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Mapping and assessment of urban ecosystems and their services

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Contents

Abbreviations

CICES:	Common International Classification of Ecosystem Services
CLC:	Corine Land Cover; Corine means 'coordination of information on the environment'
GI	Green Infrastructure
EU:	European Union
JRC:	Joint Research Centre of the European Commission
OECD	Organisation for Economic Co-operation and Development
MAES:	Mapping and Assessment of Ecosystems and their Services
UN	United Nations

Summary

Action 5 of the EU Biodiversity Strategy to 2020 aims to map and assess ecosystems and their services in the various EU member states (MAES). So far, particular attention went to mapping and assessment of condition and services provided by forests, crop- and grasslands, freshwater and marine ecosystems. This report concerns urban ecosystems and is part of the MAES urban pilot, a collaboration between the European Commission and the Member States with the aim to test mapping and assessment concepts and approaches.

This technical report serves as a background document for the MAES pilot on urban ecosystems. Here we present in detail the methods and results of an online survey and a literature review and we deliver elements for the development of an indicator framework for urban ecosystems.

The survey yielded a number of insights in terms of policy on urban green infrastructure. 66% of the respondents to the survey reported a policy on urban green infrastructure at city level; 14% of the respondents said that there is no policy which covered urban green infrastructure in their city. These respondents called for dedicated policy at all levels, including the EU level.

The presence of a national or regional policy on urban green infrastructure increases the probability that there is a policy at city level to 80%. Besides designing and implementing policy survey respondents expect that in particular bottom-up initiatives from citizens are important to improve green urban infrastructure.

There's a difference in perception with respect to public awareness and political interest between participants who identified themselves as researchers on the one hand, and policy-makers and other stakeholders on the other hand. Policy makers disagree with the statement that awareness and interest are low. Researchers agree with the statement. But both types of participants agree that the main obstacles to a better implementation of urban green infrastructure are competing interest from the development sector and a lack of financial means.

The survey results suggested that cities and regions have the capacity to support policy on urban green infrastructure with scientific evidence but we could not conclude in how far such information is actually used in the policy process. Still, we argue that there is a substantial scope for urban ecosystem assessments and for evidence based policy support on urban green.

Several elements for an EU wide indicator framework that can be used for mapping and assessing urban ecosystems and their services are now under development. This report could not conclude on a typology of urban green spaces but work is in progress. The report contains a set of indicators which can be used to assess urban ecosystem condition and urban ecosystem services. These proposals need now to be discussed within the MAES urban pilot and with the members of the MAES working group. The ambition is to present a final indicator framework

for mapping and assessment of urban ecosystems and their services in a new MAES report which should be published in the course of 2016.

1 Introduction

Action 5 of the EU Biodiversity Strategy to 2020 aims to "Improve knowledge of ecosystems and their services in the EU". It calls the EU Member States, with the assistance of the Commission, to map and assess the state of ecosystems and their services in their national territory by 2014.

In 2014 the MAES working group provided an operational framework, addressed to Member States, on how to map and assess the state of the ecosystems and their services. The framework was based on the outcomes of six pilot studies: four on Europe's main ecosystems, one on the use of conservation status and one on natural capital accounting (Maes et al. 2014).

In these pilots EU services worked hand in hand with Member States to make a review of national and European data and indicators to assess the condition of ecosystems, to quantify biodiversity and to map and assess their services. The pilot studies contributed indicators, which can be used for mapping and assessing biodiversity, ecosystem condition and ecosystem services according to the Common International Classification of Ecosystem Services (CICES v4.3).

Urban ecosystems were not considered in the first series of pilot studies but they are proposed as new pilot in a second phase of the MAES work (March 2015).

The focus on the urban environment is particularly relevant in Europe: in 2010 around 320 million people lived in so called functional urban areas (OECD 2013), accounting for 65% of the European population. Different international institutions including the OECD, the UN and the European Commission expect this number to further increase.

Cities and artificial urbanized areas have a strong environmental impact (Newman 2006). The high population density results in a high demand for ecosystem services including nature-based recreation, local climate regulation or clean air (Baró et al. 2015). This demand is likely to increase in the future; in absolute terms, as the size of cities will increase, as well as relatively due to climate change. Urban green infrastructure improves the quality of life through urban ecosystem services (Strohbach et al.; Haase et al. 2014; Beumer and Martens 2015; Snep et al. 2015). It may also reduce the environmental impact of cities by reducing energy demand or increasing local food production and water storage capacity. Ecosystem services should therefore be more systematically incorporated into urban planning and policy, to ensure a more sustainable development (Rall et al. 2015).

This systematic incorporation requires a framework based on an integrated and multidisciplinary research effort which includes a comprehensive involvement of stakeholders for the translation of scientific findings into actionable knowledge (Colding et al. 2013; Haase et al. 2014; Andersson et al. 2014a; Luederitz et al. 2015). In addition, the use of a common

framework should support coordination between multiple planning scales (national/regional/urban) and should thus include scale-independent level indicators which help understand where and how to implement policy strategies.

1.1 Objectives of the MAES urban pilot

The MAES urban pilot aims build such an operational framework for the mapping and assessment of urban ecosystem and their services. In this framework we hereto collected information directly from the most representative stakeholders: policy makers and researchers who are active at a local and regional scale.

The MAES urban pilot will pinpoint the data and indicators that can be used to develop GI policy in cities. The pilot aims to provide guidance and examples on:

1) mapping urban green infrastructure (GI);
2) mapping ecosystem conditions and services relevant for cities;
3) translation of concepts for the enhanced delivery of multiple ecosystem services into concrete action.

The pilot study follows closely the common assessment framework presented in the second MAES report (Maes et al. 2014) and was set up using similar working methods. Countries, research projects and cities were invited to join the pilot. The Joint Research Centre and the Dutch representative of the MAES working group coordinate the pilot and ensure the final delivery.

Methodologically the pilot was divided in three parts. Firstly, an online survey was developed which links policy on urban ecosystems and GI with data collection and indicators related to GI, urban ecosystem conditions and services. Secondly, the set of indicators derived from this study was complemented by a literature review. Both sources of information were the basis to draw a framework for mapping and assessment of urban ecosystems and their services. At the same time, as a third element, different cities were contacted to compare the proposed framework with the implementation of policies on urban green, data and indicators on urban ecosystems and their services in different case studies. The MAES report on urban ecosystems will describe all these developments and include working guidance for member states on how to implement Action 5 in urban areas.

This JRC technical report considers the first part of the pilot. Here we present in detail the methods and results of the online survey and the literature review and we propose the indicator framework. This report will serve as a background document for the MAES report on the pilot on urban ecosystems that will be published in the course of 2016.

1.2 Terminology

There are many terms used to indicate urban ecosystems including urban green infrastructure, urban green, green urban areas, or urban green spaces. Sometimes they refer to the same concept but they target different audiences.

For the purpose of Action 5 and MAES we mostly use the term urban ecosystems. They are defined as areas where most of the human population lives. Urban ecosystems represent mainly human habitats but they usually include significant areas for synanthropic species, which are associated with urban habitats. Urban ecosystems include urban, industrial, commercial, and transport areas, green urban areas (urban green spaces), mines, dumping and construction sites.

Green urban areas and urban green spaces are synonyms for urban areas which are partly or completely covered with vegetation such as grass, shrubs or trees.

Green infrastructure is a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services. It incorporates (urban) green spaces (or blue if aquatic ecosystems are concerned) and other physical features in terrestrial (including coastal) and marine areas. On land, GI is present in rural and urban settings.

Urban green infrastructure is the green infrastructure inside urban and peri-urban areas. But notice that rural green infrastructure can also deliver relevant ecosystem services to urban citizens (i.e. flood prevention) (Holt et al. 2015).

It is not always possible to clearly discriminate between these terms. But it is interesting to keep in mind that urban ecosystems, green urban areas and urban green spaces constitute a structural component while green infrastructure has a functional connotation. When talking about green infrastructure, we usually think of a certain purpose that it fulfills.

In the report we also refer to urban blue infrastructure which we consider a part of the overall urban green infrastructure.

2 Methods

2.1 Online survey

The survey was designed to collect information on urban ecosystems, related policies and planning instruments. The design was made by the MAES Urban Pilot working group, composed by representatives from the Joint Research Centre, the National Institute for Public health and Environment (The Netherlands) and the European Commission's Directorate General for the Environment. The survey was addressed to researchers and stakeholders in order to gather different kind of opinions and experiences.

We developed a semi-structured questionnaire, with a few open questions and with the option to add detailed material and auxiliary documents along the process of answering.

The questionnaire was divided in three sections; see Annex 1 for the complete list of questions:

- Section I – Basic information of the interviewee;
- Section II – Policy related questions;
- Section III – Mapping related questions,
    a) Features of urban green infrastructure,
    b) Condition of the natural state of urban ecosystems,
    c) Ecosystem services delivered by urban ecosystems.

The survey was administrated through an online platform and was carried on a voluntary basis. (https://ec.europa.eu/eusurvey/runner/MAES_UrbanPilot_survey_2015).

In a first stage a group of 5 experts were invited to test a preliminary version. The final version was launched on 01/06/2015 and closed on 30/11/2015.

Policy-makers, stakeholders and researches were invited through:

- E-mailing;
- Presentation of the initiative during conferences and seminars;
- Personal contacts.

64 answers were submitted originating from 15 European countries and 42 cities or regions (Figure 1). Given the substantial effort needed to complete the survey (between 1.5 and 2 hours) we believe that this number represents a good response.

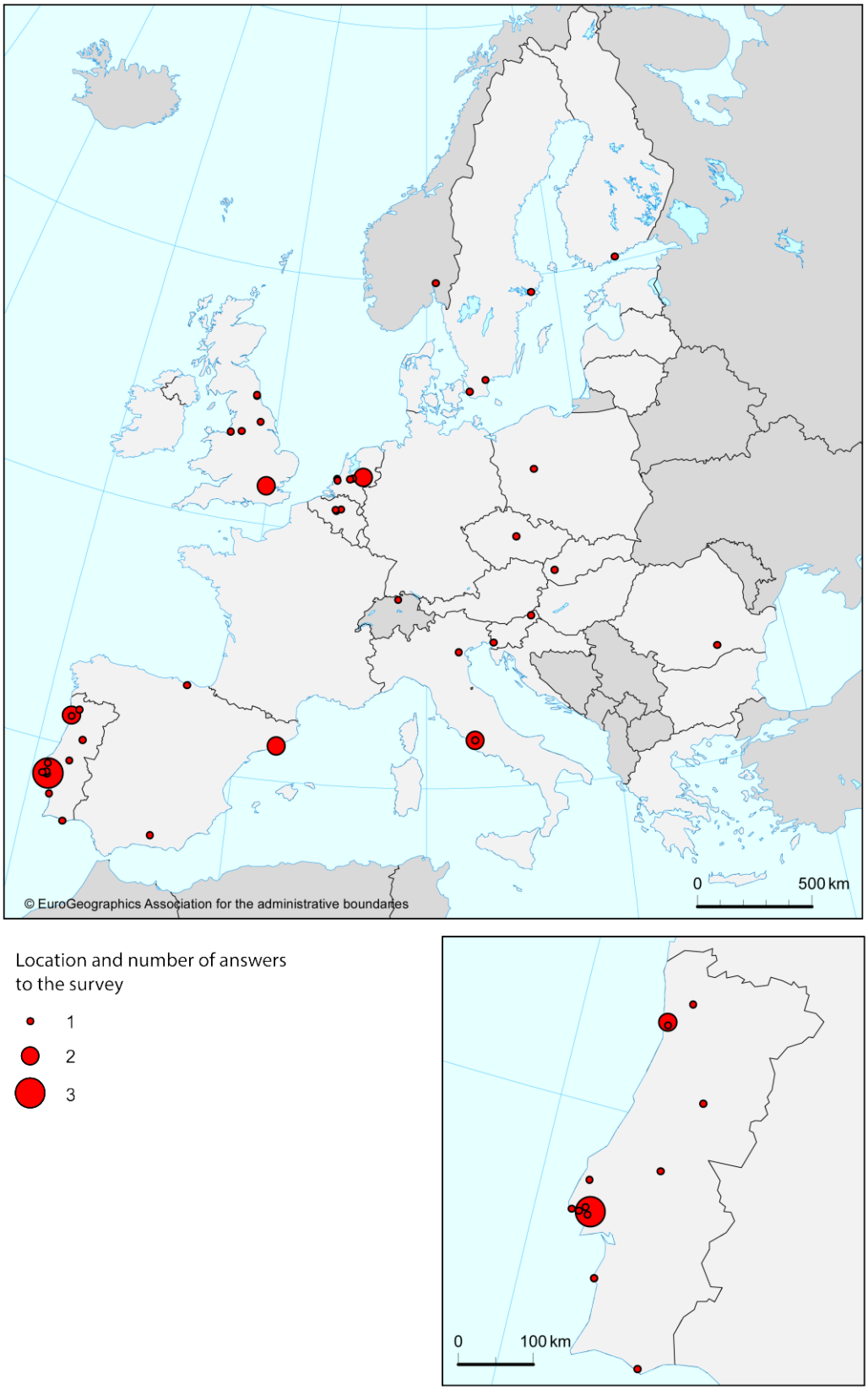


Figure 1. Location of case studies of the survey

2.2 Literature review

In addition to the survey, we performed a literature survey of articles that focus on urban ecosystems and their services

The purpose of the literature review was to assemble information regarding methods and indicators used to:

- Map urban green infrastructure;
- Assess the condition of urban ecosystems;
- Measure ecosystem services delivered by urban ecosystems.

