; European Union (EU) White Paper) (EU 2009) consider spatial planning as a basic paradigm to address both the causes and consequences of climate change: the translation of these issues into policies and processes of ordinary land management is not done explicitly.

The implementation of policies and action plans varies according to the national context and the mode of urban governance, and there is a growing amount of experience, programs, and projects that directly link local realities to the European Community, creating new networks (Covenant of Mayors, GRaBS) or relying on associative relationships already established in Italy and internationally (Italian National Coordination Local Agenda 21, ICLEI—International Council for Local

Environmental Initiatives, C40 CITIES, the Clinton Foundation, the Rockefeller Foundation's Resilient Cities program, etc.).

Local, regional, and national authorities have defined, in many cases on an experimental basis, a series of plans aimed at climate protection, which, depending on the level or type, have assumed different names, not to mention that different names do not always correspond to substantial differences in content if not different levels of attention to mitigation and adaptation. Climate strategy plans, national mitigation, climate action/protection plans, and climate mitigation plans are names of some of the tools and strategies built on the European and international scene, with the aim of introducing climate protection into spatial planning, both on a large and local scale (Benedict and McMahon 2002; Depietri and McPhearson 2017).

The latest report of the European Environmental Agency (2016) defined the main impacts that climate change has on urban centers:

- worsening of extreme climate-related events, both in frequency and in intensity, with consequent economic impacts;
- increased climate-related health problems;
- increased rainfall, storms, and sea levels in the coastal areas;
- increase in heat waves and extreme cold, both in time and intensity;
- increased energy demand, both in winter and in summer.

The strategies that aim to contribute to the subject of climate change, therefore, tend to be aligned on two main actions: mitigation and adaptation to climate change. Mitigation is aimed at progressively reducing emissions of gases responsible for global warming; adaptation to reduce environmental, social, and economic vulnerability and to increase climate resilience.

The integration of Green Infrastructures (GIs) in urban planning is considered to be one of the most appropriate tools to improve the microclimate and address the impacts of climate change (in particular UHI—Urban Heat Island, microclimate improvement, pollution control, etc.) (European Commission 2012).

Green Infrastructures, according to the E.U. definition, "… *are networks of natural and semi-natural areas planned at strategic level with other environmental elements, designed and managed in such a way as to provide a wide spectrum of ecosystem services. This includes green (or blue, in the case of aquatic ecosystems) and other physical elements in areas on land (including coastal areas) and marine areas. On the mainland, green infrastructures are present in a rural and urban context*…" (Environment Directorate 2013).

The types of GI are different and among the most common are: green roofs, green walls, urban forest, bioswales, rain gardens, urban agriculture (urban gardens; community gardening; collective greenery; peri-urban agriculture, agricultural parks), river parks, local product markets, built wetland areas, alternative energy farms and nature conservation areas.

The GIs and all nature-based solutions are important for promoting climate resilience in urban areas (Chang and Li 2014; Moreno-García and Serra-Pardo 2016; Raymond et al. 2017). The urban green areas have significant effects on the urban microclimate because they enable reductions of solar radiation input due to the trees

and produce lower temperatures that mitigate heat islands, as reported in several studies conducted in various cities (Georgi and Zafiriadis 2006; Bowler et al. 2010; Armaghan Ahmadi et al. 2017; Potcher et al. 2006; Moreno-García 2019; Zinzi and Agnoli 2012).

The importance of GIs and of nature-based solutions to mitigate the negative impacts of climate change in urban areas is recognized at the scientific and political levels. It is clear that the mere presence of urban green spaces is not the global solution, while the structure, composition, and management of specific vegetation is essential to improve the capacity of green spaces to provide ecosystem services (air purification and climate regulation).

The ecosystem services are the indirect and direct benefits provided by urban green areas for human health and the environment and the welfare of the community. The ecosystem services "… *consist of material flows, energy, and information from natural capital stocks, which are combined with the services of anthropogenic artifacts to generate well-being and quality of life …*" (Costanza 1991). They may perform the following functions: as environmental regulators; protection from hydrogeological instability; social, recreational, and therapeutic assets; cultural and educational benefits; and aesthetic-architectural features. Moreover, they can contribute to adapt cities to climate change because they help to purify the air, to regulate the urban microclimate, and to reduce noise (Hansen and Pauleit 2014; Lovell and Taylor 2013; Seppelt et al. 2011).

