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Enhancing Resilience Of Urban Ecosystems through Green Infrastructure (EnRoute)

Progress Report

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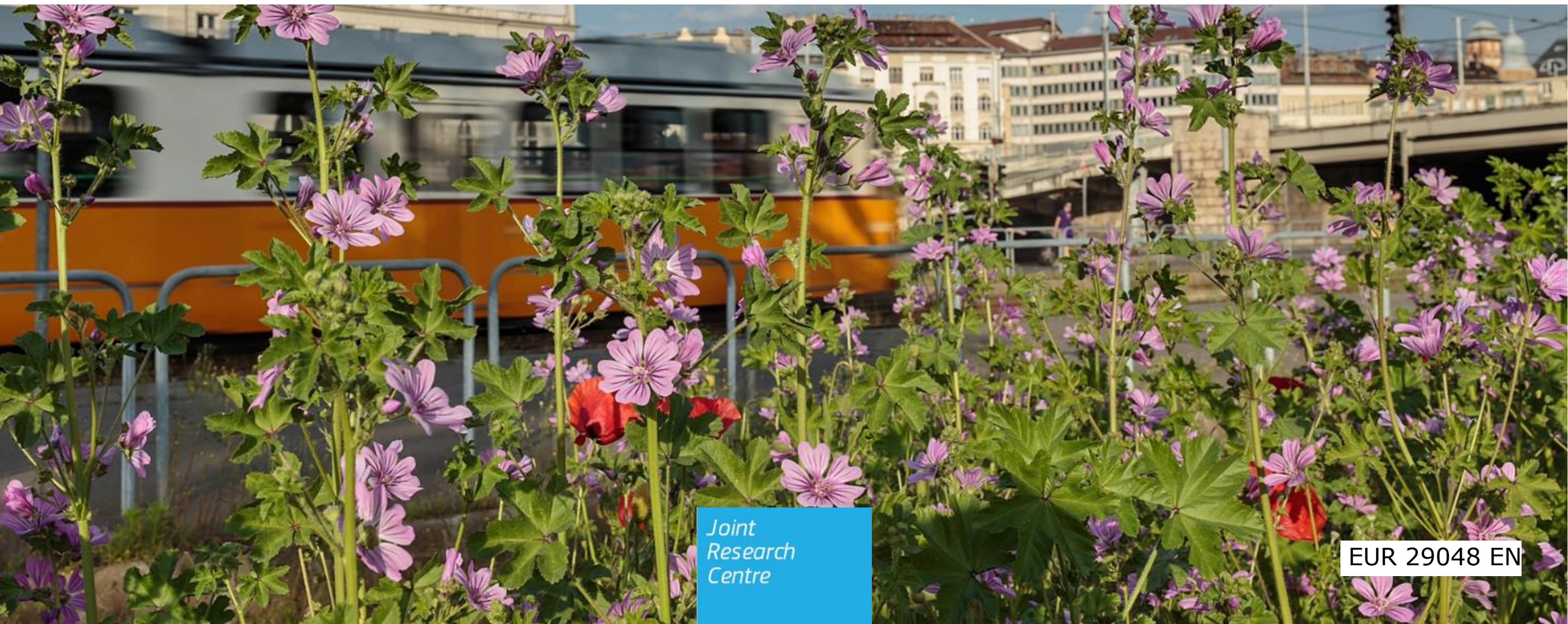

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Summary

EnRoute stands for Enhancing Resilience of urban ecosystems through green infrastructure. EnRoute is a project of the European Commission in the framework of the EU Biodiversity Strategy and the Green Infrastructure Strategy.

EnRoute provides scientific knowledge of how urban ecosystems can support urban planning at different stages of policy and for various spatial scales and how to help policy-making for sustainable cities. It aims to promote the application of urban green infrastructure at local level and delivers guidance on the creation, management and governance of urban green infrastructure. Importantly, it illustrates how collaboration between and across different policy levels can lead to concrete green infrastructure policy setting.

This report describes the progress made by EnRoute since the start of the project (01/12/2016). EnRoute is testing the MAES indicator framework on mapping and assessment of urban ecosystems in 20 cities across Europe. The report collects the relevant policy questions for these cities with respect to urban green infrastructure and identifies which indicators of the MAES analytical framework can be used to support local policy.

The report includes the datasets and models that will be used for an EU wide assessment of urban ecosystems and their services.

The report contains a first proposal for an online survey on the functionality of a science policy interface on urban green infrastructure at different governance levels.

The report describes the contributions of EnRoute to other initiatives: update of the MAES indicator framework for ecosystem condition, the task force on an impact evaluation framework for nature based solutions under Horizon 2020, and the EU urban agenda.

Supplementary information is available on CIRCA BC: The following Annexes area available on CIRCA BC: https://circabc.europa.eu/w/browse/d26e3ff7-a37a-44a3-b91a-806444142b7f

EnRoute web page on OPPLA: https://oppla.eu/enroute

1. Introduction

EnRoute is a cooperation between the European Commission and 22 European cities. In Enroute we test a framework for the assessment of values related to green areas (green infrastructure) in cities. Moreover we research the interaction between policy and science at this subject, and we aim to establish a network of European cities that wish to work with and further develop the framework.

In 2015, the working group on Mapping and Assessment of Ecosystems and their Services (MAES) carried out a pilot study on urban ecosystems and their services, the “Urban Pilot”. This pilot delivered the 4th MAES report (Maes et al. 2016), which provides a framework for the assessment of urban green infrastructure (UGI), that cities in Europe can use to support their policies, assessment and monitoring of urban GI and the urban ecosystem. Following the Urban Pilot, a two-year project has been developed under the title Enhancing Resilience Of Urban Ecosystems through Green Infrastructure: EnRoute.

EnRoute aims to introduce the MAES approach into the local policy arena, connecting the governance levels horizontally and vertically, with a view to contribute to the further deployment of Green Infrastructure in cities and in urban contexts. Hereto the European Commission and 22 European cities work closely together to:

- Operationalise the URBAN MAES-framework by demonstrating the potential of the application of the URBAN-MAES framework on a multi scale progression, from the European wide to the local urban scale (city-labs);
- Analyse how science supports policy, considering the effective interactions between the research community and the local practitioners and stakeholders (science-policy interface);
- Enhance contacts between communities of practice at different scales in order to exchange experiences and knowledge on mapping, assessment and implementation of urban green infrastructure, urban biodiversity and urban ecosystem services, so as to support the further deployment of urban Green Infrastructure (networking).

This progress report describes the results of EnRoute for 2017 and gives a preview on the foreseen activities.

2. The EnRoute local city-labs: the heart of the project

The thirteen city-labs represent 20 European cities with the objective of implementing the Urban-MAES pilot at a local level. One city-lab, represented by the Department Neurosciences, Biomedicine and Movement Sciences, University of Verona, focuses on the role of UGI connected to health and well-being.

Together with the Joint Research Centre, they are testing the applicability of the MAES indicator framework for urban ecosystems (Maes et al. 2016). One of the expected project results is a set of scalable indicators which allow comparing the performance of cities (in terms of urban ecosystem condition and ecosystem services) across and within scale and a set of methods and protocols to quantify indicators.

During the first year of the project the city-labs, together with the JRC, established the relevant local needs or policy goals and the type of indicators useful for local authorities that will be mapped during the second year. Figure 1 presents the tasks expected from each city-lab during the two years of the project.

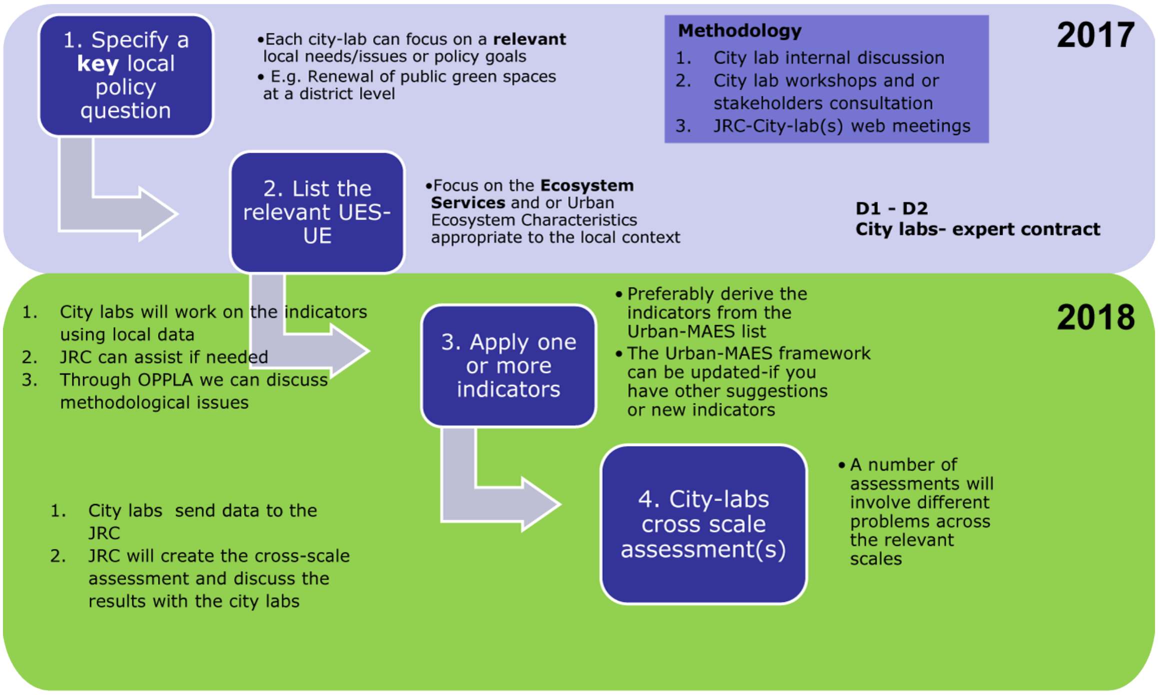


Figure 1: Summary of tasks expected from the city labs (derived from-Annex 1).

The city labs presented their policy context and how they will contribute to EnRoute during two poster sessions, held in Rome (6-7-8 March 2017) and Tallin (24-25 October 2017). The collection of posters is available in Annex 2. Table 1 presents a summary of relevant local policy questions, the type of indicators and models available

Table 1: Summary of City labs relevant policy questions (the original contributions are available in Annex 3).

City lab	Policy question
Antwerp*	The key policy question that the city has with respect to urban green infrastructure is: How to develop a city master plan green and blue infrastructure based on **multi-functional** ambition levels, supported by related maps and indicators? More specific questions include: - How to include private green spaces in the evaluation of the impact of urban green? How can we map the ecosystem condition of privately owned green areas? - How can we assess the amenity value of green and the visibility of green areas from their home
Glasgow	Policy instrument: GLASGOW OPEN SPACE STRATEGY (Consultative draft) Thus, the policy question to be addressed in this case study is to explore the contribution of green (open) spaces in the context of **urban regeneration** in the following areas: - Place-making - Climate Change, Adaptation (especially flooding) - Expanding & Enhancing Connectivity - Amenity (including well-being and Play) - Biodiversity and Ecological Connectivity and Geodiversity
Greater Dublin	The city-lab will assist with the formation of Green Infrastructural Strategies and Regional Spatial and Economic Strategies for the Dublin Region of Ireland. Outputs will aid in our **understanding of how urban policy on green infrastructure at different governance levels can be mutually reinforcing.** It aims to enhance contacts between communities at local, regional and national level in order to exchange experiences and knowledge.
Helsinki /Espoo/ Vantaa	There is no previous knowledge on pollination, therefore it was selected as the main service to be mapped in the EnRoute project. Local / urban food provision is a rising issue in Finland, and **pollination maps bring new knowledge** which can be added to already existing green infrastructure and ecosystem service maps.
Karlovo	The following policy questions were validated with the stakeholders in Karlovo: - What are the potential effects of UGI and ecosystem services on the development of Karlovo Municipality? Which territories can benefit most of such activities for development? How can UGI **contribute to the improvement of welfare in urban regions** (e.g. by creating or restoring urban and peri-urban forest parks, multiple-use, etc.)? - What kind of knowledge are still needed for local authorities to anticipate and benefit from the concept of ecosystem services? - How can UGI be further integrated in spatial planning and territorial development? How can regional and local authorities and other stakeholders be supported to develop UGI in the most effective way?
Limassol	Interest in recreation and urban heat island
Lisbon	Key interest in urban biodiversity
Manchester	Policy instrument: *Manchester Green and Blue Infrastructure Strategy (2015).* Local Action Project developed a simple, but consistent and robust framework for the assessment of natural capital- and ecosystem services-derived benefits in urban landscapes. The analysis method developed uses a series of 12 ecosystem service benefit-indicators, which can be variously used to: 1) **characterize the benefits** derived from existing natural capital; 2) **establish a baseline of benefits experienced by people living in specific communities** (facilitating a strategic assessment of need for enhancement or deficiency of provision); 3) **predict** the magnitude and diversity of benefits generated through the delivery of a targeted urban environmental management intervention programme.

Oslo	Overarching policy question in Oslo is **how to optimize and protect blue-green infrastructure while enhancing development to meet the needs of a growing population**. *Waterflow regulation and runoff mitigation* - Where should run-off control measures be **prioritized**? - What is the mitigation effect of vegetation and permeable soils? - What is the contribution of each property to run-off volumes? - Can we calculate a run-off management utility fee? *Insect pollination* - Where are the areas of high pollinator potential within Oslo built zone? - What is the carrying capacity of urban vegetation for social honey bees? - What are the habitats of endangered wild solitary bees? - For what floral resources and where do honey bees and solitary wild bees compete? - Which flowering meadows should be protected in Oslo in order to protect endangered solitary wild bees? - Where should Oslo municipality designate “precautionary zones” for honey bee keeping to protect wild pollinators? *Nature-based recreation* - Which public spaces in and around Oslo’s built zones are potential outdoor recreation areas? (Called “friluftsliv” in Norwegian, “outdoor life” areas.) - What is their relative value? (Oslo is implementing the Norwegian Environment Agency’s M98 methodology for mapping and valuing recreation areas.) - How should recreation areas classified and valued according to the M98[1] methodology be evaluated in the context of environmental impact assessments? - To what extent can M98 valuation be the basis for recommending land use zoning in Oslo?
Poznan	The policy questions behind the municipality activities in urban regeneration field focus on: - how **to identify areas with the lowest recreation** ES potential and recreation opportunities as areas in need for transformation toward nature-based solutions - how to **identify priority areas** for improvement that emerge from areas with the highest demand for recreational services
Rome	Selecting **priority areas** with the aim to restore or maximize the ecosystem functions related to regulating services implementing urban green infrastructure in the MCR “Municipio II”
Tallin	The main policy question is how does the full implementation of general plans of Tallinn districts affect the provision of certain ecosystem services (water flow and runoff mitigation, temperature regulation, accessibility to public green areas) and the status of certain condition indicators (canopy cover, permeability).
The Hague	The policy questions focus on the **impact of green infrastructure on human health**, in particular: - Which set of socio-economic indicators can be identified as a reference marker for the impact of ecosystem services city wide on human health? - As more and more data and insights become available, which tools are useful to assess the impacts at local or district level? Useful means that they use objective data, apply proven techniques, and use hands-on procedures.

1 M98: http://www.miljodirektoratet.no/Documents/publikasjoner/M98/M98.pdf

Trento	- How are ecosystem services and benefits from urban green infrastructures **currently distributed** across the city? - How can the provision of ecosystem services and related benefits be improved by the city plan?
Utrecht	Policy Instruments: *Urban Green Structure Plan (2007)-Utrecht Trees policy (2009) for a liveable and healthy city.* The overall objective is to establish a monitoring system for ecosystem services in Utrecht using maps and statistical data. The policy questions focus on the impact of green infrastructure on human health, in particular: - Which set of socio-economic indicators can be identified as a reference marker for the impact of ecosystem services city wide on human health? - As more and more data and insights become available, which tools are useful to assess the impacts at local or district level? Useful means that they use objective data, apply proven techniques, and use hands-on procedures.
Valletta (Malta)	Policy Objectives: - to identify and implement **key indicators** that may be used to assess ecosystem services in urban areas, and which may be included in urban planning **to support ecosystem-based management and promote human well-being**. To assess the **spatial variation in ecosystem** services and analyse how multifunctional green infrastructure can contribute to support the national biodiversity strategy and the delivery of key benefits to the inhabitants of the case-study area

In total the cities will map 127 indicators (65 Ecosystem Services and 62 for Urban Ecosystems condition). Figure 2 shows a summary of types of indicators that cities are mapping locally. In Figure 3 and Figure 4 we provide an overview of the relevant urban challenges that the cities will tackle. These challenges have been derived from Raymond et.al (2017) and are slightly modified to cope with aim of EnRoute. Figure 5 provides a spatial overview of the indicators mapped across the cities.

