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Research and Innovation Action

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D2.3 – NBS database completed with urban performance data

Organisation name of lead contractor for this deliverable: MUTK		
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Dissemination Level		
PU	Public	X
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Document history

History			
Version	**Date**	**Author**	**Comment**
1	03/12/2018	MUTK	First version of the draft is initiated.
2	11/12/2018	MUTK	First draft is circulated to the task partners.
3	20/12/2018	ALL	First round of reviews is obtained from the partners. Second version of the draft is initiated.
4	18/01/2019	ALL	Second round of reviews is obtained from the partners.
5	25/01/2019	MUTK	Second draft is submitted for external review.
6	14/02/2019	MUTK, external reviewers	Feedback from external reviewers is obtained. Final draft is initiated.
7	15/02/2019	MUTK	Final version of D2.3 is prepared for submission.

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Glossary

BAF	– Biotope Area Factor
BEM	– Building Energy
CNOSSOS	– Common Noise Assessment Methods
CGS	– Connectivity of Green Spaces
EMM	– Expert Models and Methods
ES	– Ecosystem services
FAO	– Food and Agriculture Organization
GI	– Green Infrastructure
GIS	– Geographic Information System
GP	– GreenPass®
IUCN	– International Union for Conservation of Nature
KPI	– Key Performance Indicator
LAI	– Leaf Area Index
LCZ	– Local Climate Zone
LULC	– Land Use/Land Cover
NBS	– Nature-based Solution
NMPB	– Nouvelle Méthode de Prévision du Bruit des Routes (French method for Road traffic noise prediction)
PFvar	– Peak Flow variation
RNPS	– Ratio Native Plant Species
SDIH	– Shannon Diversity Index of Habitats
SPI	– Sustainable Practices Indicator
SUA Tool	– Simplified Urban Assessment Tool
SUDS	– Sustainable Drainage Systems
U(s)C	– Urban (sub-)Challenge
UGSP	– Urban Green Space Proportion
UPI	– Urban Performance Indicators
UST	– Urban Standard Typologies
USC	– Urban Sub-Challenge

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Executive summary

Purpose & Methodologies

The main purpose of the report is to compile a database by synthetizing the results of the previous tasks in this Work Package and demonstrating their applicability with real European case studies. The focus of WP2 is the detailed assessment of both Urban Challenges and nature-based solutions. In order to carry out the assessment, it is essential to set up a range of performance indicators (multi-scalar and multi-thematic) which are capable to evaluate complex urban challenges and integrated projects of implementing nature-based solutions (NBS).

First yet existing indicators were identified, which can measure the impact of NBS on UC, then from these pools the most promising ones were selected, by a specific method, as Key Performance Indicators (KPI). Then, as next step, Expert Models and Methods (EMM) were selected which are user friendly and can utilize the KPIs (GreenPass®, i-Tree, TEB-Hydro or GIS related models can be mentioned as examples).

In this task the previously identified NBS archetypes were analysed, their conditions of measurability by the chosen EMM. To reach this goal the following methodology was utilized:

1. Streamlining of NBS archetypes: an initial step to determine how many groups or types of NBS can be designated in each Urban Challenge.
2. Scenario building based on the results of Streamlining processes: In addition to the parametrization of the utilized KPI, understanding the kind of information or data needed to apply the KPI, as well as what circumstances can influence the results, is key.
3. As a final step real case studies were selected from across Europe to collect examples on the applicability of EMM. It is important to understand both the benefits and the limiting factors of an EMM. A database was compiled from the collected information.

Key findings & conclusions

The possible impacts of NBS implementation are considered from the aspects of 12 urban subchallenges, as focusing only parts of an UC, subchallenges were identified in advance by the Expert Groups, formed in the beginning of the activity of this WP. During a preliminary planning phase, the consideration of these subchallenges is a sufficient general framework for implementation. This serves as a basis for the Simplified Urban Assessment Tool in T2.4.

Link with N4C Platform

The database and the report of this deliverable will be available for the users of the N4C platform, which is going to serve as an assistant to identify the best possible NBS, according to the user's requirements and predefined conditions. Also, in this report, a short description about the investigated EMM is available. As numerous EMM are free of charge, the introduced case studies can serve as a guideline for urban planners, municipalities or other related experts on the utilization and benefits of these methods.

The database of this deliverable can be applied in T2.4, where the main purpose is to develop a Simplified Urban Assessment Tool (SUA Tool) to perform a preliminary examination before the implementation of an NBS.

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Lessons learnt:

Measuring the impacts of NBS in an urban environment is quite complex. Investigation is necessary prior to NBS implementation, in order to discern the most applicable solution. This database provides a general knowledge base of these applicable solutions during the NBS planning phase.

1 Introduction

1.1 Purpose

The main objective of Work Package 2 in the Nature4Cities project is to create a basis for the evaluation of nature-based solutions (NBS) in relation to the urban challenges. The ways of measuring the impacts of NBSs on urban areas have broadened, and there is a considerable amount of literature on this subject (Raymond et al., 2017) (Eggermont et al., 2015). Within the work package, Task 2.3. was designed to complete the D.1.1 database, where NBS archetypes were identified and described in detailed. Several discussions took place among the partners on the final form of the database and how it could best serve both the N4C platform expert use. It is important to point out that this deliverable – completion of NBS database – was initially designed for use by experts only, with adequate knowledge to utilize these EMM, and not by urban planners in everyday planning routines. However, during the development, we kept in mind that an expert modelling toolbox would fill the gap successfully, by enabling a multi-purpose utilization. That is how we decided to unify three different approaches in the database.

First, the perspective of nature-based solutions is emphasized through the streamlining, which minimizes modelling scenarios. According to the characteristics of NBS, some of the initially listed 57 types in D1.1 can be grouped together, making the evaluation of impacts simpler. However, one problem emerged: several modelling scenarios should be considered for evaluating the effects of NBS. Therefore, the parametrization of expert models and methods is necessary.

It is necessary to analyse the capabilities of the EMM. The aim of parametrization is to identify the dependent and independent variables that create scenarios for modelling. With the normalization of some variables, the number of cases can be restricted. This step is useful in an early stage of urban planning when several variations of the plan still exist – as the planner might need some general data on the effects of NBSs. Still, expert advice is needed.

The third component of NBS analysis in the database is demonstrating the impact of nature-based measures through case studies. These were collected through literature review or from the experiences of partners, and they highlight the functions and utilization of expert models in real life scenarios.

These results are incorporated into the database, which forms the basis of the simplified performance assessment tool (SUAT), which will be the final outcome of this WP. By going along through this report users can see the requirements, benefits, or even the barriers of an expert model.

The following main activities will be conducted:

- A1: Streamlining of NBS and link with KPIs / UC regarding GP's UST
- A2: Definition of scenarios (guidelines for scenarios NBS + context)
- A3: Parameterization of expert models, defining data needs for simulations

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- A4: Defining assessment methods for NBS that can be evaluated in a qualitative manner and defining format of database
- A5: Quantifying KPI's for selected NBSs, compilation of database
- A6: Deliverable writing

1.2 Contribution of partners

The involved number of partners is the same as in previous tasks: 9 of 28 partners, represented by 35 experts. In order to manage all the contributions, we used two different communication tools:

- cloud-based webserver to share and collect information,
- regular meetings to discuss the methodologies.

The following table (Table 1.) presents the contribution of each partner to the T2.3 through their contributions to the deliverable.

PARTNER		CONTRIBUTION
MUTK		Coordination of the deliverable, ToC Responsible of section Glossary; Executive summary; Conclusion; 1.1; 1.2; 1.3 Contribution to section 3.1; 3.2; 3.3, regarding the selected UC and EM
AO		Contribution to section 1.3; 3.1; 3.2; 3.3, regarding the selected UC and EM
CER		Contribution to section 1.3; 3.1; 3.2; 3.3, regarding the selected UC and EM
SZTE		Contribution to section 3.1; 3.2; 3.3, regarding the selected UC and EM
G4C		Responsible of section Further utilization of results; Contribution to section 3.1; 3.2; 3.3, regarding the selected UC and EM;
ARG		Contribution to section 3.1; 3.2; 3.3
P&C		Contribution to section 3.1; 3.2; 3.3, regarding the selected UC and EM
UN/IFSTTAR		Contribution to section 3.1; 3.2; 3.3, regarding the selected UC and EM
EKO		Review of the deliverable

1. Table Contribution of the partners to the deliverable

1.3 Positioning of deliverable in the Nature4Cities Project

The WP2 objective is to provide an assessment framework for the urban performance of NBS. In this work package, certain urban challenges were selected and analysed according to the relevant experiences of expert groups. The database created and completed in this project will serve as an index of information for the implementation of various NBSs. The following tasks and work packages are connected with this deliverable (Fig. 2.).

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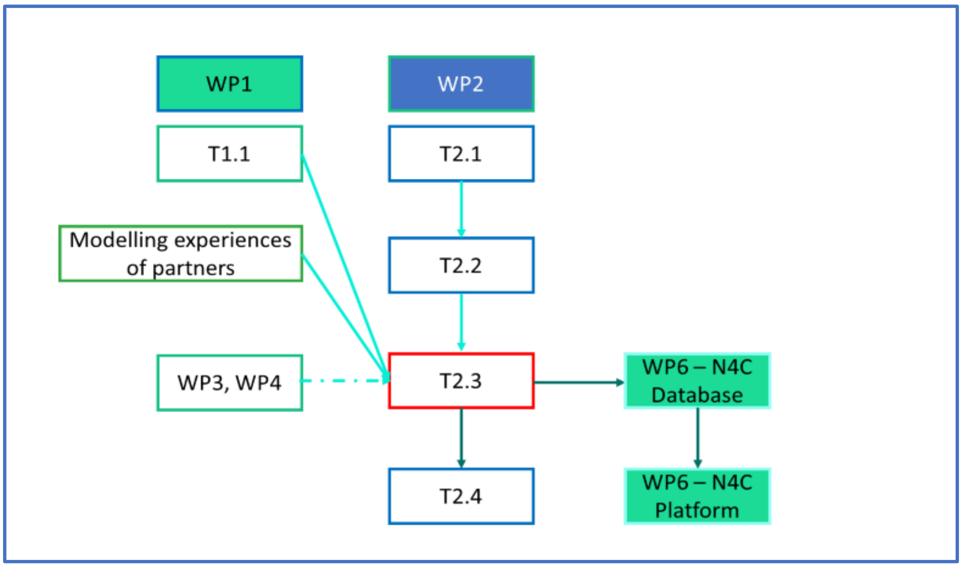

1. Figure The connection between T2.3 and other WPs and Tasks

Links with WP1

The goal of WP1 and Task 1.1 was to define an NBS list and identify the different UCs and USCs that NBSs seek to address. This approach allowed for the assessment and streamlining of T2.3 based on the final list of T1.1 typology. At the end of the assessment, the NBS factsheet will be revised with the results of the assessment.

Task 1.7 also has a strong link with the indicators, identified in WP2, because it aims to develops the data collection process, which is necessary for the assessment.

Links with the other tasks of the WP2

The connection with other tasks in WP2 is coherent and well-constructed. In the beginning of this work package the group of Urban Challenges and Sub Challenges (Table 2) were identified and in D2.1 Key Performance Indicators were selected from a wide range of indicators. The number of indicators were further decreased in D2.2, where only those which can be calculated by or implemented into the selected EMM (Table 3).

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TOPICS	URBAN CHALLENGES (UC)	URBAN SUB-CHALLENGES (USC)
CLIMATE	1 | Climate issues	1.1 | Climate mitigation
		1.2 | Climate adaption
	2 | Water management and quality	2.1 | Urban water management and quality
		2.2 | Flood management
ENVIRONMENT	3 | Air quality	3.1 | Air quality at district/city scale
		3.2 | Air quality locally
	4 | Biodiversity and urban space	4.1 | Biodiversity
		4.2 | Urban space development and regeneration
		4.3 | Urban space management
	5 | Soil management	5.1 | Soil management and quality
RESOURCE	6 | Resource efficiency	6.1 | Food, energy and water
		6.2 | Raw material
		6.3 | Waste
		6.4 | Recycling
SOCIAL	7 | Public health and well-being	7.1 | Acoustics
		7.2 | Quality of Life
		7.3 | Health
	8 | Environmental justice and social cohesion	8.1 | Environmental justice
		8.2 | Social cohesion
	9 | Urban planning and governance	9.1 | Urban planning and form
		9.2 | Governance in planning
	10 | People security	10.1 | Control of crime
		10.2 | Control of extraordinary events
ECONOMY	11 | Green economy	11.1 | Circular economy
		11.2 | Bioeconomy activities
		11.3 | Direct economic value of NBS

2. Table - Framework of Urban Challenges from D2.1

Task 2.2 proposes the most appropriate expert models and methods (based on the literature and previous modelling and methodologies of partners) to calculate the urban performance indicators (UPI) necessary for assessing urban challenges (UC) and NBS.

After summarizing and giving real examples on the utilization of EMM in Europe, this database will validate the SUA Tool, which will be the outcome of T2.4.

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Urban Challenges		Expert models & methods
Challenges	**Sub Challenges**	
CLIMATE	Climate mitigation	i-Tree Eco
	Climate adaptation	SOLWEIG (v.2016a) – *(GREENPASS is being utilized instead of SOLWEIG in this deliverable and in T2.4)*
	Storm water management and quality	HYDRUS-1D/2D
	Flood management	Burst Pipe Analysis (Flow 3D v11.2)
ENVIRONMENT	Biodiversity	Ecological habitats typology
	Urban space development and regeneration	Lecos plugin of QGIS
	Urban space management	SPI calculation method
	Soil management and quality	Textural function method
RESOURCE EFFICIENCY	Energy – (Building only)	EnergyPlus (Via Design Builder)
PUBLIC HEALTH and WELL BEING	Acoustics	NMPB2008/Noise Modelling
URBAN PLANNING AND GOVERNANCE	Urban planning and form	Segreg (plugin of Qgis)

3. Table List of EMM from D2.2

Links with WP3

Environmental assessment methodology was initiated by determining environmental KPIs from the larger list of KPIs identified in WP2. In particular, this information combined streamlined NBS with UC, and was crucial in developing system boundaries for the urban metabolism models. The databases and modelling approaches will be utilized by WP3 during the evaluation of resource efficiency and climate resilience; they will also provide the basis for developing environmental assessment quantification methods in Task 3.3.

Links with WP4

During the development of the socio-economic impact assessment tool, the results of WP2 were taken into consideration - especially the relevant KPIs. The methodologies identified in T2.2, which assess the environmental and social impacts of NBS on Urban Challenges, are also good examples for T4.2. The compiled database in this task, streamlining methods on NBS archetypes for USCs, and the selected case studies all provide a reliable base for measuring the environmental and social impacts of NBS on different urban areas in Europe.

Link with WP6

The WP6 oversees the design and deployment of the Nature4Cities platform. This platform will provide a decision-making framework where users will be able to gain knowledge on NBS, discover Implementation models and

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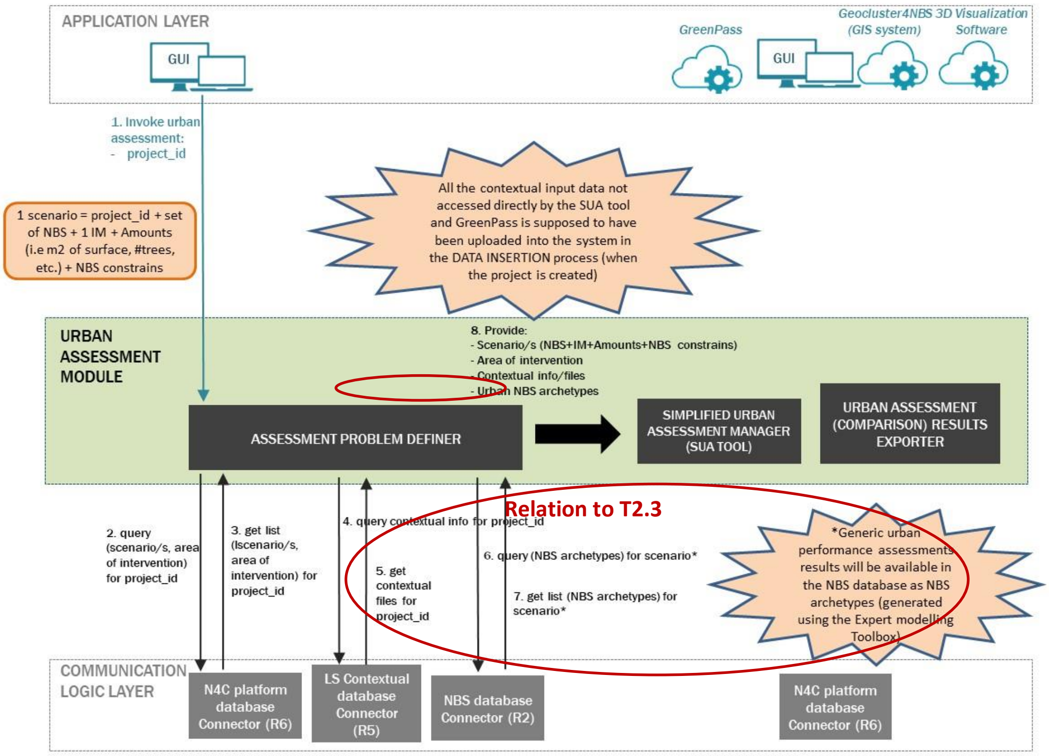
explore related pioneer projects. Additionally, the platform will allow assess to different combinations of NBS (scenarios) and visualization of these results from an urban, environmental and socio-economic point of view.

To provide the above-mentioned functionality, the Nature4Cities platform make use of the NBS database as one of the main repositories, containing essential information that not only provides knowledge to the user, but also acts as an NBS typology provider to be evaluated in the different assessment modules. As seen in **Hiba! A hivatkozási forrás nem található.**, in the case of assessment modules, a set of information must be provided to the Assessment Manager component (SUA Tool in this case) in order to evaluate scenarios containing NBS. The NBS archetypes obtained in Task 2.3 are also obtained from the NBS database and provided to the Assessment Manager. These generic urban performance assessment results are necessary to contextualize the evaluation of scenarios, which take into account the type of NBS, urban challenge and scale.



2. Figure Process scheme for the urban assessment module (see D6.2)

2 Methodology of database compilation

The methodology for database compilation can be divided into four main parts (Figure 3.). The first part is the streamlining, where the classification of NBS archetypes has been carried out. The main point of step two is scenario definition, where the relevant capabilities of expert models from D2.2 were examined. Simultaneously the parametrization was also carried out as an essential subtask. In the final step, case studies were described from all over

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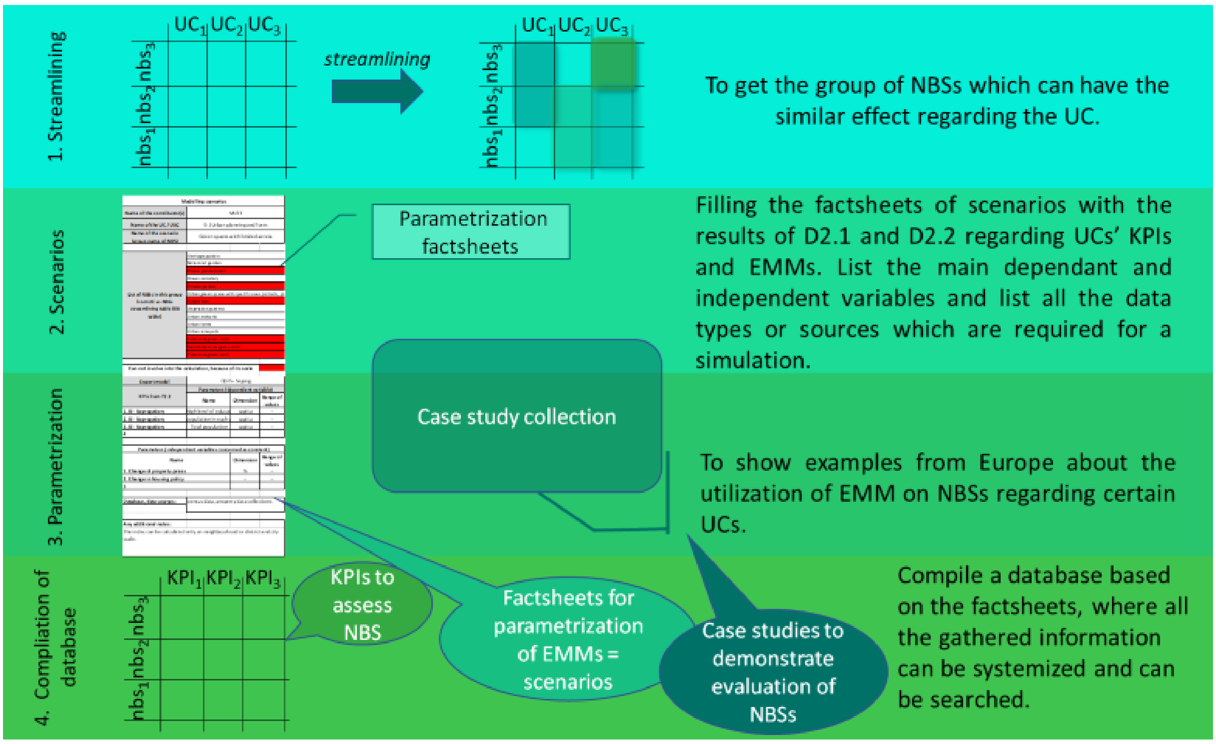
Europe, where the selected expert models were utilized. The outcomes of these stages constitute the data compilation. In the following sections the detailed descriptions of these steps can be found.

