Chapter 3
Reviewing Ecosystem Services in Urban Climate Adaptation Plans

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3.1 Introduction

In this chapter, we focus on one specific type of urban planning instrument, which has become increasingly common in the last years: urban climate adaptation plans. In these plans, ecosystem service (ES) knowledge is instrumental to propose strategies for ecosystem-based adaptation (EbA) to climate change. EbA is defined as the use of biodiversity and ES to help people to adapt to the adverse effects of climate change. EbA approaches include management, conservation and restoration of ecosystems that, by delivering ES, can help to reduce climate change exposure and effects (Munang et al. 2013). EbA can play an important role in urban contexts and help to cope with increased temperature, flood events, and water scarcity by reducing soil sealing, mitigating the heat island effect, and enhancing water storage capacity in urban watersheds (Gill et al. 2007; Grimsditch 2011; Müller et al. 2014).

The recent literature has addressed the potential role of EbA in cities (Berndtsson 2010; Bowler et al. 2010b; Müller et al. 2014). In particular, Demuzere et al. (2014) presented a comprehensive analysis of the available empirical evidence about the contribution of green infrastructures to climate change adaptation in urban areas. Nevertheless, the concept of EbA is still relatively new for cities, and little evidence is available on the inclusion of EbA measures in actual urban plans and policies (Wamsler et al. 2014). Urban planning, at least in more industrialized countries, has been increasingly addressing climate adaptation strategies and actions, as shown by recent reviews of planning documents undertaken for cities in Europe (Reckien et al. 2014), the UK (Heidrich et al. 2013), Australia (Baker et al. 2012) and North America (Zimmerman and Faris 2011). However, none of these papers addresses specifically EbA.

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In this chapter, we develop a framework to analyse the inclusion of EbA in urban climate adaptation planning, and apply it to a sample of plans in Europe. Specifically, we aim at answering the following questions:

– What are the most common EbA measures found in urban climate adaptation plans? To what climate change impact do they respond?
– In what parts of the planning documents are EbA measures present? How well and how consistently are they treated?

The ultimate purpose of the chapter is to provide an overview of the current state of the art related to the inclusion of ES in urban climate planning through EbA, and use it to identify and discuss the main shortcoming and propose possible solutions.

3.2 Methods to Analyse Urban Climate Adaptation Plans

We focused on a sample of cities considered active in climate change adaptation, by referring to the "C-40" initiative. The C-40 was established in 2005 as a network of large cities worldwide that are taking action to reduce greenhouse gas emissions and to face climate risks. This sample offers the advantage of providing information on different initiatives undertaken by cities that have been particularly active in climate adaptation strategies. Among the cities of the C-40 database, we selected the ones belonging to Member States of the European Union. We then gathered all the urban climate change responses in the form of planning documents approved by the relevant municipal authority and available on the internet (see Annex II). We use the term 'climate adaptation plan' to refer in general to plans that include strategies to reduce vulnerability to climate change in cities, even though the actual name of the plan might be different.

3.2.1 Classification of EbA Measures

As a first step, we identified and classified possible measures for EbA that are relevant for urban areas. The list of EbA proposed by EEA (2012) was revised and integrated with other typologies found in the literature. This resulted in the classification presented in Table 3.1, where definition, rationale and supporting references are provided for each measure. Measures are associated to the main climate change impact they are meant to reduce, even though it is recognized that synergies occur. For example, green roofs may contribute to reduce runoff water quantity (Berndtsson 2010), in addition to contributing to micro-climate regulation through cooling. EbA measures play at different spatial scales, ranging from building-scale interventions (e.g., green roofs and walls) to urban-scale interventions (e.g., citywide green corridors). Despite their difference in scale, the identified measures are all within the scope of urban plans; hence, they can be (at least partly) implemented by actions

Table 3.1 The classification of EbA measures for urban areas adopted in this research (building on the list proposed by EEA 2012)