Information was collected from published scientific articles only. The following search key words were used for a literature search using Science Direct in order to identify suitable case studies: (i) urban AND ecosystem*, (ii) urban AND ecosystem service*, (iii) urban AND ecosystem* OR urban AND ecosystem service* AND case stud*, (iv) urban AND green infrastructure. Generally these terms cover the main search area of urban ecosystem services and urban green infrastructure. Due to the interdisciplinary nature of the subject, results arose from a varied range of scientific disciplines (ecology, geography, geology, land use planning, forestry, and others).

After an initial screening, the resulting scientific papers were checked for relevance. The process of selection was based on the following criteria:

- Are urban ecosystem services explicitly stated?
- What types of ecosystem services are studied (provisioning, regulating and maintenance, cultural)?
- What are the main objectives of the study?
- Which indicators are used? (with reference to indicators and units)
- In which city or region is the case study located?

54 scientific papers were selected, and they were divided in three groups:

- How to map the structural elements which contribute to urban green infrastructure;
- Indicators to assess ecosystem condition;
- Urban ecosystem services and their indicators.

For each group we collected different types of information; Table 1 shows the structure of collected data and Figure 2 presents the location of the case studies of the literature review.

Table 1: Structure of the collected data.

Topic	Collected data
Urban green infrastructure	Type of green infrastructure Indicators Units of measure
Ecosystem condition	Urban ecosystem typology Indicators Output types (raster map, vector map, statistic)
Ecosystem services	Type of ecosystem service Indicators Output types (raster map, vector map, statistic) Units of measure Primary source

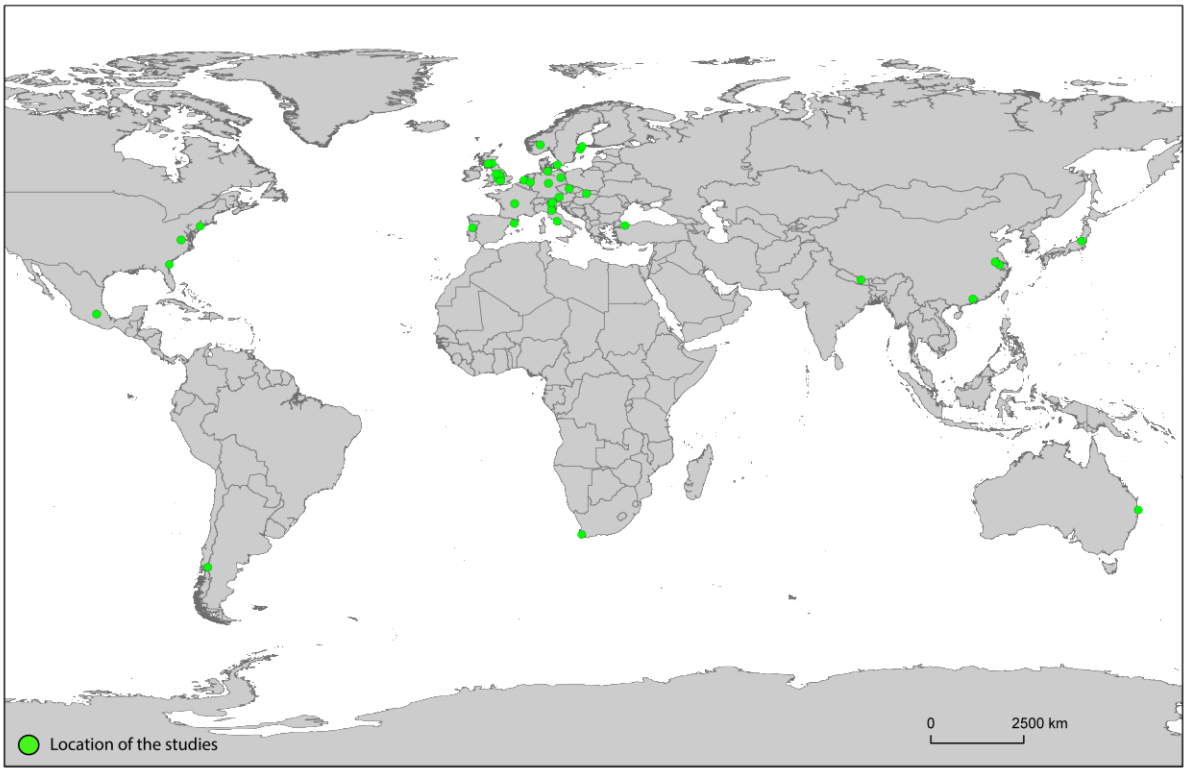


Figure 2. Location of the case studies derived from a review of the international literature.

3 Results of the survey and the literature review

3.1 Section I of the survey: profile of the respondents

Most of the respondents were researchers (44%), followed policy makers (34%) who are involved in the design or the implementation of policy on urban ecosystems or urban green infrastructure. 22% of the respondents were other interested stakeholders including a national data producer, a conservation officer, a government regulator, a forest and city public parks manager, and a collaborator of an NGO.

The group of policy-makers included:

- City administration – 14%
- Management of urban parks – 6%
- Head of unit of the green department -8%
- Design of green urban areas – 2%
- Other – 20%
- No answer – 50%
- Among other respondents indicated:
    - Advocacy
    - Enable evidence-based decision making
    - Institution responsible for urban policy
    - Management of urban trees
    - Technician in regional environmental and land management
    - Regional territorial management and planning department
    - Regional administration
    - Regional stakeholder
    - Land use Planning
    - City ecologist
    - Researcher on urban agriculture

About 50% of the policy makers has been working in the current position for more than five years (49%) and is thus considered as experienced in this matter.

When asked to the researchers about the main objectives and focuses of their studies the majority of the respondents referred to ecosystem services management and assessment related issues. Some examples include:

- Assess inequalities in spatial distribution of urban ecosystem services;
- Developing high quality urban patterns for a region under pressure considering ecosystem services;
- Assessment of the potential of green infrastructure (private and public) to provide ecosystem services;

- Review of available knowledge on the effectiveness of urban green infrastructure of ecosystem services;
- Design principles to optimize urban green infrastructure for a healthy city;
- Development of method to map and assess ecosystem services in urban areas;
- Development of indicators that enhanced expert-based assessment of ecosystem services;
- Comparison of spatial data accuracy and their influence on ecosystem services assessment;
- Evaluation of current state of the ES framework implementation;
- To quantify the structure of the urban forest and to estimate delivery of ecosystem services provided by the urban forest.

3.2 Section II of the survey: policy related questions

Section II of the survey focuses on policies related to urban ecosystems in cities or regions where the respondents are active.

Two third of the respondents affirmed that there is a policy in place at city level to improve green urban areas. One third of the replies indicated that such policy is in place at regional level, 32% at national level, 16% beyond the municipality delineation in cooperation with other municipalities (inter-city), 14% reports that there is no policy in place and 2% of the respondents didn't answer to this question (Figure 3). In 80% of the cases where there is a national policy, respondents also indicated a policy at city level. Similarly, in 75% of the cases where there is a regional policy in place there is also a policy at city level.

In case of no policy in place, an additional question was posed as to which policy level should support the implementation, enhancement and improvement of green urban areas. The results suggest that all policy levels are relevant with equal shares assigned to different levels.

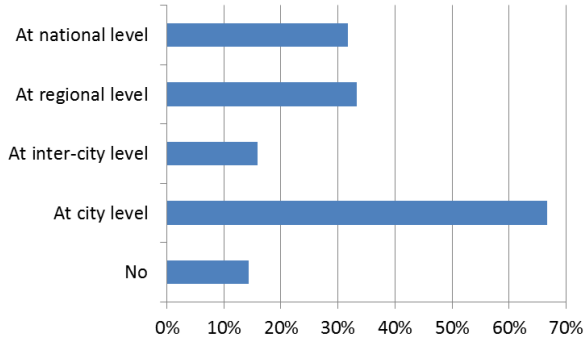
Policy on urban green area is sometimes covered by other policies or strategies so that in reality there is a dedicated policy on green urban areas but it is perhaps less visible. Sometimes urban areas are considered in climate planning, in environmental protection or in sustainable development.

"For example at National level issues concerning urban green can be found in National Urban Policy (accepted on 20th November 2015), Adaptation Plan for Sectors and Areas Sensitive to Climate Change 2020. At regional and city level issues concerning enhancement of green areas can be found in Environmental Protection Programs and Strategies of Development. Green areas are planned in local planning documents (city level) such as Studies of Condition and Direction of Development and can be protected in local plans." (Poznan, Poland)

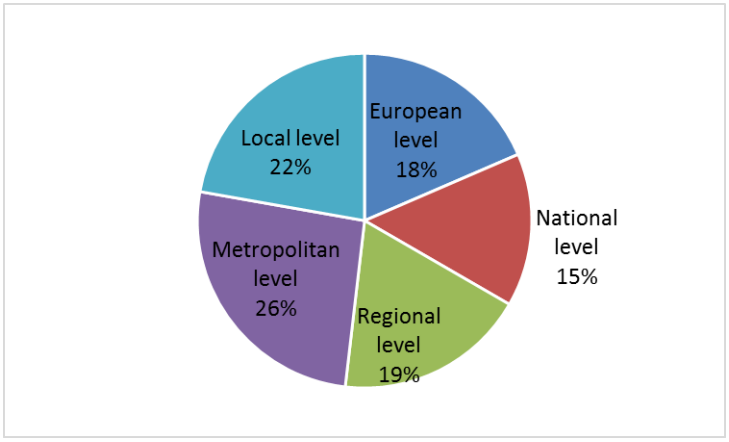
As to **other developments which can help enhance and improve green urban areas**, 44% of the respondents considered that such other initiatives should come from bottom-up initiatives from citizens (e.g. greening the neighborhood, maintaining common gardens), 23% attributes it to private sector initiatives (e.g. shops and business that green their surroundings

such as parking lots or business parks), 17% to new cooperation between private sector and NGO's (e.g. nature conservation organization with a company create together an urban green space), 11% to other initiatives and 5% did not answer to this question (Figure 3)

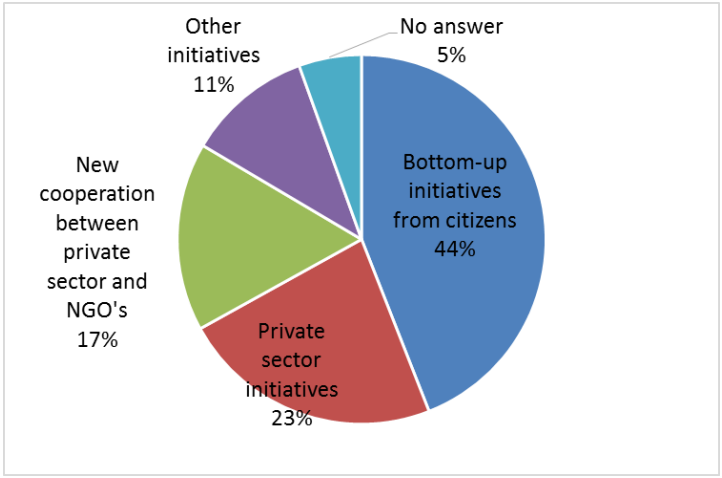
Is there a specific policy to enhance or improve green urban areas in the territory for which you work?



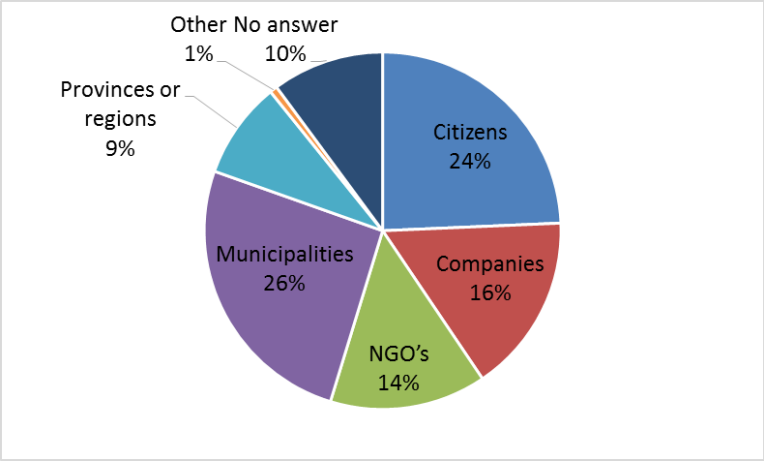
If there is no specific policy, on which policy level would support on implementation, enhancement of improvement of green urban areas needs to be given?