Almost all cities will provide maps of ecosystems condition (pressures, environmental quality and structural ecosystem attributes); three cities will provide maps of socio-economic indicators (Glasgow, The Hague and Utrecht). Between the ecosystem services cultural and regulating services are predominant. EnRoute cities confirm the trend already underlined by Haase et al. (2014) demonstrating that at urban level regulating and cultural services are the most relevant. Only two cities will provide indicators of provisioning services (Manchester and Dublin).

The city labs are mutually supporting each other. The JRC is actively collaborating with Oslo, Trento, Poznan, and Limassol on cultural ecosystem services and with Oslo and Helsinki/Espoo/Vantaa on pollination. The city lab of Rome is collaborating with the city of Karlovo for the implementation of a methodology to map air quality regulation, developed at the University La Sapienza.

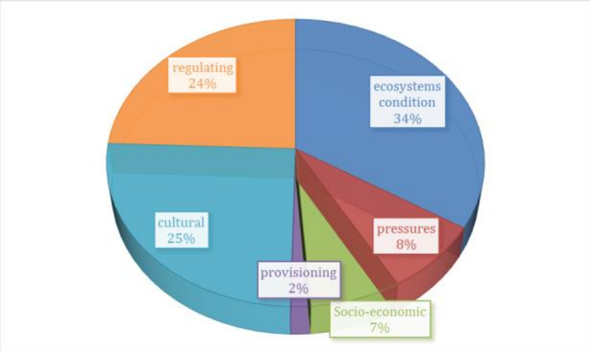


Figure 2: Categories of indicators that the EnRoute cities will map locally.

Here is a short update of the current status of the activities carried our by the city labs:

Publication of research papers or participation to conferences with a presentation of results of EnRoute:

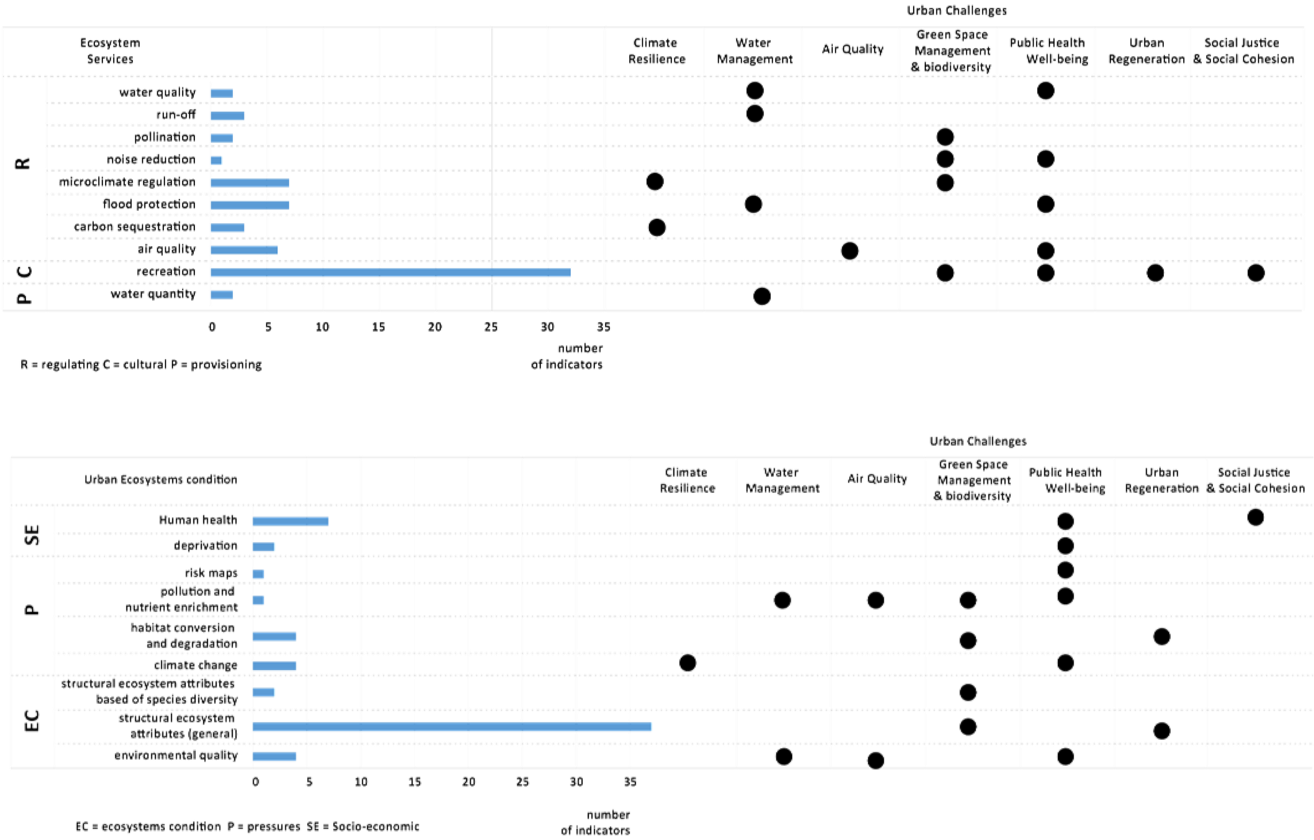
- Lina Fusaro and colleagues from the La Sapienza University of Rome have mapped the removal of PM10 and ozone by urban trees in Rome, one of the EnRoute city labs, as well as at regional level. They combined high resolution remote sensing data with measured pollutant concentrations to estimate the physical removal of pollutants by trees. A damage cost approach was used to estimate the monetary value associated to pollutant removal. The overall pollution removal accounted for 5123 and 19,074 tonne of PM10 and O3, respectively, with a relative monetary benefit of 161 and 149 Million euro for PM10 and O3, respectively.
- The city lab of Trento presented a paper at the IUFRO 8.01.02 Landscape Ecology Conference 2017 The Green-Blue Nexus: Forests, Landscapes and Services 24 - 29 September 2017 Halle Germany. Title of the paper: Assessing the recreation potential of green infrastructures in Trento (Italy): a city-scale application of the ESTIMAP model (Cortinovis C., Zulian G., Maes J. b, Geneletti D.) (the presentation is available in Annex 5).

Organization of local workshops or surveys to define the role of the city lab within the project

- The city lab of Dublin organised a stakeholder workshop and proposed a Survey prepared by the Eastern and Midland Regional Assembly. The type of contribution to EnRoute has been defined using the results of the two activities. (see Annex 6a and b).

Organization of local workshops, surveys or expert meetings to adapt ES models to the local context

- The city lab of Helsinki-Vantaa-Espoo set up an expert meeting on pollination to adapt the ESTIMAP-pollination model.
- The city lab of Trento organized a stakeholders workshop and a web survey to adapt the ESTIMAP-recreation model.



Figures 3 (Upper panel) and 4 (Lower panel): Ecosystem service indicators presented by the city labs and cross walk of urban ecosystem services with the urban challenges related to nature-based solutions (the list of urban challenges is derived from Raymond et al. 2017 who developed an indicator based impact evaluation framework for nature-based solutions, EKLIPSE project)

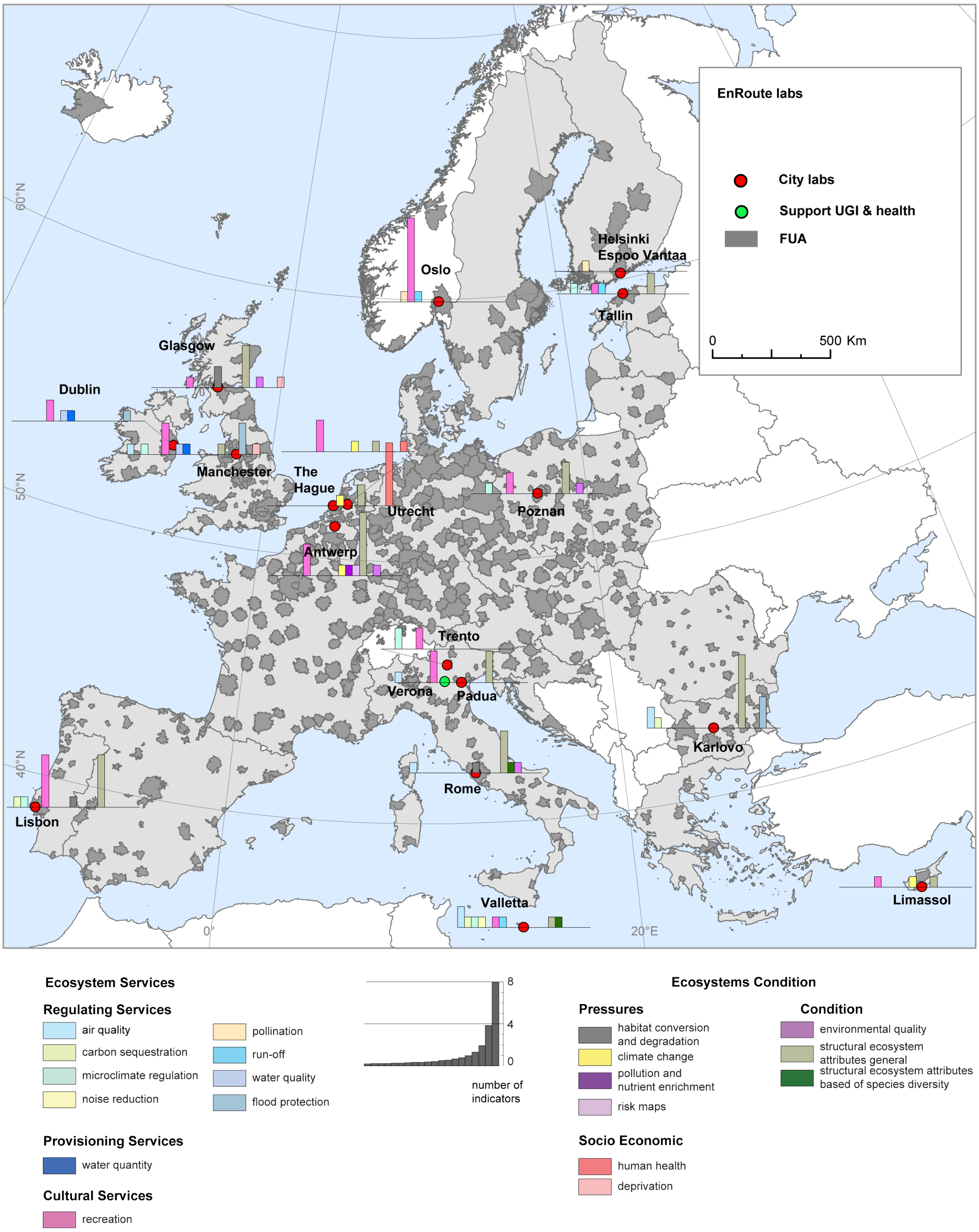


Figure 5: EnRoute city labs and their contribution to the project.

3. The city labs: Cross scale assessment of urban ecosystems in Europe

3.1. Objectives of the EnRoute EU city labs

The EnRoute EU city labs aims at implementing the Urban-MAES framework at European scale. Previous studies have investigated urban ecosystems condition or ecosystem services in European cities, considering different spatial extents and focusing on specific aspects. Fuller and Gaston (2009) explored the relationships between urban green space coverage, city area and population size in 386 Urban Morphological zones; Larondelle et al. (2014) focused on regulating services in 300 Functional Urban Areas; Larondelle and Haase (2013) presented an approach for the assessment of ecosystem services in an urban context covering the local and the regional scale, with 4 case studies. Kabisch et al. (2016) assessed green space availability in 299 EU cities according to land use and a population data grid providing a detailed analysis of two European cities – Berlin, Germany and Lodz, Poland. The authors conclude that "For a more comprehensive assessment of the social-ecological system, indicators of actual UGS accessibility and use as well as indicators of ecosystem service supply and demand will have to be included in the future".

The EU city labs wants to further explore the role of European cities regarding the provision of ES and supporting the achievement of biodiversity goals. Figure 6 presents the EU-city lab main tasks:

1) Analysing the structural and functional role of Urban Green Infrastructure, using indicators of Condition of Urban Ecosystems and landscape metric;
2) Mapping and assessing a set of relevant urban ecosystem services;
3) Analysing Nature 2000 sites within cities and exploring how UGI and urban protected areas contribute to the EU's Biodiversity goals;
4) Working, with the city labs, on a set of Cross-Scale Assessment, in order to provide a framework for a consistent policy support over scales.

The expected result is a standardized assessment of Urban Green Infrastructure (UGI) across 700 Functional Urban Areas (FUAs) in Europe, representing all the cities which participated to the Urban Atlas project.

One of the aims of the EU city labs is to compare the state of urban green infrastructure and the delivery of ecosystem services in European cities. Following the recommendations of Eurostat, for our assessment we will use the Functional Urban Area (FUA) definition. In 2011 the OECD and the European Commission developed a new definition of a city and its commuting zone and recently the concept of FUA has been recognized as the official spatial aggregation for urban related statistical analysis . This EC-OECD definition identified more than 900 cities with an urban centre of at least 50,000 inhabitants in the EU, Switzerland, Iceland and Norway. Each city is part of its own commuting zone or a polycentric commuting zone covering multiple cities. These commuting zones are significant, especially for larger cities. The cities and commuting zones put together are called Functional Urban Areas. For several urban centres stretching far beyond the city, a 'greater city' level was created to improve international comparability.

The spatial levels available are Functional Urban Area (FUA) - formerly known as Larger Urban Zone (LUZ), Greater City (formerly kernel), City (formerly core city), Sub City Districts level 1, and Sub City Districts level 2.

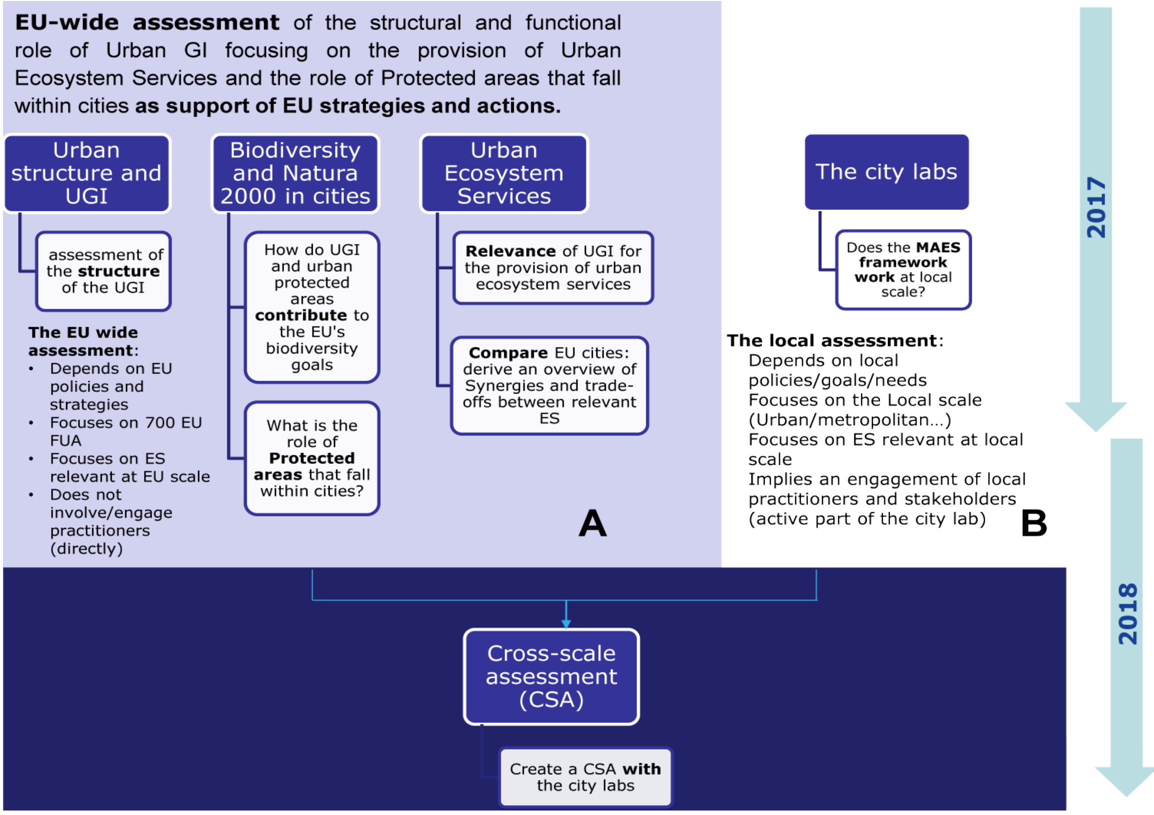


Figure 6: Overview of the different tasks of the EU wide urban ecosystem assessment

3.2. Data sets which will be used for the EU wide urban ecosystem assessment

We combine different data, most of them open and or publicly available, to derive indicators for condition of urban ecosystems and model urban ecosystem services. Table 2 and Table 3 provide the list of input data and the related indicators or models. Landscape metric indicators (Structural ecosystem attributes) will be computed using the methodologies proposed by Wegmann et al. (2017) that allow the analysis of large amounts of data in a semi-automatic manner to ensure high reproducibility and robustness. More details are available in Annex 7.