EbA Measure	Climate change impact	Rationale	References
(**a**) Ensuring ventilation from cooler areas outside the city through waterway and green areas	Heat	If carefully designed, urban waterways and open green areas have the potential to create air circulation and provide downwind cooling effect.	Oke (1988)
(**b**) Promoting green walls and roofs	Heat	Vegetated roofs and facades improve the thermal comfort of buildings, particularly in hot and dry climate	Bowler et al. (2010b); Castleton et al. (2010); Skelhorn et al. (2014)
(**c**) Maintaining/enhancing urban green (e.g., ecological corridors, trees, gardens)	Heat	Green urban areas reduce air and surface temperature by providing shading and enhancing evapotranspiration. This cooling impact is reflected, to some extent, also in the building environment surrounding green areas.	Yu and Hien (2006); Demuzere et al. (2014)
(**d**) Avoiding/reducing impervious surfaces	Flooding	Interventions to reduce impervious surfaces in urban environments (e.g., porous paving; green parking lots; brownfield restoration) contribute to slow down water runoff and enhance water infiltration, reducing peak discharge and offering protection against extreme precipitation events.	Jacobson (2011); Farrugia et al. (2013)
(**e**) Re-naturalizing river systems	Flooding	Restoring river and flood-plain systems to a more natural state in order to create space for floodwater can support higher base flows, reducing flood risk. Restoration interventions include, for example, the establishment of backwaters and channel features and the creation of more natural bank profiles and meanders.	Palmer et al. (2009); Burns et al. (2012)
(**f**) Maintaining and managing green areas for flood retention and water storage	Flooding, Water scarcity	Vegetated areas reduce peak discharge, increase infiltration and induce the replenishment of groundwater. To enhance this, retention basins, swales, and wet detention systems can be designed into open spaces and urban parks.	Cameron et al. (2012); Liu et al. (2014)
(**g**) Promoting the use of vegetation adapted to local climate and drought conditions and ensuring sustainable watering of green space	Water scarcity	Green space may exacerbate water scarcity in urban areas. To limit this problem, interventions can be directed at choosing the most appropriate tree species (that are drought resistant but still suitable as a part of the urban green space), and designing sustainable watering systems (e.g., using grey water or harvested rainwater)	EEA (2012)

proposed in planning instruments. Measures such as river re-naturalization, in most cases, cannot be handled within the border of a city alone. However, urban plans have the possibility to implement these interventions (at least for the urban sector of rivers), as well as to promote coordination with other planning levels (e.g., regional planning, river basin planning). Thus, these measures have been included in the proposed classification of EbA measures relevant for urban areas.

3.2.2 Analysis of the Content of the Plans

As in Chap. 2, the content of the plans was divided into different components, which represent thematically different parts of the plans. For climate adaptation plan, four components were identified: *information base*; *vision and objectives*; *actions*; *implementation*. The *information base* includes the analysis of current conditions and future trends (typically presented in the introductory parts of the planning documents), which is performed in order to provide a basis for the subsequent development of the plan's objectives and actions. *Vision and objectives* include the statement of the ambition and of the general and specific objectives that a plan intends to achieve. *Actions* include all the decisions, strategies and policies that the plan propose, in order to achieve its objectives. Finally, *implementation* refer to all measures (including budget-related ones) proposed to ensure that actions are carried out.

Similarly to the previous Chapter, a direct content analysis was performed, by reading all the documents associated to the selected plans and identifying – for each of the four components - the content related to EbA measures, using the classification presented in Table 3.1. This approach was preferred to a keyword-based analysis, given that there is not yet a well-established terminology in this field, and plans use a wide range of different wording to refer to concepts related to EbA and to ES in general (Braat and de Groot 2012). Hence, we searched for the presence of the different measures, irrespective of whether the plan used the term "EbA" or not to describe them.

The content analysis followed a two-step process. First, the presence of the different EbA measures in each plan component was searched, by using the following guiding questions:

- *Information base*: Does it contain data/statements/analyses that show awareness about EbA?
- *Vision and objectives*: Are there objectives associated to the development/enhancement of EbA measures?
- *Actions*: Are there actions aimed at developing/enhancing EbA measures?
- *Implementation*: Do the implementation provisions include reference to EbA measures?