In your opinion are there other developments that help enhance or improve green urban areas in the area where you work?



If there is a specific policy in place, indicate here to whom this policy is directed or who is involved? (multiple choice)



What type of policy instruments are being used to enlarge or improve green urban areas? You can select multiple choices

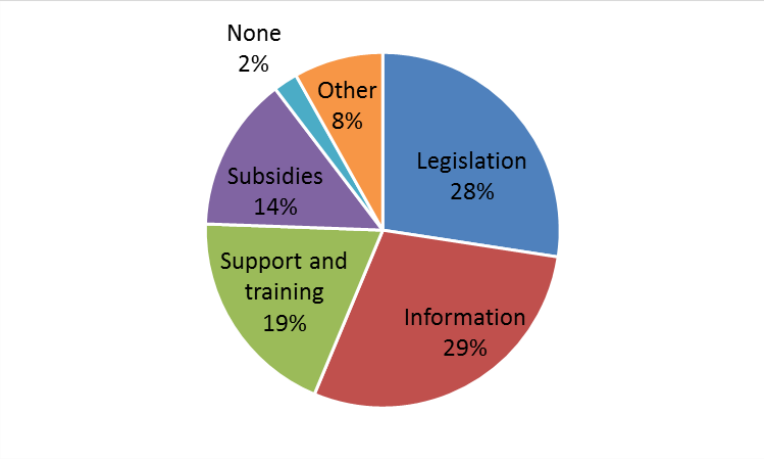


Figure 3. Survey results on policies related to urban ecosystems.

Some examples were given on other helpful initiatives to improve urban green areas, such as:

- Promotion of urban horticulture by municipalities;
- Creation of a specific department where arborists and landscape planners are involved, inside the city administration;
- Participatory budgeting - a process of democratic deliberation and decision-making, in which ordinary people decide how to allocate part of a municipal or public budget in several including green areas;
- Governmental activities to stimulate private actions and optimization of design of public green spaces;
- Local government launched initiatives;
- Activities organized by local NGO's such as "green guerrilla marketing campaigns, greening local areas in vicinity of schools and fundamentally, rising public awareness about green areas";
- Monitoring of urban species and understanding the behaviour of species in cities.

On the subject of policies currently in place, the respondents were asked what is the aim and what is the issue being addressed. The policies in place support the quality of life in terms of social function and biodiversity. Here are some examples of the purposes of the policies and opinions:

- "*A green infrastructure policy was applied, the aims of which are to ensure quality development and safeguard and enhance quality of life";*
- *"A set of policies is in place to develop ecological networks and avoid deterioration of biodiversity" (West and South Yorkshire);*
- *"In our municipality we defined a future perspective called 'the green template'. This template is the carrier of main green and blue structures and spots. All efforts are concentrated on realization of this template. Also we do have a landscape inspiration book to support and inspire initiatives" (Apeldoorn, The Netherlands);*
- *Maintaining the multi-functionality of public parks and encouragement for the social function with the greater involvement of citizens and associations (Trieste, Italy);*
- *"The city development goals are sustainable development of the city and enhancing urban quality. At regional level the structural plans are related to coordinated development, and sustainable land use. And at national level the biodiversity strategy focuses on enhancing urban quality, habitat connectivity and conservation" (Limmattal region, Switzerland);*
- *"Creation of ecological networks - territorial system of ecological stability" (Trnava region, Slovakia);*
- *"The aim of our local policy is based on how green urban spaces contribute to quality of life, mobility grids and ecosystem services" (Oeiras, Portugal);*
- *"Gateshead Council has a Green Infrastructure Delivery Plan in place. It contains a strategic green infrastructure (GI) network, and a series of 'opportunity areas', which are areas with particular potential for improving GI. It consists of a series of GI projects, spread across the borough". (Gateshead borough, England)*
- *"Lisbon´s green infrastructure program is underway since 2008. New Master Plan in 2012 had been approved and a consistent greenway´s strategy continued its progress towards increasing 20% green areas in 10 years, focusing on more urban quality, climate adaptation goals and urban biodiversity targets" (Lisbon, Portugal).*
- *"Promoting access to nature, guarantee spaces to enable the population to carry out outdoor activities that can contribute to quality of life and healthy lifestyles. In addition to access to leisure and enjoyment, it is intended to also ensure the possibility of providing urban gardens" (Torres Vedras, Portugal);*
- *"The Regional Territory Management and Planning Plan establish that the municipalities, at a local level, must identify the Municipal Ecological Network, in accordance with the rules of the regional network of protection and environmental enhancement" (Alentejo, Portugal);*

- *"Biodiversity Action Plans are in place at national - city levels. Other planning documents also have nature conservation requirements" (Newcastle, UK)*
- *"To enhance urban biodiversity in various ways";*
- *"To ensure the maintenance of biodiversity in the city" (Helsinki, Finland);*
- *"Green template as a framework for urban development, landscape-inspiration books for project developers to encourage green identity of the city and rural area, compensation of green loss, principle: every house has a garden or a green area in walking distance" (Apeldoorn, Netherlands);*
- *"The city of Malmö (Malmö, Sweden) has a green structure plan. Moreover, it is developing a new green plan, as well as a strategy for urban ecosystem service provision";*
- *"Blue and green network development, nature development" (Brussels, Belgium);*
- *"From several directions the quality of green urban spaces is being addressed. The challenges to be met consist of budgetary restrictions and settings priorities in the political agenda and the willingness of stakeholders (public, private and business) to contribute, financially or otherwise" (The Hague, The Netherlands);*
- *"The metropolitan areas of big cities in Europe is usually much degraded. In this case the policy is environmental restoration and benefit for people from ecosystem services" (Barcelona, Spain);*
- *"Participation of inhabitants, creation of awareness for biodiversity and climate change" (Delft, The Netherlands);*

Some problems were also identified:

- *"Lack of public land to install new parks and lack of support from the European Union for this purpose".*

Concerning specific policies currently applied we asked **to whom the policies are directed to or who is involved.** The results show that 26% is to the municipalities, 24% to the citizens, 16% to companies, 14% to NGO's, 10% of the respondents didn't answer this question, 9% to provinces or regions and only 1% answered other type of target (Figure 3) referring to prospective developers seeking planning consent.

When asked about what kind of **policy instruments are being used to enlarge or improve green urban areas**, 29% of the respondents selected information (e.g. information meeting on the city council for citizens), 28% chose legislation (e.g. local strategy on urban green infrastructure), 19% identified support and training (e.g. information and training sessions of urban gardening), 14% selected subsidies (e.g. payments and incentives to purchase and plant trees or hedges in the garden), 8% said other policy instruments and 2% replied that there is no policy on green urban areas in their city/region (Figure 3).

Related to the previous question a collection of answers was gathered regarding other types of policy instruments that are currently being applied to improve green urban areas, and here are some examples:

- *Municipality's improvement of urban forests;*
- *Development of control policies building on national planning policy guidance;*
- *Beyond the Municipal Master Plan, there is work done in other strategic sectorial themes, like green corridors, riparian corridors, urban reforestation and endogenous plants;*
- *Local governments have possibility to restrict areas from built-up by enact master plans (spatial planning tool) that can exclude land (green area or land designated for green area) from built-up (based on Spatial Planning and Development Act).*
- *In area of subsidies Poznan finances activities (also concerning green areas) proposed in civic budget and also subsidize selected activities proposed in competition for realization of public tasks.*
- *Though there is no recognition as a policy instrument, the City Council of Porto has been recently promoting a cycle of free public sessions with experts in urban green topics.*

With respect to the **main obstructions to enhance or improve green urban areas**, the respondents were asked to give their opinions on seven possible obstacles (Figure 4). The questions on the obstacles were negatively framed which is, in hind cast, perhaps an unfortunate choice because it complicates the interpretation.

In Figure 4 the results are reported separately for researchers and policy makers.

More researchers than policy makers believe that public awareness on the important role of green space is low. Almost two thirds of the policy makers disagrees that there is no public awareness on the role of urban green areas.

A similar result was observed for the question on political interest. Researchers were more pessimistic than policy makers. Half of the researchers think that political interest in urban green areas is low.

On possible knowledge gaps, opinions are divided over the different options and do not differ much between researchers and policy makers.

Both researchers and policy makers agree that urban green space suffers from competing interest, such as development projects. They also largely agree that budgets are insufficient to develop green urban areas.

There is in both groups strong disagreement with the statement that urban green spaces have poor reputation and that physical conditions do not allow development of more urban green space.

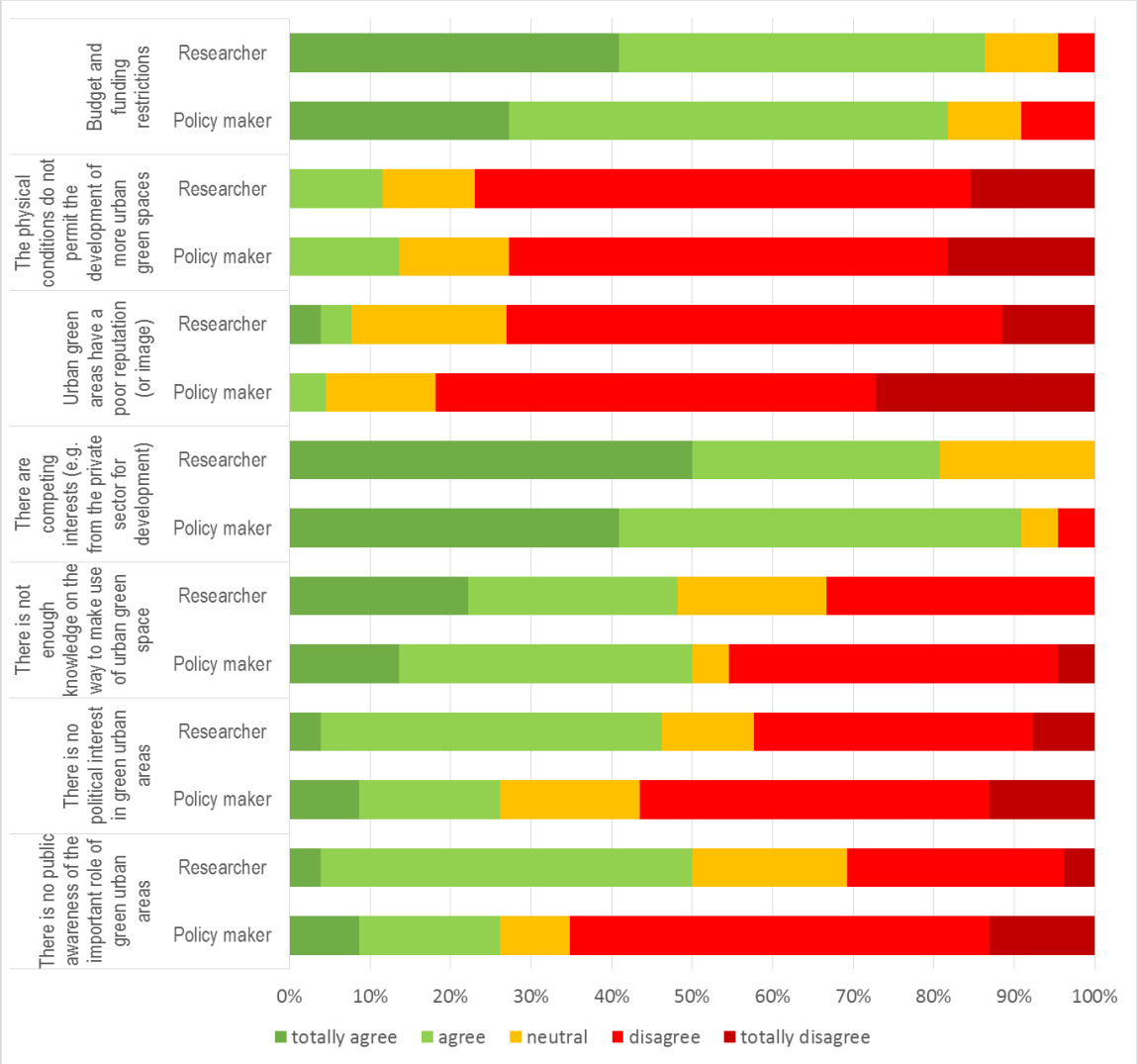


Figure 4. Survey results on the main obstructions to enhance or improve green urban areas.

Additionally, in the question "*If other*" (obstructions to improve green urban areas) other reasons where added by the respondents. Some commented in the free text box in more detail on previously asked questions. For example, financial restrictions are mentioned and some other reasons were given as well, for example:

- Cooperation between stakeholders – "*Cities are multi-stakeholder environments, in which cooperation in urban ecosystem enhancement is needed but difficult to organize"; "Structure of cooperation between local authorities, NGO's and private-public cooperation are not enough developed";*
- Political factors – "*Difference between party's that develop and benefit (e.g. health improvement by green development) private estate owners don't get enough benefits*";

- Understanding on the role of green urban areas – "*Stakeholders having a little understanding of the importance and the role of green urban areas"; "There is not enough knowledge about the social and environmental role of urban green spaces, specifically regarding the importance of using and locating different typologies in order to improve specific aspects like biodiversity and social demand"*;
- Lack of awareness of the benefits of green urban areas – "*Lack of understanding of the benefits / services provided by urban green spaces. Much more knowledge and hard data are needed to convince decision makers*";
- Limitations caused by land ownership – "*Possibilities of activities are limited on private land*";
- Regulation – "*Serious obstacles are financial consequences of planning decisions"; "Limitations in law regulation (and gaps in law) in spatial planning system that allow for built-up development in places that should not be built up (for examples in areas of high ecological value, far away from existing built-up tissue etc.)*".