The source of urban land use data will the Urban Atlas (UA) dataset, obtained from the EEA. The source of land cover data is the European Settlement Layer obtained from the JRC (Ferri et al. 2017). The combination of the two data sets increases the capacity to identify small green patches in urbanized areas (e.g. private gardens in residential, industrial or commercial areas). Madureira and Andresen (2014) applied a similar approach combining UA and a local land cover data to analyze the multi-functionality of UGI in the town of Porto (PT); Nedkov et al. (2017) combined land use and land cover data to map urban ecosystems condition in Bulgaria. At European scale this approach will be extremely useful especially when assessing urban regulating services and the structure of urban green infrastructure.

Table 2: Data and indicators to map and assess the condition of urban ecosystems in European cities (indicators are organised following the updated framework to map urban ecosystems (5^{th} MAES report on ecosystem condition, in preparation)

Class	Indicator	Data owner	Coverage
Habitat conversion and land degradation	Land annually taken for built-up areas per person (m2 person-1)	EEA	All FUA
	Soil sealing (% area) Updated raster dataset of 100 x 100 m cells; cell values represent the number of valid "sealed" 20 x 20 m cells within one 100 x 100 m cell with the associated metadata.	EEA	All FUAS
Climate change	Thermal discomfort: Annual number of combined tropical nights (above 20 °C) and hot days (above 35 °C)	EBSEMBLE FP6 project and UK Met Office (EEA is the processor)	All FUA
Pollution and nutrient enrichment	Emissions (kg year-1) of NO2, PM10, PM2.5, O3 (µg m-3)	JRC07 (Air and Climate Unit)	All FUA
	Population exposure to noise from different sources in Europe (Noise levels (dB(A)))	EEA	498 agglomerations*
Introductions of invasive alien species	Invasive alien species of union concern	JRC (EASIN) https://easin.jrc.ec.europa.eu/	All FUA
Environmental quality	Urban temperature (°C)	JRC (under development)	All FUA
	Bathing water quality Share of compliant points over the total number of points collected within the FUA (%)	EEA	All FUA
	Population density Number of inhabitants per area (number ha-1)	EEA	All FUAS
	Artificial area per inhabitant	EEA – Copernicus (Urban Atlas) JRC – ESM (European Settlement Map)	All FUAS
	Imperviousness density 2012 (%)	EEA	All FUAS
	Length of road network per area (km/ha)	JRC	All FUAS
	Share of the city's urban area that is potentially affected by river flooding	EEA	All FUAS
Structural ecosystem attributes general	Proportion of urban green infrastructure (UGI) (%) All urban green (public and private surface and linear)	EEA – Copernicus (Urban Atlas) JRC – ESM (European Settlement Map)	All FUAS

	Proportion of natural area (%)		All FUAS
	Proportion of abandoned area (%)		All FUAS
	Proportion of agricultural area (%)		All FUAS
	Fragmentation of UGI (Mesh density per pixel)		All FUAS
	Fragmentation by artificial areas (Mesh density per pixel)		All FUAS
Environmental quality Of which nature related	Proportion of urban inside and outside Natura 2000 (%)	EEA	All FUAS
	Proportion of urban inside and outside Nationally Designated Areas (%)	EEA	All FUAS
Environmental quality of which soil related	Number of contaminated sites in the city	EEA	

*> 100.000 inhabitants to be reported according to the directive

Table 3: Input data to model urban ecosystem services in European cities.

Data Sets	**Ecosystem services models**					**Resolution (m)**
	Recreation	**Pollination**	**Coastal Protection**	**Microclimate regulation**	**Air Quality regulation**	
Raster						
ESM [2.5m] 10m	X	X		X	X	10
Stream riparian areas	X	X				50
Landsat8, TIRS 10, 11 → LST 30m				X		
Vector						
Urban Audit Cities 2011-2014 (FUA)	X	X	X	X	X	50
Urban Atlas	X	X	X	X	X	50
Natura 2000 sites (2016)	X		X			Equivalent Scale 100000
Teleatlas	X	X	X		X	
EU coastal geomorphology	X		X			Equivalent Scale 100000

data						
CDDA -WDPA	X					Equivalent Scale 100000
Coastal area	X					
Blue fags	X					
Air quality database					X	
Open street map (OSM)	X	X	X			
Bathing water quality	X					

3.3. Urban ecosystem services

For mapping and assessing urban ecosystem services in European cities we are: 1) adapting the existing standard ESTIMAP models to fit the specific needs of urban setting; 2) developing new models to map ecosystem services particularly relevant in cities (such as microclimate regulation and flood protection).

The standard ESTIMAP models have been developed to map ecosystem services at continental scale (Liquete et al. 2013; Zulian et al. 2013b; Zulian et al. 2013a). The models for recreation (Paracchini et al. 2014; Liquete et al. 2016; Zulian et al. 2017), pollination (Zulian et al. 2013a) and coastal protection (Liquete et al. 2013) are so called ‘‘Advanced multiple layer LookUp Tables” (Advanced LUT), while the model for air quality regulation (Maes et al. 2015) is based on land use regressions (LUR) models[2].

For the purpose of EnRoute the ESTIMAP models are converted for use in urban areas. The adaptation process involves: 1) a consideration of the policy context that the models have to inform; 2) the scale; 3) the model configuration. The following sections present how we adapted ESTIMAP models for recreation and pollination .

3.3.1. Urban version of the ESTIMAP model for recreation

[2] Advanced LUT assign ES scores to land features according to their capacity to provide the service. We generate the values of ES scores for each input from either the literature or expert input (Schröter et al. 2015). The final value is based on cross tabulation and spatial composition derived from the overlay of different thematic maps. The air quality LUR model treats concentration data for the pollutant of interest as the dependent variable, with proximate land use, traffic, and physical environmental variables as independent variables in a multivariate model (Beelen et al. 2009; Schröter et al. 2015). Model results are then extrapolated to the whole area covered by thematic maps to predict concentrations and derive the ES that vegetation provides removing pollution. Removal capacity is then calculated as the product of the dry deposition velocity for a given land cover type and the pollutant concentration (Wesely and Hicks 2000). In their original form, both advanced LUT and LUR models consist of two parts: (1) a map of the potential capacity of ecosystems to provide a service and (2) a map of the potential flow of the service. The two maps are then combined to compare the relative levels of the potential provision and the potential use or demand of the services.

The standard ESTIMAP recreation model (ESTIMAP-R) was developed in 2013 to map outdoor nature-based recreation in Europe. In its original setup it focuses on recreation opportunities available over different ecosystems at a continental scale. So far it has been used in several large scale assessments (Liquete et. al., 2016; Grizzetti et. al., 2017; La Notte et al. 2017). For the purpose of EnRoute it has been adapted to fit different local settings and tested for use in several cities (Zulian et al. 2017).

3.3.1.1. *Importance of recreation in cities*

Cultural ESs are considered among the most important ES delivered in cities (Bolund and Hunhammar 1999; Haase et al. 2014) and they are linked, directly or indirectly, to several urban challenges, such as Green Space Management (including enhancing/conserving urban biodiversity); Urban Regeneration; Coastal Resilience; Social Justice and Social Cohesion; Public Health and Well-being (Raymond et al. 2017).

Cities and peri-urban areas are complex systems where people live, study and work. Citizens need outdoor recreation sites on a daily basis and the simple consideration of the square meters of “public green areas” per inhabitant is not sufficient to fully express the availability of outdoor recreation opportunities and the overall spectrum of possible uses of resources.

Key policy interest in urban areas can be summarized in:

- An equal availability of opportunities and an equal accessibility for all citizens’ especially young and elderly people. “...*These 'green and blue spaces' are enjoyed by all of us who live, work or visit Manchester. They need to be high quality and accessible to benefit as many people as possible. Looking after these spaces can include everyone who is interested in getting involved...*” (Manchester's 'Green and Blue Infrastructure Strategy[3])
- The walkability of neighborhoods and the possibility to reach recreational areas walking, cycling or using public transportation. “...*Maintaining support for the Equally Well project and promoting ‘Healthy Urban Planning’ by delivering more walkable places through attractive public realm, an appropriate mix of services and improved connectivity for pedestrians and cyclists...*” “..*Perhaps the greatest opportunity for open space is in creating cycling and walking routes that support green corridors. Attractive green networks, shaded by trees, can encourage greater use of cycling and walking routes: so long as routes are safe and directly link communities to the services and employment that they need in order to provide alternatives to driving cars or taking public transport*….” (Glasgow open space strategy[4])

[3] http://www.manchester.gov.uk/info/200024/consultations_and_surveys/6905/green_and_blue_infrastructure_consultation

[4] https://www.glasgow.gov.uk/CHttpHandler.ashx?id=9478&p=0

3.3.1.2. *Development of an urban version of the ESTIMAP-R model*

The ESTIMAP-R model assumes that the combination of landscape elements (Recreation Potential) and facilities (Recreation Opportunities Spectrum) determines the availability of areas for recreation.

In an urban setting the Recreation Potential (RP in Figure 7) depends on the combination of three "strands of information": 1) Suitability of Land to Support Recreation (SLSR); 2) Elements related to urban green infrastructure (UGI); 3) Water related elements (WE). To map the first strand we combine a land use map (which has a functional connotation) with a land cover map (which has a structural connotation). The second strand depends on the combination of inland natural elements (such as viewpoints, peaks, springs and cliffs), urban parks and green spaces, urban protected areas. The third strand is related to the presence of inland and marine water bodies, the presence of natural riparian areas, the distance from the coast, the geomorphology of coast, the bathing water quality and the presence of natural springs.

Especially in urban setting the availability of infrastructures to reach and enjoy recreation areas is crucial. For this reason the Recreation Opportunity Spectrum (ROS) depends on two types of infrastructures: 1) facilities to reach recreational areas (walk and bike paths and low traffic road network); 2) facilities to enjoy recreational areas (we derived most of the data from Open Street Map, using leisure tags; tourism tags and blue flag locations).

The potential users of the service are expressed using a cumulative opportunity model (Vale et al. 2015) by assessing the share of population, within each residential area, by Urban Local Administrative Unit (LAU) that lives at different distances from the 'high value recreational areas for a daily use'.

Figure 7 presents the configuration of the ESTIMAP-R model adapted to urban areas. See also Table 3 for the list of input data used. At European scale the main constraints are data availability, attribute accuracy and local cultural differences.

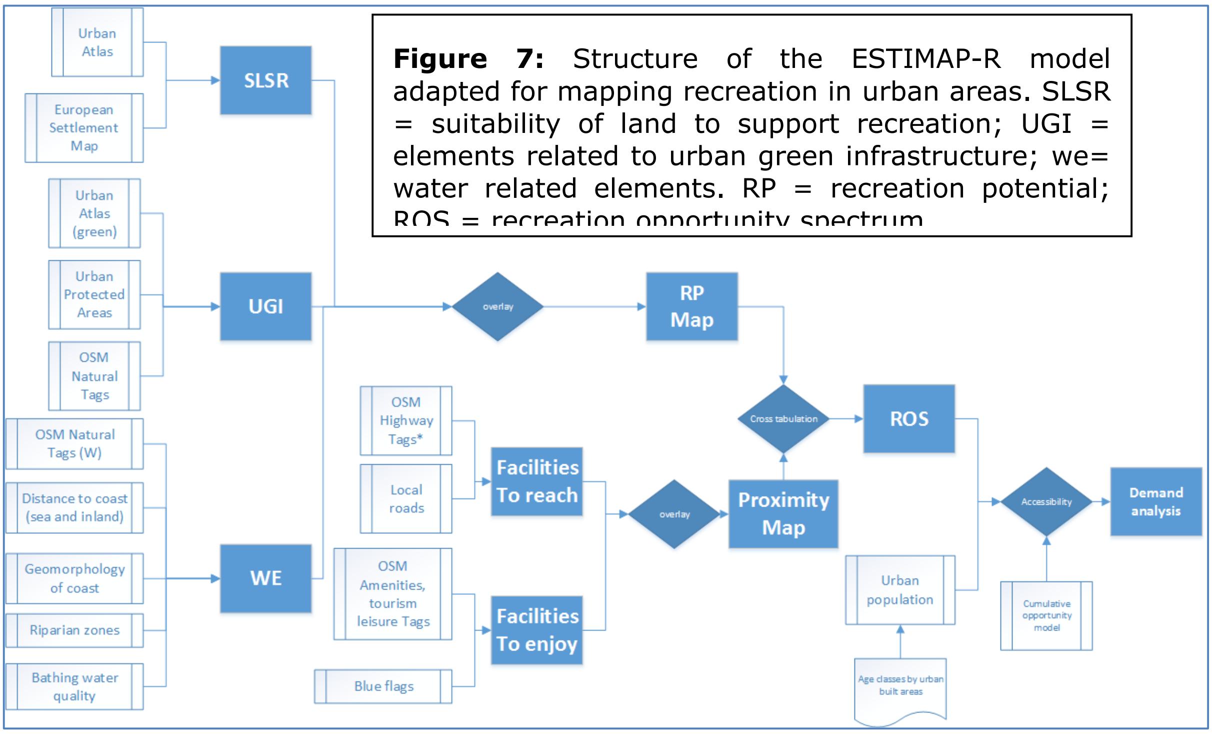


Figure 7: Structure of the ESTIMAP-R model adapted for mapping recreation in urban areas. SLSR = suitability of land to support recreation; UGI = elements related to urban green infrastructure; we= water related elements. RP = recreation potential; ROS = recreation opportunity spectrum

3.3.1.3. *Test of the urban version of the ESTIMAP-R model*

The urban version of ESTIMAP-R was tested in collaboration with two city labs Trento and Poznan[5]. JRC mapped recreation in these cities using the urban version of the ESTIMAP-R model and using European datasets as model input (see also Figure 8 and 9 for examples of the output of the recreation model). The city labs used the same model but based on local input data, engaging local stakeholders with a strong focus on the local context (see Annex 5 and 6).

In Trento the main interest was the analysis of opportunities for day-to-day nature-based recreation, considering both urban and non-urban activities; in Poznan a key policy interest was the renewal of urban riparian zones.

This test resulted in two main conclusions:

1. The urban version of ESTIMAP-R improved its performance to map the recreation opportunity spectrum for citizens with, on average, 13%[6] relative to the standard version of ESTIMAP-R which maps recreation opportunities for all ecosystems at European scale. Using EU wide urban datasets strongly improved the performance of the model.

[5] In addition, tests were also performed for the cities of Varese and Lecco (which are close to the JRC-Ispra). These cities are not participating in EnRoute

[6] To verify if the new configuration of urban version of ESTIMAP-R could provide a more comprehensive overview of recreation opportunities in cities than the standard version of ESTIMAP-R we compared the results of both models with a locally used version of the model using local datasets. This comparison is based on the Fuzzy Numerical (FN) approach (Hagen-Zanker, 2006). The FN approach generates a statistic ranging from 0% (completely different) to 100% (identical) with the FN index representing the average numerical similarity between the two maps, and FN maps that show the FN values for each pixel (Zulian et al., 2017).