Second, whenever the answer to the previous questions was positive, the content was further analysed in order to assess the extent to which EbA measures were addressed, by using the four-level scoring system presented in Table 3.2. Finally, an

Table 3.2 Scoring system used to evaluate the plan components

Score	Information base	Vision and objectives	Actions	Implementation
0	No evidence of information related to EbA measures	No evidence of objectives related to EbA measures	No evidence of EbA measures	No evidence of implementation provisions related to EbA measures
1	Acknowledges EbA measures only generally (not in connection to specific climate change issues)	Mentions EbA-related objectives, but lacks further definition	Mentions EbA measures, but lacks further definition	Mentions implementation provisions related to EbA measures, but lacks further definition
2	Acknowledges EbA measures in the context of specific climate change issues	Includes EbA measures in the objectives and provides some details on their specific content and how to pursue them	Includes EbA measures in the actions and provides some details on their application and activities	Includes EbA-related implementation provisions and provides some details on their application
3	Acknowledges EbA measures and describes (at least qualitatively) the potential climate change adaptation effects	Includes EbA measures in the objectives, provides details on their content, and describes links with related planning and policy processes at the local/regional level	Includes EbA measures in the actions, provides information on their application and activities, including locally-specific details	Includes EbA-related implementation provisions and provides information on their application, including details on budget, responsible bodies, etc.

average score was obtained for each type of EbA measure by computing the average value obtained by that measure in all the plans where the measure is found, and for all plan components.

3.3 Results

3.3.1 What EbA Measures are Included in the Plans and How?

In total, 44 EbA measures were found in the selected plans. Figure 3.1 illustrates the breakdown in the seven types. As can be seen, measures *c* (maintaining/enhancing urban green) and *f* (maintaining and managing green areas for flood retention and water storage) are the most common ones, and are found in 85% of the selected plans. Examples of measures *c* include efforts to increase green areas and neighbourhood gardens (Paris), proposals for enhancing the connectivity among existing

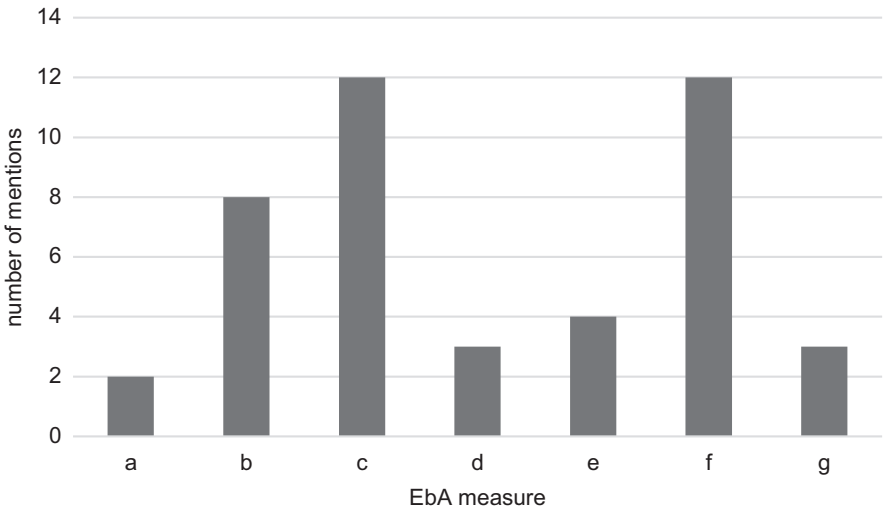

Fig. 3.1 Number of mentions of the seven types of EbA measures (see legend in Table 3.1) in the sample of plans

green areas through the design of green corridors and rings (Milan), and the use of plants to provide shade in new industrial estates (Amsterdam). Measures *f* consist, for example, in the creation of new wetland areas and ponds (Berlin), and the design of green spaces to store rainwater in the event of torrential rain (Copenhagen).