Some studies (e.g., Vieiraa et al. 2018) have, in fact, shown that vegetation consisting of a more complex structure (trees, shrubs, and herbaceous layers) and the absence of agronomic practices (pruning, irrigation, and fertilization) had a greater capacity to provide the ecosystem services of air purification and climate regulation.

The management of the contemporary city provides the answer to several complex situations that, on the one hand, are linked to environmental, social, and economic problems and, on the other, to the coordination of projects and actions that often develop to solve yet more emerging issues.

Therefore, it is necessary to evaluate the needs of the city in a transverse, stratified way and on a plurality of themes, focusing the research on the following points (Demuzerea et al. 2014; Jayasooriya et al. 2017; Sturiale et al. 2020): socializing; sustainability and adaptation to climate change; resilience; innovative technologies; and resources.

3 Methods

Into this scenario, one may insert the methodology called Green City Circle (Boulanger and Marcatili 2018), which is configured as a circular process, in which a first investigative phase is followed by a phase of proposed solutions and a phase of implementation up to a final phase of evaluation of results and strategic for long-term

sustainability. The effort that this model makes is to coordinate the specific interventions at the territorial level within a wider framework, defined by the multi-criteria analysis that aims to help in the construction of a long-term vision for the territory.

The multi-criteria evaluation (Munda 2008) will be combined with the circular evaluation model called the Green City Circle (Boulanger and Marcatili 2018) for a multi-layer assessment. The evaluation is set up as a circular process, followed by a first investigative phase, followed by a proactive phase of solutions and an implementation phase up to a final stage of evaluation of the results and strategic for long-term sustainability. This is a decision-making process that could be adopted as a tool operational and supportive of urban planning sustainable and resilient, with the aim of responding to European demands to facilitate the transition of cities to the circular-economy approach (Calabrò et al 2019; De Marchi and Ravetz 2001; Matthews et al 2015).

One of the principles on which the circular economy of cities is based is the regeneration of the urban natural system, which enhances the natural capital and provides for the planning of urban green areas (Qian and Wang 2016). The objectives to be achieved are: to adopt a circular use of the components of the natural ecosystem; to reduce the negative effects of pollution; and to combat the effects of climate change (Christisa et al. 2019).

The methodology applied the integration of the Green City Circle into the multi-criteria analysis. During the first phase, defined as cognitive, there is an analysis of the context through:

- documentary analysis through the examination of documents, reports, and historical data;
- urban and relational analysis of the context, internally related to a larger scale;
- analysis of the social, cultural, and informal creative dimension, also through innovative cognitive strategies, such as those of the Participant observation;
- compilation of a preliminary check-list, proposed by the tool enabling identify the main stresses that the context has.

The proposed model integrates the Green City Circle (based on the establishment of the Focus Group with the various stakeholders) and the NAIADE method (Novel Approach to Imprecise Assessment and Decision Environments), for the Social Multi-Criteria Evaluation (SMCE) of the "complex" information collected (quantitative and qualitative data) (De Marchi and Ravetz 2001; Munaretto et al. 2014; Munda 2006, 2016; Oppio et al. 2018; Scuderi and Sturiale 2019).

SMCE accomplishes the goals of being inter/multi-disciplinary (with respect to the research team), participatory (with respect to the community), and transparent (since all criteria are presented in their original form without any transformations in money, energy or whatever common measurement rod) (Greco and Munda 2017).

The methodological approach is applied to the metropolitan city of Catania to evaluate the planning of Green Infrastructures (GIs), and, in particular, the experimentation of new participatory approaches for the definition of green urban strategies. The information and results obtained can be used to develop guidelines to support

local planning policies and tools to identify climate-adaptation measures in the urban environment according to a circular economy model for three scenarios.

Three hypotheses/scenarios of green recreational strategies are envisaged:

- hypothesis 1—GARDEN: creation of parks and gardens with tree bushes and meadows (with high impact on the micro-climate)
- hypothesis 2—PLAYGROUND: creation of areas for play and socialization (with limited impact on the micro-climate)
- hypothesis 3—AGRI-URBAN: creation of areas for the creation of vegetable gardens and orchards cultivated by citizens (with medium impact on the micro-climate).