2. A comparison between an assessment based on local datasets and an assessment based on European datasets resulted in a similarity coefficient of between 40 and 70%. This means that the urban version of ESTIMAP-R based on European data is capturing fairly well local dynamics, in particular in core areas of the city.

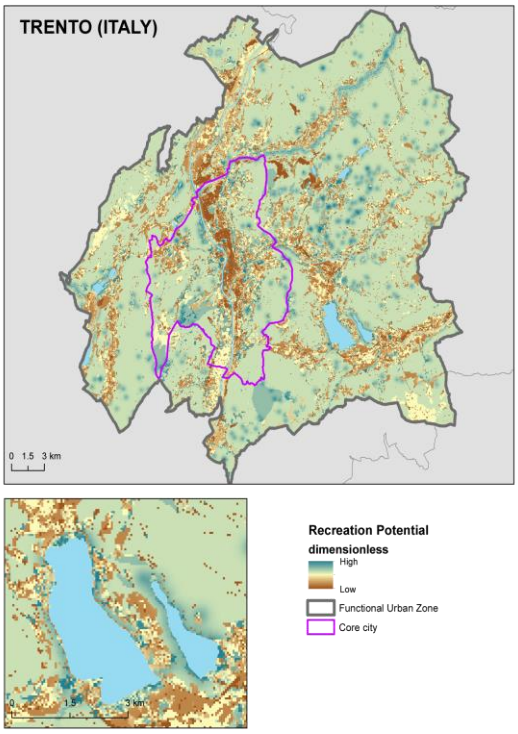


Figure 8: Example of recreation Potential map (city of Trento). The map shows where areas of high and lowe recreation potential are situated in the city.

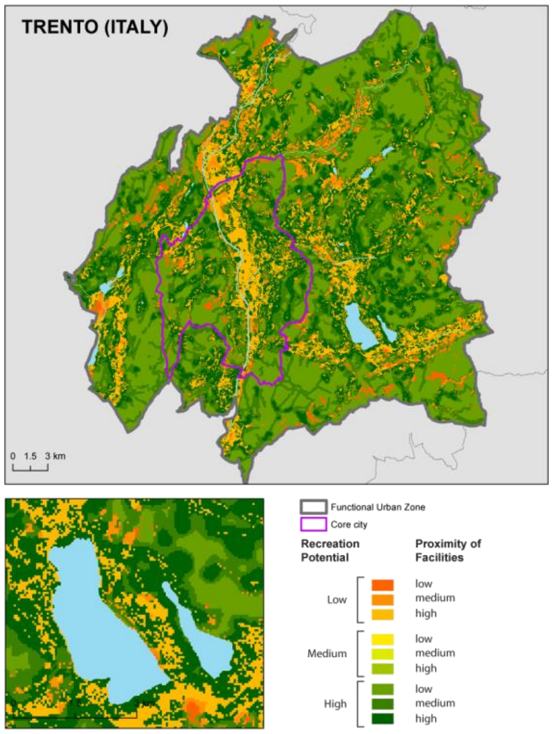


Figure 9: Example of Recreation Opportunity Spectrum map (city of Trento). The map combines information about the recration potential (from low to high) with information about the accessibility and usability of these recreation areas (also from low to high)

3.3.2. Urban version of the ESTIMAP model for pollination

Pollinating insects are an integral part of cities' natural capital and perform an important ecosystem function with a high degree of relevance to many cultural ecosystem services. Consequently, pollinators serve as a useful proxy for assessing urban biodiversity (Stange et al. 2017).High-quality urban areas are able to support good populations of insect pollinators, they can act as important source areas, refuges and corridors of favourable habitat in a hostile matrix habitat such as intensive agricultural landscapes (Baldock et al. 2015; Hall et al. 2017).

The standard ESTIMAP pollination model (ESTIMAP-P) was developed in 2013 to map the suitability of land to sustain insect pollinators (Zulian et al. 2013a). The standard configuration focuses on the contribution of wild pollinators to crop production. To be applied in urban settings the model was adapted as shown in Figure 10.

The urban version of ESTIMAP-P has been changed in two parts relative to the standard version: 1) Land use map and land cover map are combined in order to capture the degree of heterogeneity observed in vegetation cover within many of the land use categories, especially residential and commercial areas; 2) distance to semi-natural vegetation is taken into consideration in order to consider the importance of semi-natural vegetation patches, this step replaces the foraging distances modelled using a moving windows approach. The urban version of ESTIMAP-P has been tested in Oslo (Stange et al, 2017)[7]. Figure 11 presents some of the outputs. This version will be used to map pollination potential as indicator for urban biodiversity across all functional urban areas.

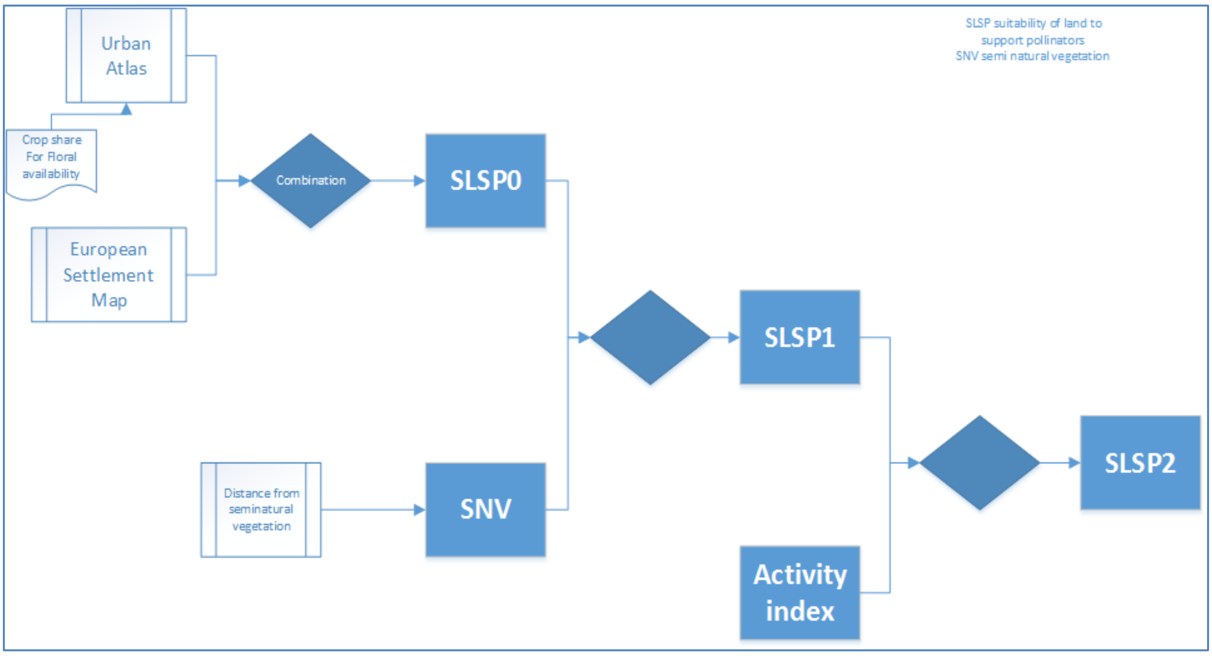


Figure 10: Structure of the ESTIMAP-P (urban version) model adapted to map pollination in European cities.

[7] https://oneecosystem.pensoft.net/article/14014/

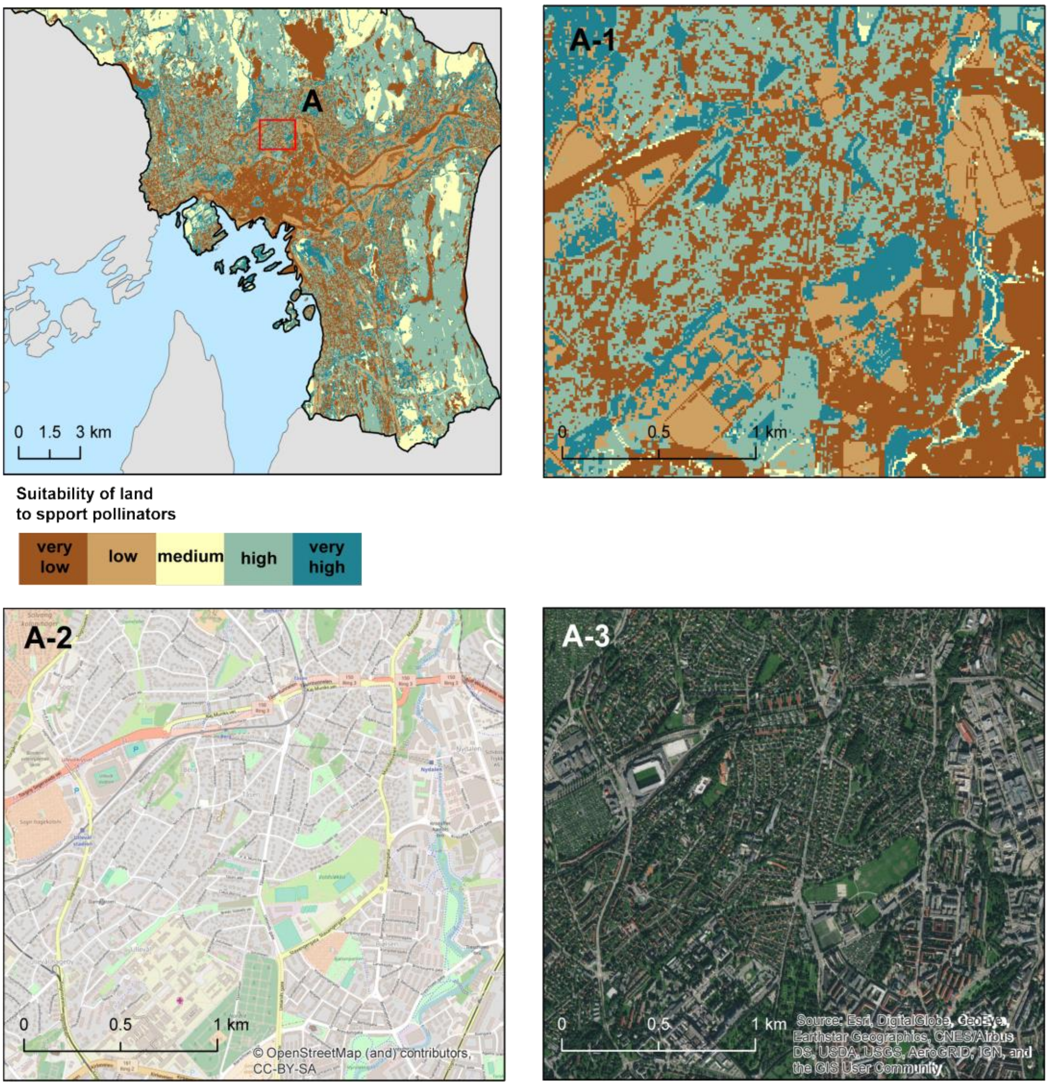


Figure 11: Urban version of ESTIMAP-P applied in Oslo. A-1 example of model result in residential area; A-2 the land use map as presented in open street maps, grey areas represent built residential areas. A-3 the urban vegetation detectable using satellite images.

3.3.3. A new model for assessing urban temperature and the indicator for microclimate regulation

Cities have elevated temperatures compared to rural areas, a phenomenon known as the "urban heat island". Higher temperatures increase the risk of heat-related mortality, which will be exacerbated by climate change. One strategy that has been suggested to address the issue is the increased use of green spaces (Skelhorn et al. 2014). Ecosystems can affect the microclimate locally, through the provision of shade and shelter and the regulation of humidity and temperature. This regulation of microclimate can have a noticeable impact on human well-being, particularly in the urban environment (Smith et al. 2013).

To map and assess the contribution of urban vegetation to microclimate regulation we are:

1. Deriving a map of Land Surface Temperature based on Landsat 8 Data (see Figure 12), using a methodology based on (Du et al. 2015).
2. Aggregating Land types to assess the changes in average temperature (see Figure 12)
3. Estimate the Influence of green cover on surface temperature index (Under development)

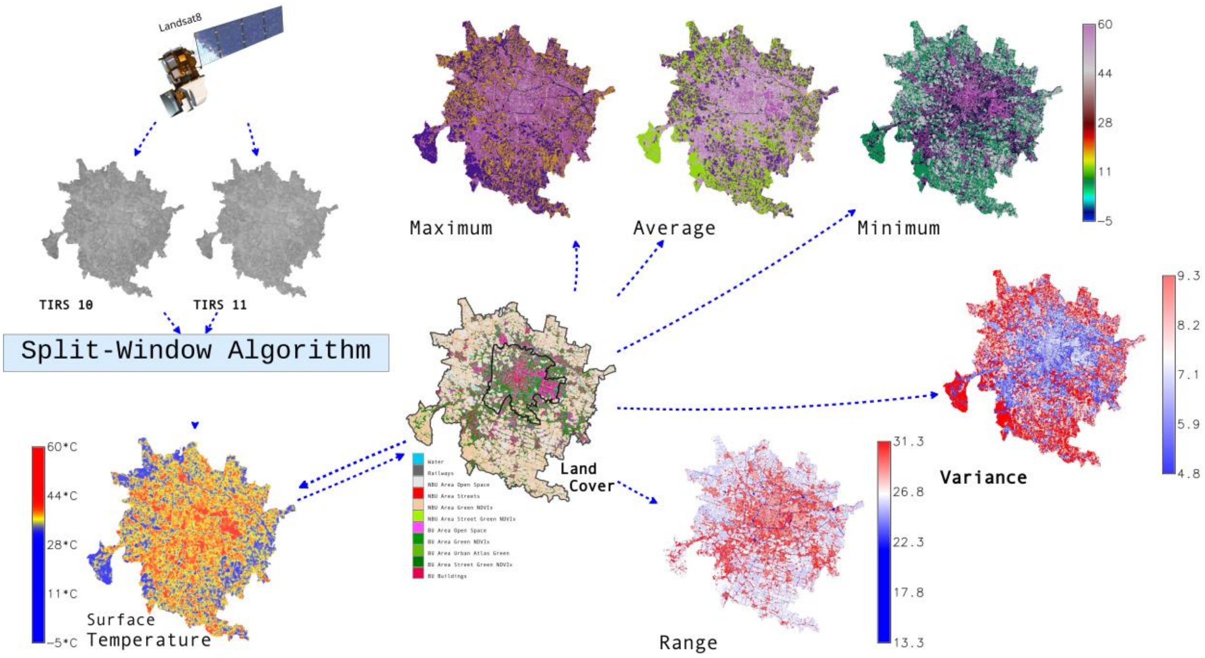


Figure 12: How we map urban temperature using remote sensing information.

In Figure 13 the double-sided bean-plot visualizes average urban surface temperature values based on land cover classes for Padua (Italy) on August 27, 2016. The left bean-sides represent values for areas in the Core part of urban area while the right bean-sides represent values for areas in the outer functional urban area. Bi- or tri-modality represents mixture of distinct clusters. In this case, Infrastructure is a mixture of three different classes. Emphasis is given on urban green classes, hence their unique representation and non-merging in one super-class, as is the case with Infrastructure.

The main observations are: The core city is hotter than the commuting zone. Built infrastructure is exposed to higher temperature than areas with green or blue infrastructure.

We are now developing an indicator based approach to measure the impact of urban green space on the average temperature of cities.