After giving their opinion on the obstacles to improve green urban areas, the respondents were asked to express their point of view on what they thought what could be helpful to minimize these obstructions ("What would in your opinion be **helpful to reduce these obstructions** or what can be helpful to enhance green urban areas?"). Six main topics were identified as the most common features or tools that can be helpful to reduce obstructions to improve green urban areas.

Geographical planning:

- Good spatial planning policy including a long term vision;
- Changes in spatial planning system could improve current problems;
- Urban plans that clearly define areas for housing and areas for green infrastructure;

Financial complications:

- Increased investment in the care, maintenance and future use and sustainability of urban green spaces by councils and spatial planners;
- Costs of implementation and maintenance of green areas are the most important barriers to a fast implementation;
- The main obstacle to the construction and improvement of supply of green areas are financial constraints;

Cooperation between different sectors:

- The development of strategies resulting from a participatory meetings with policymakers, stakeholders, NGOs and the public;
- Cooperation with other neighbouring Municipalities in other to establish a continuum of green spaces;
- Implement the participation of the public and NGOs in the management of green spaces;

Policy:

- Implementation of urban ecological structure in the process of urban planning and management;
- Specific legislation and stronger regulation;
- Implement a legal framework for a municipal strategy for urban green areas, allocating specific funding to insure the full accomplishment of the main goals;

Scientific knowledge:

- The involvement of expert (foresters, arborists, landscape architects) in urban areas administration;
- More accessible scientific knowledge to be applied in public administration at local level;
- More research on how to manage urban green spaces sympathetically for biodiversity, including an understanding of how to overcome social norms in management;

Citizen participation and public awareness:

- Citizen participation programs for improvement of green areas and campaigns to promote activities in green spaces;
- Improve the awareness of the importance of public green for the quality of life in urban environments and the protection of public health;
- More awareness rising among public and decision-makers.

The last question of the survey, related to **expectations**, allowed us to understand the prospects of the respondents regarding the delivery of the MAES Pilot on Urban Ecosystems. Generally all of the proposals were almost equally accepted, with a slight preference for:

- Scientific information about indicators to map and assess urban ecosystem services and their services (27%),
- Ready to use models to calculate benefits of urban green infrastructure (20%);
- Elements of communication about policies on green urban areas or green infrastructure (19%),
- A list of measures that can be taken to improve green urban areas (16%);
- Success stories (15%);
- Other expectations (3%).

Other thoughts were suggested including guidance on sources of funding and financial encouragement, guidelines for improving and maintaining green urban spaces. The design of an evaluation tool on how to integrate ecosystem services maps into decision-making processes was also suggested. In order to set priorities for action in countries with little development in this field, a comparison of heterogeneity in urban ecosystem assessments across Europe was suggested, as well as a set of common indicators to evaluate and compare different performances and establishing common goals concerning local policies. The creation of a European network to enhance knowledge and communication between cities was also

recommended to facilitate partnerships and mutual support in addressing issues related with urban ecosystems.

3.3 Section III of the survey and literature review: data collection and mapping

The aim of the third section of the survey was to collect information on:

- The features of the urban areas which constitute the urban green infrastructure (i.e.: street trees, green roofs, urban parks, gardens, green belts, rivers, etc.) and the type of information regarding those features;
- Indicators that are currently being used to measure and monitor the condition of the urban ecosystems and biodiversity;
- Indicators that are currently being used to measure ecosystem services.

A complete list of data and indicators is presented in Annex 2.

The third section has been integrated with information collected through the literature review (the list of papers selected is available in Annex 3; the complete list of data and indicators is presented in Annex 4).

A general observation was that the participants of the survey contributed particularly indicators for ecosystem condition and ecosystem services. However, the section where participants could fill in the (spatial) features of urban green infrastructure appeared to be more difficult. Perhaps the information to complete the table was unclear or too technical. Some participants contributed indicators for ecosystem services (e.g. tree carbon) hereby focusing on the functional aspect of urban green infrastructure while we actually wanted to collect information on the structural components of urban green infrastructure.

In any case, it demonstrates the need for clear definitions and for distinguishing between structure and function, which is not always easy for researchers and policy makers.

3.3.1 Urban Green Infrastructure

In the survey participants were asked what features of urban ecosystems are mapped and what kinds of data are used for mapping. This part of the survey did not deliver the wanted information. As explained above, the question allowed perhaps for multiple interpretations. The list of answers in Annex 2 suggests that we probably did not use the correct terminology either. Under features, participants typically included structural components of urban green infrastructure such as street trees, green areas, green roofs and walls, urban gardens and parks. When asked for the data used to map these components, participants typically listed indicators used to assess biodiversity, condition or ecosystem services.

3.3.2 Condition of urban ecosystems and biodiversity

Regarding the condition and biodiversity of urban ecosystems the findings of both the survey and the literature review are reasonably similar, differing only to a certain extent in the detail of the information collected. However, ultimately, both reflect the same knowledge.

From the outcomes of this section it seems that the information gathered from the survey has a higher level of detail and contains more specifics, compared to the literature review results. This is probably due to the level of familiarity of the respondents of the survey within their local administrative areas on the subject and the result of the application of urban planning policies regarding biodiversity and ecosystem state standards.

The indicators collected from both the survey and the literature review were studied and grouped in three sets. For condition the indicators are presented by:

- Drivers and pressures;
- State;
- Biodiversity.

The complete tables with the indicators and units can be found in Annex 4.

From the specific outcomes of the survey, 37% of the total indicators are from biodiversity related indicators, 34% are from ecosystems state and 29% from drivers and pressures (Figure 5). While from the literature review, 50% are indicators of drivers and pressures, 33% of biodiversity indicators and 17% of ecosystems state indicators (Figure 5).

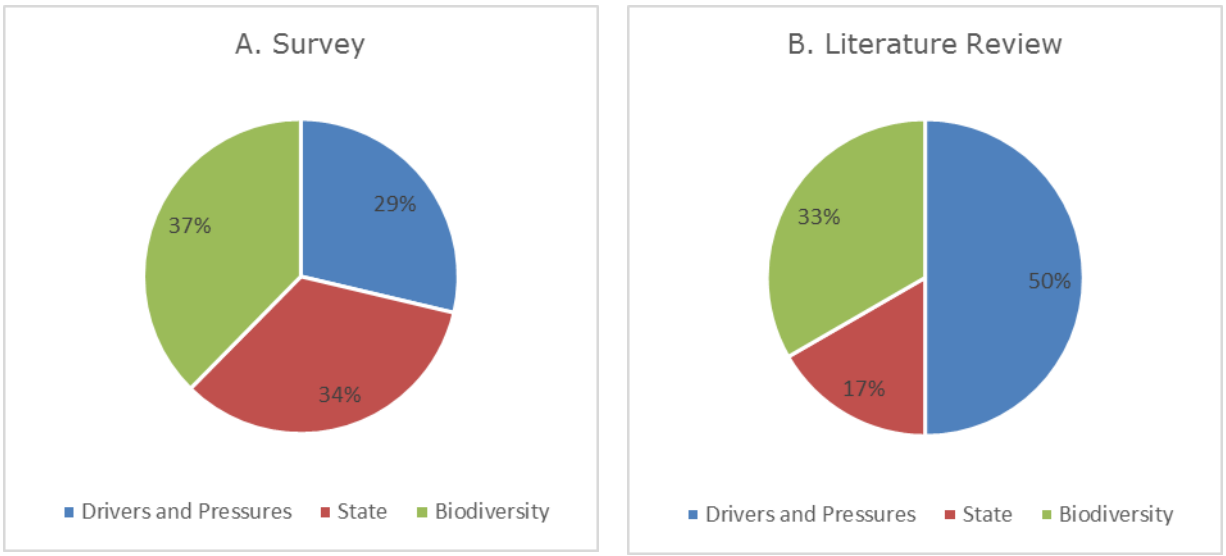


Figure 5: Condition of urban ecosystems and biodiversity indicators obtained from the overall study (literature review and survey).

3.3.3 Ecosystem services

Regarding ecosystem services our results confirm previous comprehensive literature reviews for what concerns the types of ecosystem services considered in urban areas (Carvell et al. 2012; Gómez-Baggethun et al. 2013; Hernandez-Morcillo et al. 2013; Haase et al. 2014; Luederitz et al. 2015). The choice of the service to be assessed is determined by data availability and policy or research objectives. 60% of the reported indicators referred to regulating services. Provisioning and cultural services accounted for 20 % each.

Figure 7 provides more detail on the importance of particular urban ecosystem services as can be derived from their occurrence in both studies.

More than 30 % of the indicators reported for regulating services refer to the micro and regional climate regulation class. The majority of the indicators reported for cultural ecosystem services are related to recreation. This is, indeed, the cultural ES easier to be mapped and quantified (Andersson et al. 2014; La Rosa et al. 2015; Wolff et al. 2015). As for provisioning services, timber is most frequently mentioned. In CICES, timber is classified under fibers and other materials from plants, algae and animals for direct use or processing.

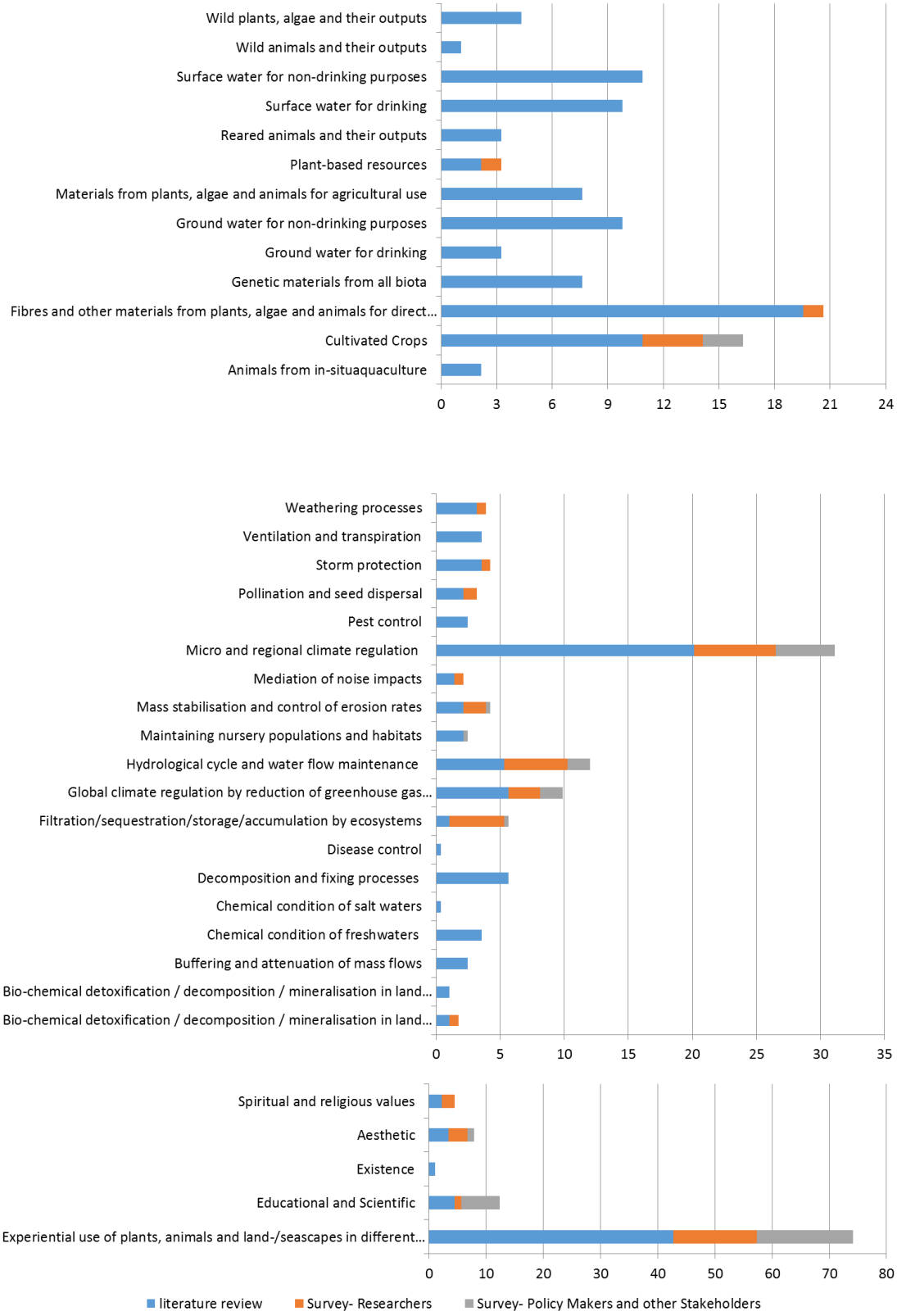


Figure 6. Ecosystem services types (%) reported in the literature review and the online survey using CICES classes as classification.