2.1 Streamlining of NBS archetypes

The grouping of NBS archetypes (from T1.1 in Appendix I) is essential not only for N4C, but for other NBS sister projects as well. The goal of this sub-task is to categorize all the NBS archetypes which can be interpreted in the context of a certain Urban Challenge. During this initial stage, the Expert models were not taken into consideration. Only certain NBSs were involved in the streamlining, and those which could not be interpreted on the scale of the UC (example: reopened streams for energy efficiency have no effect at all) were left out (Appendix II) At this stage, the focus was on the link between NBS and UC.



3. Figure The flowchart of database compilation

Beside the streamlining process, the justification or description of selected groups is also necessary to underpin the grouping procedure. This is an important part of this subtask, as other NBS related projects defined sets of NBS archetypes, but streamlining the groups makes them more coherent. The results can be found in Appendix II.

2.2 Scenario building and parametrization

The aim of this stage is to collect and organize information about the EMMs regarding streamlined NBSs. In this stage the results of the streamlining will be utilized, as the scenarios are based on the groups of NBSs. The EMM

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will determine the list of NBSs taken into consideration during the calculation. Because the scale of NBSs and the EMM calculation capacity may differ, but other models can cope with the scale on which the NBS is realized, it is important not to leave out any NBS automatically but indicate those which are out of the scope of the selected EMM.

The Key Performance Indicators (KPI's) were the base of the parametrization process as they are applied the EMMs during the scenario building. In the case of some KPI's, the indication of parameters is easy if the calculation method is not influenced by numerous variables. However, in the case of climate topics for example, the modelling process or the calculation of a given KPI is influenced by several variables, so the reduction of parameters is inevitably necessary. Only the most important ones were taken into consideration and the selection of these parameters was entrusted to the expertise of the partners.

2.3 Case study selection

After the detailed analysis of EMMs from D2.2 and the scenario building with parametrization, case studies were selected to demonstrate the utilization of EMMs in European examples. The main principle of selection was to find literature in which the formerly selected EMMs were utilized to assess the impact of NBS on specific Urban Challenges. 2 – 3 case studies were ideally selected for each UC/UsC, but in the case of Water management, a recently developed method was applied and tested.

3 The framework of assessment

In this chapter the steps of methodology will be applied on each USC. The detailed results can be seen in Appendix III. The groups of streamlined NBSs were identified by the experts of certain USC, as well the scenarios and selected parameters. Some of the case studies were carried out by expert partners within N4C, while some is the 'best practices' of the given EMM.

3.1 Streamlining of NBS's per Urban Challenges

A detailed description of identified groups and the justification of selected methods is going to be presented by each Urban Sub Challenge. The results of streamlining can be found in Appendix II. During the previous tasks there were 11 USCs in focus, which were selected for further investigation, but 12 were analysed, as Urban Water Management and Quality USC has to be divided to two parts, based on the expertise of the responsible partner, Urban Water Management and Storm Water Quality.

3.1.1 Climate Mitigation

There are several existing categorizations of urban vegetation or green spaces for climate-related assessments, though we were not aware of any specific example dealing with the challenge of climate mitigation. Climatic effects are among the most frequently studied and widely known ecosystem services of urban green infrastructure; thus, it is the focus of many urban vegetation categorizations or mapping contributions, according to the review work of Koc et al. (2017) as well. Green infrastructure categorizations can follow functional, structural and configurational principles.

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From the perspective of carbon sequestration (climate mitigation), structure-oriented categorisations seem to be a good base to follow, as carbon sequestration can be detected in the amount of biomass and its structure.

We relied mainly on the classification presented in Lehmann et al. (2014), where "Vegetation Structure Types" were formed. This contribution targets primarily microclimatic assessments, but as the classification is based mainly on the amounts of and differences in green volumes, it can serve well the streamlining for carbon sequestration and storage, which are also indicated by biomass volumes. We used the "Trees, shrubs and bushes", "Green spaces", "Residential sites, transport facilities and infrastructures", and "Grassland and low vegetation" categories. Following the logic of Koc et al. (2016), vertical and roof structures were included in the "Green roofs and green walls" category, while water-related NBSs might be merged in the "Rivers, wetlands and waterside zones" streamlined class.

3.1.2 Climate Adaptation

For Climate Adaption, the streamlining of NBS is assessed by a standardized and simplified land-use classification for climate-resilient urban planning and architecture. Beside buildings and surface materials, which are strongly related for this USC, the main types of NBSs are categorized and build the base for nearly every built NBS type and situation. The final categorization of the N4C streamlining has 8 categories, containing combinations of the above-mentioned NBS types:

id	Group Name	Description
1	Vegetation	Built out of lawn, meadow, perennials, shrubs, water, trees. All main vegetation types including water surfaces
2	Tree in small, medium or large	Trees in three different sizes and combination
3	Unsealed	Unsealed area
4	Green roofs intensive	Green roof with intensive construction height
5	Green roofs extensive	Green roof with extensive construction height
6	Green wall ground-based (climber)	Green wall based on climbing plants
7	Green wall facade-based	Green wall based on technical living wall system
8	Green wall planter	Green wall based on planters.

4. Table The result of streamlining in Climate Adaptation

Every single NBS type within the GREENPASS® Typology is standardized and clearly defined regarding technical specifications, physical parameters and plant selection, and each can be used to build a variety of comprehensive NBSs. Due to the thermal complexities and different performances of NBS types regarding climate issues, NBS measures and types must be defined in detail from the USC Climate adaption perspective.

3.1.3 Urban Water Management

For the urban water management sub-challenge, NBSs have been classified into 5 different categories. These categories have been defined according to the main processes involved and depending on their impact on urban water management.

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The main considered processes are parts of the water cycle: evapotranspiration, infiltration, interception and surface runoff.

Id	Group Name	Description
1	Parks	Mixed vegetated area containing different types of vegetation (low and high vegetation with different ratios); interception and evapotranspiration processes are favoured in addition to infiltration process.
2	Garden	Vegetated area with only or mainly low vegetation.
3	Green roofs	Vegetated area with mostly low vegetation, over a building roof, with a minimal soil layer depth; water storage and evapotranspiration processes are favoured.
4	Trees	Vegetated area with only high vegetation type; evapotranspiration and interception processes are favoured.
5	Swales	Vegetated area designed to drain stormwater and favour infiltration process in addition to evapotranspiration and interception processes. Water storage can be also favoured, depending of the soil characteristics.

5. Table The result of streamlining in Urban Water Management

3.1.4 Stormwater Quality

The streamlining of NBS for urban water quality was closely conducted in connection with urban water management UC streamlining, since water acts as a major carrier of pollutants (air-borne and water-borne pollutants). The categories were defined according to the main processes impacting urban water quality management.

The main processes, namely vegetation interception, soil filtration, settling and storage of water (specific for green roof) were defined for each NBS against the type of vegetation (low, high, mixed), the soil surface available for water infiltration and the foreseen pollutant water load. The NBSs were classified into six categories. The classification process resulted in five groups containing the same NBSs as those of urban water management, plus one group dedicated to environmental-friendly practices.

Id	Group Name	Description
1	Park	These zones with mixed vegetation receive rainwater. There are large surfaces for infiltration of water (filtration process) and interception will occur by leaves.
2	Garden	The vegetation is low, over a large surface facilitating rainwater infiltration
3	Green roofs	The low vegetation grows on surface favourable to infiltration but the green roof materials are designed for rainwater storage. Some interception occurs also by vegetation.
4	Trees	Trees are able to intercept rainwater-borne pollutants. The soil surface at the bottom of the tree is too small to be considered as favourable to water infiltration and pollutant retention
5	Swales	These systems collect polluted stormwaters and are designed for water cleaning by settling of the particulate pollutants. The heavy metals are significantly present as particulate. The soil of the swale will act as a filter medium for the pollution. Some vegetation could grow in the systems but they are not considered for interception of atmospheric pollutants.

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6	Environmental-friendly practices	Practices such as reduction or cessation of pesticides use will have an impact on water quality and should also be included in the streamlining. Other NBSs are not really relevant.

6. Table The result of streamlining in Stormwater Quality

3.1.5 Flood Management

The sustained increase of land sealing in urban areas, joint with the potential increased annual rainfall have become serious problems, as both result in increased surface runoff. In east-central Turkey, increased rainfall has been recorded in recent decades, causing flood damage, destructive winds and hail. In the context of climate change, annual temperatures are expected to increase by 1°C, and mean annual precipitation is expected to increase by 13%, both of which will increase runoff. With increasing trends in urbanization, and cities in Turkey expanding at a pace of 20 m^2/minute, this problem will only become more complex and difficult. Strategies to cope with runoff, like increasing the water intercepted captured by the soil and storage in different environmental containers, are urgent and necessary. The specific objective is therefore to determine a set of indicators describing flood risks and impacts on urban and peri-urban storm water runoff in different land use scenarios.

The streamlining of NBS have been grouped into 7 unique classifications for flood management sub-challenge. These groups are as in the table.

id	Group Name	Description
1	Large green spaces	Expansive green zones without access constraint
2	Small green places	Small green areas with access limitation
3	Trees	Prevention of rainwater contamination through trees.
4	Distributed vegetation	Uniform distribution of vegetation.
5	Management	Management of implemented NBS
6	Green roofs	The infrastructure offers a combined benefit for stormwater mitigation, as it retains water and releases it at a slower rate, but also removes a significant portion of water through transpiration
7	Strategy	Ensuring and enhancing continuity of green spaces through strategic NBSs and their implementation.

7. Table The result of streamlining in Flood management

3.1.6 Biodiversity

Seven NBS families have been created according to the Biodiversity USC. Firstly, two families are grouped together from quite different contents. The family "management" corresponds to actions rather than material achievements. These actions are of different types, including maintenance management and monitoring approaches. The family "strategy" refers to biodiversity choices that can be used in the establishment of NBS.

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The other NBS correspond to material achievements. Several NBSs are directly associated to buildings or other structures and are grouped into the “built area” family. These NBS are often associated with high levels of vegetation management. The remaining NBS are not directly associated with buildings and are grouped into four families according to their mean level of vegetation management: high, low and intermediate. Several NBS types can be composed of naturally-varied heterogeneous elements.

Id	Group Name	Description
1	extensive unbuilt area	NBS on soil with low level of vegetation management
2	intermediate unbuilt area	NBS on soil (natural or not) with intermediate levels of vegetation management
3	intensive unbuilt area	NBS on soil (natural or not) with high level of vegetation management
4	heterogeneous unbuilt area	NBS on soil (natural or not) with heterogeneous levels of vegetation management
5	built area	NBS associated to buildings (and often high level of vegetation management)
6	strategy	Biodiversity choices that can be used in the establishment of NBS
7	management	NBS management or monitoring approach

8. Table The result of streamlining in Biodiversity

3.1.7 Urban Green Space Development and Regeneration

To apply the selected KPI’s calculation methods on NBS archetypes, several parameters must be considered. The proposed streamlining reflects this issue and the following table displays the chosen groups with a description to each of them.

These parameters are:

- NBS size: The KPIs are best applied to NBSs on ‘object’ scale and rely strongly on the amount and type of vegetation or green area. One KPI can be best applied to small or medium sized NBS, while the other one shows potential at a larger scale. The first two archetypes have been chosen to help select the most relevant KPI depending on the scale at which the diagnosis is needed (ids ‘1’ and ‘2’ in the table).
- NBS configuration: One of the KPIs considered ecological connexions. It seemed relevant to be able to quickly identify linear structures to consider them as potential corridors (id ‘3’ in the table).
- NBS type: The KPIs for this UC apply to NBS of type ‘object’ but not to those of type ‘action’. The streamlining needed to reflect that. We chose however, to distinguish between three action types to better connect with other UCs (ids ‘4’, ‘5’ and ‘6’ in the table).

id	Group Name	Description
1	Large green spaces	Some indicators measure the extent of green areas, thus size is a significant factor
2	Small green places	Some indicators measure the extent of green areas, thus size is significant factor
3	Linear green areas	Relatively narrow but with large extent in one direction

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4	Maintenance technique	Greening techniques mainly for conserving the state of the NBS, quality improvement also take place, however, the main point is the easier maintenance of the NBS for a long term
5	Strategic NBSs	Ensuring and enhancing continuity of green spaces through strategic urban plans and their implementation
6	Restoration and upgrade with NBS	Improve the quality of green spaces with NBS

9. Table The results of streamlining in Urban Green Space Development and Regeneration

3.1.8 Urban Space Management

This USC KPI aims to evaluate how sustainable the management practices of a given NBS (type 'object') are. Those practices depend strongly on local regulations, policies, social demands, environment (geography, climate), etc.

Rather than trying to distinguish NBS by their physical features, we proposed to set archetypes highlighting the different NBS uses. The underlying hypothesis is that, depending on the context, different NBS implemented for the same utilization, would be managed the same way.

For instance, recreational open spaces (i.e. parks and gardens) would generally be managed to enhance and preserve recreational opportunities (aesthetics, accessibility, urban furniture state and quality, etc.). On the other hand, spaces dedicated to production (orchards, family gardens…) would be managed to optimize production quantity and sanitary quality. In those examples, it is necessary to choose between different management options to let the NBS meet the specific use(s) it was designed for.

We then use the definitions of ecosystem services by institutions like IUCN or FAO and those given in the 2005 Millennium Ecosystem Assessment, to propose a categorization of NBS' uses in urban areas. We rely on these definitions of ecosystem services (production, regulation, support and cultural) and we added societal services.

Our hypothesis is that each NBS can be associated to one or more use, described in the table below. This way, each NBS type is applied to one category, based on what the main use of this NBS may be (co-benefits or unexpected users' behaviour is not considered here).

id	Group Name	Description
1	Production	Services allowing goods (food resources, materials, medicines…) or supplying thanks to ecosystems.
2	Regulation	Services allowing proper functioning of ecosystem functions. They include biotic functions (pests and diseases regulation) and abiotic functions (air quality, climate, water regulation…).
3	Support	Services needed for production of all the other ecosystem services and ensuring proper functioning of the biosphere. Their effects indirectly influence human beings and are perceptible on the long term. They include photosynthesis, soil formation, nutrient cycling…

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4	Societal	These type of services enable, assistance to ecosystems or activities beneficial to society. We segmented this service into various categories: § Recreational § Sports § Relaxation § Memory § Public utility (parking, greenways, etc.).
5	Cultural+Societal	Cultural services: These services enable environmental amenities related to culture and assistance to ecosystems. We segmented this service into various categories: § Education § Embellishment § Inspiration
6	Societal+Regulation	
7	Regulation+Support	
8	Regulation+Support+ Societal+Cultural	
9	Societal+Regulation+ Support	

10. Table The results of streamlining in Urban Space Management

3.1.9 Soil Management and Quality

In the context of the sub-challenge "soil management and quality", we have based our reflection on the services and functions of urban soils, also called anthropogenic soils (Meuser, 2010). Anthropogenic soils have been highly modified or manufactured by Man, over a thickness of more than 50 cm from the surface (Baize, 1993). From the 56 NBS available (D1.1), we have selected seven major groups of NBS:

Id	Group name	Description
1	Transformed areas	They result entirely from human contributions of various materials. They concern urbanization, industrial or mining zones. These are the Technosols of the WRB.
2	Rebuild areas	They result from the use of pedological materials transported, reworked and then set up in gardens, parks and green spaces for ornamental plantings ("topsoil" of landscapers)
3	Mixed sealed and opened areas	They result of covering of the ground with 90% impermeable material and 10% permeable media
4	Semi-natural areas	An environment that combines the physical and biological conditions necessary for the existence of a species or group of animal for plant species.
5	Phytoremediation areas	Refers to the technologies that use living plants to clean up soil, air, and water contaminated with hazardous contaminants
6	Wet land areas	Wetlands are areas of permanent or temporary swamps, fens, peatlands or natural or man-made waters, where water is stagnant or common, fresh, brackish or salty, including bodies of marine life that does not exceed six meters at low tide.
7	Sealed areas	They result of covering of the ground with 100% impermeable material.

11. Table The selected groups in Soil Management and Quality

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3.1.10 Food, Energy, Water (focusing on Energy efficiency)

Building energy models (BEM) generally only represent one building and a part of its close environment. For that reason, very few NBS can be represented by BEM. There are those that are directly built on the building (green roofs and green walls), that produce shading (trees, pergolas) or that constitute a close cool surrounding (can't be considered in the BEM).

As a result, in the streamlining, we grouped the NBS into 4 categories:

id	Group name	Description
1	Cool surrounding surfaces	Surfaces that influence the long wave radiation exchanged between the building and its environment. In the summer, water, bare soil and green surfaces will have a lower temperature and thus won't contribute to heating the building. Very few BEM can calculate this impact as they can't assess the temperature of surfaces that don't belong to the building.
2	Green roofs	In BEM, green roof models have been developed with the possibility to define different substrate thicknesses and compositions as well as different leaf area densities and foliage characteristics.
3	Green walls	The reasoning for green walls is similar to that one for green roofs. The models allow for modulating different layers of thickness. However, built or attached planter systems won't be well represented by the models developed so far.
4	Shading	In BEM, trees and pergolas can be integrated impact on the incoming solar flux.

12. Table The selected groups in Energy efficiency

3.1.11 Acoustics

For acoustics in USC, the NBS archetypes have been classified into 5 different categories. These 5 categories have been defined according to the main processes involved and their effect/impact on environmental acoustics (urban soundscape). Thus, this classification is also linked to the way the vegetation is considered in the chosen acoustic model (NMPB/CNOSSOS) and its associated opensource software (http://noise-planet.org/noisemodelling.html). Thus the 5 categories are (see Appendix II):

id	Group name	Description
1	Large green space / horizontal + vertical / mix vegetation	low and high plants
2	Small green space / horizontal / specific vegetation	low plants
3	Small green space / vertical / specific vegetation	high plants and trees
4	Small green space / horizontal / mix vegetation	low and high plants
5	Small green space / vertical / specific vegetation	low plants

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3.1.12 Urban Planning and Form

In this Urban sub-Challenge the main principle of grouping was the utilization possibilities of a green area from the societal point of view. How citizens can connect to green places, how green spaces are or can become connection elements and improve the connectivity of the urban fabric, and if there are any restrictions and for what purpose? Also, from the inhabitant's aspect, what is the purpose of an NBS? These categories can be divided further or can overlap. Due to cultural and geographical differences between NBS implementation environments, the utilization of green spaces can vary.

id	Group name	Description
1	Large green spaces with open access	Parks or wide-open areas where there is no limitation of access, complete with their internal communication network: paths, trails and walkways. These areas can have near natural parts without intensive maintenance, but these parts can be the most insecure. These kinds of parks are socially egalitarian, as any social groups can enter here, but without strict regulations negative effects might amplify. With continuous social awareness undesirable behaviour can be avoided.
2	Green spaces with limited access	No size restriction, either in private or public ownership, but limited time-based access or specified rules apply. For example, in the case of green roofs, access to the building can be limited. Security levels are higher than in the previous category, although this might stimulate gentrification. However, this can guarantee maintenance of the green space.
3	Linear green areas	Green areas with characteristic linear or vertical features. Beside the aesthetic value of a well composed green line in an urban environment, they have numerous societal benefits. Various NBSs belong in this category: Street tree line, green stripes, green façade, green wall, green tram lines, etc.
4	Maintenance technique	Greening techniques mainly for conserving the state of NBS, quality improvements also take place; however, the main point is easier maintenance of the NBS for a long term.
5	Strategic NBSs	Ensuring and enhancing continuity of green spaces through strategic urban plans and their implementation. This usually covers large parts or the entire city, concatenating different green spaces and NBSs. After the implementation of a well-considered and nature-oriented strategy, the level of biodiversity in a metropolitan area can multiply. Further, the general welfare of citizens can increase due to the increased appearance of wildlife.
6	Restoration and upgrade with NBS	Improve the quality of green spaces with NBS, taking into account their complex nature.