The model provides for a first phase of execution of focus groups with the identified stakeholders, with the administration of customized questionnaires prepared to acquire the main information. In particular, the following stakeholders have interviewed: citizens, pensioners, cultural associations, schools, trade unions, public institutions, scientific institutions, and tertiary sector companies. The meetings were held at public social gathering places present in the area concerned, in the presence of a sociologist who was able to guide the conversation, structured by the properly prepared questionnaire.

The second phase involves the application of multi-criteria analysis using the NAIADE method, in which the basic input consists of hypotheses of alternative scenarios to be analyzed and identification of the different decision-making criteria for the relative evaluation and meetings with the various stakeholders, who express opinions on the scenarios in question.

According to this method, two types of analysis can be performed:

- multi-criteria analysis: contributes to the definition of the priorities of alternative scenarios with respect to certain decision criteria, based on the impact matrix;
- equity analysis: analyses possible alliances or conflicts that may arise between the interests of the various actors involved in relation to the proposed scenarios, based on the equity matrix.

The impact matrix (criteria/alternative matrix) is the basis of the NAIADE method, built with scores that can take the following forms: stochastic elements, sharp numbers, fuzzy elements, and linguistic elements (such as “very poor”, “poor”, “medium”, “good”, “very good”, “excellent”). The comparison between alternative scenarios is performed through the concept of distance. When operating with sharp numbers, the distance to a given evaluation criterion is calculated by subtracting the sharp numbers of the two alternative scenarios.

The classification of the alternative scenarios is performed on the basis of the impact matrix data used for:

- comparing each individual pair of alternatives with all the assessment criteria considered;

- calculating a credibility index for each of the above comparisons, using a relationship of preference between '… alternative scenario a' and 'is better/worse, etc.' alternative scenario 'b' … ;
- aggregating the credibility indices into a preference intensity index μ * (a, b) of an "a" alternative to another "b" for all the evaluation criteria (associated with the concept of entropy H * (a, b), as an indication of the change in the credibility indices);
- classifying the alternative scenarios on the basis of information obtained from the previous steps.

The intersection of the "classification Φ + " (a) (based on preference relationships 'better' and 'definitely better') and the "classification Φ −" (b) (based on preference relationships 'worst' and 'definitely worse') determines the final classification of alternatives.

4 Results

The model was tested in a suburb of the city of Catania, but it is designed to be used in feasibility studies in larger contexts, by adapting it to territorial specificities, present resources and urban planning priorities according to the principles of resilience and circularity.

The first phase, consisting of the development of focus groups with the interaction of the identified subjects, arises from the need to implement urban strategies with the involvement of potential stakeholders, including not only the resident population, but also the production and financial system, as well as associations and the cultural and creative world. The study was supported by the City of Catania, which provided images of the green areas present and the areas likely to be transformed in GIs, in the urban and peripheral environment, and often located in degraded contexts. The analysis focused on a peripheral area, where the objectives of green planning combine environmental, climate, economic, and, above all, social aspects.

In particular, respondents were asked which scenario, among those proposed, was preferred to meet climate change adaptation needs and economic and social needs.

The three scenarios proposed can be considered climate-adaptation actions, although with different microclimatic impacts, in relation to the vegetation structure foreseen in their design. However, this aspect, in particular, will be subject to further verification at another point in the research, as the priority was to verify the model of evaluation of the social perception expressed by the local community.

To evaluate the three scenarios assumed in the survey, twelve evaluation criteria (or variables) were identified, defined by the basis of the objectives set in the analyzed case, which can be considered representative of the reality of the Municipality of Catania but, overall, very similar to other metropolitan areas.

The objectives chosen to characterize the various scenarios are environmental quality, sociality, climate adaptation, economy, urban green area, and health security. For each objective, the relative evaluation criteria are defined, as listed here:

1. Environmental quality: air quality; human settlement.
2. Sociality: usability, multi-functionality.
3. Climate adaptation: reduction of temperatures, creation of accessible shaded areas, thermal excursion.
4. Economy: cost of realization.
5. Urban green areas: quality of the landscape, biodiversity.
6. Health safety: pollution, use of pesticides and fertilizers.

The equity matrix (Table 1) summarizes the framework of the stakeholders' views on the three scenarios. As highlighted in the methodology, in the multicriteria evaluation, the opinions expressed by the stakeholders are of a qualitative nature. Therefore, the following linguistic expressions are used: very poor, poor, medium, good, good, very good, and excellent (Table 1).