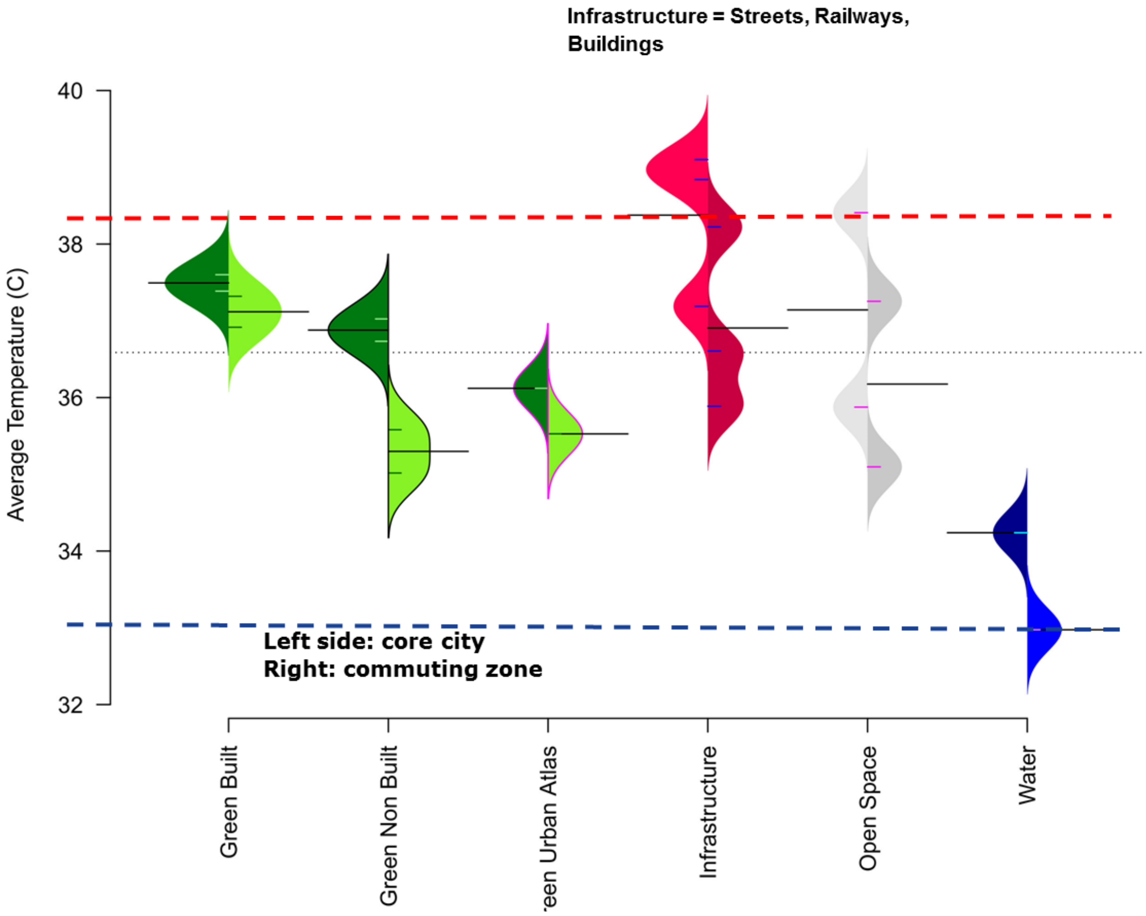


Figure 13: Average temperature and temperature distribution on a summer day in the city of Padova for different urban land types. The distribution curves pointing to the left are for core city, those pointing to the right are for the commuting zone.

3.4. An analysis of Natura 2000 sites inside functional urban areas

Urbanisation represents an alteration of land and ecosystems often regarded as one of the major threat to global biodiversity. However cities host a surprising rich and diverse wildlife (Albert et al. 2014; Beninde et al. 2015), and they can play a valuable role to help manage and protect biodiversity. While this importance of urban green infrastructure is increasingly recognized, the potential role of protected areas to support biodiversity in cities is often overlooked. Nevertheless, it can be expected that in the nearby future cities will play an increasingly important role in the management of vulnerable ecosystems and biodiversity.

This is evidenced by cross linking spatial data of urban areas and sites which are part of the Natura 2000 network. The Natura 2000 network is a key instrument to protect biodiversity in the EU. Some Natura 2000 sites are located in remote areas but most of them are part of the surrounding landscape, including urbanized areas. Overlaying spatial data of the extent of functional urban areas in the EU with the extent of the Natura 2000 network reveals that 11 041 Natura 2000 sites are at least partially within FUAs; In terms of surface area, 15.2% of the network falls inside FUAs. There are substantial national and regional differences (Figure 14) which relate to specific land use. More urbanized countries like Malta or Belgium have a higher share of Natura 2000 sites inside functional urban areas then countries such as Finland, Ireland or Sweden where Natura 2000 sites are predominantly found on the countryside. But also the configuration of the network matters. Germany created a dense network of relatively small protected sites which frequently overlap with urbanized areas. This is particularly evident from Figure 15 and Figure 16 that breaks down the relative share of Natura 2000 inside the three spatial levels of FUAs (Figure 15) and per NUTS2 region (Figure 16). In some regions in Europe but particularly in Germany nature is interwoven with urbanized areas.

Clearly, under a scenario of further urbanization, cities could be increasingly involved in the protection of valuable nature in Europe.

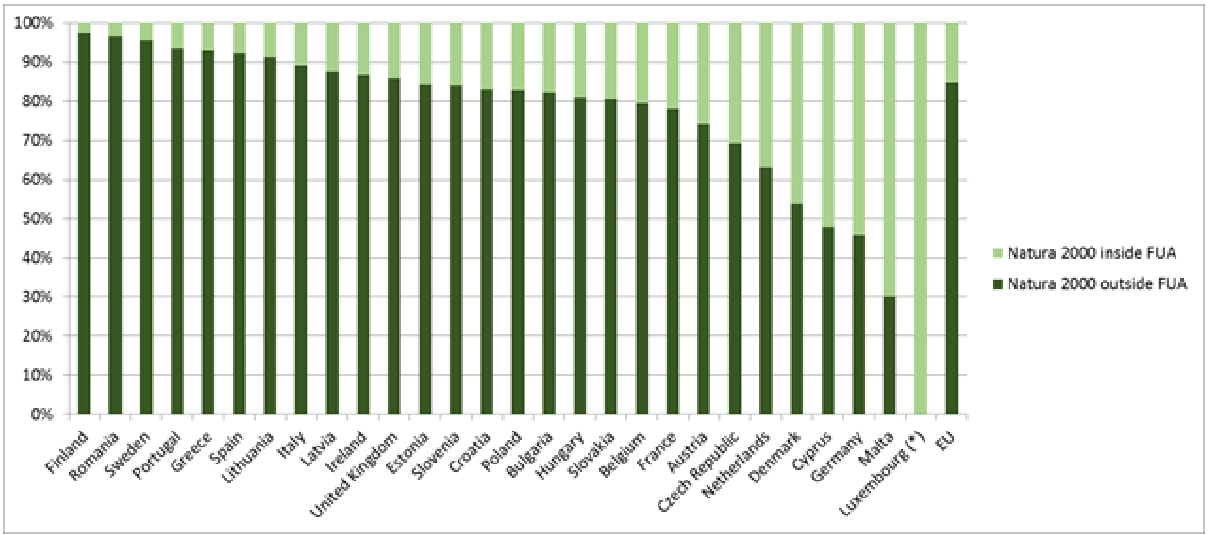


Figure 14: The share (%) of the Natura 2000 network which intersects with functional urban areas (fua). *the entire territory of Luxembourg is classified as functional urban area (commuting zone) explaining the share of 100%.

Figure 15: Proportion of urban areas covered by Nature 2000 sites (A =FUAS; B=core cities, C =greater cities).

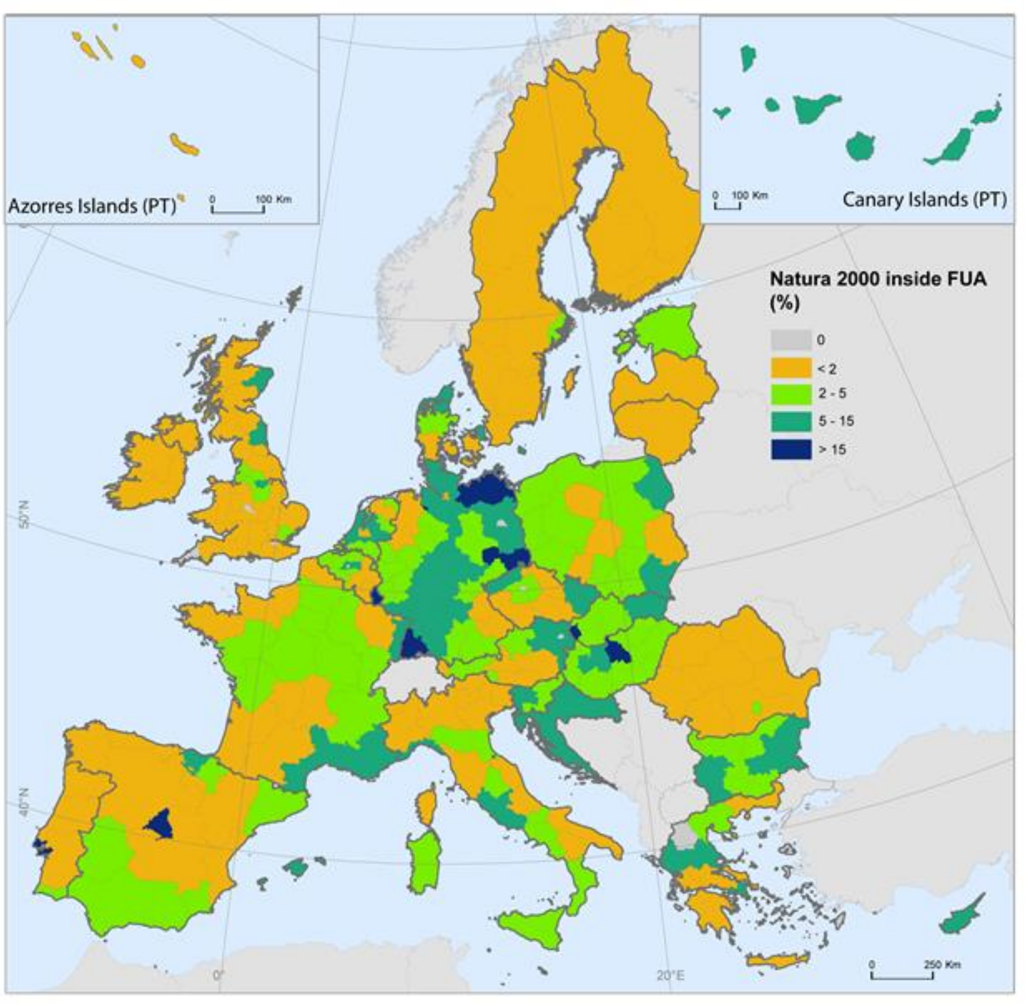


Figure 16: The share (%) of the Natura 2000 network which intersects with Functional Urban Areas (FUA) within NUTS2 regions of the EU.

3.5. Outlook for 2018

In 2018 we have two main goals:

1. To provide a Pan European analysis of condition of urban ecosystems and provision of urban ecosystem services. The idea is to compare European cities understanding the relationship and spatial distribution of multiple ecosystem services and analyzing the structural and functional role of UGI.

Tasks:

- Adapt to the urban setting ESTIMAP-air quality and ESTIMAP-coastal protection
- Implement the model to quantify the cooling capacity of urban green
- Run the models over all 700 FUAs
- Implement at urban scale the condition indicators to be included in the overall assessment

- Apply spatial analytical approaches, such as spatial variation, spatial covariance and ES bundles analyses, suited to address issues posed by spatially complex patterns (Casalegno et al. 2014; Dittrich et al. 2017)

2. To explore the synergies between policy levels

The management of ecosystem services requires scale- appropriate information about the condition, dynamics, and use of multiple, and often interacting, ecosystem services. However, choosing the scale at which ecosystem services should be assessed is not evident. The issue of scale is complex in ecosystem service research and assessment because individual and bundles of ecosystem services are generated and managed by a variety of social-ecological processes, structures and organizations each with distinct spatial scales, logic and priorities (Raudsepp-Hearne and Peterson 2016).

In EnRoute we have the opportunity to further explore:

- The spatial pattern of variation and covariation, within and between scales, with a focus on ES locally, regionally and globally relevant
- Methods: spatially explicit statistics and comparison using the EU-wide results and the local data provided by the city labs
- The coherence and or synergies between supranational, national and local policy making and local actions
- Methods: interactive discussions or semi-structured interviews with representative from the Enroute cities.

4. Contribution of EnRoute to the MAES analytical framework for ecosystem condition.

In 2017 the Working Group on Mapping and Assessment of Ecosystems and their Services has reviewed the indicators to assess ecosystem condition at EU level. The work was organized in so called ecosystem pilots. The pilot on urban ecosystems reviewed the indicator framework for condition. During a special session of the workshop in Malta, EnRoute contributed to Urban pilot by identifying the links between ecosystem condition, ecosystem services, pressures on ecosystems and policy actions.

Urban ecosystems are considered in a good condition if the living conditions for humans and urban biodiversity are good (Maes et al. 2016). This means, among others, a good quality of air and water, a sustainable supply of ecosystem services, species and habitats of Community interest in good conservation status and a high level of urban species diversity.

A list with indicators for measuring pressures on urban ecosystems and for assessing urban ecosystem condition is made available in the 5th MAES report.

Figure 17 presents a synthesis of the different links between pressures, condition and ecosystem services in an urban ecosystem. It contains the 4 main components of the conceptual framework but this time they are put next to each other.

Different relations between pressures and condition emerge. Land take has an impact on all the indicators. Conversion of land into artificial areas is a pressure on all terrestrial ecosystem types but also within the boundaries of cities it affects the average urban temperature, noise levels, air quality or the amount of urban green space. Air and water pollution have more specific impacts whereas noise and the introduction of alien species have a one to one relationship with noise levels and species diversity, respectively.

Ecosystem condition is strongly connected to the delivery of various urban ecosystem services. Consider for example urban temperature which is a key parameter for many ecological processes and thus also for the provision of ecosystem services. The same can be said for the percentage of urban green space which may be the single most important determinant for urban ecosystem services.

Urban ecosystem services enhance human wellbeing and can thus be connected to different policy objectives. The box on the right hand side contains examples of such policy objectives and is not exhaustive. Figure 17 (lower part) shows only the nodes and links if the policy objective is to reduce the impact of heat waves.

In summer cities are warmer than the surrounding peri-urban or rural areas. This is known as the urban heat island effect. In particular during heat waves this can lead to thermal discomfort among the population or worse, serious health impacts and increased mortality. Many cities have therefore a policy and targets to reduce maximum summer temperature.

Clearly, a policy on urban temperature needs to encompass actions with respect to human health, prevention of impacts, and a focus on vulnerable groups but the present indicator framework can help identify how ecosystems can help reduce the impact of heath waves in cities. Enhancing local climate regulation in cities is a key component of such an action plan. Trees and shrubs have a cooling impact on the surrounding neighborhood by providing shade and by evaporating ground water. Monitoring urban temperature, soil sealing, the percentage and composition of urban green space and the rate of land take at the cost of ecosystems with a cooling capacity are key indicator to inform decision making.