3.4 The relation between policy and scientific evidence

The survey was not really designed to conclude if and how scientific evidence including maps, data and indicators were used to support policy on urban green infrastructure. Still, we can link sections 2 and 3 of the survey. We simply cross tabulated the presence or absence of a policy (asked for in section 2) with the submission of data and indicators in section 3. We did this exercise using the location of the study site to join both pieces of information since sometimes the survey was completed by different persons.

The frequency analysis is available in Table 2. They can be interpreted as follows: 62% of the locations (including cities and regions) has a dedicated policy on urban green infrastructure and has submitted scientific evidence which can possibly be used to support such policy. 23% of the locations has a policy but did not provide us with additional data which can be used to support the policy. This is perhaps because they did not have the time to complete the survey or because they don't know if such data is available.

In the previous section we reported already that about 15% of the respondents answered that there is no policy in place which is divided in Table 2 over 3% with no data submission and 12% with data submission.

Table 2. Frequency table linking the section on policy with the section on data and indicators based on the replies for 60 locations.

		Submission of scientific evidence (data and indicators on urban green infrastructure, ecosystem condition and urban biodiversity, and urban ecosystem services)	
		No	**Yes**
Is there a policy in place on urban green infrastructure?	**No**	3%	12%
	Yes	23%	62%

Another interpretation of Table 2 is:

- If there is a policy in place, then at least 72% (62% divided by the sum of 23% and 62%) of the locations has data to potentially support it.
- Even without a policy on urban green infrastructure 80% of the locations has data to potentially support such a policy (12% divided by the sum of 3% and 12%).

Our interpretation is that it is very likely that much relevant scientific information is available across Europe which can potentially support policy on green infrastructure. It follows that there

is probably much scope for urban ecosystem assessments in Europe as well as for evidence based policy support on urban green infrastructure. However, it is also possible and likely that data sources and scientific information is scattered and thus not always available where it is needed most (although we cannot base this statement on the survey results).

We also realize that the results are probably biased towards positive couples in the survey (yes, yes) as we may not have reached a sufficient number of respondents who have nothing to report (only 3% of no, no couples).

4 Elements for an EU wide indicator framework for mapping and assessing urban ecosystems and their services

Based on the outcome of the survey and the literature research we list here a number of elements which will be used to construct a framework for mapping and assessment of urban ecosystems and their services which can be used at EU level.

Following the common assessment framework for the ecosystem pilots, also this indicator framework should contain three components: mapping urban green infrastructure, assessing the condition of urban ecosystems based on indicators for pressure, state and biodiversity, and assessing the delivery of ecosystem services using the CICES typology for reporting.

A next step will be to finalize the framework based on these elements and report in the MAES report on urban ecosystems which will be prepared during the course of 2016.

4.1 Mapping urban green infrastructure

Urban green infrastructure (GI) is composed of various types of different features, which may function at different scales and levels delivering ecosystem services, depending on their degree of complexity.

Recently, the GreenSurge project, funded under the 7th framework program for research, has proposed a typology of urban green spaces[1]. This typology may be useful for the purposes of MAES, but also for natural capital accounting which requires a detailed mapping of such green spaces. But there is a need to align it with the MAES typologies on ecosystems and ecosystem. This work still needs to be done during 2016.

Therefore we opted not to present a typology for mapping in this report but prepare one for the MAES working group meetings of 2016.

[1] http://greensurge.eu/working-packages/wp3/files/D3.1_Typology_of_urban_green_spaces_1_.pdf

4.2 Indicators for condition of urban ecosystems and urban biodiversity

At EU level the assessment of urban ecosystem condition is based on the knowledge regarding drivers, which can be direct (overexploitation of natural resources and urban growth and sprawl) or indirect (sustainability policies and geopolitical drivers), as well as pressures such as land use change, pollution and climate change. By combining both drivers and pressures information and their resulting impacts on the function and composition of the urban environment it is possible to successfully assess ecosystems condition.

The proposed list of indicators to assess condition and biodiversity of urban ecosystems aims at delivering a concise and coherent approach to assess condition across EU. Although the presented work seeks to provide a common framework at EU level, differences at national and regional level may occur due to specific drivers and pressures and particular urban planning regulations and limitations.

Table 3 provides indicators to assess condition of urban ecosystems. They have been classified in three categories:

- Urban green areas, linear elements and trees;
- Urban and peri-urban agriculture;
- Urban blue infrastructure.

Table 3. Indicators to assess condition and biodiversity of urban ecosystems. Indicators for condition have different colors codes which indicate if they relate to urban green infrastructure (●) or to urban blue infrastructure (●).

Blue/Green structure	Condition		Biodiversity
	Drivers and pressures	State	
Urban green areas, linear elements and trees	● Land use change ● Land take intensity ● Land use intensity ● Urban sprawl ● Population density ● Road density ● Concentration of Air pollutants (NO_2, PM_{10} and $PM_{2.5}$)	● Proportion of natural areas* ● Proportion of protected natural areas* ● Urban forest pattern indicators : connectivity, morphology, habitat fragmentation ● Trees damage indicators	Presence / Abundance of selected species (country/zone specific) Presence / Abundance of Species of conservation interest (country/zone specific) (see Red List Index for European species)
Urban and peri-urban agriculture[2]	● Soil sealing ● Consumption of pesticides (AEI 17) ● Mineral fertilisers consumption (AEI 5) ● Irrigation (AEI 7) ● Gross nitrogen balance (AEI 15) ● Ammonia emissions (AEI 18) ● GHG emissions (AEI 19)	● Degree of fragmentation ● Isolated patches ● Presence of landscape features ● Proportion of protected areas (i.e. NATURA2000) ● Organic farming (AEI 4)	Presence / Abundance of selected species (country/zone specific) Presence / Abundance of Species of conservation interest (country/zone specific) (see Red List Index for European species)

[2] Examples refer to the Glossary of Agri-environmental indicators (AEI) http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Agri-environmental_indicator_(AEI)

Inland freshwater (rivers and lakes) and marine ecosystems	• Concentration of water pollutants • Modification of river system	• Ecological status (WFD) • Environmental status (MSFD)	Specific indicators to assess the ecological status (WFD Annex V, Table 1.1,)

*from CBI (https://www.cbd.int/doc/meetings/city/subws-2014-01/other/subws-2014-01-singapore-index-manual-en.pdf)

4.3 Indicators for urban ecosystem services

The purpose of this section is to provide a guideline for classification and development of indicators of urban ecosystem services.

Using the literature review and the analysis of the survey we identified the most important and used classes of ES for provisioning, regulating/maintenance and cultural services. They are described in Table 4, Table 5 and Table 6. Alongside the indicators suggested, they are identified as supply or demand type of indicators, and the units of measured and the scale (regional and/or urban level) are also presented.

Information regarding supply and demand is specified for each indicator: ● supply ● demand.

We also specify an *Extent*, that is the boundary to be used for the computation of indicators or models (i.e. Regional refers to the NUTS 3 boundary, Urban refers to the Municipality). The level of details of indicators depends on the data availability.

Table 4: Indicators for provisioning services provided by urban ecosystems

Division	Group	Class	Indicators	Units	Extent
Nutrition	Biomass	Cultivated Crops	● Agriculture production ● Yield	ton/ha/year; euro/ha	Regional
			● Net primary production	ton C/ha; kJ/ha	Regional
			● Total area of cultivable/ agricultural land and orchards	ha	Regional
			● Harvested crops	ton/ha	Regional
			● The ratio of gross output value of agriculture to GDP	%	Regional
	Water	Surface water for drinking	● Drinking water provision	m^3/ha/year	Urban
			● Water consumption by sectors	m^3	Urban
			● Cost for unit volume of water	euro/m^3	Urban

		Ground water for drinking	• Water consumption	m^3	Urban
			• Drinking water extracted	m^3/ha/ year	Regional
Materials	Biomass	Fibers and other materials from plants, algae and animals for direct use or processing	• Amount of large and mature trees per ha of dense forest	ton/ ha	Regional
			• Harvestable amount of wood	m^3/ha/year	Regional
			• Timber in forest plantations	m^3/ha	Regional
			• No. of species of medical value per ha; harvestable amount	number/ha euro/ha (kg or ton) per ha	Regional
			• Market value of timber	euro/ha	Regional
	Water	Surface water for non-drinking purposes	• Cover of natural forest	%	Regional
			• Water retention of forest	% of runoff	Regional
			• Hydropower production	kWh ha/year	Regional
			• Daily rainfall	mm	Regional
			• Storm water runoff rate	mg/L	Regional
			• Presence of water bodies such as no. of springs, ponds and streams; no. of projects using water	m^3/ha/year	Regional
		Ground water for non-drinking purposes	• Change in ground water level	m	Regional
			• Soil water storage capacity	mm	Regional
			• Soil water infiltration capacity	cm/h	Regional
			• Ground water recharge rate	m^3/ ha	Regional
			• Water consumption by sectors	m^3	Urban

Table 5. Indicators for regulating and maintenance services delivered by urban ecosystems

Division	Group	Class	Indicators	Units	Extent
Mediation of waste, toxics and other nuisances	**Mediation by ecosystems**	**Filtration/sequestration/ storage/ accumulation by ecosystems**	• Carbon stored in vegetation and soil	kg/ha /year	Regional
			• Amount of carbon stored in the tree canopies	ton/ha	Regional
			• Pollutants removed by trees and shrubs (PM_{10} and $PM_{2.5}$, SO_2, NO_2, CO, O_3, CO_2)	ton /ha/year	Regional
Mediation of flows	**Liquid flows**	**Hydrological cycle and water flow maintenance**	• Soil water storage capacity	mm	Regional
			• Soil water infiltration capacity	cm/h	Regional
			• Cost for unit volume of water	euro/m^3	Regional
			• Water retention capacity by vegetation and soil	ton/km^2	Regional
			• Intercepted rainfall	m^3/ year	Regional
			• Surface runoff	mm	Regional
			• Daily Rainfall	mm	Regional
Maintenance of physical, chemical, biological conditions	**Atmospheric composition and climate regulation**	**Global climate regulation by reduction of greenhouse gas concentrations**	• CO_2 sequestration	ton/ha/ year	Regional
			• CO_2 tradable emission permit value	euro/ton CO_2	Regional
			• Carbon storage in soil	ton C /ha	Regional
			• Carbon storage in vegetation	kg C/ ha	Regional
			• Global warming potential	kg CO_2/ ha/year	Urban and Regional
			• Annual pollutant absorption rates	kg/ha	Urban and Regional
			• Cooling by vegetation	°C	Regional
			• Reduction of emission of greenhouse gases	%	Urban and Regional
		Micro and regional climate regulation	• Tree shade area (urban temperature regulation)	m^2	Regional
			• Tree cooling potential	ton C/ha	Urban and Regional
			• Evapotranspiration	Mm	Regional
			• Soil carbon stocks (climate regulation)	kg/ m^2	Regional
			• Forest cover (Carbon sequestration)	ton/ ha/ year	Urban and Regional

			• Change in biomass (carbon sequestration)	ton /ha	Regional
			• Amount of Carbon captured by tree cover and tree biomass	ton C/ ha/ year ; ton CO2	Urban and Regional
			• Carbon stored in vegetation and soil	kg/ha /year	Urban and Regional
			• Total area of public green spaces	m^2	Urban and Regional
			• Biomass average growth	m^3/ha	Urban and Regional
			• Wood density of trees	ton/m^3	Regional
			• Coarse and fine vegetated area by average storage rate	Kg C/m^2	Regional
			• Soil area by carbon density	Kg C/m^2	Regional
			• Dry deposition rate	cm/s	Regional
			• Carbon footprint of the town	ton CO_2	Urban
			• Local climate mitigating effect	°C	Urban

Table 6. Indicators for cultural services delivered by urban ecosystems

Division	Group	Class	Indicators	Units	Extent
Physical and intellectual interactions with biota, ecosystems, and land-/seascapes [environmental settings]	**Physical and experiential interactions**	**Experiential use of plants, animals and land-/seascapes in different environmental settings**	• Land suitable for outdoor recreation	%	Urban and Regional
			• Number of recreation sites	number	Urban and Regional
			• Proximity of green infrastructure to green travel routes	km	Urban
			• Recreation potential	dimension-less (between 0 and 1)	Regional
			• Recreation opportunities	qualitative	Regional
			• Surface of parks per inhabitant	ha /inhabitant	Regional
			• Playgrounds for children	m^2	Urban

			• Accessibility[3] to public recreation sites	Inhabitants within 1 km from a public park	Urban and Regional
			• Spatial distribution of runners and bikers	number of bikers or runners/hour /km	Urban
			• Number of visitors per year	number/year	Regional
			• Frequency of visits to parks	number/ year	Urban and Regional
			• Entry fees to parks	euro	Urban and Regional
			• Number of walkers	number/ha /year	Urban
			• Number of excursions and number of visiting researchers	number/year	Urban
			• Density of rural tourism establishments	number/km^2	Urban and Regional

[3] Accessibility measures can be based on: Travel cost (based on travel frictions or impediments. Travel impediments measures can include: Physical or Network distance (also computed by mode of transportation); Travel Time (by mode or by network status – congestion, free-flow, etc.); Service Quality (eg. public transport frequency).
Cumulative opportunity models (Defines catchment areas by drawing one or more travel time contours around a node, and measures the number of opportunities within each contour (inhabitants within 1 km from a park).
Potential accessibility models (Defines catchment areas by measuring travel impediment on a continuous scale).