The results show the clear preference of the stakeholders for the Garden scenario, followed closely by the Playground scenario and, finally, the Agri-Urban scenario, which revoked the lowest reported evaluations (Fig. 1).

Table 1 The equity matrix—stakeholder opinions of three hypotheses

Typology of stakeholder	Group	Scenario Garden A	Scenario Playground B	Scenario Agri-urban C
Citizens	A1	Excellent	Excellent	Poor
Pensioners	A2	Very good	Good	Good
Cultural associations	A3	Excellent	Excellent	Poor
Schools	A4	Very good	Excellent	Very good
Trade unions	A5	Good	Good	Good
Public institutions	A6	Very good	Very good	Good
Scientific institutions	A7	Excellent	Good	Good
Tertiary sector companies	A8	Very good	Very good	Poor

Source Our elaboration

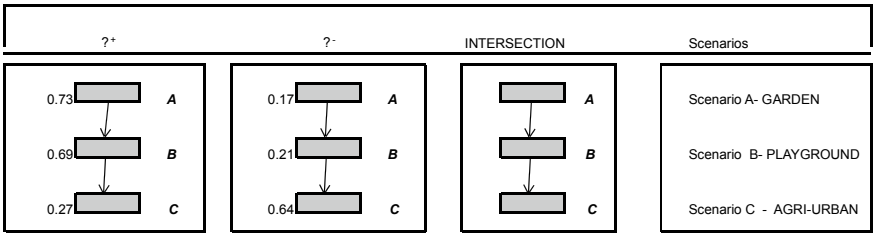

Fig. 1 Intersection and final classification of the three hypotheses scenarios. *Source* Our elaboration

Table 2 Consensus levels and relative definition of the priorities of scenarios

Classification scenarios	**Consensus levels**					
	0.7312	0.6934	0.7136	0.5235	0.6239	0.7089
	A	A	A	A	A	A
	B	B	B	B	B	B
	C	C	C	C	C	C
Groups with alliances and each level consent	All groups	All groups except A1	All groups except A2	All groups except A6	All groups except A2–A6	All groups except A4

Source Our elaboration

The results obtained through the equity analysis were used to examine possible alliances or conflicts among the opinions expressed by stakeholders on the three scenario hypotheses. The information reported in Table 2 shows the values attributed to the classification of the corresponding scenarios based on the relative level of consensus. These results show that a large number of stakeholders agree on the final classification of the three scenario hypotheses and, in any case, the Garden hypothesis is the preferred one, as it is the one with the highest consensus.

In the following phases, consistent with the methodological aspect, we will have to make some drawings of the garden and a metric calculation which will be followed by a business plan. To evaluate the best design solution, a cost–benefit analysis will be made. This phase will have to be shared with the population also attracted through social media to continue the participatory planning of the area. The project after completion must be monitored, through the indicators provided in the design phase, linked to climate change, as well as an overall assessment of the project to assess the benefits and losses that have emerged, as a source of experience for future planning activities.

The proposed evaluation approach, based on the integration of multi-criteria analysis and participatory planning, applies to a complex urban reality from an environmental and social point of view, making it possible to acquire useful information and to reach the choice of the preferred scenario for the local community.

5 Conclusion

In the last decade, cities have shown growing awareness of climate issues and a greater need for involvement in government activities, especially those concerning the design and management of public green spaces and environmental improvement projects (Baró et al. 2014).

Current environmental legislation gives a particularly significant role to municipalities in terms of actions and responsibilities (Bekessy et al. 2012). This evolution has helped local administrations to gradually assume environmental responsibilities,

thus shortening the distance between the citizen and the administration, generating greater mutual responsibility (Escobedo et al. 2011).

The experience conducted in the city of Catania, as a model of city and scenario of surveys and concrete applications, has also represented a moment of verification of the opening of an institution to tackle issues not yet fully included in the practices of the public administration. The willingness shown by the administrators and citizens who participated both in the survey phase, through the questionnaire, and in the collection of information, has shown that the actors involved are beginning to be aware of environmental issues. Moreover, the sharing of the project proposals, i.e., the three scenarios to be evaluated, leads to the objective of making the adaptation actions foreseen by the administration accepted and re-appropriating parts of cities that could guarantee better climatic and environmental conditions.