Measure *b* (promoting green walls and roofs) was found in 57% of the plans. For example, Paris's plan contains provisions for the establishment of roof and wall gardens (measure *b*), including the identification of priority spots for this type of green infrastructures. Measure *e* (re-naturalizing river systems) was found in 29% of the plans. In Madrid, for example, this consisted in a series of bank improvement projects aimed at reducing flood hazard and expanding riverside public space. Measures *a*, *d* and *g* (respectively, ensuring ventilation, avoiding/reducing impervious surfaces, and promoting climate-adapted vegetation and sustainable watering) were less common, and found only in 14–21% of the plans. For example, concerning measure *a*, cold air networks to ensure ventilation and prevent over-heating are mentioned in Copenhagen's plan, whereas Madrid's provides for the promotion of *ecobarrios* where ventilation will be one of the factors considered in the design of greening interventions. Berlin's plan attains the reduction of impervious surfaces (measure *d*) through renovation projects for buildings and school playgrounds that include interventions to improve soil permeability and in situ infiltration. Finally, concerning measure *g*, Venice's plan promotes the use of autochthonous species adapted to the local climate, and Madrid's contains detailed guidelines for "sustainable gardens" with recommendations for the selection of plant species and sustainable watering systems.

The results of the application of the scoring systems were used to compute an average score for each type of EbA measure (Fig. 3.2), representing the average

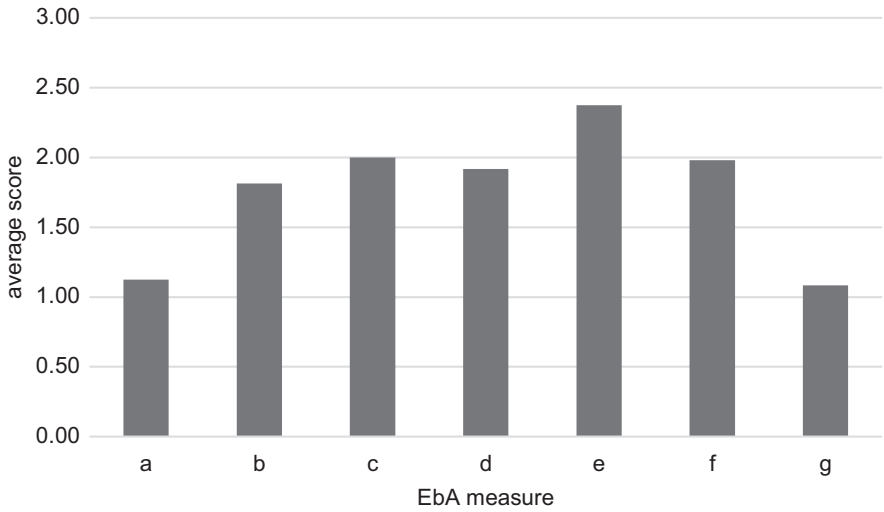

Fig. 3.2 Average scores of the seven types of EbA measures (see legend in Table 3.1)

value obtained by the measure in all the plans where it is found, and for all plan components. The average score ranges from 1.1 (achieved by measures *a* and *g*) to 2.4 (measures *e*). Measures *c* and *f*, which are the most frequently found, are also the ones with the highest scores, together with action *e*.

3.3.2 How Are EbA Measures Reflected Within Plan Components?

Figure 3.3 shows in which plan components EbA measures are reflected. About 91% of the measures are present in the *vision and objectives* component. This means that, when a plan includes an EbA measure, this is very often listed as (part of) one of the objectives that the plan intends to achieve. For example, Paris's plan objectives include the development of a multi-year scheme to promote roof gardens. Almost 91% of the EbA measures are addressed in the *actions* component, meaning that the plans include specific policies or activities to attain them. For example, Milan's plan includes a series of linear greening interventions along canal banks, roads, biking routes, etc. The *information base* component of the plans contains data relevant to EbA measures only in 79% of the cases. That is, 21% of the measures found in the plans are not supported by any baseline information or analysis. Even when baseline information is present, this consists mostly of general statements and descriptions. For example, Berlin's plan contains descriptions of how energy efficiency of buildings or industry could be usefully combined with projects to support sustainable local water management systems, by increasing the permeability of soil and planting