3.2 Parametrization of Expert Models according to scenarios

The base of this section is the Expert Models and Methods (EMM) toolbox from T2.2. In addition to the groups of the previous subtask, the Key Performance Indicators (KPI) from D2.1 and the EMM are in the centre of this subtask. KPIs determine the EMM during the selection of models or methods, and the calculation capabilities of the USC's KPI's

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are a defining factor. Here the measurement conditions of the assessment of NBSs' impacts on USC are collected. In addition to the data requirements, the other parameters of the calculation are essential.

The parameters can vary as the dependent and independent variables, connections to and effect on the KPI. Independent variables can be modified or standardized in favour of simplifying the calculation or decrease the number of necessary simulation cases. These are listed and detailed in Appendix 2, as well with input data types, which are essential to the calculation of the KPIs.

3.2.1 Climate Mitigation

For the climate mitigation UC, one expert model – i-Tree - was assessed with scenarios. It is one of the most frequently used ecosystem service models in urban context. It is developed for U.S. circumstances and used mostly there, but there are some European applications as well (e.g. Baró et al., 2014; Guidolotti et al., 2016; Morani et al., 2014). It was developed for the assessment and valuation of trees, which limits the usability of the i-Tree toolset in a scenario context. I-Tree Eco is working on a single tree basis, but it can form a base for assessments or mapping of larger areas on neighbourhood or city scales, too (Alonzo et al., 2016; Pothier and Millward, 2013). The "Green spaces", "Residential sites", "Trees, shrubs and bushes", "Transport facilities and infrastructures" and "Agricultural sites" NBS groups were investigated. However, NBS groups that do not contain trees, cannot be involved in scenario assessments (e.g. "Lawn", "Vegetated pergola", "Grass tram tracks", "Vegetable gardens").

For the scenario, i-Tree can calculate one Key Performance Indicator: the "Annual carbon sequestration". The most reliable calculations can be delivered for such NBSs where individual trees' size data and condition can be measured.

Concerning parameters, size (and health-) related data can be considered as dependent parameters, these primarily determine the differences in carbon sequestration capacity between trees according to their morphology (height, crown base height, crown diameter, diameter at breast height, missing parts in the crown, crown dieback). Species information, geographic and climate characteristics can be included in the group of independent variables. Among them, the parameter 'species' is the most important, whereas the data need on climate is moderate for the carbon calculations in i-Tree. For international assessments (which means outside the U.S. where the tool was designed), climate mitigation calculations are, for our intended purpose, not limited, as carbon calculations don't need the detailed (1-hour) weather and pollution datasets.

3.2.2 Climate Adaptation

The GREENPASS® application and ENVI-met expert model can be used for district to object scale – limited only by computational power. It's possible to digitalize and analyse nearly every built NBS and surface material or building by accurately indicating their physical specifications and parameters. Defining environmental conditions and climatic input parameters is also important. The expert models offer different services, which are differentiating in their grade of detail regarding the evaluation and following the KPIs.

The scenario needs a digitalized planning base transformed to a digital georeferenced simulation model with defined surfaces and NBS. The application offers a standardized and automatic process by using its own typology and standardized input parameters. It analyses state-of-the-art climate resilience KPIs, based on ENVI-met simulation

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outputs. ENVI-met offers a wide-range and comprehensive scope for evaluation and analysis methods and illustrates the urban complex by considering all particulate and physical processes within the urban atmosphere.

The application has developed standardized so-called Urban Standard Typologies (USTs) with different greening grades and NBS types (for main types see 3.1.2), based on an aerial image analysis of 5 international Case-Study Cities. Due to the process of database matching on a wide database, its assessment delivers a rough impact assessment for potential greening of urban development projects, showing 5 main climatic evaluation scores and KPIs:

- TLO – Thermal Load Score
- TCS – Thermal Comfort Score
- TSC – Thermal Storage Score
- ROS – Run-off Score
- CSS – Carbon Sequestration Score

3.2.3 Urban Water Management

Both district (as a catchment) and city (or a large part of a city composed of several catchments) scales are studied for this sub-challenge. For each spatial scale, an expert model has been chosen (Deliverable 2.2): URBS for the catchment scale and TEB-Hydro for the city scale. Both the meteorological data and the soil properties (input data) are the same for each scenario. Only the building, total and low and high vegetation ratios are modified. By running both models with these different datasets and comparing the simulated discharge peaks with the reference simulated ones, the Peak Flow variation (**PFvar**) is calculated.

At the catchment scale, we developed 5 NBS scenarios:

Name of Scenario	Description
PARK	We chose to implement a park within a shared housing parcel by decreasing the building surface area down to zero and replacing its surface with vegetated land use. The parcel was taken in the middle of the catchment.
GARDEN	In this scenario, the impervious surface of the parcels, apart from the buildings, were replaced by vegetated areas, in this case grass; we thus considered that every car park, small paved street or way inside the parcel, may be transformed with a grass surface. We adopted 2 scenarios with 50% and 100% of this impervious surface modification.
SWALES	The stormwater sewer network was replaced by a swales network, considering that the storm water could be drained by vegetated swales. The swales infiltrated the storm water into the soil, and with natural soil permeability, this water drained downstream if it could not be totally infiltrated. Two scenarios were tested, either 100% of the sewer network was transformed or 50%. In this last scenario, the swales were implemented in the downstream part of the sewer network. We changed 2,4 km of the sewer network with swales (100%) or 1,2 km (50%).
GREENROOF	In the reference scenario, no green roof was considered. Flat roofs were first detected on the catchment, and green roofs were introduced on these flat roofs. A 15cm substrate green roof was chosen, with a sedum vegetated layer. 19% (50% scenario) and 38% (100% scenario) of the total built surface area was replaced with green roofs.
TREE	Street trees were introduced in this scenario, with one row in the streets with a width smaller than 12m, and two rows in the streets with width larger than 12m. Two scenarios with 50% and 100% of possible street trees

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	planted were adopted. As the reference catchment already has street trees (4% of total surface area), a zero-tree scenario was added, considering that we can cut out the trees. The street trees varied from 0 (zero-tree scenario) to 5 (50% scenario) and to 6,5 % (100% scenario) of the total surface area.

At the city scale, the objective was to study the same scenarios at the catchment scale. Due to a simpler way to divide space and the land use (average ratio by mesh grid), in link with a coarser spatial resolution, some of the parameterizations were different. Moreover, the scenario SWALES was not applied at the city scale, as such NBS type has not been parameterized yet in TEB-Hydro. Thus, only four scenarios were studied with TEB-Hydro at the city scale. However, thanks to a larger domain, several catchments, with different land uses, were studied.

Name of Scenario	Description
PARK	As at the catchment scale, the objective was to create new parks in the city. Then buildings ratios were largely decreased (to 0.01%, the minimal value for numerical reasons) and replaced by vegetated areas: existing vegetated areas are enlarged and densified. This takes place in different catchments over the domain. Thus, in the defined areas, the vegetated areas ratio is assigned to 90%, with a low and high vegetation ratio of 40% and 60%, respectively. The built part is decreased in consequence.
GARDEN	The vegetation ratio is modified without changing the high vegetation area by grid mesh. Three different scenarios were produced (a vegetation ratio with a minimal value of 80%, then 50% and with a maximal value of 30%). As a result, the high and low vegetation ratios were modified.
GREENROOF	In the reference scenario, no green roof was considered. Green roofs are introduced in the city in three different ways: only over public or collective buildings, wherever their location, in the same buildings located upstream from the catchments, and in same buildings located downstream to the catchments.
TREE	Only the high vegetation was modified, while the vegetation ratio was kept constant. Then, the low vegetation ratio was modified in consequence.

3.2.4 Storm Water Quality

The NBS evaluation for storm water quality urban sub-challenge aims at calculating the cleaning efficiency of the drainage systems at the system scale. The categories ‘swales’ and ‘green roofs’ are selected for applying scenarios. ‘Swales’ category systems are specifically dedicated to water quality improvement. The ‘Green roofs’ category is designed to store water, but some studies have demonstrated that the air-borne pollutants and pollutants from the materials used in green roofs should be considered in NBS evaluation. The KPI will be calculated either by a simple function (ratio between outlet and inlet solutions) and by comparison with thresholds, or by using an expert model depending on the variability of data. The scenarios aim at evaluating the effect of the variability of water quality and flux on NBS performance. The variability will be introduced by parameters on water quality and soil quality in the systems. The geometry and characteristics of systems are the independent parameters.

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3.2.5 Flood Management

Enhanced green infrastructure (GI) in urban areas, such as green roofs, parks and green spaces can make a significant contribution to enhancing the provision of fundamental ecosystem services (ES), through nature-based solutions. These positive effects include increasing interception capacity due to increasing vegetation cover, increasing of storage capacity and infiltration of the soil, thus reducing storm water runoff, and producing substantial improvements in the urban drainage system, whose infrastructure is very difficult and expensive to modify or expand. We present an indicator based on the runoff coefficient, which quantifies the impact on runoff due to the increase of GI. In a second step, we propose a method to relate the indicator with the risk of flooding.

Four scenarios were evaluated: a baseline scenario and three hypothetical scenarios, considering a moderate and severe waterproofing situation, respectively, and one green scenario with increased GI. The results show that the moderate and severe waterproofing scenarios produce an increased risk of flooding from 1.9 times to 4 times, respectively. This implies a necessary reinvestment in urban storm water infrastructure in order to keep the original security levels. The green scenario does keep the runoff coefficient, even considering major increases in population and urbanization. Improving GI constitutes a strong strategy that adapts to climate and urban changes, coping with upcoming increases in precipitation and urbanization.

3.2.6 Biodiversity

Many NBS have significant positive or negative effects on urban biodiversity. The selected indicators can be used to assess these impacts, and in particular RNPS (Ratio Native Plant Species) and SDIH (Shannon Diversity Index of Habitats). It will be calculated for wooded habitat only. The scenarios studied aim to compare plant biodiversity of several NBS including the variability of two parameters (dependent variables) that can have large influences:

- the space management intensity
- and the landscape characteristics (especially the urban rural gradient).

These two parameters of two modalities are crossed for the KPI's calculation. The calculation of these indices needs the plant species list of NBS and their indigenous or exotic status in the site and the area of each ecological habitat type (bare and turf grass, of rough, grassland and herbs, of shrubs, of trees and of built environment). It's necessary to use management typologies related to the NBS studied, and the surrounding landscape type (type of use, according to an urban-rural gradient).

3.2.7 Urban Green Space Development and Regeneration

The evaluation for urban green space development and regeneration aims to assess land use at plot scale, for any existing or planned development. The model BAF EM allows to discriminate between heavily transformed / sealed areas and developments allowing for undisturbed soil preservation. Sensible parameters are the superficies corresponding to each land use considered in the model (expressed as proportions of the total area), i.e.: Sealed surfaces; Partially sealed surfaces; Semi-open surfaces; Vegetation on shallow unconnected soil; Vegetation on deep unconnected soil; Vegetation on connected soil; Impermeable water surfaces; Permeable water surfaces; Shrubs; Trees small (around

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5m height); Trees medium (around 10m height); Trees large (around 15m height); Extensive green roof; Semi-intensive green roof; Intensive green roof; Green wall.

3.2.8 Urban Space Management

We plan to run GIS and Chloe on Angers and Nantes from the maps produced in Urbio, varying some spaces (according to the typology proposed earlier) in different proportions (increase the number of large or small spaces (e.g. green roofs), add alignments, and position some strategic spaces).

LeCos is a plugin for QGIS (open-source desktop geographic information system software) for an automated calculation of landscape metrics to evaluate landscape structure attributes or its changes from raster of habitat classes (Jung, 2016). This tool can model urban green space proportion (UGSP) at object, neighbourhood and city scale. UGSP may be calculated with GIS without any specific spatial analysis plugin but use of LeCos is useful in order to calculate other indicators in other challenges (for example configuration metrics as CGS) and to save time.

Chloe2012 is also a free open-source software dedicated to landscape spatial analysis based on raster maps like Fragstat and has been developed to use sliding window analysis in addition to grid or point analysis (Boussard and Baudry, 2014). Chloe2012 is based on the software library APILand (Vannier et al., 2011).

Another KPI for this UC is the Sustainable Practices Indicator (SPI). The expert model for SPI calculation relies on more than a hundred criteria assessed through binary questions (Yes/No). Sensible variables relate all to the management practices implemented on-site. Each assessment domain weights as much in the final note as the number or criteria it covers (list below).

Taking ecological connexions into account (2 criteria)
Planning and formalising differentiated management practices (7 criteria)
Knowing soils (3 criteria)
Preserving soils (2 criteria)
Enhancing soils' ecological functions (9 criteria)
Limiting weeding impacts (2 criteria)
Limiting green walls impacts (2 criteria)
Managing water resources (5 criteria)
Managing irrigation and watering (7 criteria)
Managing fountains (6 criteria)
Using alternatives to potable water for watering (5 criteria)
Implementing ecological management practices (11 criteria)
Managing plantations (7 criteria)
Managing plants (21 criteria)
Managing pests (7 criteria)
Managing waste (6 criteria)
Knowing and monitoring furniture (11 criteria)
Saving fuel (5 criteria)
Saving energy (5 criteria)
Reducing annoyance due to maintenance operations (3 criteria)

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Training personnel (11 criteria)
Welcoming the public (2 criteria)
Informing and securing (5 criteria)
Engaging visitors (2 criteria)
Ensuring cleanliness (5 criteria)

3.2.9 Soil Management and Quality

The scenarios studied in the context of the sub-challenge "soil management and quality" tend to determine the performance of the NBSs using the seven archetypes defined in paragraph 3.1.9 from the urban soils in term of fertility (physical and chemical aspects). To do this, we have opted to use the models and methods highlighted in task 2.2 for studying urban soils: fertility evaluation method (Cannavo et al., 2014; Šimanskỳ et al., 2014; Yilmaz et al., 2018), Hydrus-1D/2D (Šimŭnek et al., 2016), Ecotox method evaluation and Soil biological activity evaluation method (Nunes et al., 2016).

In each model and method, we have focused on the variable parameters that most influenced NBS in urban areas in relation to urban area management (type of management, type of cover, age of NBS and soil classification). The entire table describing the scenarios for this sub-challenge is included the Appendix 1.

3.2.10 Food, Energy, Water (focusing on Energy efficiency)

In all the scenarios concerning the building energy simulation, we distinguish three families of parameters that can vary in a different way but influence NBS impact on building energy needs. They are:

- NBS intrinsic characteristics: the characteristic of the NBS itself will have an influence, its surface, volume (LAI for plants), spatial distribution, and its thermal and optical characteristics
- Building characteristics: depending on the different thermal characteristics of the building (inertia, glazing ratio, insulation, compactness…) and it's use (kind of equipment, occupancy schedule), the impact of NBS on building thermal behaviour can differ considerably. For example, it has been proven that green roofs and walls will have less impact on insulated buildings and trees than on buildings with a lower glazing ratio.
- Contextual characteristics: the local characteristics represent two kinds of contexts, the built context (built density) and the climate context. The built density can indirectly modulate NBS impact. For example, in a very dense area with high buildings, the trees will have fewer shading effects as the buildings are already shaded by the urban form. The kind of climate is also important, and it has been proven that vegetation impact is greater in hot climates.

These parameter groups are then detailed in many parameters that are used to describe 1/ the NBS, 2/ the building and 3/ the context. Creating scenarios and varying all of them varying would lead to numerous simulations. One will have to decide, in accordance with the other UC assessments, to fix some of them as constants.

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3.2.11 Acoustics

For this urban sub challenge both "Neighbourhood" and "City" scales were studied (see WP2 spreadsheets) but NOT the "Object" scale because this is not necessary for sound environment. For this task, an expert model has been chosen (see Deliverable 2.2): NMPB/CNOSSOS and its associated opensource software (http://noise-planet.org/noisemodelling.html).

Well adapted KPI (e.g. Lden, see T2.2) and very well documented input data (BD TOPO®, Open Street Map, road traffic databases, Nantes Metropole urban databank, etc.) are utilized. Thus, the model can compare different NBS scenarios, in terms of vegetation percentage (%) for urban horizontal AND vertical surfaces (high or low plants), which have a significant effect/impact on sound absorption due to the soil/subtract porosity (depending on the root system of the plants).

Thus, the previous list of NBS from UC vs NBSs streamlining table has been analysed regarding the capacity and robustness of our model to consider each NBS. This analysis has leaded to 3 scenario types (see Appendix 1.).

- Horizontal AND large vegetation, typically public parks, private gardens, etc.
- Horizontal AND small vegetation, typically urban farms, vegetable gardens, etc.
- Vertical vegetation, typically urban green walls

Note that it is not always easy to distinguish between the 2 former scenario types because of the space scale, which is sometimes the same one.

3.2.12 Urban Planning and Form

The scenarios of this USC can be applied at neighbourhood or city level. The utilized EMM is the SegReg module in QGIS. The module can calculate the Local/Global Dissimilarity beside several other indices, where the required input data depends on the geographical extent of the study area and as well on census data for the distribution of population – and the level of education and the population of each subdivision in the total area. Other additional data can influence the accuracy of the calculation. Data from tax office or property data can create a more accurate separation of different areas. Also, the change of housing policy and property prices can affect on the level of segregation.

3.3 Case studies

In this part, case studies were collected from all over Europe by the expert partners. The objective of this section is to underpin of the utilization of EMM. In Appendix III general information and further details can be found about the case studies. The benefits required datasets and the limits and difficulties of case studies utilization will be described.

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3.3.1 Climate Mitigation

The city-level i-Tree assessment for Szeged was based on a complete tree inventory, which is being constantly developed in partnership with the local authority. Carbon storage and sequestration were calculated for every tree (Kiss et al. 2015). The dataset is large enough (>3000 trees) to enable deriving consequences for the behaviour of different species or for smaller stands. One example for the latter is an investigation of the effects of tree management intensity on carbon sequestration (and the other processes). The large (and continuously developing) dataset can be used as a source for developing proxy values in ecosystem service provision for relevant places. Climatic background data (number of frost-free days, to indicate the length of the growing season) were derived from the locally measured, "official" meteorological dataset of the city.

Baró et al. (2014) provided an example for the incorporation of climate mitigation capacity of an urban forest in climate policy for the city (Barcelona). The i-Tree evaluation was plot-based (which is the more frequent approach in city-wide assessments), regarding other aspects, the i-Tree assessment was "general". The results for carbon sequestration were compared with the greenhouse gas emission inventory of the city (differently for the land use types). The incorporation of mitigation capacity of NBSs can be a possible policy need in other cities of Europe as well in the future.

The contribution of McPherson (2003) gives an example for one possible approach of using the methodology of i-Tree in scenario assessments (the i-Tree itself was not applied, only most of the background equations). The aim of the work was to investigate the cost-benefit characteristics of trees with different ages. It can be useful for urban tree management applications in Europe as well, as this question frequently emerges. (Is it worth preserving trees until high ages, the derivable benefits or the costs of it are higher?)

3.3.2 Climate Adaptation

GREENPASS® has been applied successfully by more than 20 projects and case studies in different Austrian cities and abroad, from object to district scale (Scharf, 2018). ENVI-met is the state-of-the art expert simulation for microclimate simulation and has been applied and validated by a wide variety of projects and publications worldwide and in different climatic zones.

GREENPASS® development is based on 5 international case study cities (Wien, London, Hong Kong, Kairo and Santiago de Chile). The Urban Standard Typologies (USTs) is based on 200x200 m areas with abstracted city morphologies and are clustered to represent a larger area (limited only by computational power). It was developed within the ERASME Project 'Green4Cities', the 25 USTs, which are linked to LCZ (Stewart et al., 2012), exist in 4 various scenarios with different greening grades and enables a classification of urban areas (Scharf et al., 2017).

The following table (Table 8.) shows a collected over- view of the USTs and their sub-versions, a short description and, if available, the link to the respective LCZ.