5 Conclusions and further steps for the MAES urban pilot

Urban policy becomes more important in the EU. The Dutch presidency (The Netherlands presided the Council of the European Union in the first halve of 2016) will present an urban agenda for the EU. Through the EU Urban Agenda, national governments, cities, European institutions and other stakeholders will be working together for a sustainable, innovative and economically powerful Europe that offers a good quality of life. The MAES urban pilot can serve as an excellent example of how such collaboration can be set up.

This report serves as a first technical input to the MAES urban pilot and contains the necessary elements to draft an indicator framework for the mapping and assessment of urban ecosystems and their services. This framework should enable a consistent and harmonized assessment of urban ecosystems at multiple spatial scales.

The survey yielded a number of insights in terms of policy on urban green infrastructure. 66% of the respondents reported a policy on urban green infrastructure at city level; 14% of the respondents said that there is no policy whatsoever which covered urban green infrastructure in their city. These respondents called for dedicated policy at all levels, including the EU level. The presence of a national or regional policy on urban green infrastructure increases the probability that there is a policy at city level to 80%. Besides designing and implementing policy survey respondents expect that in particular bottom-up initiatives from citizens are important to improve green urban infrastructure. Participants who identified themselves as researchers differed with policy-makers and other stakeholders with respect to public awareness and political interest; in that policy makers disagree with the statement that awareness and interest are low. But both types of survey participants agree that the main obstacles to a better implementation of urban green infrastructure are competing interest from the development sector and a lack of financial means.

The survey results suggested that cities and regions have the capacity to support policy on urban green infrastructure with scientific evidence but we could not conclude in how far such information is actually used in the policy process. Still, we argue that there is a substantial scope for urban ecosystem assessments and for evidence based policy support on urban green.

Several elements for an EU wide indicator framework that can be used for mapping and assessing urban ecosystems and their services are now under development. This report could not conclude on a typology of urban green spaces but work is in progress. The report contains a set of indicators which can be used to assess urban ecosystem condition and urban ecosystem services. Herby we observed that indicators for condition and biodiversity are less specific than indicators for ecosystem services. There is thus a further need to deliver condition indicators which can effectively be monitored.

These proposals need now to be discussed within the MAES urban pilot and with the members of the MAES working group. The ambition is to present a final indicator framework for mapping

and assessment of urban ecosystems and their services in a new MAES report which should be published in the course of 2016.

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Annex 1. Structure and contents of the online-survey

This part of the survey is about your role and asks for details about the location of the city, region or country for which you can provide information

	Question	Structure	answers	dependencies	mandatory
2.1	**Who are you?**	Single choice	1. A policy maker 2. A researcher 3. Other type of stakeholder	YES	YES
1. if a policy maker or 3. If other type of stakeholder					
2.2	If other type stakeholder	Open question		NO	NO
2.3	If you work as policy maker or in a position related to the implementation of policy, describe your role?	Single choice	- city administration - management of urban parks - head of unit of the green department - design of green urban areas - other		
2.4	If other define your role	Open question	//		
2.5	How long have you been engaged in this sector or how long are you working in your current position?	Single choice	- Less than one year - Between one and five years - More than five years		
2.6	If other type of stake holder define your role	Open question	//		
2.7	What is the location for which you will provide information?	Open question	//		
2.8	If a brochure, a document, a publication or promotional material is already available on your green urban areas, you can upload it here.	upload	//		
2. if a researcher					
2.9	If you intend to base this survey on a case study, what is the name of the location? and what were its main objectives?	Open question	//	YES	NO
2.10	If your case study is published, please cite your study or eventually provide a link to an online document.	upload	//	NO	NO
2.11	If you want to share your published work on urban green areas (publication, report, power point), you can	upload	//	NO	NO

	upload it here.				

Structure of section 2: Policy-related questions. "The questions of this part relate to the policy on urban ecosystems of the city, region or country where you are active (as stakeholders or researcher). They are best completed by someone working in a policy department or with the city administration. If it is more convenient to address these questions on a separate document, then use the upload option."

	Question	Structure	answers	dependencies	mandatory
3.1	As an alternative to this questionnaire, you can also upload a text file which addresses the questions on Part 2.	upload	//	NO	NO
3.2	Is there a specific policy to enhance or improve green urban areas in the territory for which you work?	Multiple choice	1. Yes, there is such a policy at national level 2. Yes, there is such a policy at regional level 3. Yes, there is such a policy at city level 4. Yes, there is such a policy beyond the municipality delineation in cooperation with other municipalities 5. No	YES	NO
5. If no					
3.3	If there is no specific policy, on which policy level would support on implementation, enhancement of improvement of green urban areas need to be given?	Multiple choice	- European level - National level - Regional level - Metropolitan level - Local level - On all of these levels - Others	YES	NO
3.4	**If others provide an example**	Open question	//	NO	NO
3.5	**In your opinion are there other developments that help enhance or improve green urban areas in the area where you work?**	Multiple choice	- Bottom-up initiatives from citizens (e.g. greening the neighborhood, maintaining common gardens) - Private sector initiatives (e.g. shops and business that green their surroundings such as parking lots or business parks) - New cooperation between private sector and NGO's (e.g. a nature conservation organization with a company create together an urban green space) - Other initiatives	YES	NO
3.6	**If other initiatives provide an example**	Open question	//	NO	NO
3.7	If there is a specific policy in place, what is the aim of this policy or what type of	Open question	//	NO	NO

	problem is to be addressed by this policy?				
3.8	If there is a specific policy in place, indicate here to whom this policy is directed or who is involved? (multiple choice)	Multiple choice	- Citizens - Companies - NGO's - Municipalities - Provinces or regions - Other	YES	NO
3.9	**If other provide an example**	Open question	//	NO	NO
3.10	What type of policy instruments are being used to enlarge or improve green urban areas?	Multiple choice	- Legislation (e.g. a local strategy on urban green infrastructure) - Information (e.g. information meetings of the city council for citizens) - Subsidies (e.g. payments and incentives to purchase and plant trees or hedges in the garden) - Support and training (e.g. information and training sessions of urban gardening) - None (there is no policy on green urban areas) - Other	NO	NO
3.11	**If other provide an example**	Open question	//	NO	NO
3.12	What are in your opinion the main obstructions to enhance or improve green urban areas? Please indicate if you agree or not agree with the proposed obstructions	Multiple choice (Likert scale)	See Structure of question 3.12	No	No
3.13	**If other provide an example**	Open question	//	NO	NO
3.14	What would in your opinion be helpful to reduce these obstructions or what can be helpful to enhance green urban areas?	Open question	//	NO	NO

Structure of question 3.12

	Totally agree	Agree	Neutral	Disagree	Totally disagree
There is no public awareness of the important role of green urban areas					
There is no political interest in green urban areas					
There is not enough knowledge on the way to make use of urban green space					
There are competing interests (e.g. from the private sector for housing development)					
Urban green areas have a poor reputation (or image)					
The physical conditions do not permit the development of more urban green spaces					
Budget and funding restrictions					
other					

Structure of section 3: "Mapping urban ecosystems"

	Question	Structure	Information asked	dependencies	mandatory
4.1	In this section, we are trying to find out what are the features of your urban area that you collect data on (like street trees, green roofs, urban parks, gardens, green belts, rivers), and what type of data you collect in relation to these. We would also like to know if you represent this data in maps or not. If you are collecting specific data, please provide a list. A maximum of ten entries is foreseen. You can also provide us with an excel table using the upload function at the bottom of the page.	Table multiple	See: Types of information asked regarding the mapping session	NO	NO
4.2	As an alternative you can also upload a file (*.xls or other formats) with the different entries.	Upload	//	NO	NO
4.3	**Assessing the condition of the natural state of urban ecosystems.** In this section, we are trying to find out what indicators you use to measure and monitor the state of your urban ecosystem. Such indicators could relate to biodiversity, such as numbers of different of birds or plants, it could related to alien species, or pollution of groundwater, or more detailed indicators related to your ecosystem, such as the conditions of soil. Examples: - indicators that measure urban biodiversity such as species richness of urban bird or plant communities - indicators that measure pressures on urban ecosystems such as alien species occurrences, groundwater contamination or pesticide use - indicators that assess the state of urban ecosystems such as fragmentation, soil compactness or foliage damage. A maximum of ten entries is foreseen. You can also provide us	Table multiple	See: Types of information asked regarding the mapping session	NO	NO

	with an excel table using the upload function at the bottom of the page.				
4.4	As an alternative you can also upload a file (*.xls or other formats) with the different entries.	Upload	//	NO	NO
4.5	**Assessing the ecosystem services delivered by urban ecosystems** MAES uses the CICES classification system as typology for ecosystem services but we accept other classifications as well. Link to CICES: http://biodiversity.europa.eu/maes/common-international-classification-of-ecosystem-services-cices-classification-version-4.3 Important ecosystem services in urban areas are: - air quality regulation - local climate regulation - recreation - water regulation A maximum of ten entries is foreseen. You can also provide us with an excel table using the upload function at the bottom of the page.	Table multiple	See Types of information asked regarding the mapping session	NO	NO
4.6	As an alternative you can also upload a file (*.xls or other formats) with the different entries.	Upload	//	NO	NO

Types of information asked regarding the mapping session

question	Information asked
4.1	Feature
	Type of data
	Are you collecting spatial data?
4.3	indicator
	units
	Is you output a map
	notes
4.5	Ecosystem service
	indicator
	units
	Is you output a map
	notes

Annex 2. Survey and literature data on ecosystems and ecosystems services collected and mapped

Table 7. Information collected from the respondents to the survey on green infrastructure.

Feature	Type of data
Street trees and tree coppice	Morphological characteristics (stem perimeter, trunk size, height, type of tree well, sex); pollination strategy; species and their variety; location; state of health of trees; type of management; condition; geographic data; map of maintenance; tree diversity Index (Hulbert's Index); life form and phase; planting day; area projected to the soil by the tree coppice
Wetland	Biodiversity inventory
Green areas	Species; pollination strategy; sex; morphological characteristics; area and type of green space (peri-urban park, central park, urban park, neighborhood park); national area of protected areas and areas classified under international commitments
Urban gardens, Parks and other amenity grassland	Number; surface area; type of management; flowering plants, pollinators and birds; plant species diversity survey and their characteristics (also birds, amphibians, butterflies); imperviousness change; link to hydrology; extension and type of species; furnishing elements; number of nest boxes; presence of invasive species; type of management; tree stem perimeter; tree height; size and frequency of maintenance; location; opening date; structural diversity
Urban forests and Urban nature reserves	Dendrometric data; remote sensing; users perception; flowering plants and pollinators
Green belts	Land uses; surface and protected surface; recreation and aesthetic services; biodiversity; carbon storage service; water flow regulation; location
Green roofs and Walls	All physical processes involved; plant species diversity; performance of species and link to remotely sensed data
Water bodies	Water quality (pH, conductivity, organic matter, nutrients, fecal indicators); volume; uses in the flood plains
Traffic islands and Road verges	Surface and type of vegetation (grass, shrub, flowers...); flowering plants and pollinators
Cemeteries	Flowering plants and pollinators
Beach social use	Relative density from high resolution satellite image
Spatial distribution of bikers and walkers	From social networks and on site stratified counts
Relative density of ES demand	Mapping population density from different types of urbanization
Dune response to storms	Fieldwork
Brownfields	Soil; vegetation; pollinators
Open space	Land use and designations; mean nearest neighborhood distance between green infrastructure patches (m); permeable area (%); green infrastructure edge contrast (%)

Recreation areas	Location; area; type of fitness equipment; extension difficulty level of walking routes; roads, footpaths, hiking trains and bike paths and their length; type of management; biotic/abiotic/built features of public parks; type of play tools and condition of maintenance; dimension of facilities
Exotic invasive plant species	Area, plant species
Birds	Species and their diversity, conservation interest, abundance
Species	Location, protection, abundance
Habitats	Location, extent, condition
Autochthonous plant species	Number and species
Non invasive exotic plant species	Number, species and cultural value
Socio-economic strata	Socio-economic division of the city
Tree carbon	Estimated C content of urban trees
Estimated tree decontamination potential	Estimated tree decontamination potential
Climate sensitive locations and heat stress areas	Like schools, nursery

Table 8: Indicators collected from the respondents to the survey for the assessment of condition of the natural state of urban ecosystems