The approach of the proposed method proved particularly appropriate to achieve the result that the administration wanted to achieve. A concrete process of improvement of the urban environment will have to start from the involvement of all the social and economic actors who live and know the city, its potential, and, above all, the needs of the community.

This work in its proposal offers a series of ideas aimed at introducing, into the tools for urban planning, measures to adapt to climate change, and to promote innovative choices that can be useful for the future of our cities based on economic, social, and environmental sustainability. The tool adopted have proven to be innovative and useful as a support to strategic policy choices for the sustainable development of the city according to a resilient and circular model.

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References

Alpert P, Ben-Gai T, Baharad A, Benjamini Y, Yekutieli D, Colacino M, Anguluri R, Narayanan P (2017) Role of green space in urban planning: outlook towards smart cities. Urban For Urban Greening 25:58–65

Armaghan Ahmadi V, Tenpierik M, Alireza MH (2017) Heat mitigation by greening the cities, a review study. Environ Earth Ecol 1(1):5–32

Baró F, Chaparro L, Gómez-Baggethun E, Langemeyer J, Nowak DJ, Terradas J (2014) Contribution of ecosystem services to air quality and climate change mitigation policies: the case of urban forests in Barcelona, Spain. Ambio 43(4):466–479

Bekessy SA, White M, Gordon A, Moilanen A, McCarthy MA, Wintle BA (2012) Transparent planning for biodiversity and development in the urban fringe. Landscape Urban Plann 108:140–149

Benedict MA, McMahon ET (2002) Green infrastructure: smart conservation for the 21st century. Renew Resour J 20(3):12–17

Boulanger SOM, Marcatili M (2018) Site-specific circular methodology for the resilience of existing districts: the green city circle. Techne Open Access 15:203–211

Bowler DE, Buyung-Ali L, Knight TM, Pullin AS (2010) Urban greening to cool towns and cities: a systematic review of the empirical evidence. Landscape Urban Plann 97(3):147–155

Bulkeley H (2010) Planning and governance of climate change. In: Davoudi S, Crawford J, Mehmood A (eds) Planning for climate change. Strategies for mitigation and adaptation for spatial planners. Routledge, Taylor Book and Francis Group, London

C40 (2017) Ending climate change begins in the city (available on: https://www.c40.org/ending-climate-change-begins-in-the-city)

Calabrò F, Cassalia G, Tramontana C (2019) Evaluation approach to the integrated valorization of territorial resources: the case study of the Tyrrhenian area of the metropolitan city of Reggio Calabria. In: Calabrò F, Della Spina L, Bevilacqua C (eds) New metropolitan perspectives, ISHT 2018, Proceedings of the smart innovation, systems and technologies, vol 101. Springer, Berlin, pp 3–12

Caspersen OH, Olafsson AS (2010) Recreational mapping and planning for enlargement of the green structure in greater Copenhagen. Urban For Urban Greening 9:101–112

Chang CR, Li MH (2014) Effects of urban parks on the local urban thermal environment. Urban For Urban Greening 13(4):672–681

Christisa M, Athanassiadis A, VercalsterenaI A (2019) Implementation at a city level of circular economy strategies and climate change mitigation—the case of Brussels. J Cleaner Prod 218:511–520

COM (2013) The European strategy on adaptation to climate change. European Commission (2013) 216, Brussels

Costanza R (ed) (1991) Ecological economics: the science and management of sustainability. Columbia University Press, New York, NY, USA

De Gregorio Hurtado S, Olazabal M, Salvia M, Pietrapertosa F, Olazabal E, Geneletti D, D'Alonzo V, Si Leo S, Reckien D (2015) Understanding how and why cities engage with climate policy. An analysis of local climate action in Spain and Italy. TeMA J Land Use Mobility Environ 8(Special Issue ECCA 2015):23–46. https://doi.org/10.6092/1970-9870/3649

De Marchi B, Ravetz J (2001) Participatory approaches to environmental policy, concerted action EVE. Policy research brief, no 10

Demuzerea M, Orrubc K, Heidrichd O, Olazabalej E, Genelettif D, Orrugh H, Bhavei AG, Mittali N, Feliue E (2014) Mitigating and adapting to climate change: multi-functional and multi-scale assessment of green urban infrastructure. J Environ Manage (146):107–115