The following figure shows, based on the example of UST 004, the development process of every UST including the final four scenarios of each global UST (Fig. 3). The simulation results for these scenarios for different climatic

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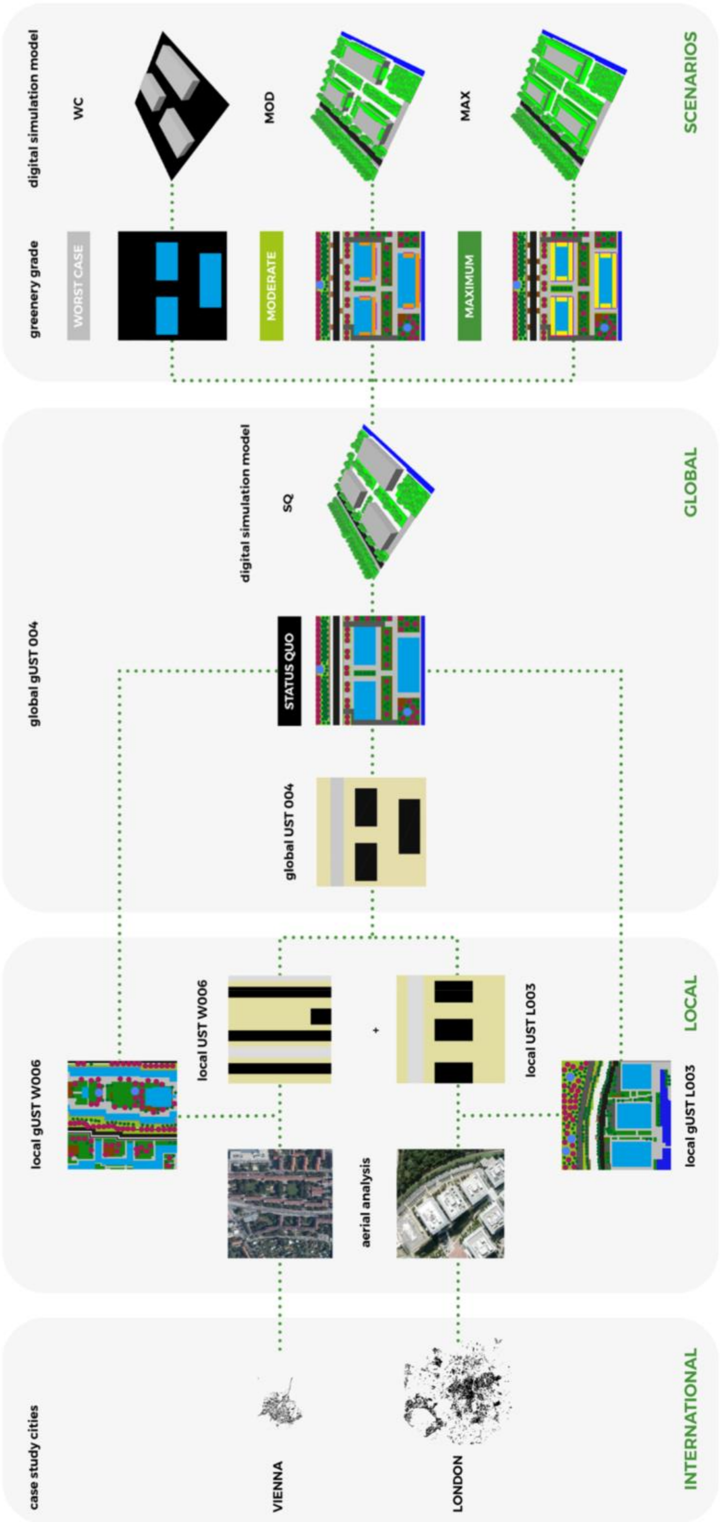
conditions and with different directions of wind flows builds the base for the GREENPASS® Assessment and delivers a quick and rough evaluation of urban development projects worldwide.



3. Figure GREENPASS® Urban Standard Typologies | example | UST 004 (unpublished Kraus, 2018)

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No.	UST	Sub-version	Description	**LCZ** (Stewart and Oke, 2012)
1	UST 001	001	Dense high-rise	LCZ 1 | Compact high-rise
2		001 HIGH	Dense very high-rise	LCZ 1 | Compact high-rise
3	UST 002	002	Dense midrise	LCZ 2 | Compact midrise
4		002 HIGH	Dense midrise with high-rise	LCZ 2_4 | Compact midrise with Open High-Rise
5	UST 003	003	Open high-rise	LCZ 4 | Open high-rise
6		003 HIGH	Open very high-rise	LCZ 4 | Open high-rise
7		003 WATER	Open high-rise + Water	LCZ 4_G | Open high-rise with Water
8	UST 004	004	Open midrise	LCZ 5 | Open midrise
9	UST 005	005	Open lowrise	LCZ 6 | Open lowrise
10	UST 006	006	Dense lowrise	LCZ 7 | Lightweight lowrise
11	UST 007	007	Large lowrise	LCZ 8 | Large lowrise
12	UST 008	008	Drops	LCZ 9 | Sparsely built
13		008 MID	Drops midrise	LCZ 9 | Sparsely built - midrise
14	UST 009	009	Park	LCZ D+B | Scattered trees + Low plants
15		009 WATER	Water	LCZ G | Water
16		009 SAND	Sand	LCZ F | Bare soil or sand
17		009 PAVED	Paved	LCZ E | Bare rock or paved
18	UST 010	010	Dense high-rise + Green	LCZ 1_D | Compact high-rise + Low plant
19	UST 011	011	Perimeter Block	-
20	UST 012	012	Grouped Midrise	-
21	UST 013	013	Grouped high-rise	-
22	UST 014	014	Midrise + Park	-
23	UST 015	015	Large dense midrise	-
24	UST 016	016	Large midrise	-
25	UST 017	017	Large lowrise + Green	-
26		017 WATER	Large lowrise + Water	-
27	UST 018	018	Fifty-Fifty	-
28		018 PAVED	Street	-
29	UST 019	019	Midrise block	-
30	UST 020	020	Dense lowrise	LCZ 3 | Compact lowrise
31	UST 021	021	Field	LCZ D | Low plants
32	UST 022	022	Woodland	LCZ A | Dense trees
33	UST 023	023	Railbed and track	LCZ E | Bare rock or paved
34	UST 024	024	Belt	-
35	UST 025	025	Street + Green	-

13. Table GREENPASS® UST overview and link to LCZ

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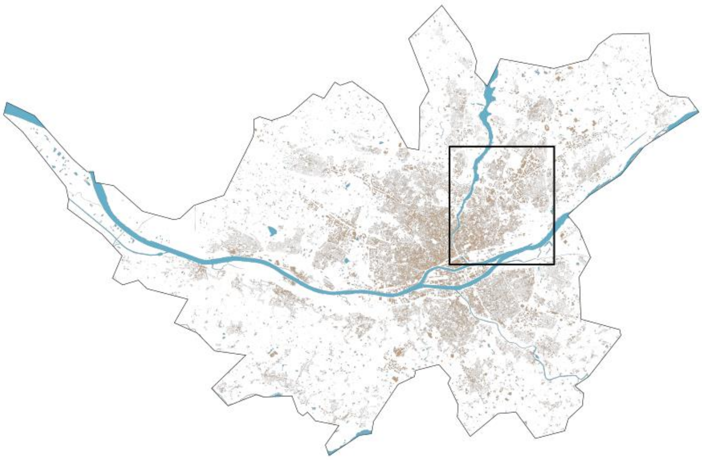
3.3.3 Urban Water Management

For the Urban Water Management sub challenge, due to the difficulty in obtaining (in a short time) and communicating sewer network data, the chosen case study is over the territory of Nantes Metropolitan area. It presents two different scales: the catchment (district) one and the city (a large part of the city) one. The City of Nantes is the sixth most populous city in France (582,159 inhabitants in 2009), covering a 534 km² area and composed of various types of land uses: dense urban in the city centre, business and retail zones, suburban zones, and rural zones at the periphery. The relief is quite flat (from 0 to 90 m). The drainage network, however, is rather dense. Nantes' urban areas are also drained by artificial networks: a combined sewer system in the historic city centre, and a combination of storm water and wastewater networks in newer areas.

The domain at the city scale covers a 46 km² area representative of the whole city land use (Fig. 4) (Chancibault et al, 2014, Allard, 2015). It is located at the northeast of the city, between the Erdre and the Loire Rivers. The oceanic climate allows mild and rainy winters and fresh summers with annual total rainfalls of 819 mm with frequent but low intensity rains. Inside this domain, the studied catchment is the Pin Sec district (Le Delliou et al, 2009), developed between 1930 and 1970. Its area of 31 ha is mainly residential including single housing with private gardens in the West and shared housing with public parks in the East. The separated sewer network is 50 years old. For both scales, the simulation will run 884 days from 05/01/2010.

At the City scale, several catchments with different urban morphologies will be simulated at a same time (residential, shared housing, commercial areas, …), for each scenario. The soil properties will be assigned to observed values on the Pin Sec catchment, for lack of more data.



4. Figure Nantes Metropolitan area drained by the Loire and the Erdre Rivers (blue). The rectangle delineates the studied area at the city scale. The Pin Sec catchment is located in the centre of this rectangle.

3.3.4 Storm Water Quality

Case studies were chosen in Nantes (swales category) (Legret et al., 1995; Durin et al., 2007) and in Nancy (green roof/SUDS) (Schwager et al., 2015). The two cities are representative of two strongly different pedo-climatic conditions. See above for a description of the oceanic climate in Nantes. Soils of Nantes are formed mainly from

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alteration of mica schists and granite. The anthropogenic influence is marked in old centre of the city around former industrial zones. Some SUDS are foreseen, such as those collecting the storm waters of the major bridge on the road-ring of Nantes (90 000 vehicles/day). The impact of scenarios (variation of storm water quality) will be studied with the data collected during a 4 years period (2002-2005) (about 15 sampling campaigns). Other SUDS are available for evaluation of scenarios with data collection within the Matriochkas project (2016-2018). The urban area of Nancy has 434 000 people, it is in Eastern France in a continental climate (10°C mean annual temperature, 775 mm annual rainfall).

An experimentation on a green roof was conducted over a period of two years for evaluation of hydrologic process and of water quality. The performance assessment of SUDS and green roof will be conducted on heavy metals, as for other pollutants data are not fully available. Some of the case studies on other NBS categories are not relevant against the water quality UC (rainwater). Even if category 6 is relevant, data or literature on environmental-friendly practices including no pesticides use are rarely available. All the spatial scale application is 'object'.

3.3.5 Flood Management

The study area is in Trabzon province and covers approximately 16 416 ha. The study region extends along ED 50 datum Zone 41° 0' 9.709" N 39° 43' 0.347" E on the East Black Sea Region of Turkey. The Trabzon city, the centre of the Black Sea region in Turkey, is an open door to Asia for West Black Sea region and Turkey.

West Black Sea region is situated on an area around 30,000 km², incorporating 12 towns and four river basins. The greater part of the seepage territories of these rivers have short main courses, with soak inclines and are somewhat dismembered with profound valleys. During floods the flows have a high speed and, due to elevated sediment load, are muddy and viscous. Man has harmed the backwoods cover and the water-holding limit of the seepage basins has diminished, so erosive energy is very high. A lot of erosion and debris materials are hauled by the streams and saved in the plainer low-lying regions. Sudden floods, especially occurring in the short river courses are common and these produce widely devastating flash floods in the study area, most frequently between May and July. Because of topography, nearby individuals utilize the surge fields of streams situated in restricted valleys both for urban settlement and agriculture in rustic regions. Since the ripe land is constrained to the narrow valleys, it has a high esteem and is used without considering the hazardous conditions (Gurer, et al. 2019).

3.3.6 Biodiversity

Case studies based on previous works were selected in the west part of France where wooded areas were analysed according to their vegetation biodiversity (Daniel et al 2013, Vallet et al. 2010). The study area (in common with Urban Space Management) covers the three most important conurbations of the Massif Armorican (i) Angers (47°28' N - 0°33' W), (ii) Nantes (47°13' N - 1°33'W) and (iii) Rennes (48°06' N - 1°40' W) in north-western France.

The climate is oceanic (average annual rainfall from 618 mm in Angers to 790 mm in Nantes; average annual temperature from 11.4°C in Rennes and 11.9°C in Nantes). Conurbation areas are between 510 km² and 610 km² for about 300 000 to 600 000 inhabitants. Forest cover is very low (10% of the studied areas) with numerous small forested fragments. Land use and land cover maps have been produced to distinguish impervious surfaces and green areas. The relief is not significant (plain).

In terms of local climate zone, the study area has a Western European oceanic climate influenced by its proximity to the Atlantic Ocean. Winters are usually mild and rainy (average temperature of 5 °C). Summers are

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moderately warm (average temperature of 18.5 °C). The application spatial scale is city, city part and neighbourhood and the database extended from 2006 to 2011. Fifty wooded sites were sampled and the collected data was used for the scenarios.

3.3.7 Urban Green Space Development and Regeneration

As for now, there exist two case studies for the BAF EM (Duquesnoy-Mitjavila, 2018), picked from the pioneering NBS experiences described in D1.4.

- Quay Gardens in Nantes, France. Implementation of vegetated rafts as habitats for local species on a city centre river. Artificial shelters for fauna (nesting box, insect hotels, artificial spawning areas…) and vegetation supports were installed. Wooden terraces were also installed to allow citizens to enjoy and observe biodiversity. Latitude: 47.220984; Longitude: -1.552654. This NBS displays 6 of the 16 land uses described in BAF EM.
- "Séqué" eco-district in Bayonne, France. Design and construction of an eco-district with the ecological networks and biodiversity as starting point. The implementation of this project is based on an environmental approach to urban planning. The district is an environmentally-friendly project and favours collective housing to preserve green areas. Latitude: 43.509207; Longitude: -1.433361. This NBS displays 12 of the 16 land uses described in BAF EM.

These case studies have shown that the BAF indicator is quite flexible and understandable but includes some limitations. For example, this indicator is a surface ratio, and it does not assess the ecological potential of a developed area. Instead, it approximates the interest of this area for life support, based on hypothesis on soil cover permeability, planted soil depth and isolation. This way, this indicator would be of interest to compare alternative developments on the same area, but not to compare different projects.

Another teaching of these case studies is that, as far as we know, required data type do not fit land use open databases. The consequence is that input data must be collected on site or by interviewing the area's managers or designer.

3.3.8 Urban space Management

In these case studies the foci are on the one hand on UGSP (Urban Green Space Proportion) and CGS (Connectivity of Green Spaces), which are two common indicators of determining the ratio and distribution of green spaces in urban area, while on the other hand on the SPI (Sustainable Practices Indicator) which aims to investigate best practices of implementing NBSs due to surveys and interviews.

For UGSP and CGS

The study area covers the three most important conurbations of the Massif Armoricain (i) Angers (47°28' N - 0°33' W), (ii) Nantes (47°13' N - 1°33'W) and (iii) Rennes (48°06' N - 1°40' W) in north-western France. The climate is oceanic (average annual rainfall from 618 mm in Angers to 790 mm in Nantes; average annual temperature from 11.4°C

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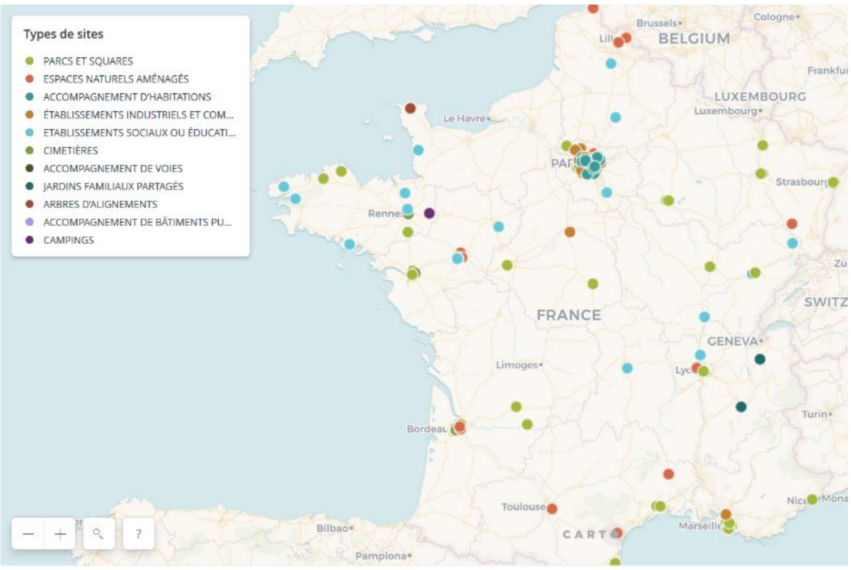
in Rennes and 11.9°C in Nantes). Conurbation areas are between 510 km² and 610 km² for about 300.000 to 600.000 inhabitants.

Forest cover is very low (10% of the studied areas) with numerous small forested fragments. Land use and land cover maps have been produced to distinguish impervious surfaces and green areas. The relief is not significant (plain). In term of local climate, the study area has an oceanic climate influenced by its proximity to the Atlantic Ocean. Winters are usually mild and rainy (average temperature of 5 °C). Summers are moderately warm (average temperature of 18.5 °C). The application spatial scale is city, city part and neighbourhood and the database extends from 2006 to 2011.

For SPI EM

The SPI EM, in its French version, has been successfully used on 391 sites since its publication in 2011. These sites are all located in the Metropolitan French area (see map below) and http://label-ecojardin.fr/sites-labellises). They all correspond to an identified NBS type in Nature4Cities. Those NBS types range from City parks (small and large) to Cemeteries, Family gardens, Street trees or Natural areas. At this date, there is no complete case study of the SPI EM English version.



5. Figure Study site types of SPI EM

Legend, from top to down: Site types

- Parks and gardens
- Natural area
- Housing
- Business or industry
- Schools
- Cemeteries
- Road verges
- Family gardens
- Street trees
- Public buildings
- Camping grounds

Those applications have shown that the method is fit for objective assessment of the management practices of a given site. The results allow a monitoring approach at site scale (i.e. to follow management improvement or degradation through time). The method was not designed to compare different sites, so the results have not been used this way. Instead, all the assessments put together show which management best practices are the most implemented, and where lies room for improvement (for more details and examples see http://www.arb-idf.fr/article/retour-rencontre-ecojardin-2016 document "Bilan EcoJardin 2012-2015". Jonathan Flandin, ARB îdF).

3.3.9 Soil Management and Quality

The case study is the city of Paris. It is the capital of France (48°51′12″ N, 2°20′55″ E). This city is included in the Grand Paris Metropolis, which is the urbanized centre of the region Ile-de-France. It covers an area of 815 km² (Paris city covers 105 km²), including 17.4 km² occupied by water. The population was 7.0 million inhabitants in 2014 (with

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nearly 2.22 million in Paris city) and the total population density was 8.60 inhabitants per km^2, but it was 21,067 inhabitants per km^2 in Paris city.

Finally, this region accounted for approximately 10.6% of the total population of metropolitan France (INSEE – French National Institute of Statistics and Economic Studies, 2014). The altitude is between 24 m and 180 m. According to the Köppen climate classification system, the climate is temperate oceanic (Cfb) with an average temperature of 11.6 °C (annual low and high temperatures: + 7.86 °C and + 15.5 °C) and an average rainfall of 591 mm per year. In terms of local climate zone, the city of Paris has a typical Western European oceanic climate (Köppen climate classification: Cfb) which is affected by the North Atlantic Current. The overall climate throughout the year is mild and moderately wet. Summer days are usually warm and pleasant with average temperatures between 15 and 25 °C, and a fair amount of sunshine. Paris has an average annual precipitation of 641 mm, and experiences light rainfall distributed evenly throughout the year.

In terms of urban form of the case study, according to Masson et al., (2014), most of Paris' city LCZ are: ancient centre (LCZ2), industrial building (LCZ8 and 10), high-rise tower (LCZ4), discontinuous block (LCZ5) and continuous block (LCZ1). The application spatial scale is between object and city scale and the database has been built since 1993. For the case of N4C project, the focus is on the time interval between 2007 and 2017.

3.3.10 Food, Energy, Water (focusing on Energy efficiency)

For a case study, a previous study was proposed that has been carried out in Laurent Malys PHD thesis (Malys, 2012; Malys, Musy, & Inard, 2016) using Solene-microclimat. It contained in the detailed simulation of the impact of green roofs, walls and lawns on a residential 5-story buildings (Fig. 6) located in a mid-dense district (Fig. 7) in Nantes. Buildings are divided into two categories: insulated or not. As the simulation has not been carried out with climate data hot enough to generate cooling demand, the impacts have been assessed in terms of indoor comfort.