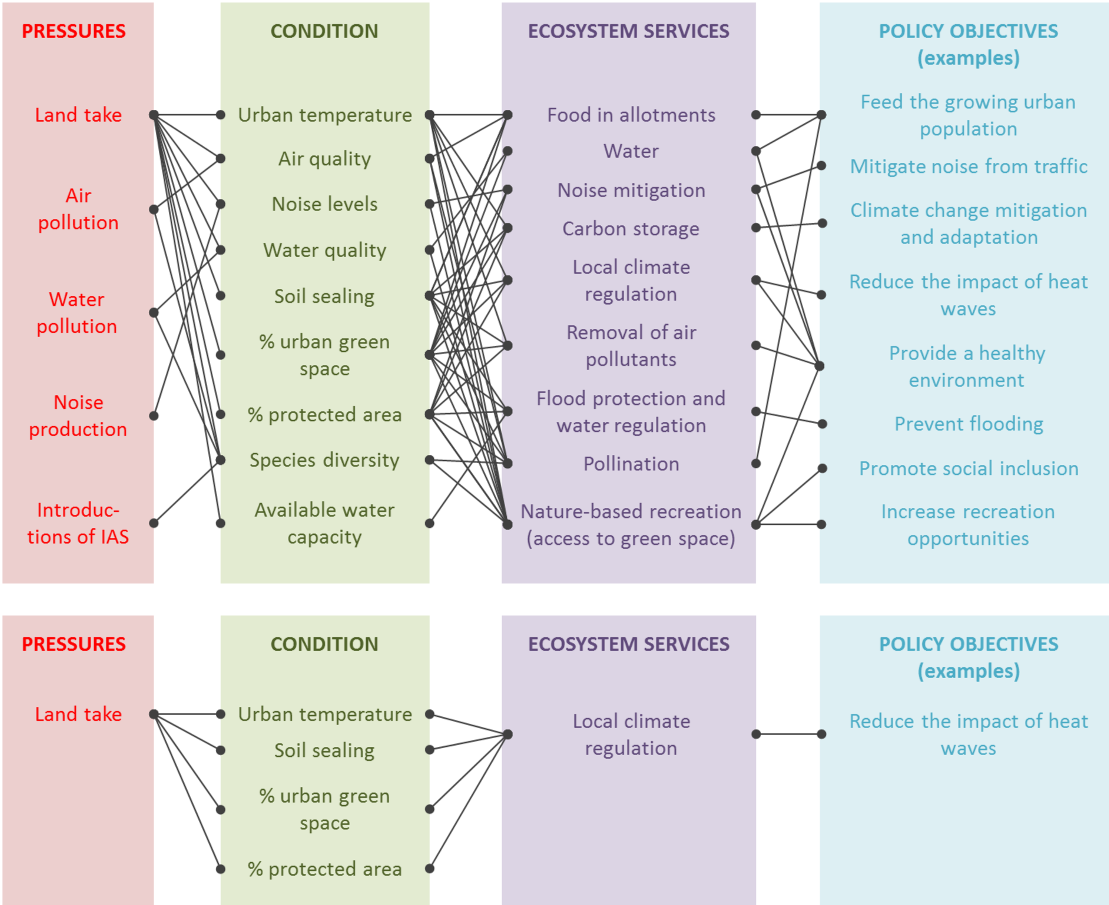


Figure 17: Synthesis of the links between pressures, condition and ecosystem services in urban ecosystems and extract for reducing the impact of heat waves

The example shows that the analytical indicator framework can be used to (1) put the actions and policy options in an ecosystem perspective; (2) to measure the different factors that increase or limit outdoor activities; (3) to assess the present situation and see where actions can be taken to increase outdoors activities (this usually requires other, locally collected data); (4) link ecosystem based approaches to other policies of the city.

5. Contribution of EnRoute to the impact evaluation framework for nature-based solutions

5.1. Linking the MAES indicator framework for urban ecosystems with the impact evaluation framework for nature-based solutions (IEF-NBS)

Enroute organized a meeting for project partners in Tallinn, Estonia, on 24 October 2017. The meeting was organised as a side event of a larger conference on Nature-based solutions, under the Estonian presidency of the EU.

During the morning session of the side event EnRoute partners connected the MAES indicator framework for urban ecosystems and the impact evaluation framework for nature-based solutions (IEF-NBS). EKLIPSE, a H2020 project, has delivered a set of indicators that can be used to monitor how nature based solutions address different societal challenges (NBS-IEF or nature-based solutions - impact evaluation framework). The MAES urban ecosystems indicator framework is designed to measure the condition of and services delivered by urban ecosystems. Both indicator frameworks overlap partially, in particular for those challenges where nature-based solutions depend on ecosystem services (table 1).

Importantly, EnRoute tests the applicability of the MAES indicator framework at EU scale and in 20 cities across Europe. One of the project results will be a list with scalable indicators which allow assessing the performance of cities (in terms of urban ecosystem condition and ecosystem services) across and within scale and a set of methods and protocols to quantify indicators.

The task force on "NBS Impact Evaluation Framework version 2.0" will update the NBS-IEF with the aim to deliver a set of core indicators so that

- As many societal challenges as possible are addressed by the H2020 projects
- At least 1 – 2 indicators per challenge are common between all H2020 projects
- For each indicator there is a set of common protocols and / or standards are used to allow meta level analyses
- There is consistency with the MAES indicator framework for ecosystem condition and ecosystem services and with sustainable development goals.

At the meeting we crosslinked the MAES and NBS-IEF indicator frameworks by addressing the following questions:

- Which indicators for urban ecosystem condition and urban ecosystem services are relevant to measure impact of NBS with respect to the different societal challenges?
- Which EnRoute cities can share expertise (protocols to measure the indicators) or experiences where the indicators were used to inform policies/planning or management options.

5.2. Main outcomes and messages for the task force

EnRoute notes that the 10 challenges identified by the impact evaluation framework for nature-based solutions (IEF-NBS) do not make biodiversity figuring prominently as the underlying and required enabling framework for nature-based solutions. The role of biodiversity to sustain NSB should be kept in mind and communicated appropriately.

It also notes that those challenges refer to both ecosystem services and the associated benefits or values. Tackling challenges 1 to 5 are to some extent dependent on enhancing natural capital and ecosystem services whereas challenges 6 to 10 relate to benefits derived from other forms of capital. Indicators for challenges 1 to 5 could be typically indicators that measure the supply side of ecosystem services (the potential or capacity to generate services). Indicators for challenges 6 to 10 relate to the demand side of ecosystem services (what do people want from ecosystems).

➔ EnRoute suggests selecting, where possible, indicators which measure a combination of supply (challenges 1-5) and demand of ecosystem services (challenges 6-10). Such indicators address multiple challenges and are easy to communicate. They are scalable and can thus measure impact from very local to continental scale. Examples of such indicators are (including challenges):

- Share of the population with access to green space within (e.g.) 250 m (%) (challenge 4, 8, 9)
- Share of population connected to urban waste water treatment (%) (challenge 2, 8, 9)
- Share of population with access to public areas of high quality recreation opportunities (%) (Challenge 4, 8, 9)
- Public green space suitable for pollinators (ha or %) (challenge 4)
- Share of population profiting from cooling by urban vegetation (%) (challenge 1, 5, 8, 9)
- Number of properties removed from flood risk (number) (Challenge 1, 2, 9)

➔ Indicators which include population (e.g. people exposed to particular levels of air quality, equal access to urban green, different age groups benefiting from cooling or flood protection) can support challenge 8, in particular if more detailed socio-economic data is available so that the vulnerability of different population groups can be assessed.

➔ EnRoute will also provide indicators which measure only the supply of ecosystem services by urban ecosystems and will make available the protocols to measure these indicators. A list with indicators per crosslinking challenges with the MAES indicator framework is available as excel file.

➔ EU Directives on air quality, water quality, floods, noise, and nature can be used for strategic planning to support nature-based solutions; they also provide indicator frameworks and hooks to policy use.

Table 4: Cross linking the NBS-IEF and the MAES analytical framework for mapping and assessing urban ecosystem condition and urban ecosystem services.

List with the societal challenges for NBS projects	**MAES indicator framework for urban ecosystems (Main classification for ecosystem services and ecosystem condition)**	
1) Climate mitigation and adaptation; 2) Water management; 3) Coastal resilience; 4) Green space management (including enhancing/conserving urban biodiversity); 5) Air/ambient quality; 6) Urban regeneration; 7) Participatory planning and governance; 8) Social justice and social cohesion; 9) Public health and well-being; 10) Potential for new economic opportunities and green jobs.	Provisioning ecosystem services	Vegetables produced by urban allotments and in and the commuting zone
		Surface water for drinking
		Ground water for drinking
		Surface water for non-drinking purposes
		Ground water for non-drinking purposes
	Regulating ecosystem services	Regulation of air quality by urban trees and forests
		Climate regulation by reduction of CO_2
		Urban temperature regulation
		Noise mitigated by urban vegetation
		Water flow regulation and run off mitigation
		Flood control
		Insect pollination
	Cultural ecosystem services	Recreation (+ accessibility to green space)
		Education (+ accessibility to green space)
		Heritage, cultural
		Others
	Pressure indicators of urban ecosystems	Urban sprawl
		Air pollution
		Temperature
		Noise pollution
		Water pollution
	State indicators of urban ecosystems (build and green infrastructure)	Population density
		Land use and land use intensity
		Road density
		Urban forest pattern
		Tree health and damage
		Connectivity of urban green infrastructure
	State indicators related to the ratio between green and build infrastructure	Land use (proportion)
	Indicators of urban biodiversity	Species diversity
		Conservation
		Introductions

6. How EnRoute is developing the Science Policy Interface

Scientific information can play a positive informing role in the development of policies. The implementation of scientific knowledge in (local) policies is, however, not always perfect. EnRoute is all about this implementation. It wants to test-case the use of scientific information about the supply and demand of ecosystem services by local policymakers. The collaboration between scientists and policymakers is often referred to as the science policy interface (SPI). The presumption is that a good functioning SPI results in a good implementation of scientific information in policies.

The SPI task of EnRoute is meant to further research this, in order to explore/examine how science is used in policy/planning and how, potentially, it could inform policy/planning in operational terms. It also wants to examine the potential of urban GI as a catalyst for engagement in increasing urban resilience in a number of contexts (within communities and organizations) in different urban socio-economic, climatic and cultural settings through an online-survey, workshops and trainings; next to this it is relevant to know how urban policy on GI at different governance levels are mutually reinforcing.

This brings us to the following questions:

- How can MAES-related research play a role from a multi-scale point of view?
- What is the added value of an UGI-policy at a higher policy level (regional, national, EU) in addition to the local level (city, municipality)?
- What do local policy makers need from higher policy-levels?
- How can science help policy?

6.1. Exploring (or understanding) the science policy interaction

In 2017 we focussed on question: 'How can science help policy? Valentina Vodopivec and Yvon the Vries, master students of the Athena Institute VU-Amsterdam, did a literature study, followed by a workshop with the EnRoute community, and a series of interviews. Their aim was to investigate how the MAES framework and knowledge base could be successfully implemented in the policy context, challenges and city planning.

To research this the following research questions were formulated:

- What are the key internal and external contextual factors that have a differential influence on decision-makers in urban planning?
- How do these factors support or obstruct the integration of scientific evidence on urban green infrastructure benefits into urban policy and planning?
- What changes in the SPI have the potential to increase the likelihood of urban GI implementation?

The research was based on a reflective and adaptive research approach and embedded multiple case study design. Data was gathered through a participatory expert workshop (EnRoute, Rome, March 2017), and ten semi-structured interviews with city planners and policy makers. Results were analysed and interpreted based on a conceptual framework for consideration of evidence in decision-making contexts, in development of policy recommendations (Dobrow et. al., 2006). The essence of this framework is that the validity of evidence is context specific. It distinguishes between the internal context (within the governmental organization) and the external context.

The aim of the participatory expert workshop was for the participants to reflect on their roles and needs in the process of science-supported policy-making. It was concluded that the participants played their role as might be expected in a good SPI. Policymakers mainly focused on describing the type and format of evidence they needed to support their decision-making and the influencing of other stakeholders to approve policy plans. Scientists focused on the provision of quality scientific data and terminology that would be understandable to policy-makers. They did however express their struggles to cope with the fluidity and complexity of the policy arena.

This led to the conclusion that the reason for suboptimal urban GI implementation might not originate in the lack of scientific evidence, or the inability of policymakers to understand it (as previously hypothesized). Participating policy-makers and advisors explicitly stated they do not have trouble getting scientific information, and that they do not need it to be overly simplified. However, the scientific information that they need should not only support their own information needs, but should also inform the other internal and external stakeholders. Based on this insight the research further focused onto the characteristics of the broader policy decision-making context, as this defines the type of evidence that is needed.

To further investigate this 10 semi-structured interviews were conducted amongst policymakers at local and regional and provincial level. These interviews confirmed the conclusions mentioned above. The interviews also produced an insight in the aspects that were relevant in the different policy contexts. At the local level the interviewees focused mainly on implementation, environmental quality and social cohesion. And obviously for local policymakers the implementation of goals and guidelines delegated by higher governmental levels is very relevant.

All participants highlighted the importance of having as much local evidence as possible. Several of them mentioned the problem of actual outcomes of NBS implementation to be very unpredictable. Thus, given time and resource constraints, there is often a preference for research projects that aim at answering context-specific questions. More general evidence gathered from databases, is seen as much less relevant and informative. In general, the policymaker attempts to lower the level of uncertainty regarding the actual effects of the planned approach by conducting studies and experiments within the local environment.

General conclusions:

- There’s much more to influence municipal sustainability policies than scientific knowledge. Empirical data represents only one of the elements the decision-makers have to consider between a wide variety of information and stakeholders’ input.
- One of the most influential factors seems to be public support. This can be influenced through education and marketing. In order to achieve the objectives of the EnRoute project (or NBS in general), more attention and financial resources could be allocated to inform the public on a local municipal level.

6.2. Development of an on-line survey to deepen our understanding on science policy interface on urban green infrastructure

In 2018 we will further challenge the conclusions of section 6.1 using an online survey. The survey is under development and expected to be ready for testing early January 2018. The survey is designed as follows:

- Sampling: we will conduct an explorative research, researchers and urban planners will be invited using the project network.
- Data collection method: we will open a web self-administered questionnaire through the EUSurvey platform.
- Structure of the questionnaire: the survey has 2 sections, one for researchers and one for policy makers

The structure of the survey is based on the URBACT Guide (2016) and the work described in Felson et (2016). It is organized in seven parts. Whereas the first four describe the policy action cycle, the fifth the application of scientific outcome and the last two analyse the background of the policy action as well as the participants.

1) Initial contact

a) Science section: asks about the initiative of the first contact and the awareness of scientists about their role as information provider. First obstacles are also figured out.

b) Policy section: participants are filtered based on their experience of urban green infrastructure and SPI projects. If there is no experience, obstacles are figured out. It also asks about the initiative of the first contact and the knowledge scientists had, to prepare information.

2) Contract and framework defining

The second section analyses the scope of the scientific involvement defining the policy action plan, scientific activities and expected outcomes.

3) Consultation and design clarification

The third section shows how strong the scientific impact is and what type of actions were covered by the scientific part. Asking about the realized partnerships gives a hint about the long-term effect the SPI might have and the freedom scientists had in collaboration and extend of work.

4) Post-processing

The last section out of the policy action cycle shows if scientist were also included into long-term actions and hence effects.

5) Assessment

This section refers to the SPI in terms of including the specific scientific outcomes into a policy action plan.

6) SPI functions

To understand the dimension, complexity and possible obstacles it is very important to understand the SPI structure behind.

7) Personal background

Often success of a project refers to the person itself. So the final section figures the relationship between scientists and policy maker out as well as the person's amount of experience.

The survey addresses both scientists and policy makers. Participants have to indicate whether they are affiliated to research or to policy after which a separate path will be followed. Figure 18 presents the flow of questions for the scientists while the questions are presented in Table 5. Figure 19 presents the flow of questions for the scientists while the questions are presented in Table 6.