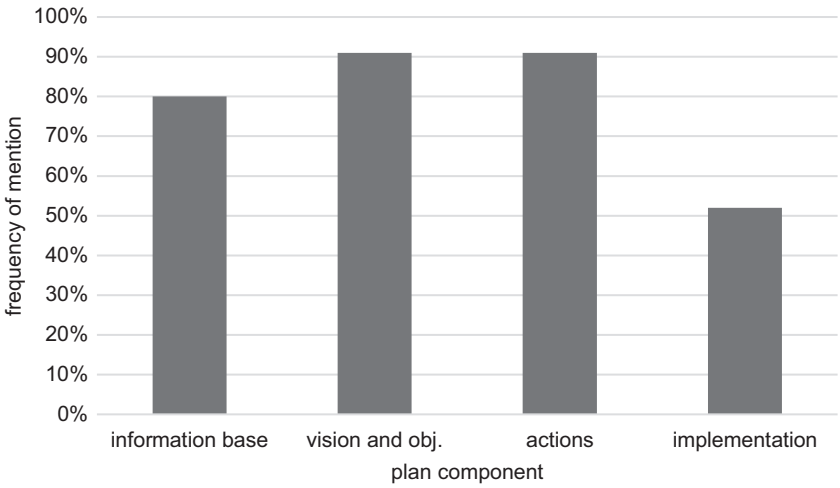

Fig. 3.3 Frequency of presence of information about the 44 EbA in the different plan components

vegetation. The *implementation* component of the plans performs even more poorly: references to EbA measures are found in only 52% of the cases. Therefore, about half of EbA measures are not associated to any action to ensure that they are carried out. When information about implementation measures are present, this consists mainly of budget-related details, as for example in the case of Madrid's plan (where each action is linked to a plan of implementation and budget), and Rotterdam's, where there are indications about green roofs subsidies.

In order to assess how well EbA measures are reflected within the different plan components, we computed the average score obtained by all EbA measures that are found in each of the four components. For example, out of the 44 EbA measures, 35 are present in the *information base* component of the selected plans. The average score represents the average of the scores obtained by these 35 EbA according to the adopted scoring system. The results show that *actions* component scored the highest (average score: 2.8), followed by the *implementation* (2.5), the v*ision and objectives* (2.2) and the *information base* (1.8). Concerning the good performance of *actions*, examples include London's plan, which describes in detail the actions and associated sub-actions, specifies the responsible bodies and identifies links with other plans and policies. Similarly, Madrid's plan provides action fact-sheets, with the identification of responsible bodies and associated budget. The poorer scores of the *visions and objectives* component are because their description tend to be very general. The i*nformation base* typically lacks details on the links between measures and climate-related issues, particularly concerning the results expected from the application of the measure.

Finally, Fig. 3.4 provides a visual overview of the distribution of information on the identified EbA measures across plan components. This figure helps to understand how consistently EbA measures are treated across the different plan components, and