However, for the insulated buildings, it has been shown that the vegetation had a very small impact. For the non-insulated building, the simulation results clearly allow hierarchizing the impact of these three solutions on indoor temperature and energy demand would follow the same tendencies (Fig. 8 & 9).

(a) (b)

6. Figure Pictures of the studies building

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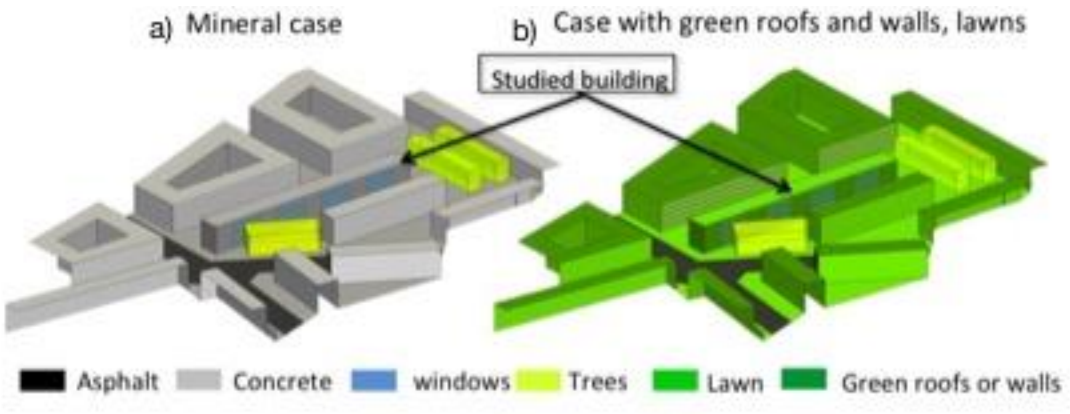
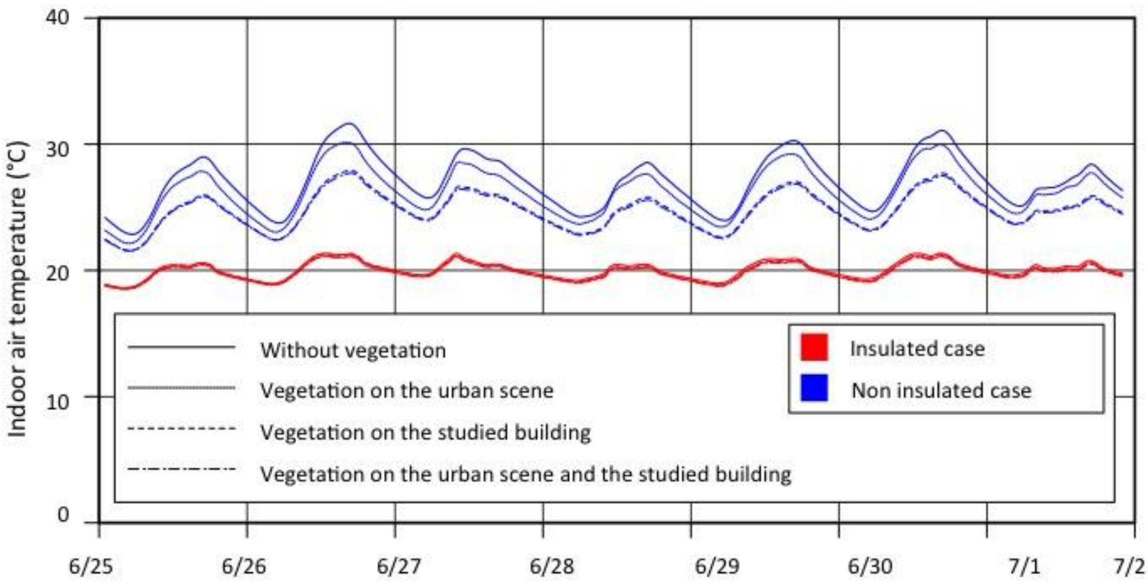


7. Figure The urban form and the two extreme scenarios



8. Figure Results showing indoor temperature of the 2nd floor, for the different scenarios. In the case of an insulated building, the greening has a very little effect.

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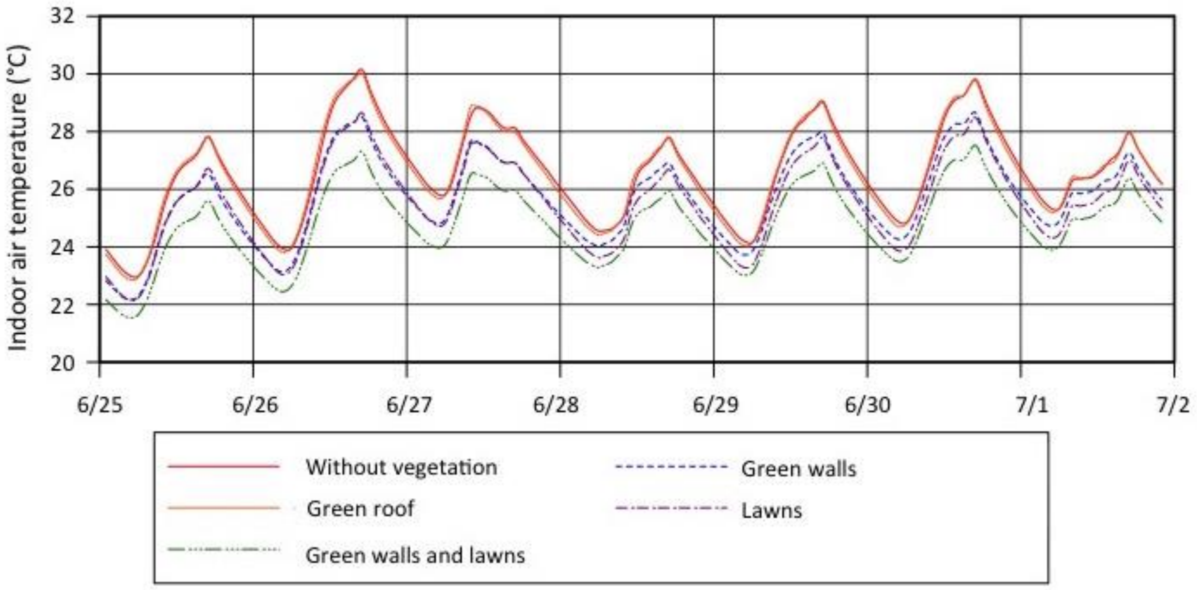

9. Figure Results showing indoor temperature of the 2nd floor (non-insulated building) when applying green roofs or green walls on the building or lawns to the surrounding surfaces.

3.3.11 Acoustics

Regarding the acoustics sub challenge, to easily access a wide quantity AND accurate description of influent parameters (input data such as land cover, road traffic counts, etc., see corresponding Appendix 1), we will work on the same case study as for urban water management (see above Section 3.3.3). This is the City of Nantes, the sixth most populous city in France (582,159 inhabitants in 2009) covering a 534 km² area and composed of various types of land uses: dense urban in the city centre, business and retail zones, suburban zones, and rural zones at the periphery.

More precisely, regarding space scale, after previous work on NBS effects at street scale (Guillaume et. al., 2014,2015), we plan to work in N4C framework we will work on both “Neighbourhood” and “City” scales (see above Section 3.2.11), focusing on the same particular “Pin Sec” district of Nantes, developed between 1930 and 1970. Its area of 31.29 ha is mainly residential including single housing with private gardens in the North and shared housing with public parks in the South.

Thus, we will have access to very well documented input data (BD TOPO®, Open Street Map, road traffic databases, Nantes Metropole urban databank, etc.) in order to compare different NBS scenarios in terms of vegetation percentage (%) for urban horizontal AND vertical surfaces (see above Section 3.2.11).

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3.3.12 Urban Planning and Form

Measuring the level of segregation in urban areas has quite a long history and several types of measurement methods and indices have developed (Barros & Feitosa, 2018). The indices are influenced by several defining factors or parameters, which could considerably modify the results. The indices were applied on London and Sao Paulo in the framework of an international project and the results showed that the indices are not interchangeable.

The comparison of different studies can be difficult depending on whether the study chose only representative groups to measure segregation or tried to identify all the groups. In this case a reduced number of groups is utilized.

The size of the area and the total population number and density can make the comparison more complicated. In the case of comparing Sao Paulo and London, the greater population of Sao Paulo required that the administrative border in London be extended to equalize the populations of the two cities.

In this relation, different calculations were carried out to determine the differences between the results of segregation indices and their sensitivity regarding the parameters which were taken into consideration.

The results of the study show how the segregation indices alter regarding the considered parameters. However, it should be mentioned that this study did not involve the topic of NBS or the relevance of green infrastructure on the level of segregation. Most of the reviewed studies (Catney, 2017; Clark et al., 2015; Fowler, 2016; Östh et al., 2015) did not consider the importance of green surfaces, although those which did (K.N. Irvine et al., 2013; Haffner, 2015), failed to apply this module of QGIS.

The impact of an NBS project can be proven in two ways. As mentioned, it is possible to track the effect on a timely basis. Measuring segregation at the beginning of an NBS project and 5 years after its end ensure, the changes in segregation levels are quantified.

On the other hand, the impact of implementing an NBS can also be proven with spatial comparison of the measured neighbourhood (where NBS has been implemented) and another one that has similar features, but no actions, has been done. This allows to prove the effectiveness of NBS projects on segregation if there are no timely data available.

It is also important to mention that there might be other dependent variables that cannot be influenced by the implementation of NBS projects. These variables (general changes throughout the city, changes of the real-estate market, etc.) need to be normalized before carrying out the correlation analysis.

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Conclusion

The main purpose of Work Package 2 in Nature4Cities project is to assess the urban performance of NBS on different Urban Challenges. Eventually to create a SUA Tool which can make the urban planning in an early phase more predictable. In favour of this, indicators were identified by expert groups in each USC, then KPIs were nominated by a scoring method called RACER. In the next stage models and methods were investigated to find the most appropriate ones with which the selected KPIs can be calculated. In the next stage an NBS database was compiled by integrating the streamlined NBS archetypes, the parametrized EMMs and scenarios and the Europewide real life case studies.
As a result of the deliverable 2.3 we can list three most important findings.

First of all, the streamlining of the NBS archetypes were carried out in each USC, with maximum 5-6 groups per USC, to keep the coherence of the database. In favour of identifying the impact mechanisms of NBSs, those with low effect or no significance on the USC were omitted from the process as they were not relevant. (Initially there were eleven subchallenges, but it has been proven, that water quality needs to be divided into urban water management and storm water quality, thus 12 columns emerged.) The NBS streamlining has a relevance not only within the project structure – as previously described, but also makes connection with other "sister" NBS projects (Task Force for NBS assessment), funded under Horizon 2020, as all of the projects have difficulties how to separate NBS from GI, where the borderline should be drawn. Through this process it has been proved, that nature-based solutions can be clearly grouped according to their impact on urban subchallenges.
Secondly, the parametrization process is also an important result of Task 2.3, however, this might be considered the trickiest part of the work. On the one hand, in the cases of some commonly used KPIs there are existing and accepted normalization methodologies, that made parametrization easier. On the other hand, KPIs need to be complex, and therefore some specific indicators are hard to be normalized without losing relevant pieces of information. This is the case usually with social indicators, where the result is dependant to countless factors and is hardly predictable. Presumably, urban planners will tend to use those indicators within the SUA Tool, where they will get clear, comparable and easy-to-use results without the necessity of giving too many or too detailed data as an input.
Thus, building scenarios with the help of the NBS streamlining and the parametrization was not easy as at this point two, seemingly contradictory requirements meet each other. On the one hand, normalization should be lossless, and scenarios should abstract reality best as possible, on the other hand, scenarios should be easy-to-use. Therefor it has been decided to use real case-studies to describe modelling scenarios. Case studies came from either the experience of the expert groups or based on detailed literature review.
Finally, the main output of the deliverable is a selection of case studies that makes the modelling process; the assessment methodologies; and the impact mechanisms of NBSs on urban subchallenges clear. In some respect these are stories demonstrating the process of evaluating NBSs in fighting the negative effects of urbanization.

Further utilization of results

Most importantly, the results of T.2.3 will be a basic input for the following T.2.4 Task. The development of a simplified urban performance assessment tool (SUA Tool). GREENPASS® will be used to cover USC climate adaption

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and, partially, biodiversity. Colouree® will be used for urban planning indicators which utilize open-source databases for the calculation of designated KPIs.

A further aim is to use additional expert models to extend related databases to enable a European-wide assessment. The collected case studies within this task will be integrated to the SUA Tool in a descriptive form as evaluation guidance.

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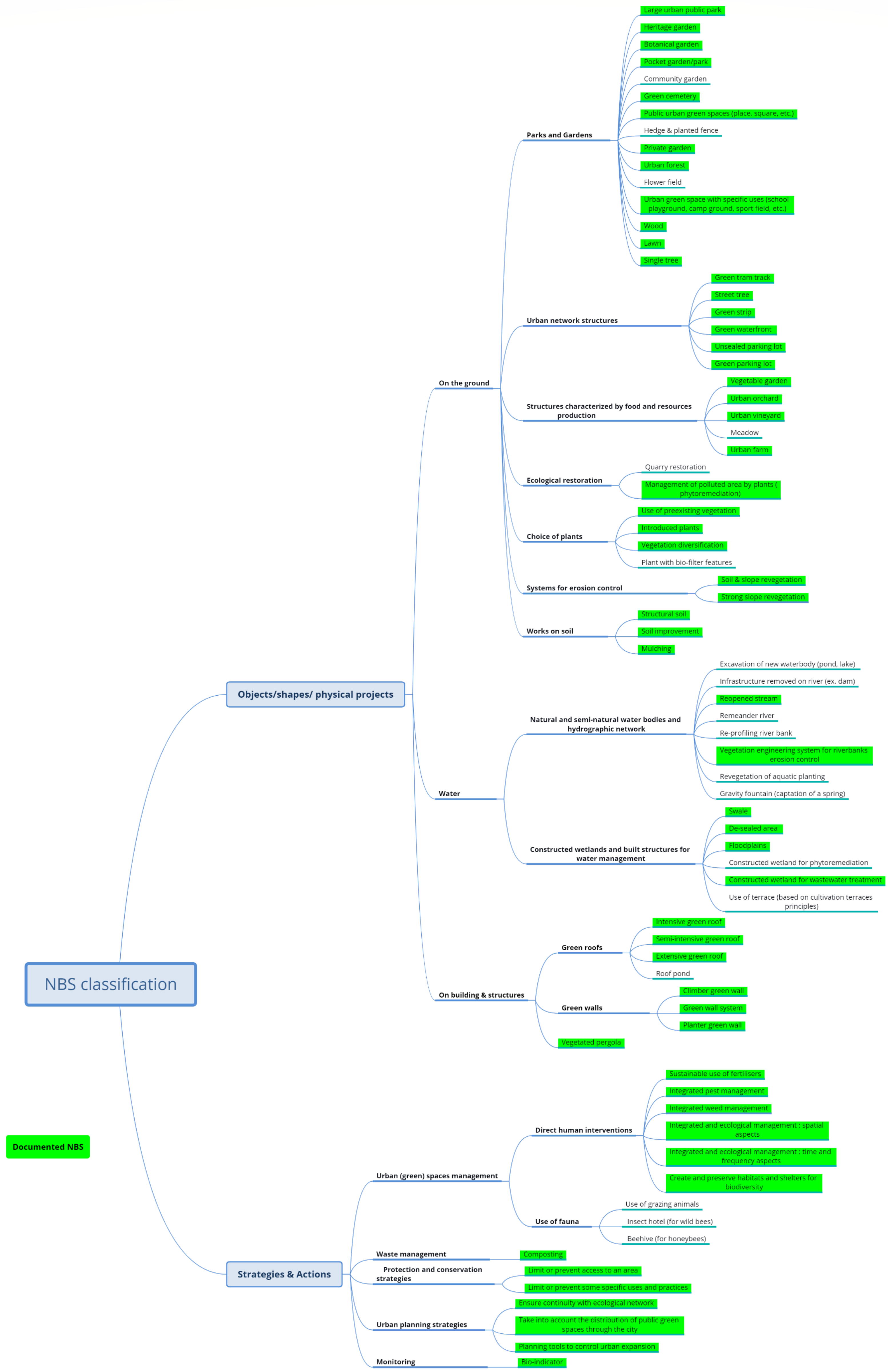
Appendix I: List of NBS archetypes



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Appendix II: The results of streamlining in case of each USC

NBS TYPES – Objects / shapes / physical projects – On the ground		SZTE 1.1 CLIMATE MITIGATION	G4C 1.2 CLIMATE ADAPTATION	UN-IFSTTAR 2.1 URBAN WATER MANAGEMENT	UN-IFSTTAR STORMWATER QUALITY	ARG 2.2 FLOOD MANAGEMENT	AO 4.1 BIODIVERSITY	MUTK 4.2 URBAN GREEN SPACE DEVELOPMENT AND REGENERATION	AO and P&C 4.3 URBAN SPACE MANAGEMENT	AO 5.1 SOIL MANAGEMENT AND QUALITY	CER 6.1 ENERGY EFFICIENCY	UN-IFSTTAR 7.1 ACOUSTICS	MUTK 9.1 URBAN PLANNING AND FORM
Parks and Gardens	Large urban public park					Large green spaces	heterogeneous unbuilt area	Large green spaces			Cool surrounding surfaces	green space / large / horizontal / mix vegetation (low and high plants)	Large green spaces with open access
	Heritage garden												
	Botanical garden						intensive unbuilt area		Cultural+societal	small rebuild areas			
	Pocket garden/park	Green spaces				Small green places		Small green places				green space / small / horizontal / mix vegetation (low and high plants)	Green spaces with limited access
	Green cemetery								societal				
	Public urban green spaces (places, squares etc.)			park	park	Large green spaces	heterogeneous unbuilt area	Large green spaces	Cultural+societal	small transformed areas		mixed green and grey space / small / horizontal / mix vegetation (low and high plants)	Large green spaces with open access
	Urban forest		Vegetation				extensive unbuilt area		Regulation+support	Small semi-natural areas		green space / large / horizontal / mix vegetation (low and high plants)	
	Private garden	Residential sites				Small green places		Small green places	societal			green space / small / horizontal / mix vegetation (low and high plants)	
	Urban green space with specific uses (schools, playgrounds, camp grounds, sport fields)					Large green spaces	heterogeneous unbuilt area	Large green spaces	regulation+support+societal+cultural	small rebuild areas	Cool surrounding surfaces	mixed green and grey space / small / horizontal / mix vegetation (low and high plants)	Green spaces with limited access
	Wood	Green spaces		trees	trees	trees	extensive unbuilt area	Small green places	societal	Small semi-natural areas		green space / large / horizontal / specific vegetation (high plants)	Large green spaces with open access
	Lawn			gardens	gardens	Large green spaces	intermediate unbuilt area	Large green spaces	Regulation+support			green space / small / horizontal / specific vegetation (low plants)	
	Single tree	Trees, shrubs and bushes	Tree in small, medium or large	trees	trees	trees		Small green places			Shading	green space / small / horizontal / specific vegetation (high plants)	Green spaces with limited access
Urban network stuructures	Grass tram tracks		Vegetation	gardens	gardens	Distributed vegetation	intensive unbuilt area		societal+regulation+support	small transformed areas	Cool surrounding surfaces	green space / small / horizontal / specific vegetation (low plants)	
	Street trees	Transport facilities and infrastructures	Tree in small, medium or large	trees	trees	trees	intermediate unbuilt area	Linear green areas	Regulation+support		Shading	green space / small / horizontal / specific vegetation (high plants)	Linear green areas
	Green strips		Vegetation	gardens			extensive unbuilt area		societal+regulation+support	Large transformed areas		green space / small / horizontal / mix vegetation (low and high plants)	
	Green waterfront city	Waterside zones					heterogeneous unbuilt area			medium rebuild areas			Strategic NBSs
	Unsealed parking lot				gardens	Distributed vegetation	intermediate unbuilt area						Restoration and upgrade with NBS
	Green parking lot	Transport facilities and infrastructures	Unsealed				intensive unbuilt area		societal+regulation	Mixed sealed opened areas	Cool surrounding surfaces	mixed green and grey space / small / horizontal / mix vegetation (low and high plants)	
Structures characterized by food and resources production	Vegetable gardens			gardens				Small green places		medium rebuild areas		green space / small / horizontal / specific vegetation (low plants)	Green spaces with limited access
	Urban orchards	Agricultural sites	Vegetation		park	Small green places			Production				
	Urban vineyards						heterogeneous unbuilt area			medium semi-natural areas			
	Urban farms	Grassland											
Ecological restoration	Management of polluted areas by plants (phytoremediation)						intermediate unbuilt area	Restoration and upgrade with NBS	Regulation	medium rebuild areas			Restoration and upgrade with NBS
Choice of plants	Introduced plants				gardens			Maintenance technique					Maintenance technique
	Use of preexisting vegetation						strategy		Support	phytoremediation areas			
	Vegetation diversification								Cultural+societal				
Systems for erosion control	Soil & slope revegetation									large transformed areas			
	Strong slope revegetation					Large green spaces	extensive unbuilt area	Restoration and upgrade with NBS	Regulation	small transformed areas			Restoration and upgrade with NBS
Works on soil	Structural soil												
	Soil improvement			gardens									
	Mulching					management	management	Maintenance technique	Support	small rebuild areas			Maintenance technique