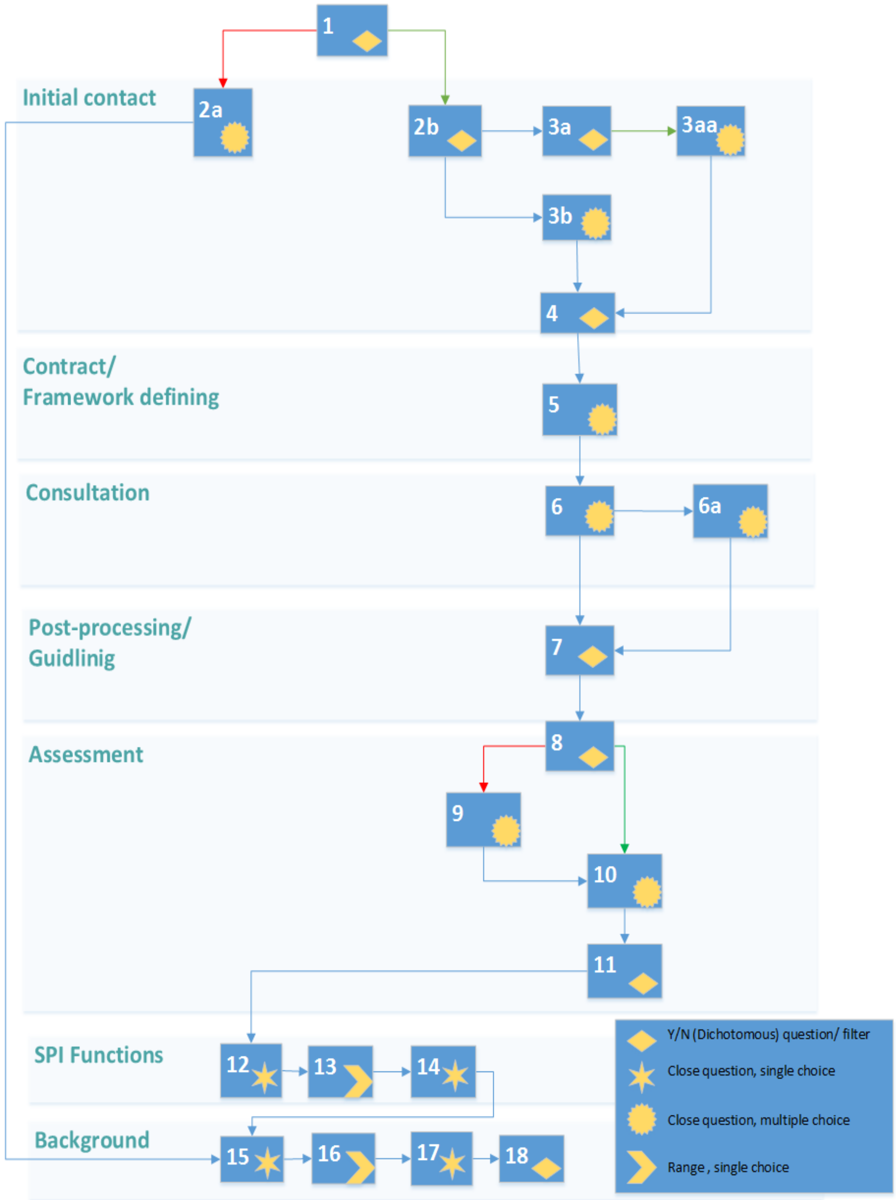


Figure 18: Flowchart of the questions for scientists participating to the survey

Table 5: Proposal for a list of questions for the science-policy section.

Questions of the science part
Q1- Did you ever provide scientific support to an urban green infrastructure project
Q2a-What was the reason why you could not participate in an urban green infrastructure project? I had no opportunity I did not find a contact a person There was no interest from the policy side I have no convincing show case My topic was not relevant for policy I have no knowledge about how to enter or to start a policy action I am not working on urban green Other
Q2b) Think about your last experience of an urban green infrastructure project: Who started the contact between you and the policy? - Me, a colleague, or another scientists from the research institute - A policy maker
3a) If policy makers: **The policy maker asked me…** - To provide information - To give scientific advice - To point out arguments to justify the green urban infrastructure project - To calculate possible costs - To understand if there is sufficient support amongst citizens for the urban green infrastructure project -For advice to upscale experience about green infrastructure pro-jects to regional or national level - Other
3b) If science: **How did you get in contact with the policy?** - I talked to a policy maker about a possible project during an occasion or event *e.g (….)?* - I went to a policy maker with an interesting proposal - My observation or a research finding about green infra-structure in cities triggered the attention of a policy maker - other
3aa) Did the policy maker articulate clearly for what need, reason or purpose he needed your support?
4) Was the urban green infrastructure project based on a scientific proposal? **- Yes** **- No** **- I don't know**
5) Did a policy maker or the city administration involve scientists in the project proposal of the urban green infrastructure project? - Yes, scientists helped define the time frame - Yes, scientists proposed a budget - Yes, scientists suggested specific objectives - Yes, scientists identified possible solutions and outcomes -Yes, scientists gave scientific information - No, scientists was not involved in the project proposal
6) Now, think about the actual implementation of the green infrastructure project: Have scientists been involved in: - They made an own scientific study *(e.g. for instance to understand the impact of the green infrastructure plan or project on the wellbeing of citizens; or they monitored the trend of bird species in an new park*) - They provided scientific information - They created contact with other scientific organizations - They created contact with other non-scientific organizations (NGO) - They helped to bring scientific information into practice - They helped clarifying the project design - Scientists were not involved in the actual implementation

6a) If providing Information: In which form did you provide the information? -Examples -Report -Scientific article -Website -Presentation -Policy brief -Social media -Other
7)Now, think about the end of the green infrastructure project: How have been scientists involved: - Scientists monitored the impact of the project (*e.g. on Biodiversity, ecosystem services, human well-being etc.*) - Scientists helped in the project evaluation - No scientists were involved
8) Were the scientific results used for a final policy output (***e.g. guidelines, recommendation, action plan, or further green infrastructure projects***) - Yes - No
9) What was the reason not to use scientific results? - The scientific output was to specific - The scientific data were too poor - The research needed more time then was available - The relevance of research outcomes was not enough - The scientific results did not match the expectations (e.g. an impact is expected but could not be shown) - The communication of the outcomes was insufficient - Institutional regulations, laws, old practices prevent changes - There was a political change (e.g. following elections) - Political motives prevent changes (e.g. sensitive outcome. Fear for loosing elections) - Institutional regulations, laws, old practices prevent changes - The scientific results did not match the expectations (e.g. an impact is expected but could not be shown)
10) If any, where did you face problems? - The communication with the policy maker was sometimes difficult - The topic of green infrastructure is to complex - There were difficulties with the political procedure - Other
11) After finishing the urban green infrastructure project, do you still have contact with the policy maker who were involved? **- Yes** **- No**
12) What governance level was the research activity connected -Neighborhood - City - Regional - National - Supranational
13) How many stakeholders were involved in the urban green infrastructure project? Less than 5 5-15 More than 15
14) The urban green infrastructure project was -long-term (more than 1 year) - short-term (less than 1 years)
15) What is your position? - PhD - Scientific staff - Project leader

- Professor - Head of Department - Other
16) For how many years have you been working in this field Up to 3 - 3-10 More than 10
17) How frequently do you have contact to scientists? - Weekly, - Monthly - Several times a year - Once a year or less - Never
18) Where you involved in a green infrastructure project before??

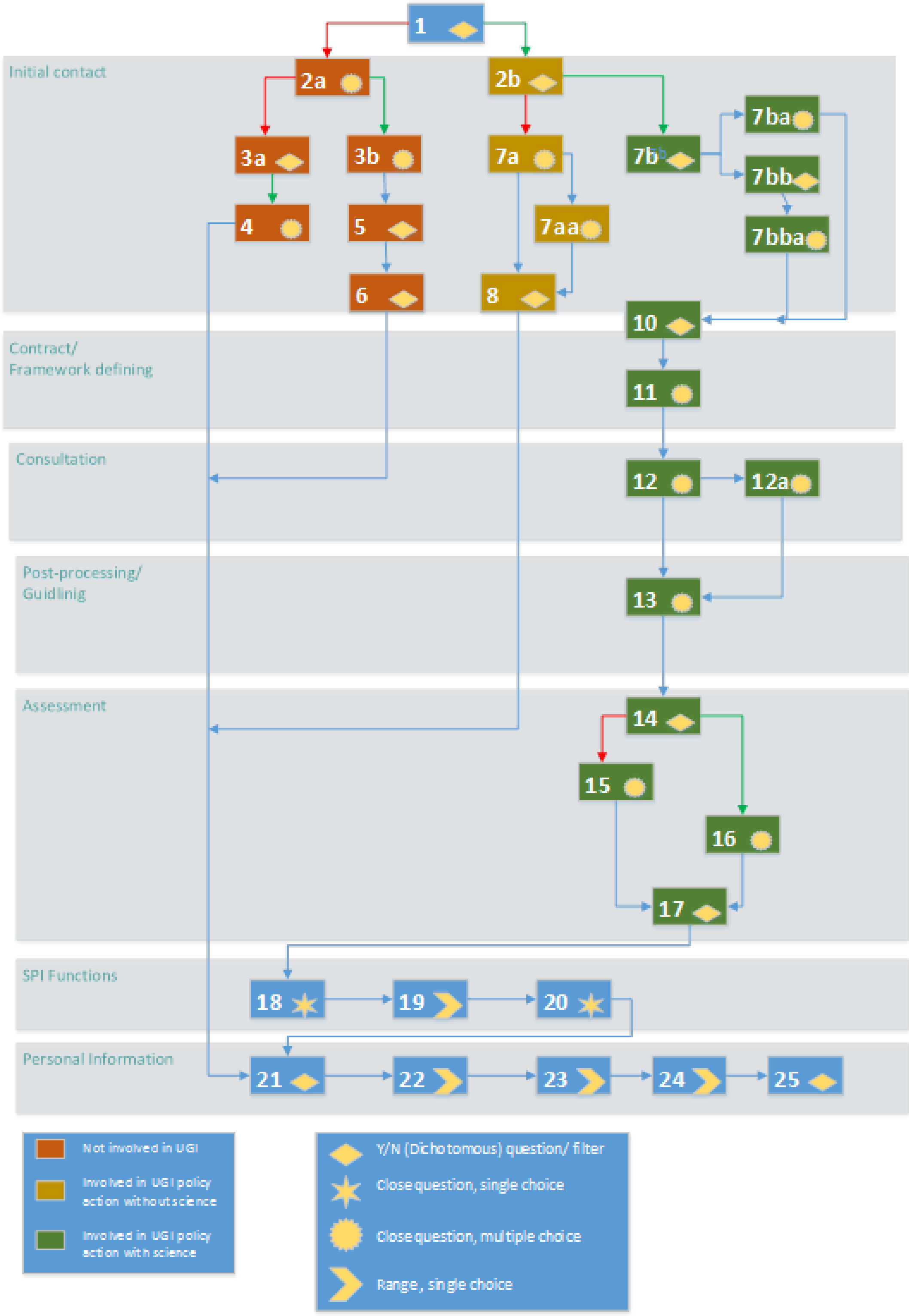


Figure 19: Flowchart of the questions for policy makers participating to the survey

Table 5: List of questions for the policy-science section.

The colors represent the following possibilities (see also Figure 19**Error! Reference source not found.**) - Not involved into UGI - Involved in UGI but without science - Involved in UGI with scientific support
Questions of the policy part
1) Have you ever been involved in an urban green infrastructure project?
2a) Did you know that urban green infrastructure helps amongst others in: - Water management - Cooling the city during hot summer days - Human well being
3a) Would you be interested in a collaboration with scientists to work on urban green infrastructure?
3b) How did you find information about urban green infrastructure? - My Colleagues told me - I attended a presentation given by scientists(on a workshop, a conference or a seminar) - From scientists in policy advisory committees - I read a policy brief (of one page or less) - I read a review article (of several pages) - I read scientific articles
4) What information about urban green infrastructure could be helpful for you? - Information coming from different experts panels - A briefing made by other colleagues - A scientific presentation (on a workshop, a conference, or a seminar) - Participation of scientists in policy advisory committees - In a summary policy brief (one page or less) - A review article (several pages) - A scientific article - Other
2b) Think about your last experience of a green infrastructure project: **Were there any scientists involved in this project?**
7a) Who informed you about the important role of green infrastructure in cities? - My direct colleagues - Policy makers in my country - Policy makers from other countries - Policy makers from international organizations (e.g. the European Union or United Nations) - People from non-governmental organizations (NGOs) - Scientists - My own experience from the project - None of them
7aa) if ticked scientific information: Where did you find scientific information about the benefits and advantages of urban green infrastructure? - In a policy brief - In a scientific presentation (on a workshop, a conference, or a seminar) - From scientists in policy advisory committees - In a summary policy brief (one page or less) - In a review article (several pages) - In a scientific article - None of them
8) Have been other people involved in the urban green infrastructure project who made scientific information better understandable for you? - Yes, people from an environmental consultancy - Yes, people from a non-governmental organization (NGO) - Yes, other - No, nobody
7b) **Who started the contact between you and scientists?**

- Me, a Colleague or a policy maker of the municipality did
- A scientist (from a university or research institute) did

7ba) If science:
How did you get in contact?
- I talked to a scientists about a possible project during an occasion or event *e.g (….)?*
- A scientist came to me with an interesting proposal
- An observation or a research finding about green infrastructure in cities triggered my attention
- None of them

7bb) If policy started contact:
Why did you or your colleagues start the contact to the scientist?
- We were looking for more information
- We wanted scientific advice
- We needed arguments for justifying a project
- We wanted to understand possible costs
- We wanted to understand if there is sufficient support among citizens for the urban green infrastructure project
- We wanted advice to upscale experience about green infrastructure projects to regional or national level
- Other reasons

7bba) During your or your colleagues contact to the scientist, did you told the scientist what the specific need, reason or purpose of their given information in the policy is or for what you used the information?

10) Was the green infrastructure project based on a scientific study?
- Yes
- No

11) Were scientists involved in the project proposal?
- Yes, they helped define the time frame
- Yes, they proposed a budget
- Yes, they suggested specific objectives
- Yes, they identified possible solutions and outcomes
-Yes, they gave scientific information
- No, scientists were not involved in the project proposal

12) Now, think about the actual implementation of the green infrastructure project: How have been scientists involved?
- They made an own scientific study (*e.g. for instance to understand the impact of the green infrastructure plan or project on the wellbeing of citizens; or they monitored the trend of bird species in an new park*)
- They provided scientific information
- They created contact with other scientific organizations
- They created contact with other non-scientific organizations (NGO)
- They helped to bring scientific information into practice
- They helped clarifying the project design
- Scientists were not involved in the actual implementation

12a) If providing Information:
In which form did you receive information?
-Examples and case studies of other projects
-Report
-Scientific article
-Website
-Presentation
-Policy brief
-Social media
-Other

13) Now, think about the end of the green infrastructure project: How have been scientists involved
- Scientists monitored the impact of the project (*e.g. on Biodiversity, ecosystem services, human well-being etc.*)
- Scientists helped in the project evaluation
- Scientists were not involved

14) Were the scientific results scientific advice used for a final policy output (*e.g. guidelines, recommendation, action plan, or further green infrastructure projects***)**

15) What was the reason not to use scientific results? - The scientific output was to specific - The scientific data were too poor - The research needed more time then was available - The relevance of research outcomes was not enough - The scientific results did not match the expectations (*e.g. an impact is expected but could not be shown*) - The communication of the outcomes was insufficient - Institutional regulations, laws, old practices prevent changes - There was a political change (*e.g. following elections*) - Political motives prevent changes (*e.g. sensitive outcome. Fear for loosing elections)* - Institutional regulations, laws, old practices prevent changes - The scientific results did not match the expectations (e.g. an impact is expected but could not be shown)
16) If any, where did you face problems? - The communication with scientists was sometimes difficult - I did not always understand the scientific terminology - The topic of green infrastructure is to complex - The scientists did not understand the political procedure - I did not face any problems
17) After finishing the urban green infrastructure project, do you still have contact with the scientists who were involved?
18) What governance level was the urban green infrastructure project involved in? - Neighborhood - City - Regional - National - Supranational (e.g. European Union, United Nations)
19) How many stakeholders were involved in the urban green infrastructure project? Less than 5 5-15 More than 15
20) The urban green infrastructure project was -long-term (more than a year) - short-term (less than a year)
21) For which governance level are you working? - City - Regional - National - Supranational
22) How many years are you working in this field - up to 3 - 3-10 - more than 10
23) How frequently do you use scientific information? - Weekly, - Monthly - Several times a year - Once a year or less -Never
24) How frequently do you have contact to scientists? - Weekly, - Monthly - Several times a year - Once a year or less -Never
25) Where you involved in a green infrastructure project before?

7.EnRoute networking activities

7.1. EnRoute workshops

In 2017 EnRoute organized three workshops (Rome, Valetta, Tallin), and a conference (back to back with the meeting in Valetta).

We started in Rome where we had a kick-off meeting. Some 50 participants of cities and scientific organizations discussed the desired results of the EnRoute. The aim of this kick-off workshop was to present the overall structure of the EnRoute project, to discuss the contribution of city experts, to consider a common work program for a cross-scale urban ecosystem assessment and to work on the build of community sense between the participants in EnRoute.

During the workshop the EnRoute project was introduced to the participants, and it was framed in its policy context. The three lines of the project were introduced and the participants worked on the development of shared goals and a common work plan for a cross scale urban ecosystem assessment. The participants also shared what their skills and knowledge (Annex 10). With this information they can more easily connect to the right person in the community when confronted with a question or challenge.

At the meeting in Rome a network of involved cities and scientific institutions emerged that worked closely together in 2017 and will continue to do so in 2018. To further develop this network EnRoute organized a conference in Valletta in June 2017, back to back with a meeting of the EnRoute community.