Condition		**Biodiversity**
Drivers and Pressures	**State**	
Habitat fragmentation	Ecological efficiency	Species richness (N° of Species/surface)
Soil contaminated (Surface (ha))	Tree health and stability status	Tree diversity Index
Pesticide use (Type and location)	Protected areas (ha)	Trees species composition and density (number of trees/administrative unit)
Groundwater contamination (spots and quality)	Topography (distance from sea level)	Aerial connectivity trough coppice (ha)
Pollen emissions (N[a] pollen grains/crown surface)	Extent of different types of green infrastructure (ha)	Plant species richness (number)
Atmospheric contamination	Condition of Local Wildlife Sites	Plant abundance (number)
Air pollution (μg/m[3])	Soil pH (number)	Tree species (Shannon/richness)
Carbon (C ton/ha)	Air quality	Vascular plants (Shannon/richness)

Absorption pollutants (%)	Soil contamination and former landfills	Number of trees in public space (trees for inhabitant)
Flooding (mm)	Service area of green spaces (distance of residential areas)	Number of animal and plant species (number)
Noise Contamination (dB)	Green typology (% cover)	Population size
Nutrient reduction in storm water (%)	Total Public Green Urban Areas (m^2)	Pollinator abundance (number)
Groundwater contamination	Total of Urban Vegetable Gardens (m^2)	Bird abundance (number; Shannon/richness)
Heat reduction (degrees Celsius)	Total of Green Areas (m^2)	Bird species richness (number)
Susceptibility to desertification	Share of green infrastructure (%)	Mammals species (number)
Heat island effect	Km of accessible green corridors (km)	Reptiles species (number)
Urbanization rate (% per year)	Historical park (area)	Amphibian's species (number)
Education rate (% primary education)	Availability of public spaces and services (% of inhabitants within 300 m from green spaces)	Butterflies species (number)
Political instability	Spatial Ecological value	Benthonic macroinvertebrates (number)
Economic pressure (GDP capita−1 day−1)		Insects (mainly ants) (number)
Sea level rise (% flooded)	Surface water quality (Water Quality Index)	Sparrow and swift breeding locations (number)
Urban drainage flood (% flooded)	Biodiversity quality	Monitoring red list species (threats)
River peak discharges (% flooded)	Quality of the beaches	Alien species occurrences (number)
Land subsidence	Regional ecological function	Occurrence of endangered species (number)
Freshwater scarcity (% use of renewable resource)	Conservation of priority wild species	Wild plants and birds (number of species)
Groundwater scarcity (% use of renewable resource)	Conservation of natural habitats	Species composition alleys (number)
Salinization and seawater intrusion	Evolution of forest cover with native species	Pollinator species richness (number)
Flood attenuation (%)	Conservation of nature and biodiversity - Integrated area in protected areas of regional, inter-municipal or city	Various plant-pollinator network metrics (number)
Peak flow reduction (%)	Water quality in bathing areas - Proportion of bathing areas with quality acceptable or good water face full of bathing areas	Presence of domestic predators (on camera traps - nº images/hour)
	Storm water retention	Pathogens reduction (%)
	Retention capacity (m^3)	Biocenters (number/ area)
		Biocorridor (m)

Table 9: Indicators for urban ecosystem services: provisioning.

Provisioning Services			
Division	**Group**	**Class**	**Indicator**
Nutrition	Biomass	Cultivated Crops	Fruit trees and potential production (kg/ha)
			Vegetables and fruits produced (kg/€ market value)
			Agricultural land and orchards (ha)
			Sum of agricultural areas (ha)
Materials	Biomass	Fibers and other materials from plants, algae and animals for direct use or processing	Merchantable volume of timber (m^3/ha)
			Timber production (ha)
Energy	Biomass-based energy sources	Plant-based resources	Biofuels production (ha)

Table 10: Indicators for urban ecosystem services: regulating/maintenance.

Regulating/ Maintenance Services			
Division	**Group**	**Class**	**Indicator**
Mediation of waste, toxics and other nuisances	Mediation by biota	Bio-chemical detoxification / decomposition / mineralization in land / soil, freshwater and marine systems including sediments; decomposition / detoxification of waste and toxic materials e.g. waste water cleaning, degrading oil spills by marine bacteria, (phyto)degradation, (rhizo)degradation	Soil carbon content (%)
			Soil carbon density and presence of trees (ha)
	Mediation by ecosystems	Filtration/sequestration/storage/accumulation by ecosystems	Pollutant removal from soil/water by vegetation (ha)
			PM10 and PM2.5 removed by trees and shrubs (ton; Kg/ha)
			SO2 removed by trees and shrubs (ton; Kg/ha)
			NO2 removed by trees and shrubs (ton; Kg/ha)
			CO removed by trees and shrubs (ton; kg/ha)
			O3 removed by trees and shrubs (ton; kg/ha)
			CO2 capture and sequestration by vegetation (ton CO2)
		Mediation of noise impacts	Noise reduction by vegetation (dB)
Mediation of flows	Mass flows	Mass stabilization and control of erosion rates	Control of erosion rates (km of sand dunes)
			Presence of green infrastructure on surfaces prone to erosion (ha)
	Liquid flows	Hydrological cycle and water flow maintenance	Fraction of the annual water flow stored in the soil (%)
			Retention capacity (m3)
			Level of highest wave run-up (geocoded points and wash over evidence)
			Flooding frequency

			Water storage capacity (m3)
			Runoff mitigation (% or mm)
			Unsealed area (%)
			Water infiltration/interception/etc.
			Soil type
			Slope relief (degrees)
			Rainfall (mm)
			Area controlled by retention / infiltration basins (ha)
			Soil porosity (ha)
			Nº of residents in flood areas
			Soil permeability for flood regulation (ha)
	Gaseous / air flows	Storm protection	Wind shelter
			Proximity of suitable green infrastructure to the coast (ha)
		Ventilation and transpiration	Density of trees (Number of trees/ha)
Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Pollination and seed dispersal	Pollen emissions (pollen grains/m3 air/hour)
			Pollinator abundance and richness (number)
		Maintaining nursery populations and habitats	Maintaining nursery populations and habitats (ha)
	Pest and disease control	Pest control	Threatened species and biodiversity conservation
	Soil formation and composition	Weathering processes	Amount of C sequestered in tree biomass and soil (ton sequestered)
	Water conditions	Chemical condition of freshwaters	Water quality: conductivity (µS/cm at 20ºC)
			Water quality: pH (pH scale)
			Water quality: turbidity (NTU)
			Water quality: field temperature (ºC)
			Water quality: coliform bacteria, Escherichia coli, enterococcus and Clostridium perfringens (NMP/100 mL and/or UFC/100 mL)
			Water quality: Salmonella spp. (Presence / Absence)
	Atmospheric composition and climate regulation	Global climate regulation by reduction of greenhouse gas concentrations	C stored in living trees (ton C)
			Carbon stored in living trees and soil (ton C/ha)
			Heat reduction (°C)
			Urban heat effect reduction by evapotranspiration
			Cooling by shadow (% or °C)
			Heat locations (°C)
			Reduction of emission of greenhouse gases (%)

		Micro and regional climate regulation	Local climate regulation (surface of green and blue areas per total surface (%))
			Tree shade area (m2)
			Pollutants removed by trees (t/ha)
			Local climate mitigating effect (°C)
			Number of trees and amount of vegetated areas (ha)
			Wind conditions (prevailing wind)
			Total area of public green spaces (m2)
			Coppice area (ha)
			Avoided runoff by trees (m3/year; m3/ha/year)
			Tree cooling
			Carbon footprint of the town (ton CO2)
			Estimated tree decontamination potential
			C stored/tree (ha)
			Proximity of trees to main roads - trapping air pollutants
			Density of trees (trees/ha)
			Surface of green areas (%)
			Surface of water bodies (%)

Table 11: Indicators for urban ecosystem services: cultural

Cultural Services			
Division	**Group**	**Class**	**Indicator**
Physical and intellectual interactions with biota, ecosystems, and land-/seascapes	Physical and experiential interactions	Experiential use of plants, animals and land-/seascapes in different environmental settings	Visitors rate (number of visitors per year)
			Spatial distribution of runners and bikers (n° bikers or runners/hour or per km)
			Surface of parks/inhabitants (ha/inhabitant)
			Wildlife experience (number and type of species)
			Green areas (m2)
			Playgrounds for children (m^2)
			Sports areas (m^2)
			Access to greens pace (distance in m)
			Public and private green space (ha)
			Protected areas (km^2)
			Demand for green spaces (users/visitor per year)
			Distance to nearest green with different characteristics (seconds or meters to travel)
			Accessibility of public and private sites (ha)
			Proximity of green infrastructure to green travel routes (ha)
			Recreation potential and opportunity (1-5 scale)
			Recreation opportunity
	Intellectual and representational interactions	Educational and Scientific	Environmental education - number of infrastructures (Number/ inhabitant)
			Number of environmental education activities in parks (Number/ inhabitant)
			Participation in green actions (Number)
			Impact of green on housing values (% value increase)
			Proximity to educational establishments (ha)
		Aesthetic	Aesthetic quality (1-5 scale)
			Flowering plant abundance and richness (Number)
			Opportunity to hear more natural sound - Distance from roads (ha)
			Compliance with desired landscape character (ha)
Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes	Spiritual and/or emblematic	Spiritual and religious values	Heritage designations (ha)
			Cultural value of sites (ha)

Annex 3. List of articles used in the literature study

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Annex 4. List of indicators collected from literature review

Table 12: List of indicators for urban green infrastructure

Green infrastructure feature or element	**Indicator**
Street and park trees	Area (m^2)
	Mean tree density (trees m^2)
	Number of trees (number)
	Carbon stored in trees (kg)
	Size of trees
	Average costs of street trees
	Proportionate of tree cover
	Relation between number of street trees and population
	Tree species
Herbaceous Vegetation and Shrub	Area (m^2)
	Mean tree density (trees $m^{2)}$
Parks, public gardens and urban forests	Green Urban area(m^2 $inhab^{-1}$)
	Total area (km^2)
	Population density ($inhabit.km^{-2}$)
	Minimum park area (m^2/inhabitant)
	Accessibility (m (local level); km (district and city level))
	Vegetation surfaces (%)
	Tree cover (ha)
Playgrounds and sport facilities	min. area/ 1000 inhabitants (ha per inhabitant)
	Accessibility (m)
	Vegetation surfaces (%)
	Index of impermeableness (%)
	Total area an type of biota (fauna and flora)
Cemeteries	Area
Residential, commercial or industrial landscape	Area/ land cover (km^2)
Agricultural fields, pastures, forests, wetlands	Total area (ha)
Water bodies	Total area (km^2)
	Water environment
	Type of biota (fauna and flora)
Natural areas and reserves	Total area an type of biota (fauna and flora)
Broad-leaved, coniferous and mixed forest	Area/ land cover (km^2)
Landownership parcels	Total area (km^2)
	Buffer distance from wetlands and creeks
	Vulnerability to storms and floods
Developed open space	Total area
Artificial woodland : Settlement woodland; Traffic woodland; Garden woodland; community parks	Area (ha)
Artificial lawn: Traffic lawn; Garden lawn; community parks	Area (ha)
Vacant lots	Area (ha)
	Number of lots (Total population)

Table 13: Indicators used in the studies to assess condition and biodiversity

Condition			Biodiversity
Drivers and Pressures		State	
Direct Drivers	Land use change	Air quality	Species abundance
	Overexploitation of natural resources	Biodiversity state and quality	Number and diversity of species (Shannon Diversity Index)
	Pollutants emissions	Water quality	Species richness
	Urban growth and sprawl	Habitats conservation status	Local rarity of a specific species
	Industrialization	Ecological and environmental status	Species of conservation interest
	Suburbanization development	Conservation of natural habitats	Number of threatened species
Indirect Drivers	Economics	Soil condition	Mean percentage of threatened sites for each species
	Geopolitical	Protection of endangered species	Spatial distribution and status of group species
	Social issues		Control and managing of the pest species
	Sustainability policies		Competition processes (Predator-prey; Parasite-transmitter-host; Pollinator and plant)
	Demography		Proportion cover of green space
	Science and technology		Diversity of ecosystem types
	Culture and religion		Habitat diversity and organisms
Pressures	Habitat changes: Land use changes		Total biomass
	Habitat changes: Change of species		Presence of endangered species
	Climate change: Extreme events		Monitoring of invasive species
	Invasive alien species		
	Over-exploitation		
	Atmospheric pollution		
	Nutrient enrichment		
	Water pollution		
	Habitats fragmentation		
	Soil contamination		
	Noise contamination		

Table 14: List of indicators of Provisioning ecosystem services used in the studies