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				1.1 CLIMATE MITIGATION	1.2 CLIMATE ADAPTATION	2.1 URBAN WATER MANAGEMENT	STORMWATER QUALITY	2.2 FLOOD MANAGEMENT	4.1 BIODIVERSITY	4.2 URBAN GREEN SPACE DEVELOPMENT AND REGENERATION	4.3 URBAN SPACE MANAGEMENT	5.1 SOIL MANAGEMENT AND QUALITY	6.1 FOOD, ENERGY AND WATER (focusing on ENERGY EFFICIENCY)	7.1 ACOUSTICS	9.1 URBAN PLANNING AND FORM
NBS TYPES	Objects / shapes / physical projects	Water	Natural and semi-natural water bodies and hydrographic network: Reopened streams	Waterside zones						Linear green areas	Regulation+support	wet land areas			
			Vegetation engineering systems for riverbanks erosion control			swales	swales	Large green spaces	extensive unbuilt area			Large semi-natural areas			Restoration and upgrade with NBS
			Constructed wetlands and built structures for water management: Swales						heterogeneous unbuilt area	Restoration and upgrade with NBS		small transformed areas			Maintenance technique
			De-sealed areas (and associated systems, ex.permeable paving)			gardens	gardens	Lawns and low vegetation	intensive unbuilt area		Regulation	Small mixed sealed opened areas	Cool surrounding surfaces		Restoration and upgrade with NBS
			Constructed wetland for wastewater treatment			swales	swales	swales				transformed areas			Strategic NBSs
			Floodplains	Waterside zones					extensive unbuilt area	Strategic NBSs		Large semi-natural areas			
		On building structures	Green roofs: Intensive green roofs		Green roofs intensive						societal+regulation+support				
			Semi-intensive green roofs	Green roofs	Green roofs extensive	Green roofs	Green roofs	Green roofs			Regulation+support		green roof		Green spaces with limited access
			Extensive green roofs												
			Green walls: Climber green walls		Green wall climber				built area	Small green places		small transformed areas			
			Green wall system	Green wall	Green wall facade-based		trees				societal+regulation+support		green wall	green space / small / vertical / specific vegetation (low plants)	Linear green areas
			Planter green wall		Green wall planter										
			Vegetated pergola	Residential sites	Green wall	Green roofs							Shading		
	Actions & strategies	Urban green spaces management	Sustainable use of fertilizers												
			Integrated pest management				environmental-friendly practices								
			Integrated weed management					management		Maintenance technique					Maintenance technique
			Integrated and ecological management: Time and frequency aspect						management						
			Integrated and ecological management: Spatial aspects												
			Create and preserve habitats and shelters for biodiversity							Strategic NBSs					Strategic NBSs
		Waste management	Composting (as a treatment of green debris)							Maintenance technique	Support				Maintenance technique
		Protection and conservation strategies	Limit or prevent access to an area												
			Limit or prevent some specific uses and practices												
		Urban planning strategies	Ensure continuity with ecological network						strategy	Strategic NBSs					Strategic NBSs
			Take into account the distribution of public green spaces through the city			parks		strategy							
			Planning tools to control urban expansion												
		Monitoring	Bio-indicators						management	Maintenance technique					Maintenance technique

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Appendix III: The factsheets of data matrix in each USC

10. FigureMatrix of Climate Mitigation USC

Modelling scenarios	
Name of the contributor(s)	SZTE
Name of the UC / USC	**1.1 Climate mitigation**

Expert model	i-Tree Eco		
KPIs from T2.2	Parameters (dependent variable)		
	Name	Dimension	Range of values
Annual carbon sequestration	Tree height	m	-
	Crown base height	m	-
	Crown diameter	m	-
	Diamater at breast height	cm	-
	Missing parts in the crown	%	0-100
	Crown dieback	%	0-100

Parameters (independent variables concerned as constant)		
Name	Dimension	Range of values
1. Number of frost-free days (from hourly climatic data)	count	-
2. Species of the trees	-	-
3. Geographical location	-	-

Database, data sources: Dependent variables: from field tree inventory (data is partly obtainable with remote sensing techniques).
Independent variables: 1: Tree species: from the field inventory, 2: Location-related data: from publicly available data sources, and from local (or global) climatic datasets

Can not involve into the calculation, because they are not trees or not contain trees

Name of the scenario - group name from the streamlining of NBS archetypes	Green spaces	Residential sites	Trees, shrubs and bushes	Transport facilities and infrastructures
List of NBSs in this group from UC vs NBSs streamlining table	Large urban public park	Private garden	Single tree	Street trees
	Heritage garden	Vegetated pergola		Grass tram tracks
	Botanical garden			Green strips
	Pocket garden/park			Unsealed parking lot
	Green cemetery			Green parking lot
	Public urban green spaces (places, squares etc.)			
	Urban forest			
	Urban green space with specific uses (schools, playgrounds, camp grounds, sport fields)			
	Wood			
	Lawn			

Name of the scenario - group name from the streamlining of NBS archetypes	Agricultural sites	Waterside zones	Grassland	Green roofs	Green wall
List of NBSs in this group from UC vs NBSs streamlining table	Urban orchards	Reopened streams	Urban farms	Extensive green roofs	Climber green walls
	Vegetable gardens	Green waterfront city		Semi-intensive green roofs	Green wall system
	Urban vineyards	Floodplains		Intensive green roofs	Planter green wall

CASE STUDY	
Name of the case study	Ecosystem Services of Urban Forests in Barcelona
Expert modell from T2.2	i-Tree Eco
Scale of the case study area	City
Area / Location	Barcelona, Spain
Elevation (plain, hill, mountain, other)	plain and on the seaside
Local climate zone	
Urban form of the case study (see types of LCZ)	
When research was carried out? (year)	2014 (Fieldwork from May to July, 2009)
Others	

Short describtion of case study: Plot-based i-Tree study, which means that the model uses individual trees' data, but stratified in plots, which describe the city's spatial heterogenity (it is the more frquent approach in city-wide assessments). The measured data of the trees are species, and several size and condition-related paramaters. The place of the case study is the municipality of Barcelona, Spain (1,62 million inhabitants, 101,21 km2). The calculations are based on in-built biomass equations and ecosystem processes related to the investigated ecosystem services (carbon sequestration, air pollution removal). The results for carbon sequestration were compared with the greenhouse gas emission inventory of the city (differently for the land use types). The calculated mitigation capacity of the nature-based solutions can be incorporated in city-level climate adaptation strategies. The methodological approach can be used by other cities in Europe with similar policy needs.

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11. Figure Matrix of Climate Adaptation USC

Modelling scenarios	
Name of the contributor(s)	G4C
Name of the UC / USC	**1.2. Climate Adaptation**

Expert model	GREENPASS® ENVI-met		
KPIs from T2.2	Parameters (dependent variable)		
	Name	Dimension	Range of values
AT - Air temperature **TCS - Thermal Comfort Score** **PET - physiological equivalent temperature**	location (solar altitude)	GPS	longitude and latitude
	CO_2 Fixation type	-	C3 or C4
	Leaf Type	-	Grass, Deciduous, Conifer
	Leaf Albedo to shortwave radiation	Frac	0-1
	Plant height	m	0-
	Root Zone depth	m	0-
	Leaf Area (LAD) Profile	Frac	0-1.00000 for 1/10-10/10
	Root Area (RAD) Profile	Frac	0-1.00000 for 1/10-10/10
	Simulation date	xx.xx.xxxx	date
	Wind speed in 10m	m/s	0-
	Wind direction	degree	0-360
	Roughness length at measurment site	-	0.001-0.1
	Initial temperature of atmosphere	°C	xx.xx
	specific humidity at model top (2500 m)	g/kg	x.x
	relative humidity in 2m	%	0-100
	Clouds: cover of low clouds	octas	0-8(total)
	Clouds: cover of medium clouds	octas	0-8(total)
	Clouds: cover of high clouds	octas	0-8(total)
	Solar radiation (by default calculated)	adjustment factor	x.x
	Soil humidity (usable field capacity) for three soil layers + initial temperature	%	0-100
	CO_2 background level	ppm	350 (standard)

Parameters (independent variables concerned as constant)	
Build digital model with environment and buildings including defined materials and walls (out of materials) with following informations: **Material:** **- default thickness (m) = Default/ typical thickness of this material** **- absorption (Frac) = Fraction of shortwave radiation absorbed by the material** **- transmission (Frac) = Fraction of shortwave radiation transmitted through the material** **- reflection (Frac) = Fraction of shortwave radiation reflected by the material (Albedo)** **- emissivity (Frac) = Emissivity for longwave thermal radiation** **- specific heat (J/(kg*K)) = Specific Heat of the material** **- thermal conductivity (W/(m*K)) = Thermal conductivity through the material on moleculare basis** **- density (kg/m3) = Density of material**	**Wall:** **- thickness of layers = Thickness of Layers. Enter the thickness of the different material layer used in this wall.** **Outer layer - width** **Center layer - width** **Inner layer - width** **- Total thickness (cm)** **- possible usage:** **Wall or Roof** **Roof only** **Wall only**

Database, data sources:	GP UST-database. Needed GP data specifications including classification due to GP typology
Any additional notes:	Standardazid NBS Types (GP Typology) and standardized USTs in different scenarios for rough impact assessment

Name of the scenario (group name of NBS)	Vegetation	Tree in small, medium or large	Unsealed	Green roofs intensive
List of NBSs in this group from UC vs NBSs streamlining table	Large urban public park	Single tree	Unsealed parking lot	Intensive green roofs
	Heritage garden	Street trees	Green parking lot	
	Botanical garden	Single tree		
	Pocket garden/park			
	Green cemetery			
	Public urban green spaces (places, squares etc.)			
	Urban forest			
	Private garden			

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	Urban green space with specific uses (schools, playgrounds, camp grounds, sport fields)
	Wood

Name of the scenario (group name of NBS)	Green roofs extensive	Green wall climber	Green wall facade-based	Green wall planter	Green wall
List of NBSs in this group from UC vs NBSs streamlining table	Semi-intensive green roofs	Climber green walls	Green wall system	Planter green wall	Vegetated pergola
	Extensive green roofs				

CASE STUDY	
Name of the case study	GREENPASS® UST database
Expert modell from T2.2	GREENPASS® + ENVI-met
Scale of the case study area	Neighbourhood (every UST has a standard size of 200x200 m in her origin)
Area / Location	Vienna, London + (HongKong, Santiago de Chile and Cairo)
Elevation (plain, hill, mountain, other)	The relief is not significant (plain)
Local climate zone	In total 30 USTs in some variatons - every one in 4 scenarios. If available, link to LCZ, but much more detailed.
Urban form of the case study (see types of LCZ)	own urban standard typologies including NBS
When research was carried out? (year)	Since 2015 + ongoing; Start: 2017 - Green.Resilient.Cities Project
Others	

Short describtion of case study: The GREENPASS® USTs are a cluster of standardized and abstracted urban morphologies worldwide. The USTs are splitting up to global (1) and local (2) USTs. (1) These global structures are based on an analysis and clustering of the local USTs and are linked and defined by a allocation to the LCZ from STEWART-OKE (2011, 2012) The allocation of the local USTs to the respective LCZ is based on building area ratio, building heights, usage and appearance respectively the written description of the LCZ. The result are XX global UST and XX variations. (2) The local Urban Standard Typologies (local UST) are urban morphologies based on an aerial photo analysis of the international GREENPASS® case studies cities Santiago de Chile, London, Wien, Kairo and Hong Kong. These 200m x 200m grids show the typical standardized building typology and percentages of building, street and open space area of the case study cities. They set a detailed and city-specific description of the city and cannot be allocated totally to the exisiting LCZ. Therefore new classes, which describe specific urban structures, have been developed, e.g. typical high-rised building in Hong-Kong or perimeter block typically occuring in Vienna.
The greened Urban Standard (gUST) Typologies Subsequently, the global USTs got invested with existing Green Infrastructure (GI) and Nature-based solutions (NBS) in relation to the local USTs. The results are the gUSTs: [1] global gUSTs, [2] local gUSTs
[1] global gUST: The global gUSTs are based on the underlying local gUSTs and their greening ratio. If a global gUST has several underlying local gUSTs, the average for the respective type of green infrastructure was applied.
[2] local gUST: As base for the local gUST, the local USTs got analysed out of the aerial photo analysis and greened regarding the occuring vegetation (GI and NBS) in the respective urban structure.
Urban scenarios Finally, four urban scencarios of the global gUST got configured. The following scenarios with different level of green infrastructure implemenations are based on a transparent greening recipe: Status Quo (SQ), Worst Case (WC), Moderate (MOD), Maximum (MAX).

12. Figure Matrix of Urban Water Management USC

Modelling scenarios	
Name of the contributor(s)	IFSTTAR
Name of the UC / USC	URBAN WATER MANAGEMENT
Database, data sources:	meteo france , local meteorological sensing, BD TOPO®, Nantes Metropole urban databank

Can not involve into the calculation, because of its scale	

Name of the scenario (group name of NBS)	PARK		
List of NBSs in this group from UC vs NBSs streamlining table		TEB-hydro	URBS
	Large urban public park	x	x
	Heritage garden	x	x

Name of the scenario (group name of NBS)	Greenroof		
List of NBSs in this group from UC vs NBSs streamlining table		TEB-HYDRO	URBS
	Semi-intensive green roofs		x
	Extensive green roofs	x	x
	Vegetated pergola		
Expert model	URBS/TEB-Hydro		
KPIs from T2.2	Parameters (dependent variable)		
	Name	Dimension	Range of values
1.Peak flow variation		-	-
2. vegetation percentage (of high and low vegetation)		%	-

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	Botanical garden	x	x
	Pocket garden/park	x	x
	Green cemetery		
	Public urban green spaces (places, squares etc.)		
	Urban forest	x	x
	Private garden	x	x
	Urban green space with specific uses (schools, playgrounds, camp grounds, sport fields)		
	Take into account the distribution of public green spaces through the city		
	Planning tools to control urban expansion		
Expert model	**URBS-TEB-Hydro**		
KPIs from T2.2	**Parameters (dependent variable)**		
	Name	**Dimension**	**Range of values**
1.Peak flow variation		-	-
2. vegetation percentage (of high and low vegetation)		%	-
3.area imperviousness percentage		%	-
Parameters (independent variables concerned as constant)			
Name		**Dimension**	**Range of values**
1. Soil texture, Ks		-	-
2. Meteorological forcing (ETP, rain intensity etc.)		-	-
3. localisation and Distribution of parks in the area		-	-
4. Depth of root zone			
Any additional notes: The KPI can be calculated on both neighbourhood (using URBS) and city scales (using TEB-HYDRO)			

Name of the scenario (group name of NBS)	**TREE**		
List of NBSs in this group from UC vs NBSs streamlining table (06 table)		TEB-HYDRO	URBS
	Wood		x
	Single tree		x
	Street trees	x	x
Expert model	URBS/TEB-Hydro		
KPIs from T2.2	**Parameters (dependent variable)**		

	surface of buildings with greenroofs fraction	%	-
Parameters (independent variables concerned as constant)			
Name		**Dimension**	**Range of values**
1. Soil texture, Ks		-	
2. Meteorological forcing (ETP, rain intensity etc.)		-	-
3. Position of the greenroof in the chosen area		-	-
4. Type of the greenroof (thickness of the substrat, thickness of the drain)		-	-
5. Type of buildings chosen to equip with greenroofs		-	-
Any additional notes: These indicators can be calculated on both neighbourhood (using URBS) and city scale (using TEB-HYDRO)			

Name of the scenario (group name of NBS)	**Swales**		
List of NBSs in this group from UC vs NBSs streamlining table		**TEB-HYDRO**	**URBS**
	Vegetation engineering systems for riverbanks erosion control		
	Swales		x
	Constructed wetland for wastewater treatment		
	Floodplains		
Expert model	URBS		
KPIs from T2.2	**Parameters (dependent variable)**		
	Name	**Dimension**	**Range of values**
1.Peak flow variation	vegetation percentage (of high and low vegetation)	%	-
	roads fraction	%	-
Parameters (independent variables concerned as constant)			
Name		%	0 - 100
1. soil texture		-	-
2. meteorological forcing(ETP, rain intensity etc.)		-	-
3. localisation of the swale		-	-
4. type of swale(Ks-swale, swale surface , roughness of swales)		-	-
5. Number of swales in the area			

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	Name	Dimension	Range of values
1.Peak flow variation	High vegetation percentage	%	-
	roads fraction	%	-
Parameters (independent variables concerned as constant)			
Name		**Dimension**	**Range of values**
1. soil texture, Ks		-	-
2. meteorological forcing(ETP, rain intensity etc.)		-	-
3. localisation of the trees		-	-
4. depth of root zone , height of trees		-	-
5. low vegetation percentage		-	-

CASE STUDY	
Name of the case study	**The city of Nantes (TEB-hydro), the Pin Sec neighborhood (URBS)**
Expert modell from T2.2	**TEB-HYDRO and URBS**
Scale of the case study area	**city part and neighborhood**
Area / Location	**Nantes is a city located on the Loire River, in the northwestern parrt of France.The Pin Sec basin is located on the east side of the city of Nantes**
Elevation (plain, hill, mountain, other)	**The relief is not significant (plain)**
Local climate zone	**The study area has a Western European oceanic climate influenced by its proximity to the Atlantic Ocean. Winters are usually mild and rainy (average temperature of 5 °C). Summers are moderately warm (average temperature of 18.5 °C). the annual rain average is 820 millimetres**
Urban form of the case study (see types of LCZ)	**we don't have enough information to establish these LCZ**
When research was carried out? (year)	
Others	

Short describtion of case study: The study area is located in the northen east part of the city of Nantes, the sixth most populous city in France. The Urban Community of Nantes Metropole has an area of 534 km2. Its population is expected to increase by 100,000 inhabitants in by 2030 (INSEE, 2012). Nantes Metropole is characterized by various types of land use: urban dense, commercial areas, residential areas and rural areas. The relief is not significant. However its drainage network is rather dense. Nantes is on the Loire River and is flowed into by many tributaries. The case study covers 46km^2 , it has a 44% of built surface, 46% of natural surfaces and 8% of water .The Pin sec basin is located inside the study area and covers 31ha ,the wooded area of the basin covers 18%, the built surface 17% and the surface of the streets 23%, and 11% of paved surface other than buildings and the street.