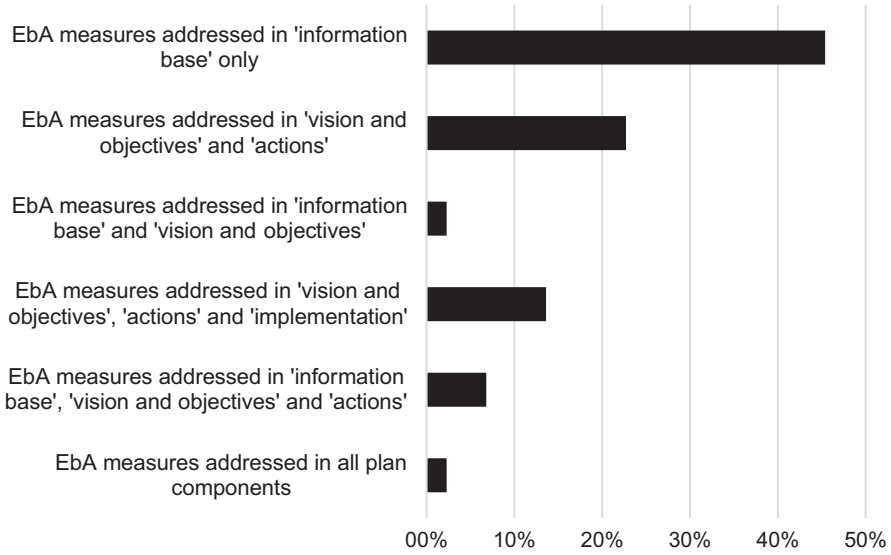

Fig. 3.4 Distribution of information on the identified EbA measures across the plan components (see text for further explanation)

where the gaps are. The figure shows that the 44 EbA measures identified in the plans can be grouped in six categories:

- Measures addressed in all the four plan components, from the *information base* through the *implementation*. This is obviously the most desirable situation, but it occurred only for 45.5% of the EbA measures. In all other cases, at least one component is lacking;
- Measures addressed in the first three components of the plans, but not in the *implementation* part. This occurs for 22.7% of the EbA measures;
- Measures addressed only in the *vision and objectives* and *actions* with no links to the *information base* or *implementation* (13.6%);
- Measures addressed only in the *information base* and *vision and objectives*, with no follow-up in the rest of the plan (6.8%);
- Measures addressed in the *information base* only, with no follow-up in the rest of the plan (2.3%)
- Measures addressed in the *vision and objectives*, *actions* and *implementation* components, with no links to the *information base* (2.3%).

3.4 Conclusions

The review concluded that maintaining/enhancing urban green spaces (e.g., ecological corridors, trees, gardens) is the most common measure, showing that there is strong awareness of the role that green areas play in addressing climate change challenges, both in terms of mitigating heat waves (measure *c*) and preventing floods (measure *f*).

The frequency of these measures is perhaps not surprising giving that they result in the enhancement of green areas, which is a typical objective that planners pursue to improve the urban space for a variety of purposes that go beyond climate change adaptation (e.g., providing recreation opportunities, improving air quality) (Tzoulas et al. 2007). So, their frequency could be explained by the fact that these measures rely on actions that are part of the standard approaches applied by planners for decades.

A general conclusion suggested by the review is that EbA measures are finding their way in climate adaptation plans, in response to a broad range of climate change challenges. However, a critical issue that we detected is that the proposal of these EbA measures in the plans is rarely backed-up by specific information on the expected outcomes, as well as the target beneficiaries. For example, the enhancement of green areas to reduce heat or to prevent floods is typically proposed as a general measure that will do some good, without providing details and justification for critical decisions, such as the design and the location of these interventions, and the distribution and vulnerability of the expected beneficiaries. Most plans are affected by a lack of specificity and details that may hamper the possibility for these measures to be actually implemented, as well as their overall effectiveness.

The baseline information upon which EbA measures are proposed and designed needs to be enhanced. Methods to assess the existing stock of green/blue infrastructures, and their potential to provide climate adaptation services must be mainstreamed in planning practice. Particularly, assessments of the flow of ES at local scales are often missing, given that many climate change impact and vulnerability studies provide results at larger scales, which limits their usefulness for developing local adaptation strategies (Vignola et al. 2009). A better knowledge base, including information on spatial pattern of vulnerability, would allow better targeting the design and implementation of EbA measures. The limited knowledge base used to design ES-related actions, as well as the lack of information about ES beneficiaries, have emerged as critical issues also in the review of urban plans presented in Chap. 2. The next two chapters address these issues. Chapter 4 illustrates a model that can help planners to assess the provision of a specific ES (micro-climate regulation), and to design urban green space accordingly. In Chap. 5, the outcomes of this and other ES models are combined with information on the potential beneficiaries to support urban planning interventions.