Depietri Y, McPhearson T (2017) Integrating the grey, green, and blue in cities: nature-based solutions for climate change adaptation and risk reduction. In: Kabisch N, Konn H, Stadler J, Bonn A (eds) Nature-based solutions to climate change adaptation in urban areas. SpringerOpen, Switzerland

DG (2013) Environment Directorate-General for the Environment. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Green Infrastructure (GI)—Enhancing Europe's Natural Capital, Bruxelles

Ellen Macarthur Foundation (2017) Cities in the circular economies: an initial exploration (available on: https://www.ellenmacarthurfoundation.org/assets/downloads/publications/Cities-in-the-CE_An-Initial-Exploration.pdf)

Environment Directorate-General for the Environment (2013) Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Green Infrastructure (GI)—Enhancing Europe's Natural Capital; Environment Directorate-General for the Environment, Bruxelles, Belgium

Escobedo FJ, Kroeger T, Wagner JE (2011) Urban forests and pollution mitigation: analyzing ecosystem services and disservices. Environ Pollut 159:2078–2087

EU (2009) White paper adapting to climate change: towards a European framework for action. COM 2009 147/4, Brussels

European Commission (2012) The multifunctionality of green infrastructures. Science for environment policy/in-depth reports, Bruxelles

European Commission (2016) The forms and the functions of the green infrastructures. European Commission/Environmental, Brussels
European Environmental Agency (EEA) (2016) Urban adaptation to climate change in Europe 2016. Transforming cities in a changing climate. Publications Office of the European Union, Luxembourg
Evans JM, Schiller S (1996) Application of microclimate studies in town planning: a new capital city, an existing urban district and urban river front development. Atmos Environ 30:361–364
Georgi NJ, Zafiriadis K (2006) The impact of park trees on microclimate in urban areas. Urban Ecosyst 9(3):195–209
Gill SE, Handley JF, Ennos AR, Pauleit S (2007) Adapting cities for climate change: the role of the green infrastructure. Built Environ 33(1):115–133
Gómez-Baggethun E, Barton DN (2013) Classifying and valuing ecosystem services for urban planning. Ecol Econ 86:235–245
Greco S, Munda G (2017) Multiple-criteria evaluation in environmental policy analysis. Routledge, London
Haaland C, van Den Bosch CK (2015) Challenges and strategies for urban green-space planning in cities undergoing densification: a review. Urban For Urban Greening 14:760–771
Hansen R, Pauleit S (2014) From multifunctionality to multiple ecosystem services? A conceptual framework for multifunctionality in green infrastructure planning for urban areas. Ambio 43:516–529
Hunt A, Watkiss P (2011) Climate change impacts and adaptation in cities: a review of the literature. Climatic Change 104:13–49
Jayasooriya VM, Muthukumaran A, Perera B (2017) Green infrastructure practices for improvement of urban air quality. Urban For Urban Greening 21:34–47
Kabisch N (2015) Ecosystem service implementation and governance challenges in "urban green spaces" planning-the case of Berlin, Germany. Land Use Policy 42:557–567
Langemeyerab J, Gómez-Baggethuncf E, Haasede D, Scheuerd S, Elmqvistb T (2016) Bridging the gap between ecosystem service assessments and land-use planning through multi-criteria decision analysis (MCDA). Environ Sci Policy 62:45–56
Lindner P, Mooij C, Rogers H (2017) Circular economy in cities around the world. A selection of case studies (available on: https://www.circulareconomyclub.com/wpcontent/uploads/2017/07/Report_CollectionCaseStudies2017_FinalV2-1.pdf)
Lovell ST, Taylor JR (2013) Supplying urban ecosystem services through multifunctional green infrastructure in the United States. Landscape Ecol 28:1447–1463
Matthews T, Lo AY, Byrne JA (2015) Reconceptualizing green infrastructure for climate change adaptation: barriers to adoption and drivers for uptake by spatial planners. Landscape Urban Plann (138):155–163
Moreno-García MC (2019) The microclimatic effect of green infrastructure (GI) in a Mediterranean city: the case of the urban park of Ciutadella (Barcelona, Spain). Arboric Urban Forest 45(3):100–108
Moreno-García MC, Serra-Pardo JA (2016) El estudio de la isla de calor urbana en el ámbito mediterráneo: una revisión bibliográfica. Biblio 3W XXI(1):179
Moughtin C, McMahon K, Signoretta P (2009) Urban design health and the therapeutic environment. Architectural Press, New York
Munaretto S, Siciliano G, Turvani M (2014) Integrating adaptive governance and participatory multicriteria methods: a framework for climate adaptation governance. Ecol Soc 14(19):74
Munda G (2006) A NAIADE based approach for sustainability benchmarking. Int J Environ Technol Manage 6:65–78
Munda G (2008) Social multicriteria evaluation for a sustainable economy. Springer, Berlin
Munda G (2016) Multiple criteria decision analysis and sustainable development. Springer, Berlin
Oke TR (2006) Towards better scientific communication in urban climate. Theor Appl Climatol 84:1–3