The one-day conference 'Evidence-based planning for greener cities' (June 2017) at the Institute of Applied Sciences of the Malta College of Arts, Science and Technology was organized in collaboration with the Maltese presidency of the EU and brought together circa 70 scientists and policymakers. The conference opened with a policy session on the role, challenges and opportunities of urban green infrastructure to improve the quality of life for European citizens. Representatives from the city of Lyon, the Maltese Planning Authority, the European Commission dg Environment, and the Institute for applied sciences presented their views on the importance of green infrastructure for urban challenges. Commissioner for Environment, Maritime Affairs and Fisheries Mr. Karmenu Vella in a video message stressed the need for a better understanding of urban ecosystem services to make informed decisions.

This session was followed by a series of presentations that showed local and international examples of how urban green infrastructure can be included in the urban planning process. Showcases involved recreation, health, climate change adaptation, and biodiversity. In the afternoon 3 parallel sessions were organized. One regarding the science policy interface on urban green infrastructure, one regarding spatial management based on serious gaming, and one regarding the use of data and tools for planning of urban GI and urban ecosystem services. The conference was closed by mr vd. Berk of the network organization 'The Green City'. The Green City is established by sme's that work in the field of city-green (development and maintenance). Their aim is to intensify the use of green infrastructure to face urban challenges of the future (http://thegreencity.com).

Following this one day conference the next day the EnRoute community further worked on various aspects of the mapping and assessing of ecosystem services in the urban context. Amongst others a frame was discussed to assess the condition of urban ecosystems and a discussion was held on how to further develop the EnRoute network. Next to that we discussed the deliverables that the citylabs are supposed to deliver. A more detailed report of the conference in Valetta may be found in Annex 8.

The focus of the workshop in Tallin was on the connection of EnRoute to the Nature Based Solutions projects. EnRoute was presented in the plenary session of the first day of a conference regarding the NBS projects of H2020, see Figure 21. Next to this we discussed how EnRoute can contribute to the science, practice and policy of NBS. We concluded that there are many ways to do so: (1) by providing scientific knowledge of how urban ecosystems can support urban planning; (2) by delivering guidance on the creation, management and governance of urban green infrastructure; (3) by promoting collaboration between scientists and policy makers.

Next to this connection to the NBS-projects the EnRoute community also worked on their own tasks in the EnRoute project. Each city lab presented a poster that highlighted their main policy question, the set of indicators used to address this question, and the methods used to quantify the indicators. They looked together at synergies by exploring how they can help each other in achieving the goals of the EnRoute project. The city-labs concluded that they were ready to proceed with their work for EnRoute. A more detailed report of the workshop in Tallin may be found in Annex 9.

7.2. EnRoute workshops in 2018: outlook

EnRoute plans two more workshops in 2018. A first meeting is scheduled on 24 and 25 April 2018 in Sofia, Bulgaria[8]. The first day of the meeting will be dedicated to urban biodiversity. If we think about nature conservation or increasing essential ecosystem services we usually think of protected areas, conserving valuable ecosystems such as forest and wetlands, or maintaining rural landscapes. But can cities also help achieve biodiversity goals and targets? This largely depends on the amount, the quality and management of urban green infrastructure. However, the potential of cities to help protect biodiversity and ecosystem services is likely underestimated. This EnRoute conference aims to deliver a set of key messages and principles on how cities can contribute to regional, national and European biodiversity policy, goals and targets. The second day will be an EnRoute workshop to measure progress of the project.

The final EnRoute workshop will be held in Brussels. This workshop will bring together EnRoute cities and stakeholders from the Commission and aims to demonstrate how urban green infrastructure can be mainstreamed into EU policies.

7.3. Networking activities

[8] https://ec.europa.eu/jrc/en/event/conference/biodiver-city

OPPLA: EnRoute has a dedicated page on OPPLA[9]. Oppla is a new knowledge marketplace; a place where the latest thinking on ecosystem services, natural capital and nature-based solutions is brought together. EnRoute communicates on OPPLA about its activities and workshops. It will also use OPPLA to disseminate the main project deliverables such as case study fact sheets of the city labs.

Horizon 2020. EnRoute is closely connected to several H2020 projects on nature-based solutions. It actively contributes to the task force on indicators and helps develop an updated version of the impact assessment framework for nature-based solutions.

EU urban agenda. Under the EU urban agenda there is a special partnership on sustainable land use and nature based solutions. Through the JRC and DG ENV, EnRoute can provide valuable input into this partnership. Key issues for the partnership are redeveloping brownfield and underutilized areas in cities and promoting nature-based solutions. EnRoute can contribute to the Action plan for the partnership by suggesting a number of actions for better regulation, better knowledge and better financing of sustainable land use and nature based solutions in cities.

7.4. Options for maintaining a network of interested cities after EnRoute

EnRoute could lay a fundament for a more persisting network of cities on urban green infrastructure. Three useful options are available and will be explored over the course of 2018. We will contact the Covenant of Mayors, EuroCities and ICLEI to see if there are opportunities to create a network of cities on urban GI and nature-based solutions.

[9] https://oppla.eu/enroute

Annexes

The following Annexes area available on CIRCA BC: https://circabc.europa.eu/w/browse/d26e3ff7-a37a-44a3-b91a-806444142b7f

- Annex 1 (a-b-c): Presentations given by Grazia Zulian (JRC) during the EnRoute workshops held in Rome, Valletta and Tallin. The presentations contain the instructions for the city labs.
- Annex 2: The collection of posters presented in Rome and Tallin.
- Annex 3: Original deliverables (D1 and D2) prepared from the city labs experts.
- Annex 4: Table with the indicators extracted from the deliverables
- Annex 5: Presentation given by Chiara Cortinovis (the city lab of Trento) at the IUFRO 8.01.02 Landscape Ecology Conference 2017 The Green-Blue Nexus: Forests, Landscapes and Services 24 - 29 September 2017 Halle Germany.
- Annex 6: City lab Dublin. Local workshop and stakeholders' consultation report
- Annex 7: Detailed list of data available to map condition and ecosystem services.
- Annex 8: Report of the conference in Valetta
- Annex 9: Report of the workshop in Tallin
- Annex 10: Outcomes of the Market place of EnRoute partners at the EnRoute meeting in Rome, March 2017

References

Albert C, Aronson J, Fürst C, Opdam P (2014) Integrating ecosystem services in landscape planning: requirements, approaches, and impacts. Landsc Ecol 29(8): 1277–1285. doi: 10.1007/s10980-014-0085-0

Baldock KCR, Goddard MA, Hicks DM, Kunin WE, Mitschunas N, Osgathorpe LM, Potts SG, Robertson KM, Scott A V, Stone GN, Vaughan IP, Memmott J (2015) Where is the UK's pollinator biodiversity? The importance of urban areas for flower-visiting insects.

Beelen R, Hoek G, Pebesma E, Vienneau D, de Hoogh K, Briggs DJ (2009) Mapping of background air pollution at a fine spatial scale across the European Union. Sci Total Environ 407: 1852–1867. doi: http://dx.doi.org/10.1016/j.scitotenv.2008.11.048

Beninde J, Veith M, Hochkirch A (2015) Biodiversity in cities needs space: a meta-analysis of factors determining intra-urban biodiversity variation. Ecol Lett 18(6): 581–592. doi: 10.1111/ele.12427

Bolund P, Hunhammar S (1999) Ecosystem services in urban areas. Ecol Econ 29: 293–301. doi: http://dx.doi.org/10.1016/S0921-8009(99)00013-0

Casalegno S, Bennie JJ, Inger R, Gaston KJ (2014) Regional Scale Prioritisation for Key Ecosystem Services, Renewable Energy Production and Urban Development. PLoS One 9(9): e107822.

Dittrich A, Seppelt R, Václavík T, Cord AF (2017) Integrating ecosystem service bundles and socio-environmental conditions – A national scale analysis from Germany. Ecosyst Serv 28(Part C): 273–282. doi: https://doi.org/10.1016/j.ecoser.2017.08.007

Du C, Ren H, Qin Q, Meng J, Zhao S (2015) A Practical Split-Window Algorithm for Estimating Land Surface Temperature from Landsat 8 Data. Remote Sens. 7:

Ferri S, Siragusa A, Sabo F, Pafi M, Halkia S (2017) The European Settlement Map 2017 Release; Methodology and output of the European Settlement Map (ESM2p5m).

Fuller RA, Gaston KJ (2009) The scaling of green space coverage in European cities. Biol Lett 5: 352–355.

Fusaro L, Marando F, Sebastiani A, Capotorti G, Blasi C, Copiz R, Congedo L, Munafò M, Ciancarella L, Manes F (2017) Mapping and Assessment of PM10 and O3 Removal by Woody Vegetation at Urban and Regional Level. Remote Sens. 9:

Haase D, Larondelle N, Andersson E, Artmann M, Borgström S, Breuste J, Gomez-Baggethun E, Gren Å, Hamstead Z, Hansen R, Kabisch N, Kremer P, Langemeyer J, Rall E, McPhearson T, Pauleit S, Qureshi S, Schwarz N, et al (2014) A Quantitative Review of Urban Ecosystem Service Assessments: Concepts, Models, and Implementation. Ambio 43(4): 413–433. doi: 10.1007/s13280-014-0504-0

Hall DM, Camilo GR, Tonietto RK, Ollerton J, Ahrné K, Arduser M, Ascher JS, Baldock KCR, Fowler R, Frankie G, Goulson D, Gunnarsson B, Hanley ME, Jackson JI, Langellotto G, Lowenstein D, Minor ES, Philpott SM, et al (2017) The city as a refuge for insect pollinators. Conserv Biol 31(1): 24–29. doi: 10.1111/cobi.12840

Kabisch N, Strohbach M, Haase D, Kronenberg J, Strohbach M, Haase D, Kronenberg J (2016) Urban green space availability in European cities. Ecol Indic 70: 586–596. doi: http://dx.doi.org/10.1016/j.ecolind.2016.02.029

La Notte A, Vallecillo S, Polce C, Zulian G, Maes J (2017) Implementing an EU system of accounting for ecosystems and their services. Initial proposals for the implementation of ecosystem services accounts (Report under phase 2 of the knowledge innovation project on an integrated system of natural capital and eco.

Larondelle N, Haase D (2013) Urban ecosystem services assessment along a rural–urban gradient: A cross-analysis of European cities. Ecol Indic 29: 179–190. doi: http://dx.doi.org/10.1016/j.ecolind.2012.12.022

Larondelle N, Haase D, Kabisch N (2014) Mapping the diversity of regulating ecosystem services in European cities. Glob Environ Chang 26: 119–129. doi: http://dx.doi.org/10.1016/j.gloenvcha.2014.04.008

Liquete C, Piroddi C, Macías D, Druon J-N, Zulian G (2016) Ecosystem services sustainability in the Mediterranean Sea: Assessment of status and trends using multiple modelling approaches. Sci Rep. doi: 10.1038/srep34162

Liquete C, Zulian G, Delgado I, Stips A, Maes J (2013) Assessment of coastal protection as an ecosystem service in Europe. Ecol Indic 30: 205–217. doi: http://dx.doi.org/10.1016/j.ecolind.2013.02.013

Madureira H, Andresen T (2014) Planning for multifunctional urban green infrastructures: Promises and challenges. URBAN Des Int 19(1): 38–49. doi: 10.1057/udi.2013.11

Maes, Zulian, G., Thijssen, M., Castell, C., Baró, F., Ferreira, A.M., Melo, J., Garrett, C.P., David, N., Alzetta, C., Geneletti, D., Cortinovis, C., Zwierzchowska, I., Louro Alves, F., Souto Cruz, C., Blasi, C., Alós Ortí, M.M., Attorre, F., Azzella, M. J, Union PO of the E, Resources S (2016) Mapping and Assessment of Ecosystems and their Services. Urban Ecosystems. Publications Office of the European Union, Luxembourg

Maes J., Fabrega N., Zulian G. BA, Vizcaino P., Ivits E., Polce C., Vandecasteele I. M, Rivero I., Guerra C., Perpiña Castillo C. VS, Baranzelli C., Barranco R. B e SF, Jacobs-Crisoni C., Trombetti M. LC (2015) Mapping and Assessment of Ecosystems and their Services: Trends in ecosystems and ecosystem services in the European Union between 2000 and 2010.

Nedkov S, Zhiyanski M, Dimitrov S, Borisova B, Popov A, Ihtimanski I, Yaneva R, Nikolov P, Bratanova-Doncheva S (2017) Mapping and assessment of urban ecosystem condition and services using integrated index of spatial structure. One Ecosyst 4(4): e14499.

Paracchini ML, Zulian G, Kopperoinen L, Maes J, Schägner JP, Termansen M, Zandersen M, Perez-Soba M, Scholefield PA, Bidoglio G (2014) Mapping cultural ecosystem services: A framework to assess the potential for outdoor recreation across the EU. Ecol Indic 45: 371–385. doi: 10.1016/j.ecolind.2014.04.018

Raudsepp-Hearne C, Peterson GD (2016) Scale and ecosystem services: how do observation, management, and analysis shift with scale;lessons from Quebec. Ecol Soc. doi: 10.5751/ES-08605-210316

Raymond, C.M., Berry, P., Breil, M., Nita, M.R., Kabisch, N., de Bel, M., Enzi V, Frantzeskaki, N., Geneletti, D., Cardinaletti, M., Lovinger, L., Basnou C, Monteiro, A., Robrecht, H., Sgrigna, G., Munari, L. Calfapietra C (2017) An Impact Evaluation Framework to Support Planning and Evaluation of Nature-based Solutions Projects. Report prepared by the EKLIPSE Expert Working Group on Nature-based Solutions to Promote Climate Resilience in Urban Areas.

Schröter M, Remme RP, Sumarga E, Barton DN, Hein L (2015) Lessons learned for spatial modelling of ecosystem services in support of ecosystem accounting. Ecosyst Serv 13: 64–69. doi: 10.1016/j.ecoser.2014.07.003

Skelhorn C, Lindley S, Levermore G (2014) The impact of vegetation types on air and surface temperatures in a temperate city: A fine scale assessment in Manchester, UK. Landsc Urban Plan 121: 129–140. doi: http://dx.doi.org/10.1016/j.landurbplan.2013.09.012

Smith P, Ashmore MR, Black HIJ, Burgess PJ, Evans CD, Quine TA, Thomson AM, Hicks K, Orr HG (2013) REVIEW: The role of ecosystems and their management in regulating climate, and soil, water and air quality. J Appl Ecol 50(4): 812–829. doi: 10.1111/1365-2664.12016

Stange EE, Zulian G, Rusch GM, Barton DN, Nowell M (2017) Ecosystem services mapping for municipal policy: ESTIMAP and zoning for urban beekeeping. One Ecosyst 2: e14014.

Vale DS, Saraiva M, Pereira M (2015) Active accessibility: A review of operational measures of walking and cycling accessibility.

Wegmann M, Leutner BF, Metz M, Neteler M, Dech S, Rocchini D (2017) r.pi: A grass gis package for semi-automatic spatial pattern analysis of remotely sensed land cover data. Methods Ecol Evol : n/a-n/a. doi: 10.1111/2041-210X.12827

Wesely ML, Hicks BB (2000) A review of the current status of knowledge on dry deposition. Atmos Environ 34(12–14): 2261–2282. doi: http://dx.doi.org/10.1016/S1352-2310(99)00467-7

Zulian G, Maes J, Paracchini M (2013a) Linking Land Cover Data and Crop Yields for Mapping and Assessment of Pollination Services in Europe. Land 2(3): 472–492. doi: 10.3390/land2030472

Zulian G, Paracchini M-L, Maes J, Liquete Garcia MDC (2013b) ESTIMAP: Ecosystem services mapping at European scale. European Commision

Zulian G, Stange E, Woods H, Carvalho L, Dick J, Andrews C, Baró F, Vizcaino P, Barton DN, Nowel M, Rusch GM, Autunes P, Fernandes J, Ferraz D, Ferreira dos Santos R, Aszalós R, Arany I, Czúcz B, et al (2017) Practical application of spatial ecosystem service models to aid decision support. Ecosyst Serv. doi: https://doi.org/10.1016/j.ecoser.2017.11.005

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