Name of the scenario (group name of NBS)	**Garden**		
List of NBSs in this group from UC vs NBSs streamlining table (06 table)		TEB-HYDRO	URBS
	Grass tram tracks		
	Green strips	x	x
	Unsealed parking lot	x	x
	Green parking lot	x	x
	Vegetable gardens	x	x
	Urban orchards		
	Urban vineyards		
	Urban farms		
	Introduced plants		
	Use of preexisting vegetation		
	Vegetation diversification		
	Strong slope revegetation		
	Structural soil		
	Soil improvement		
	Mulching		
	De-sealed areas		

Expert model	URBS/TEB-Hydro		
KPIs from T2.2	**Parameters (dependent variable)**		
	Name	**Dimension**	**Range of values**
1.Peak flow variation	Low vegetation percentage	%	-
	area Imperviousness percentage	%	-
Parameters (independent variables concerned as constant)			
Name		**Dimension**	**Range of values**
1. soil texture, Ks		-	
2. meteorological forcing(ETP, rain intensity etc.)		-	-
3. localisation of the garden		-	-
4. depth of root zone		-	-
5. high vegetation percentage		-	-

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13. Figure Matrix of Storm Water Quality USC

Modelling scenarios	
Name of the contributor(s)	IFSTTAR
Name of the UC / USC	STORM WATER QUALITY
Database, data sources:	meteo france , local meteorological sensing, BD TOPO®, Nantes Metropole urban databank

Name of the scenario (group name of NBS)	Swales		
List of NBSs in this group from UC vs NBSs streamlining table		HYDRUS 1D/2D	
	Vegetation engineering systems for riverbanks erosion control		
	Swales		
	Constructed wetland for wastewater treatment		
	Floodplains		
Expert model	HYDRUS 1D/2D		
KPIs from T2.2	Parameters (dependent variable)		
	Name	Dimension	Range of values
1.Efficiency ratio of depollution	vegetation percentage (of low vegetation)	%	-
	incoming water flow	L.T-1	
	pollutant concentration	M.L-1	1-500 µg.L-1

Parameters (independent variables concerned as constant)		
Name	Dimension	Range of values
1. European threholds for water quality	M.L-1	
2. geometry of the system	L	-
3. nature of soil	-	-
4. meteorological data	-	-
Any additional notes: The KPI can be calculated only on object scale		

Name of the scenario (group name of NBS)	Green roof		
List of NBSs in this group from UC vs NBSs streamlining table		HYDRUS 1D/2D	
	Semi-intensive green roofs	x	
	Extensive green roofs	x	
	Vegetated pergola		
Expert model	HYDRUS 1D/2D		
KPIs from T2.2	Parameters (dependent variable)		
	Name	Dimension	Range of values
1.Efficiency ratio of depollution	vegetation percentage (of low vegetation)	%	-
	incoming water flow	L.T-1	
	pollutant concentration	M.L-1	1-500 µg.L-1

Parameters (independent variables concerned as constant)		
Name	Dimension	Range of values
1. European threholds for water quality	M.L-1	
2. geometry of the system	L	-
3. nature of soil	-	-
4. meteorological data	-	-
Any additional notes: The KPI can be calculated only on object scale		

CASE STUDY	
Name of the case study	SUDS (retention-infiltration basin)
Expert modell from T2.2	HYDRUS 1D/2D
Scale of the case study area	object
Area / Location	Nantes is a city located on the Loire River, in the northwestern parrt of France.The Pin Sec basin is located on the east side of the city of Nantes
Elevation (plain, hill, mountain, other)	The relief is not significant (plain)
Local climate zone	The study area has a Western European oceanic climate influenced by its proximity to the Atlantic Ocean. Winters are usually mild and rainy (average temperature of 5 °C). Summers are moderately warm (average temperature of 18.5 °C). the annual rain average is 820 millimetres
Urban form of the case study (see types of LCZ)	we don't have enough information to establish these LCZ
When research was carried out? (year)	2006 (Cheviré pond), 2017 (Matriochkas project)
Others	

Short describtion of case study: The study area is located in the northen east part of the city of Nantes, the sixth most populous city in France. The Urban Community of Nantes Metropole has an area of 534 km2. Its population is expected to increase by 100,000 inhabitants in by 2030 (INSEE, 2012). Nantes Metropole is characterized by various types of land use: urban dense, commercial areas, residential areas and rural areas. The relief is not significant. However its drainage network is rather dense. Nantes is on the Loire River and is flowed into by many tributaries. About 350 SUDS are implemented in the Urban Community of Nantes Métropole, data on water flux and water quality are available for some of the retention-infiltration basins.

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14. Figure Matrix of Flood Management USC

Modelling scenarios	
Name of the contributor(s)	ARG
Name of the UC / USC	2.2 Flood Management

Expert model	Burst Pipe Analysis		
KPIs from T2.2	Parameters		
	Name	Dimension	Range of values
1	Variation of flooaded area	mm	
Can not involve into the calculation, because of its scale			

Name of the scenario (group name of NBS)	Large green spaces
List of NBSs in this group from UC vs NBSs streamlining table	Large urban public park
	Heritage garden
	Botanical garden
	Green cemetery
	Public urban green spaces (places, squares etc.)
	Urban forest
	Urban green space with specific uses (schools, playgrounds, camp grounds, sport fields)
	Lawn
	Strong slope revegetation
	Reopened streams
	Vegetation engineering systems for riverbanks erosion control
	Use of preexisting vegetation

Name of the scenario (group name of NBS)	Small green spaces
List of NBSs in this group from UC vs NBSs streamlining table	Pocket garden/park
	Private garden
	Vegetable gardens
	Urban orchards
	Urban vineyards
	Urban farms

Name of the scenario (group name of NBS)	Trees
List of NBSs in this group from UC vs NBSs streamlining table	Wood
	Single tree
	Street tree

Name of the scenario (group name of NBS)	Distributed vegetation
List of NBSs in this group from UC vs NBSs streamlining table	Grass tram tracks
	Green strips
	Green waterfront city
	Unsealed parking lot
	Green parking lot

Name of the scenario (group name of NBS)	Management
List of NBSs in this group from UC vs NBSs streamlining table	Structural soil
	Soil improvement
	Mulching
	Integrated weed management

CASE STUDY		
Name of the case study	The city of Ankara	
Expert modell from T2.2	Burst Pipe Analysis	
Scale of the case study area	neighborhood	
Area / Location	Ankara, Turkey	
Elevation (plain, hill, mountain, other)	The relief is not significant (Plain)	
Local climate zone	The climate is warm and temperate in Ankara. The winters are rainier than the summers in Ankara. This climate is considered to be Csa according to the Köppen-Geiger climate classification. The average annual temperature in Ankara is 11.6 °C. The rainfall here averages 383 mm.	
Urban form of the case study (see types of LCZ)		Open midrise
When research was carried out? (year)		2012
Others		

Short describtion of case study: The study is focused on the city of Ankara, located at latitude 39° 55' N and longitude 32° 51' E. The population is around 4.5 million. Ankara has an area of 25.632 km² with highly urbanized areas. The climate is warm and temperate in Ankara. The winters are rainier than the summers in Ankara. The average annual temperature in Ankara is 11.6 °C. The rainfall here averages 383 mm.

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15. Figure Matrix of Biodiversity USC

Modelling scenarios			
Name of the contributor(s)	AO		
Name of the UC / USC	4.1 Biodiversity		
Expert model	SBA Evaluation Method		
KPIs from T2.2	Parameters (dependent variable)		
	Name	Dimension	Range of values
RNPS: Ratio Native Plant Species	management level		
RNPS: Ratio Native Plant Species	type of use		
RNPS: Ratio Native Plant Species	management level		
RNPS: Ratio Native Plant Species	type of use		
Parameters (independent variables concerned as constant)			
Name		Dimension	Range of values
Richness in indigeneous plants		number of sp	0 - ...
Richness in exotic plants		number of sp	0 - ...
Can not involve into the calculation, because of its scale			

Name of the scenario (group name of NBS)	Extensive unbuilt area
List of NBSs in this group from UC vs NBSs streamlining table	Floodplains
	Green strips
	Reopened streams
	Soil & slope revegetation
	Strong slope revegetation
	Urban forest
	Vegetation engineering systems for riverbanks erosion control
	Wood

Name of the scenario (group name of NBS)	Intermediate unbuilt area
List of NBSs in this group from UC vs NBSs streamlining table	Lawn
	Management of polluted areas by plants (phytoremediation)
	Single tree
	Street trees
	Unsealed parking lot

Name of the scenario (group name of NBS)	Intensive unbuilt area
List of NBSs in this group from UC vs NBSs streamlining table	Botanical garden
	Constructed wetland for wastewater treatment
	De-sealed areas (and associated systems, ex.permeable paving)
	Grass tram tracks

Modelling scenarios			
Name of the contributor(s)	AO		
Name of the UC / USC	4.1 Biodiversity		
Expert model	SBA Evaluation Method		
KPIs from T2.2	Parameters (dependent variable)		
	Name	Dimension	Range of values
SDIH: Shannon diversity index of habitats	management level	-	-
SDIH: Shannon diversity index of habitats	type of use	-	-
UGSP: Urban Green Space Proportion	management level	-	-
UGSP: Urban Green Space Proportion	type of use	-	-
Parameters (independent variables concerned as constant)			
Name		Dimension	Range of values
Area of each ecological habitat types (bare and turf grass, of rough, grassland and herbs, of shrubs, of trees and of built environment)		m^2	-
Area of the NBS		m^2	-
Can not involve into the calculation, because of its scale			

Name of the scenario (group name of NBS)	Built area
List of NBSs in this group from UC vs NBSs streamlining table	Climber green walls
	Extensive green roofs
	Green wall system
	Intensive green roofs
	Planter green wall
	Semi-intensive green roofs
	Vegetated pergola

Name of the scenario (group name of NBS)	Strategy
List of NBSs in this group from UC vs NBSs streamlining table	Ensure continuity with ecological network
	Introduced plants
	Limit or prevent access to an area
	Limit or prevent some specific uses and practices
	Planning tools to control urban expansion
	Take into account the distribution of public green spaces through the city
	Use of preexisting vegetation
	Vegetation diversification

Name of the scenario (group name of NBS)	Management
List of NBSs in this group from UC vs NBSs streamlining table	Bio-indicators
	Composting (as a treatment of green debris)
	Create and preserve habitats and shelters for biodiversity

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	Green parking lot
	Heritage garden
	Pocket garden/park
	Vegetable gardens

Name of the scenario (group name of NBS)	Heterogeneous unbuilt area
List of NBSs in this group from UC vs NBSs streamlining table	Green cemetery
	Green waterfront city
	Large urban public park
	Private garden
	Public urban green spaces (places, squares etc.)
	Swales
	Urban farms
	Urban green space with specific uses (schools, playgrounds, camp grounds, sport fields)
	Urban orchards
	Urban vineyards

Short describlion of case study: The study area covers the 3 most important conurbations of the Massif armoricain (north-western France) : Angers (47°28'N - 0°33'W), Nantes (47°13'N - 1°33'W) and Rennes (48°06'N - 1°40'W) in north-western France where climate is oceanic (average annual rainfall from 618mm in Angers to 790mm in Nantes ; average annual temperature from 11.4°C in Rennes eto 11.9°C in Nantes). Conurbation areas are between 510km² and 610km² for about 300000 to 600000 inhabitants.
Forest cover is very low (10% of the studied areas) with numerous small forested fragments. We selected small woodlands dominated by oak (Quercus robur) and/or chestnut (Castanea sativa) along an urban–rural gradient from near urban centres to more rural areas to study their biodiversity.

	Integrated and ecological management: Spatial aspects
	Integrated and ecological management: Time and frequency aspect
	Integrated pest management
	Integrated weed management
	Mulching
	Soil improvement
	Structural soil
	Sustainable use of fertilizers

CASE STUDY	
Name of the case study	Cities of Nantes, Rennes and Angers
Expert modell from T2.2	Plant Typology
Scale of the case study area	neighborhood
Area / Location	Angers, Nantes and Rennes (France)
Elevation (plain, hill, mountain, other)	The relief is not significant (plain)
Local climate zone	The study area has a Western European oceanic climate influenced by its proximity to the Atlantic Ocean. Winters are usually mild and rainy (average temperature of 5 °C). Summers are moderately warm (average temperature of 18.5 °C). the annual rain average is 820 millimetres.
Urban form of the case study (see types of LCZ)	we don't have enough information to establish these LCZ
When research was carried out? (year)	from 2006 to 2011
Others	

16. Figure Matrix of Urban Green Space Development and Regeneration

Modelling scenarios	
Name of the contributor(s)	P&C
Name of the UC / USC	4.2 Urban space development and regeneration

Expert model	BAF EM		
KPIs from T2.2	Parameters (dependent variable)		
	Name	Dimension	Range of values
1. BAF	Superficy for each land use category	m²	> 0
Parameters (independent variables concerned as constant)			
Name		Dimension	Range of values
1. NBS total area		m²	> 0

Database, data sources: Geodatabase of land use / land cover	
Can not involve into the calculation, because of its scale	

Name of the scenario (group name of NBS)	Maintenance techniques
List of NBSs in this group from UC vs NBSs streamlining table	Introduced plants
	Mulching
	Swales
	Sustainable use of fertilizers
	Integrated pest management
	Integrated weed management
	Integrated and ecological management: Spatial aspects
	Integrated and ecological management: Time and frequency aspect
	Composting (as a treatment of green debris)
	Bio-indicators

Name of the scenario (group name of NBS)	Green spaces with limited access
List of NBSs in this group from UC vs NBSs streamlining table	Heritage garden
	Botanical garden
	Pocket garden/park

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Name of the scenario (group name of NBS)	Large green spaces with open access
List of NBSs in this group from UC vs NBSs streamlining table	Large urban public park
	Public urban green spaces (places, squares etc.)
	Urban forest
	Wood
	Lawn

Name of the scenario (group name of NBS)	Linear green areas
List of NBSs in this group from UC vs NBSs streamlining table	Grass tram tracks
	Street trees
	Green strips
	Climber green walls
	Green wall system
	Planter green wall
	Vegetated pergola

Any additional notes: vegetalised walls and pergolas for themselves cannot be assessed through BAF EM (model not designed for vertical vegetation alone). But the BAF can be calculated for a larger site involving vertical vegetation and BAF EM allows to take this kind of object into account, in a larger setting.

Name of the scenario (group name of NBS)	Strategic NBSs
List of NBSs in this group from UC vs NBSs streamlining table	Green waterfront city
	Floodplains
	Constructed wetland for wastewater treatment
	Create and preserve habitats and shelters for biodiversity
	Limit or prevent access to an area
	Limit or prevent some specific uses and practices
	Ensure continuity with ecological network
	Take into account the distribution of public green spaces through the city

	Green cemetery
	Private garden
	Urban green space with specific uses
	Single tree
	Green parking lot
	Vegetable gardens
	Urban orchards
	Urban vineyards
	Urban farms
	Intensive green roofs
	Semi-intensive green roofs
	Extensive green roofs

Name of the scenario (group name of NBS)	Restoration and upgrade with NBS
List of NBSs in this group from UC vs NBSs streamlining table	Unsealed parking lot
	Management of polluted areas by plants
	Use of preexisting vegetation
	Vegetation diversification
	Soil & slope revegetation
	Strong slope revegetation
	Structural soil
	Soil improvement
	Reopened streams
	Vegetation engineering systems for riverbanks erosion control
	De-sealed areas

Any additional notes: yellow cells: The BAF indicator is only relevant if an NBS of type 'object' is considered (i.e. a physical site featuring a reopened stream). If the scenario considers the strategy in itself and in all its details, then the BAF is not relevant.

CASE STUDY	
Name of the case study	**Cities of Nantes, Rennes and Angers**
Expert modell from T2.2	**QGis and Chloe**
Scale of the case study area	**city, city part and neighborhood**
Area / Location	**Angers, Nantes and Rennes (France)**
Elevation (plain, hill, mountain, other)	**The relief is not significant (plain)**
Local climate zone	**The study area has a Western European oceanic climate influenced by its proximity to the Atlantic Ocean. Winters are usually mild and rainy (average temperature of 5 °C). Summers are moderately warm (average temperature of 18.5 °C). the annual rain average is 820 millimetres.**
Urban form of the case study (see types of LCZ)	**we don't have enough information to establish these LCZ**
When research was carried out? (year)	**from 2006 to 2011**
Others	

Short describtion of case study: The study area covers the 3 most important conurbations of the Massif armoricain (north-western France) : Angers (47°28'N - 0°33'W), Nantes (47°13'N - 1°33'W) and Rennes (48°06'N - 1°40'W) in north-western France where climate is oceanic (average annual rainfall from 618mm in Angers to 790mm in Nantes ; average annual temperature from 11.4°C in Rennes eto 11.9°C in Nantes). Conurbation areas are between 510km² and 610km² for about 300000 to 600000 inhabitants.
Forest cover is very low (10% of the studied areas) with numerous small forested fragments. Land use and land cover maps have been produced to distinguish impervious surfaces and green areas.

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17. Figure Matrix of Soil Management and Quality USC

Modelling scenarios	
Name of the contributor(s)	AO-UN-IFSTTAR
Name of the UC / USC	5.1 Soil management and quality

Expert model	Fertility evaluation method		
KPIs from T2.2	**Parameters (dependent variable)**		
	Name	**Dimension**	**Range of values**
1. SWR - Soil water reservoir of plants;	type of maintenance	-	low, medium, high
1. SWR - Soil water reservoir of plants;	type de vegetation	-	Horticultural massive, Lawn and grass, Tree and shrub, Street tree (planted in pit), Vegetative mix (lawn mix, flowers)
1. SWR - Soil water reservoir of plants;	age of the NBS	-	0 - 100
2. SCr - Soil Crusting;	type of maintenance	-	-
2. SCr - Soil Crusting;	type de vegetation	-	-
2. SCr - Soil Crusting;	age of the NBS	-	0 - 100
Parameters (independent variables concerned as constant)			
Name		**Dimension**	**Range of values**
1. Soil organic matter content - SOM		g/kg	0 - 100
2. Soil classification		-	-
3. Soil water content at field capacity		m3/m3	0.1 - 0.8
4. Soil water content at wilting point		m3/m3	0 - 0.2
5. Soil bulk density		g/cm3	0.6 - 2
6. Soil thickness		m	0.1 - 5
7. Stone fraction content		-	0 - 0.9
8. Soil pH		-	4 - 9
Database, data sources: Dependent variables: scientific literature, city database, measurment Independent variables: Additional data: scientific literature measurements (field experiments)			
Any additional notes: The index can be calculated only on object and neighbourhood scales			
Can not involve into the calculation, because of its scale and the presence of soil			

Name of the scenario (group name of NBS)	Transformed areas
List of NBSs in this group from UC vs	Public urban green spaces (places, squares etc.)
	Single tree
	Grass tram tracks

Expert model	HYDRUS 1D		
KPIs from T2.2	**Parameters (dependent variable)**		
	Name	**Dimension**	**Range of values**
1. Cfer - Chemical fertility of soil ;	type of maintenance	-	low, medium, high
1. Cfer - Chemical fertility of soil;	type de vegetation	-	Horticultural massive, Lawn and grass, Tree and shrub, Street tree (planted in pit), Vegetative mix (lawn mix, flowers)
1. Cfer - Chemical fertility of soil;	age of the NBS	-	0 - 100
Parameters (independent variables concerned as constant)			
Name		**Dimension**	**Range of values**
Date/time		-	-
Vegetation (height, LAI)		**-**	**-**
Albedo		-	0 - 1
air temperature		**°C**	**-**
relative humidity		%	0 - 100
wind speed		**m/s**	≥0
Global radiation		W/m2	≥0
rainfall		**mm/h**	≥0
Potential Evapotranspiration		mm/h	≥0
bulk density		**kg/m3**	≥0
solute transport parameters (adsorption isotherm coefficients		**-**	**-**
solute concentration (incoming water)		**g/m3**	≥0
Soil classification ;		-	-
Root depth		m	0.1 - 5
Database, data sources: Dependent variables: scientific literature, city database, measurment Independent variables: Additional data: scientific literature measurements (field experiments)			
Any additional notes: The index can be calculated only on object and neighbourhood scales			

Expert model	Ecotox method evuluation		
KPIs from T2.2	**Parameters (dependent variable)**		
	Name	**Dimension**	**Range of values**

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NBSs streamlining table	Street trees
	Soil & slope revegetation
	Strong slope revegetation
	Swales
	Intensive green roofs
	Semi-intensive green roofs
	Extensive green roofs
	Climber green walls
	Green wall system
	Planter green wall

Name of the scenario (group name of NBS)	Rebuilt areas
List of NBSs in this group from UC vs NBSs streamlining table	Large urban public park
	Heritage garden
	Botanical garden
	Pocket garden/park
	Green cemetery
	Private garden
	Urban green space with specific uses (schools, playgrounds, camp grounds, sport fields)
	Green waterfront city
	Vegetable gardens
	Urban orchards
	Urban farms
	Management of polluted areas by plants (phytoremediation)
	Structural soil
	Soil improvement
	Mulching

Name of the scenario (group name of NBS)	Mixed sealed opened areas
List of NBSs in this group from UC vs NBSs streamlining table	Unsealed parking lot
	Green parking lot
	De-sealed areas (and associated systems, ex.permeable paving)