Oppio A, Bottero M, Arcidiacono A (2018) Assessing urban quality: a proposal for a MCDA evaluation framework. Ann Oper Res 1–18. https://doi.org/10.1007/s10479-017-2738-2
Petit-Boix A, Leipold S (2018) Circular economy in cities: reviewing how environmental research aligns with local practices. J Cleaner Prod 195:1270–1281
Potcher O, Cohen P, Bitan A (2006) Climatic behavior of various urban parks during hot and humid summer in the Mediterranean city of Tel Aviv, Israel. Int J Climatol 26(12):1695–1711
Qian G, Wang C (2016) Circular economy cities. In: Li J, Yang T (eds) China's eco-city construction. Research series on the Chinese dream and China's development path. Springer, Berlin
Raymond CM, Frantzeskakib N, Kabischc N, Berryd P, Breile M, Razvan M, Geneletti ND, Calfapietra C (2017) An impact evaluation framework to support planning and evaluation of nature-based solutions projects. Report prepared by the EKLIPSE Expert Working Group on nature-based solutions to promote climate resilience in urban areas. Centre for Ecology and Hydrology, Wallingford, UK
Scuderi A, Sturiale L (2019) Evaluations of social media strategy for green urban planning in metropolitan cities. Smart Innovation Syst Technol 100:76–84
Seppelt R, Dormann CF, Eppink FV, Lautenbach S, Schmidt S (2011) A quantitative review of ecosystem service studies: approaches, shortcomings and the road ahead. J Appl Ecol 48:630–636
Spanò M, Gentile F, Davies C, Lafortezza R (2017) The DPSIR framework in support of green infrastructure planning: a case study in Southern Italy. Land Use Policy 61:242–250
Sturiale L, Scuderi A (2018) The evaluation of green investments in urban areas: a proposal of an eco-social-green model of the city. Sustainability 10:4541
Sturiale L, Scuderi A (2019) The role of green infrastructures in urban planning for climate change adaptation. Climate 7(10):119
Sturiale L, Timpanaro G, Foti VT, Scuderi A, Stella G (2020) Social and inclusive "value" generation in metropolitan area with the "urban gardens" planning. Green energy and technology. In: Mondini G et al (eds) Value and functions for future cities. Springer International Publisher, AG, Part of Springer Nature, New York, pp 285–302
Tzoulas K, Korpela K, Venn S, Yli-Pelkonen V, Kaźmierczak A, Niemela J, James P (2007) Promoting ecosystem and human health in urban areas using green infrastructure: a literature review. Landscape Urban Plann 81:167–178
UNEP (2017) Resource efficiency as key issue in the new urban agenda (available on: https://www.unep.org/ietc/sites/unep.org.ietc/files/Key%20messages%20RE%20Habitat%20III_en.pdf)
Vieiraa J, Matosa P, Mexia T, Silva P, Lopes N, Freitas C, Correia O, Santos-Reisa M, Branquinho C, Pinhoad P (2018) Green spaces are not all the same for the provision of air purification and climate regulation services: the case of urban parks. Environ Res 160:306–313
Wei J, Qian J, Tao Y, Hu F, Ou W (2018) Evaluating spatial priority of urban green infrastructure for urban sustainability in areas of rapid urbanization: a case study of Pukou in China. Sustainability 10:327
Werguin AC, Duhem B, Lindholm G, Oppermann B, Pauleit S, Tjallingi S (2005) In: European Commission, Brussels (ed) Green structure and urban planning: final report (COST Action, No. C11). Office for Official Publications of the European Communities, Luxembourg
Zinzi M, Agnoli S (2012) Cool and green roofs. An energy and comfort comparison between passive cooling and mitigation urban heat island techniques for residential buildings in the Mediterranean region. Energy Buildings 55:66–76