Section	Division	Group	Class	Frequency (times mentioned)	Indicators	Units (// = not reported)
Provisioning	Nutrition	Biomass	Cultivated Crops	10	Agriculture production	ton/ha/year; ton/ha; kg/produce
					Harvested crop	ton/ha ; kJ/ha
					Net primary production	Ton C/ha ; kJ/ha
					Yield	€/ha
					Cultivable land;	ha
					Amount of food materials	ton/ha
					Standing crop(at the time of harvest)	kg/ha/year
					Total food crops output	ton
					The ratio of gross output value of agriculture to GDP	%
			Reared animals and their outputs	3	Milk production	m^3/ha
					Density of head of cattle	N/100 ha
					The amount of beef, mutton and pork	Million ton/km^2
			Wild plants, algae and their outputs	4	Authorized area for mushroom harvesting	//
					Amount of harvested mushrooms and berries	kg
					Tea yield	ton/km^2
			Wild animals and their outputs	1	Consumable meat (wild boar and European roe deer)	kg/km^2/year
			Animals from *in-situ* aquaculture	2	Total annual production in aquiculture	ton/year
					Aquaculture and fishing products	Million \$/km^2
		Water	Surface water for drinking	9	Cost for unit volume of water	euro/m^3
					Drinking water provision	m^3/ha/year
					Surface water harvesting for human use	//
					Surface water harvesting for agriculture	//
					Water consumption	m^3
					Yield of annual water	Billion ton/km^2
			Ground water for drinking	3	Water consumption	m^3

					Drinking water extracted	m^3/ha/year
	Materials	Biomass	Fibers and other materials from plants, algae and animals for direct use or processing	18	Harvestable amount of wood	m^3/ha/year
					Harvest/Yield (wood and timber)	m^3/ha
					Timber in forest plantations	m^3/ha
					Volume of harvest (timber)	m^3
					Number of large and mature trees per ha of dense forest	Ton/ha
					Market value of timber	$/ha
					Number of species of medical value per ha/harvestable amount (kg or ton) per ha	Number/ha; ton/ha
			Materials from plants, algae and animals for agricultural use	7	Fodder plant harvest	ton/ha; kJ/ha
					Net primary production	ton C/ha; kJ/ha
					Yield	€/ha
					Area used for harvesting fodder	ha
					Number of fodder producing species per ha and hectares of grassland	Ton/ha
					Standing grass (consumed by animals)	t dm/ha/yr
			Genetic materials from all biota	7	Number of vascular plant species	Number
					Pest insect predation	%
					Bird species richness	//
					Plant species richness	//
					Species conservation value	//
					Total bird density	birds/ha
					Number of species of medical value per ha/harvestable amount (kg or ton) per ha	no./ha; ton/ ha
		Water	Surface water for non-drinking purposes	10	Runoff = renewable water supply	mm
					Cover of riparian forest in river margins	% in 25 m buffer
					Cover of natural forest	% of municipality's surface
					Water retention of forest	% of runoff
					Hydropower production	kWh/ ha/year
					Daily Rainfall	mm
					Storm water runoff rate	mg/L
					Presence of water bodies such as no. of springs, ponds and streams; no. of projects using water	ML/ha/year
			Ground water for non-drinking purposes	9	Aquifer recharge	Hm-3 year

					N-export with seepage water	kg N /ha
					Change in ground water level	m
					Soil water storage capacity	mm
					Soil water infiltration capacity	cm/h
					Groundwater harvesting for agriculture	//
					Water harvesting for industry use	//
					Ground water recharge rate	m^3/ha
	Energy	Biomass-based energy sources	Plant-based resources	2	Amount of wood fuel for bioenergy	m^3
					Amount of firewood for heating private houses	m^3

Table 15: List of indicators of regulating ecosystem services used in the studies

Section	Division	Group	Class	Frequency (# times mentioned)	Indictors	Units (// = not reported)
Regulation & Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Bio-chemical detoxification / decomposition / mineralization in land / soil, freshwater and marine systems including sediments; decomposition / detoxification of waste and toxic materials e.g. waste water cleaning, degrading oil spills by marine bacteria, (phyto)degradation, (rhizo)degradation etc.	3	Organic C in soil (Maintenance of soil fertility)	ton C/ha
					Water purification by cover of riparian forest in river margins	%
					Total quantities of pollutants removed by green space (water purification)	ton/ year
		Mediation by ecosystems	Filtration/sequestration/storage/accumulation by ecosystems	3	Carbon stored in vegetation and soil	kg/ha/year
					Amount of carbon stored in the tree canopies	ton/ha
					Amount of carbon sequestered by tree biomass	tonCO_2
			Mediation of noise impacts	4	Leaf area and distance to roads (noise reduction)	//
					Type of foliage (noise reduction)	//
					Percentage of tree cover (noise buffering)	%
					Absence of noise and Physical attempts to buffer noise	//
	Mediation of flows	Mass flows	Mass stabilization and control of erosion rates	6	Soil loss (control of erosion)	Ton/ha/ year
					Net savings in soil loss per ha	Ton/a/

						year
					Forest areas protecting against natural hazards	ha
					Erosion control	Mg/ha/ year
					Soil bearing capacity	
			Buffering and attenuation of mass flows	7	Tree structure (storm protection)	//
					Net savings in soil loss per ha (soil protection)	Ton/ha/ year
					Capacity of the vegetation cover to retain soil	ton/km^2
					Value of storm protection for estuarine marshes	//
					Erosion difference between forest land and non-forest land	ha
					Forest area	ha
					Soil density	g/cm^3
		Liquid flows	Hydrological cycle and water flow maintenance	15	Aquifer recharge	H/m^3/ year
					Soil water storage capacity	mm
					Soil water infiltration capacity	cm/h
					Water retention of forest	% of runoff
					Cost for unit volume of water	euro/m^3
					Forest area	ha
					The water retention capability of the litter layer and soil	Million ton/km^2
					Intercepted rainfall	m^3/ year
					Surface runoff	mm
					Daily Rainfall	mm
		Gaseous / air flows	Storm protection	10	Forest areas protecting against natural hazards	ha
					Tree structure	//
					Capacity of the vegetation cover to retain soil	ton/km^2
					Estimate of the cost of damages avoided from natural assets	$
					Estimate of the costs associated with additional preventative management measures	$

					Number of landslides and other natural hazard cases per year	Number / year
					Net savings in soil loss per ha	Ton/ha/ year
					Frequency of storms	
			Ventilation and transpiration	10	CO2 sequestration by trees	Ton/ year
					Forest area	ha
					Filtering dust particles (PM_{10} removal)	//
					Above ground biomass volume	m^3/ha/ year
					Trees pollution absorption capacity	//
					Annual absorption rates	Kg/h
					Dry deposition rate	cm/s
					Total leaf area (TLA)	TLA/ ha
					PM10 capture by vegetation	Mg/m^2
	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Pollination and seed dispersal	6	Nesting and food space for bees	
					Extent/abundance of flowering plants	
					Apollo butterfly, oil beetle as indicators	
					Amount of food (crop pollination)	Ton/ha
					Number of pollinators	Number / ha
			Maintaining nursery populations and habitats	6	Number of vascular plant species	Number
					Special protection area	% of municip ality's surface
					Habitat of community interest	% of municip ality's surface
					Threat density	km
					Fragmentation	km
					Connectivity	ha
		Pest and disease control	Pest control	7	Threatened species conservation	BCI

					Pest insect predation	%
					Special protection area	% of municipality's surface
					Threat density	km
					Habitat-conservation value	Score
					Species conservation value	Score
					Number of new plants and wild animals	Number / ha
			Disease control	1	Number of people affected by water and air borne diseases	Incidents/ year
		Soil formation and composition	Weathering processes	9	Organic C in soil	Ton C/ha
					Erosion difference between forest land and non-forest land	ha
					Forest area	ha
					Soil density	g/cm^3
					Soil carbon stock	kgC/ha
					Soil nutrients	
					Capacity of the vegetation cover to retain soil	ton/km^2
					Above ground biomass	ton/ha/year
					Forest area	ha
			Decomposition and fixing processes	16	Total above ground biomass	Ton/year
					N assimilation: percent N assimilation	%
					Nitrogen loading level	kg/ha/year
					Phosphorous loading levels	kg/ha/year
					Cycling path density	m/ha
					N and P - sequestration soil	kg/year
					N and P -sequestration forest biomass	kg/year
					Denitrification	kg/year
					Forest area	ha
					Soil density	g/cm^3
					Net primary production	g/m^2

					Dry mass of standing and downed dead trees	
					Above ground biomass	ton/ha/year
					Above ground biomass volume	m^3/ha/ year
					Wood density (carbon fixation)	t-dm/m^3
					Total carbon fixed	Ton/ year
					N assimilation: percent N assimilation	%
		Water conditions	Chemical condition of freshwaters	10	Cover of riparian forest in river margins	% in 25 m buffer
					Cover of natural forest	% of municipality's surface
					Cost for unit volume of water	euro/m^3
					Forest area	ha
					N and P retention (water purification)	Kg/ha/ year
					Nutrient leaching	kg NO_3/ ha/ year
					Intercepted rainfall	m^3/ year
					Removal pollutants by per unit area	Kg/ha
					Electrical conductivity; dissolved oxygen; pH and discharge flow	K25; DO;pH; Q_3/m^3/s
					Quality and quantity of purified water	m^3/ha
			Chemical condition of salt waters	1	Number of species for water purification	Number
		Atmospheric composition and climate regulation	Global climate regulation by reduction of greenhouse gas concentrations	16	CO_2 sequestration	Ton/ha/ year
					Carbon storage	Ton/ha
					Storage of C in vegetation	Kg C/ha
					Above-ground carbon storage	Mg C/ha
					PM_{10} capture by forests	kg PM_{10}
					Social cost of carbon (SCC)	kg C

					Global Warming Potential	kg CO_2/.ha/ year
					Carbon sequestration of forest and green space	kg C/km^2
					Annual pollutant absorption rates	Kg/h
					Cooling by vegetation	degree Celsius
					CO2 tradable emission permit value	euro/tC O_2
			Micro and regional climate regulation	57	Tree shade area (urban temperature regulation)	%
					Tree cooling potential	MgC/ha
					Evapotranspiration	mm
					Cool air production	m^3/h/h
					Soil carbon stocks (climate regulation)	Kg/ m^2
					Increasing hectares of forest cover (Carbon sequestration)	Ton/ha/ year
					% of large trees per ha (Carbon sequestration)	Mg/ha/ year
					Change in biomass (carbon sequestration)	ton/ha
					Amount of Carbon captured by tree cover and tree biomass	tonC/ ha
					Carbon stored in vegetation and soil	kg/ha/ye ar
					Change in atmospheric fine dust concentration	PPM, g/m^3
					C-sequestration in forest biomass	ton/year
					Biomass average growth	m^3/ha
					Wood density of trees	ton/m^3
					Forest and woodland area	ha
					Street length	km
					Coarse vegetated area by average storage rate	kgC/m^2
					Fine vegetated area by average storage rate	kgC/m^2
					Soil area by carbon density	kgC/m^2
					Dry deposition rate	cm/s

					PM_{10}, SO_2, NO_2 removal rate	Mg/year
					Removal of carbon monoxide, ozone, nitrogen dioxide, sulfur dioxide, and particulate matter (PM_{10})	kg/km^2
					PM_{10} capture by vegetation	Mg/m^2

Table 16: List of indicators of Cultural ecosystem services used in the studies

Section	Division	Group	Class	Frequency (# times mentioned)	Indicators	Units
Cultural	Physical and intellectual interactions with biota, ecosystems, and land- /seascapes [environmental settings]	Physical and experiential interactions	Experiential use of plants, animals and land-/seascapes in different environmental settings	38	(Suitability for outdoor recreation)	
					Number of walkers	Number/ ha/ year
					Number of excursions and number of visiting researchers	Number/ year
					Density of rural tourism establishments	Number/ km2
					Recreational area	ha
					Recreational area per capita	ha/popul ation size
					Number of recreation sites	Number
					Number of visitors	h/year/h a
					Number of visitors per year	Number/ year
					Number of hunters	Permits
					Number of permits for mushroom picking	Permits
					Frequency of visits	Visits/ week
					Annual visits per ha	1000/ha
					Accessibility of recreational area	
					use of the recreational infrastructure	
					Potential recreational use	Score
					Landscape value	Score

					Potential recreational use	Score
					Entry fees	$
					Travel costs	$
					Cycling path density	m/ha
					Bird watching	
					Kayaking, sailing, scuba diving	
					marine mammal observation	
					Ratio of protection zones under pressure of built-up area	
					Ratio of wild life under pressure of built-up area	
					Ratio of loss in endemic plants under pressure of built-up area	
		Intellectual and representational interactions	Educational and Scientific	4	Number of excursions and number of visiting researchers	Number/ year
					Number of PhD Theses on water	
					Number of scientific publication on aquatic ecosystems	
					Number of university students	Persons/ km2
			Aesthetic	3	No. of visitors appreciating the visual quality of the landscape	Number/ year
					coastal attributes: “scenic beauty”, “biological diversity”	
					Scenic beauty, visual quality	
	Spiritual, symbolic and other	Spiritual and/or	Spiritual and religious values	2	Locations of temples	Number

	interactions with biota, ecosystems, and land- /seascapes [environmental settings]	emblematic			and spiritual sites	
					Number of people visiting these locations	Visitors/ year
		Other cultural outputs	Existence	1	*Reflection; Attachment; Continuity with past*	

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