1. EcoF - Ecotoxicology factor;	type of maintenance	-	low, medium, high
1. EcoF - Ecotoxicology factor;	type de vegetation	-	Horticultural massive, Lawn and grass, Tree and shrub, Street tree (planted in pit), Vegetative mix (lawn mix, flowers)
1. EcoF - Ecotoxicology factor;	Soil classification	-	-
1. EcoF - Ecotoxicology factor;	age of the NBS	-	0 - 100
Parameters (independent variables concerned as constant)			
Name		**Dimension**	**Range of values**
half-life time - DT50		days	20 - 100
Concentration (or activity) of an ion causing a 50% reduction in the rate of a process - EC50		mg/kg (for soil)	0 - 1e5
Concentration (or activity) of an ion causing a 50% lethal effect in the rate of a process - LD50		mg/kg (for soil)	0 - 1e5
Trace metal concentration (Pb, Cu, Zn, Mg, etc.)		mg/kg (for soil)	-
Pesticides and herbicides dose		kg/ha or liters/ha	[Herbogil (dinoterb), mineral oil Oleo (paraffin oil)]
Pesticides and herbicides concentration		mg/kg or µl/kg	[Herbogil (dinoterb), mineral oil Oleo (paraffin oil)]

Database, data sources: Dependent variables: scientific literature, city database, measurment
Independent variables: Additional data: scientific literature measurements (field experiments)

Any additional notes: The index can be calculated only on object and neighbourhood scales

Expert model	SBA Evaluation Method		
KPIs from T2.2	**Parameters (dependent variable)**		
	Name	**Dimension**	**Range of values**
1. SR - Soil respiration;	Type of maintenance	-	low, medium, high
1. SR - Soil respiration;	Type de vegetation	-	Horticultural massive, Lawn and grass, Tree and shrub, Street tree (planted in pit), Vegetative mix (lawn mix, flowers)
1. SR - Soil respiration;	Carbon : Nitrogen ratio	-	0 - 50
1. SR - Soil respiration;	age of the NBS	-	0 - 100
Parameters (independent variables concerned as constant)			
Name		**Dimension**	**Range of values**
Soil organic matter		g/kg	0 - 100
Matric potential		MPa (negative values)	0 - 1.6
soil temperature		°C	-
soil moisture		m3/m3	0 - 1

Database, data sources: Dependent variables: scientific literature, city database, measurment
Independent variables: Additional data: scientific literature measurements (field experiments)

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Name of the scenario (group name of NBS)	Semi natural areas
List of NBSs in this group from UC vs NBSs streamlining table	Urban forest
	Wood
	Lawn
	Urban vineyards
	Vegetation engineering systems for riverbanks erosion control
	Floodplains

Name of the scenario (group name of NBS)	Phytoremediation areas
List of NBSs in this group from UC vs NBSs streamlining table	Introduced plants
	Use of preexisting vegetation
	Vegetation diversification

Name of the scenario (group name of NBS)	Wet land areas
List of NBSs in this group from UC vs NBSs streamlining table	Reopened streams

Any additional notes: The index can be calculated only on object and neighbourhood scales

CASE STUDY	
Name of the case study	**The city of Paris**
Expert modell from T2.2	**HYDRUS-1D/2D, SBA EM, Fert EM, Ecotox EM**
Scale of the case study area	**Object and neighborhood**
Area / Location	**Paris, France**
Elevation (plain, hill, mountain, other)	**24 m to 180 m (mostly plain)**
Local climate zone	**Paris has a typical Western European oceanic climate (Köppen climate classification: Cfb) which is affected by the North Atlantic Current. The overall climate throughout the year is mild and moderately wet. Summer days are usually warm and pleasant with average temperatures between 15 and 25 °C, and a fair amount of sunshine. Paris has an average annual precipitation of 641 mm, and experiences light rainfall distributed evenly throughout the year.**
Urban form of the case study (see types of LCZ)	**According to Masson et al., (2014) most of Paris' city LCZ are: ancient center (LCZ2), industrial building (LCZ8 and 10), high-rise tower (LCZ4), discontinuous block (LCZ5), continuous block (LCZ1).**
When research was carried out? (year)	**Since 1993 + ongoing; for N4C project (2007-2017)**
Others	

Short describtion of case study: Paris is the capital of France (48°51′12″ N, 2°20′55″ E). This city is included in the Grand Paris Metropolis, which is the urbanized centre of the region Ile-de-France.
It covers an area of 815 km² (Paris city covers 105 km²), including 17.4 km² occupied by water.
The population was 7.0 million inhabitants in 2014 (with nearly 2.22 million in Paris city) and the total population density was 8.60 inhabitants km-2, but it was 21,067 inhabitants km-2 in Paris city.
Finally, this region accounted for approximately 10.6% of the total population of metropolitan France (INSEE – French National Institute of Statistics and Economic Studies, 2014).
The altitude is between 24 m and 180 m.
According to Köppen climate classification system, the climate is temperate oceanic (Cfb) with an average temperature of 11.6 °C (annual low and high temperatures: + 7.86 °C and + 15.5 °C) and an average rainfall of 591 mm per year.

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18. Figure Matrix of Energy Efficiency USC

Modelling scenarios	
Expert model	Solene-microclimat
Name of the contributor(s)	CER
Name of the UC / USC	6.1 Food, Energy & water (restricted to BEN)
Name of the scenario (group name of NBS)	Greenwalls
List of NBSs in this group from UC vs NBSs streamlining table	Planter green wall
	Climber green walls
	Green wall system

Name of the scenario (group name of NBS)	Green roofs
List of NBSs in this group from UC vs NBSs streamlining table	Semi-intensive green roofs
	Intensive green roofs
	Extensive green roofs

Name of the scenario (group name of NBS)	Shading
List of NBSs in this group from UC vs NBSs streamlining table	Vegetated pergola
	Street trees
	Single tree

KPIs from T2.2	Parameters (dependent variable)		
	Name	Dimension	Range of values
Parameters related to NBS			
1. BEN (direct & indirect effects);	LAI	m2/m3	-
2. BEN (direct & indirect effects);	Albedo and emissivity	/	0-1
3. BEN (direct & indirect effects);	surface	m2	-
4. BEN(direct & indirect effects);	spatial distribution, location		
5. BEN (direct & indirect effects);	watering conditions		
6. BEN (direct & indirect effects);	substrate characteristics (depth, conductivity, thermal capacity, density)		
Parameters related to building			
7. BEN (direct & indirect effects);	climate		
8. BEN (direct & indirect effects);	urban form		
9. BEN (direct & indirect effects);	type of building (use, insulation, glasing ratio…)		

Database, data sources:	Climate, building materials, uses scenarios

Any additional notes: Results will differ depending on climate and buildings, it is why a sensitivity analysis on these parameters is necessary. The different NBS will be represented by varying the NBS parameters.

Name of the scenario (group name of NBS)	Cool surrounding surfaces
List of NBSs in this group from UC vs NBSs streamlining table	Botanical garden
	Climber green walls
	Constructed wetland for wastewater treatment
	De-sealed areas
	Extensive green roofs
	Grass tram tracks
	Green cemetery
	Green parking lot
	Green strips
	Green wall system
	Green waterfront city
	Heritage garden
	Intensive green roofs
	Large urban public park

Modelling scenarios	
Expert model	Energy Plus / TRNSYS
Name of the contributor(s)	CER
Name of the UC / USC	6.1 Food, Energy & water (restricted to BEN)
Name of the scenario (group name of NBS)	Greenwalls
List of NBSs in this group from UC vs NBSs streamlining table	Planter green wall
	Climber green walls
	Green wall system

Name of the scenario (group name of NBS)	Green roofs
List of NBSs in this group from UC vs NBSs streamlining table	Semi-intensive green roofs
	Intensive green roofs
	Extensive green roofs

Name of the scenario (group name of NBS)	Shading
List of NBSs in this group from UC vs NBSs streamlining table	Vegetated pergola
	Street trees
	Single tree

KPIs from T2.2	Parameters (dependent variable)		
	Name	Dimension	Range of values
Parameters related to NBS			
1. BEN (only direct effects);	LAI	m2/m3	-
2. BEN (only direct effects);	Albedo and emissivity	/	0-1
3. BEN (only direct effects);	surface	m2	-
4. BEN (only direct effects);	spatial distribution, location		
5. BEN (only direct effects);	watering conditions		
6. BEN (only direct effects);	substrate characteristics (depth, conductivity, thermal capacity, density)		
Parameters related to building			
6. BEN (only direct effects);	climate		
7. BEN (only direct effects);	urban form		
8. BEN (only direct effects);	type of building (use, insulation, glasing ratio…)		

Database, data sources:	Climate, building materials, uses scenarios

Any additional notes: Results will differ depending on climate and buildings, it is why a sensitivity analysis on these parameters is necessary. The different NBS will be represented by varying the NBS parameters.

Name of the scenario (group name of NBS)	Cool surrounding surfaces
List of NBSs in this group from UC vs NBSs streamlining table	Botanical garden
	Climber green walls
	Constructed wetland for wastewater treatment
	De-sealed areas
	Extensive green roofs
	Grass tram tracks
	Green cemetery
	Green parking lot
	Green strips
	Green wall system
	Green waterfront city
	Heritage garden
	Intensive green roofs
	Large urban public park

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	Lawn
	Management of polluted areas by plants
	Planter green wall
	Pocket garden/park
	Private garden
	Public urban green spaces (places, squares etc.)
	Reopened streams
	Semi-intensive green roofs
	Soil & slope revegetation
	Strong slope revegetation
	Swales
	Unsealed parking lot

Can not involve into the calculation, because of its scale	

KPIs from T2.2	Parameters (dependent variable)		
	Name	Dimension	Range of values
Parameters related to NBS			
1. BEN (direct & indirect effects);	Hydric stress	/	0 -1
2. BEN (direct & indirect effects);	LAI	m2/m3	-
3. BEN (direct & indirect effects);	Albedo and emissivity	/	0-1
4. BEN (direct & indirect effects);	surface	m2	-
5. BEN (direct & indirect effects);	spatial distribution		
Parameters related to building			
5. BEN (direct & indirect effects);	climate		
6. BEN (direct & indirect effects);	urban form		
7. BEN (direct & indirect effects);	type of building (use, insulation, glasing ratio…)		

Any additional notes: With Solene-micrcolimat, direct and indirect effects can be calculated asthe impact of the surfaces on local climate is calculated. Results will differ depending on climate and buildings and urban form it is why a sensitivity analysis on these parameters is necessary.

	Lawn
	Management of polluted areas by plants
	Planter green wall
	Pocket garden/park
	Private garden
	Public urban green spaces (places, squares etc.)
	Reopened streams
	Semi-intensive green roofs
	Soil & slope revegetation
	Strong slope revegetation
	Swales
	Unsealed parking lot

Can not involve into the calculation, because of its scale	

KPIs from T2.2	Parameters (dependent variable)		
	Name	Dimension	Range of values
Parameters related to NBS			
1. BEN (only direct effects);	Hydric stress	/	0 -1
2. BEN (only direct effects);	LAI	m2/m3	-
3. BEN (only direct effects);	Albedo and emissivity	/	0-1
4. BEN (only direct effects);	surface	m2	-
5. BEN (only direct effects);	spatial distribution		
Parameters related to building			
6. BEN (only direct effects);	climate		
7. BEN (only direct effects);	urban form		
8. BEN (only direct effects);	type of building (use, insulation, glasing ratio…)		

Any additional notes: With EnergyPlus or TRNSYS, only direct effects can be calculated as impact of the surfaces on local climate is not calculated. Results will differ depending on climate and buildings, it is why a sensitivity analysis on these parameters is necessary. Results will only include impact in short-wave radiation

CASE STUDY	
Name of the case study	Nantes City
Expert modell from T2.2	Solene-microclimat
Scale of the case study area	object
Area / Location	Nantes (France)
Elevation (plain, hill, mountain, other)	The relief is not significant (plain)
Local climate zone	The study area has a Western European oceanic climate influenced by its proximity to the Atlantic Ocean. Winters are usually mild and rainy (average temperature of 5 °C). Summers are moderately warm (average temperature of 18.5 °C). the annual rain average is 820 millimetres
Urban form of the case study (see types of LCZ)	we don't have enough information to establish these LCZ
When research was carried out? (year)	2012
Others	

Short describtion of case study: The study area is located in the northen east part of the city of Nantes, the sixth most populous city in France. The Urban Community of Nantes Metropole has an area of 534 km2. Its population is expected to increase by 100,000 inhabitants in by 2030 (INSEE, 2012). The building is located in the Pin sec district, located inside the study area and covers 31ha ,the wooded area of the basin covers 18%, the built surface 17% and the surface of the streets 23%, and 11% of paved surface other than buildings and the street. The building is situated in a group of buildings from the 70 that have been lightly refurbished.

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19. Figure Matrix of Acoustics USC

Modelling scenarios	
Name of the contributor(s)	IFSTTAR
Name of the UC / USC	7.1 Acoustics

Expert model	NMPB_NoiseModelling (see http://noise-planet.org/noisemodelling.html)		
KPIs from T2.2	Parameters (dependent variable)		
	Name	Dimension	Range of values
Global Sound Pressure Level for Day-Evening-Night (Lden) in dB(A)	Vegetation percentage of urban horizontal surface (high or low plants)	%	-
Parameters (independent variables concerned as constant)			
Name		Dimension	Range of values
1. Road traffic (noise sources)		-	-
2. Meteorological conditions (assumed to be homogeneous)		-	-
Database, data sources: BD TOPO® , Open Street Map, road traffic databases, Nantes Metropole urban databank			
Any additional notes: The KPI can be calculated on both neighbourhood and city scales (using the same model).			

CASE STUDY	
Name of the case study	**Evaluation of NBS scenario impact on sound environment in the city of Nantes (France)**
Expert modell from T2.2	**NMPB**
Scale of the case study area	**neighborhood**
Area / Location	**Nantes city (France), in particular the "Pin Sec"**
Elevation (plain, hill, mountain, other)	**The relief is not significant (plain)**
Local climate zone	**The study area has a Western European oceanic climate influenced by its proximity to the Atlantic Ocean. Winters are usually mild and rainy (average temperature of 5 °C). Summers are moderately warm (average temperature of 18.5 °C). the annual rain average is 820 millimetres.**
Urban form of the case study (see types of LCZ)	**we don't have yet enough information to establish these LCZ**
When research was carried out? (year)	**2014-2015**

Short describtion of case study: The study area is located in the northen east part of the city of Nantes, the sixth most populous city in France. The Urban Community of Nantes Metropole has an area of 534 km2. Its population is expected to increase by 100,000 inhabitants in by 2030 (INSEE, 2012). Nantes Metropole is characterized by various types of land use: urban dense, commercial areas, residential areas and rural areas. The relief is not significant. However its drainage network is rather dense. Nantes is on the Loire River and is flowed into by many tributaries. the case study covers 46km² , it has a 44% of built surface, 46% of natural surfaces and 8% of water .The Pin sec basin is located inside the study area and covers 31ha ,the wooded area of the basin covers 18%, the built surface 17% and the surface of the streets 23%, and 11% of paved surface other than buildings and the street.

Name of the scenario (group name of NBS)	Green space / small / horizontal / mix vegetation (low and high plants)	
List of NBSs in this group from UC vs NBSs streamlining table	Pocket garden/park	x
	Private garden	x
	Green strips	x
	Green waterfront city	x

Name of the scenario (group name of NBS)	Mixed green and grey space / small / horizontal / mix vegetation (low and high plants)	
List of NBSs in this group from UC vs NBSs streamlining table	Green cemetery	x
	Public urban green spaces (places, squares etc.)	x
	Urban green space with specific uses (schools, playgrounds, camp grounds, sport fields)	x
	Green parking lot	x

Name of the scenario (group name of NBS)	Green space / small / horizontal / specific vegetation (low plants)	
List of NBSs in this group from UC vs NBSs streamlining table	Lawn	x
	Grass tram tracks	x
	Vegetable gardens	x

Name of the scenario (group name of NBS)	Green space / small / horizontal / specific vegetation (high plants)	
List of NBSs in this group from UC vs NBSs streamlining table	Single tree	x
	Street trees	x

Name of the scenario (group name of NBS)	Green space / small / vertical / specific vegetation (low plants)	
List of NBSs in this group from UC vs NBSs streamlining table	Climber green walls	x
	Green wall system	x
	Planter green wall	x

Name of the scenario (group name of NBS)	Green space / large / horizontal / mix vegetation (low and high plants)	
List of NBSs in this group from UC vs NBSs streamlining table	Large urban public park	x
	Heritage garden	x
	Botanical garden	x
	Urban forest	x

Name of the scenario (group name of NBS)	Green space / large / horizontal / specific vegetation (high plants)	
List of NBSs	Wood	x

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20. Figure Matrix of Urban Planning and Form USC

Modelling scenarios			
Name of the contributor(s)	MUTK		
Name of the UC / USC	9.1 Urban planning and form		

Expert model	QGIS - Segreg		
KPIs from T2.2	Parameters (dependent variable)		
	Name	Dimension	Range of values
1. SI - Segregation;	High level of education	capita	-
2. SI - Segregation;	Total population	capita	-
3. SI - Segregation;	Population in each subdivision	capita	-
Parameters (independent variables concerned as constant)			
Name		Dimension	Range of values
1. Change of property prices		%	0 - 100
2. Change of housing policy		-	-
Database, data sources: census data, electorial district, tax office, property data collections			
Any additional notes: The index can be calculated only on neighbourhood or district and city scale.			
Can not be involved into the calculation, because of its scale			

Name of the scenario (group name of NBS)	Green spaces with limited access
List of NBSs in this group from UC vs NBSs streamlining table	Heritage Garden
	Botanical garden
	Pocket garden/park
	Green cemetery
	Private garden
	Urban green space with specific uses (schools, playgrounds, camp grounds, sport fields)
	Single tree
	Vegetable gardens
	Urban orchards
	Urban farms
	Urban vineyards
	Intensive green roofs
	Semi-intensive green roofs
	Extensive green roofs

Name of the scenario (group name of NBS)	Large green spaces with open access
List of NBSs in this group from UC vs NBSs streamlining table	Large urban public park
	Public urban green spaces (places, squares etc.)
	Urban forest
	Wood
	Lawn

Name of the scenario (group name of NBS)	Linear green areas
List of NBSs in this group from UC vs NBSs streamlining table	Grass tram tracks
	Street trees
	Green strips
	Climber green walls
	Green wall system
	Planter green wall
	Vegetated pergola

Name of the scenario (group name of NBS)	Maintenance technique
List of NBSs in this group from UC vs NBSs streamlining table	Introduced plants
	Mulching
	Swales
	Sustainable use of fertilizers
	Integrated pest management
	Integrated weed management
	Integrated and ecological management: Time and frequency aspect
	Integrated and ecological management: Spatial aspects
	Composting (as a treatment of green debris)
	Bio-indicators

Name of the scenario (group name of NBS)	Strategic NBSs
List of NBSs in this group from UC vs NBSs streamlining table	Green waterfront city
	Constructed wetland for wastewater treatment
	Floodplains
	Create and preserve habitats and shelters for biodiversity
	Limit or prevent access to an area
	Limit or prevent some specific uses and practices
	Ensure continuity with ecological network
	Take into account the distribution of public green spaces through the city
	Planning tools to control urban expansion

Name of the scenario (group name of NBS)	Restoration and upgrade with NBS
List of NBSs in this group from UC vs NBSs streamlining table	Unsealed parking lot
	Green parking lot
	Management of polluted areas by plants (phytoremediation)
	Use of preexisting vegetation
	Vegetation diversification
	Soil & slope revegetation
	Strong slope revegetation
	Structural soil

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CASE STUDY	
Name of the case study	Comparison of Segregation Indices
Expert modell from T2.2	Segreg
Scale of the case study area	city
Area / Location	London
Elevation (plain, hill, mountain, other)	The relief is not significant
Local climate zone	Oceanic climate - Cfb
Urban form of the case study (see types of LCZ)	As whole city was involved, not defined specifically
When research was carried out? (year)	2018
Others	Barros & Feitosa, 2018

	Soil improvement
	Reopened streams
	Vegetation engineering systems for riverbanks erosion control
	De-sealed areas (and associated systems, ex.permeable paving)

Short description of the case study: Barros & Feitosa (Barros & Feitosa, 2018) describe the implementation of Segreg through analisys of of sensitivity of spatial indicies. The study is a by-product of the project RESOLUTION: REsilient Systems fOr Land Use TransportatION measuring vulnarability and resilience caused by spatial and social segregation with a mobility focus. The study compares the segregation of Greater London Area and Sao Paolo agglomeration.According tot he study, Segreg was mainly utilized for the sensitivity check of spatial indicies, that is, presenting the results of different spatial versions using differing sets of indicators, such as: definition of geographical areas, grouping systems and scales.

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