NBS impact simulator and monitor

D4.2 Report

28/11/18

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Dissemination level		
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Deliverable administration						
No & name	**D4.2 NBS impact simulator and monitor**					
Status	Final	**Due**	M18	**Date**	2018-11-28	
Author(s)	ENG, UAV					
Description of the related task and the deliverable. Extract from DoA	**T4.3 NBS Simulation & Data Visualisation Tools (UAV, ENG) M1-48** Taking into account the requirements and functionalities of the systemic decision support tool (SDST) refined and applied in WP3, and ICT framework requirements defined in T4.1, this task aims to develop an NBS Impact Simulator & Monitor, i.e. the UNaLab ICT framework tool representing the user interface underlying the SDST defined in WP3 as well as an ICT platform for visualisation of monitoring data and geo-data published in the UNaLab database in addition to datasets produced using the Visual Data Mash-up Creator. This task will: i) create a geodatabase containing five sets of data (reference scenario, nature-based scenarios, population growth scenarios, climate change scenarios and combined scenarios) categorised in three periods of time (2015, 2030, 2050), and where end-users will be consulted as to the data/layers to be included in the database (with WP3 and WP5); ii) develop the SDST user interface in which Geodatabase sets and layers will be integrated, using e.g. CommunityViz for ArcGIS10 or similar, such that scenario simulations can be defined, visualised and assessed in real-time, using visualisation tools (2D/3D) in the NSB Impact Simulation & Monitor to enable understanding of alternatives, opportunities and feedbacks; and iii) co-test and co-validate the SDST during a preparatory period, including SDST training sessions with 'expert users' in front-runner cities (FRC). In turn a prototype SDST will be developed, containing a representative set of scenarios and corresponding indicators for testing, validation, adaptation and learning with stakeholders (with WP3, WP5). The SDST geodatabase will be updated as additional simulation results become available (T3.2). UNaLab will use the SDST in combination with touch tables/screens in front-runner cities to deliver powerful geo-visualisation tools to support understanding of NBS impacts, participatory planning and decision-making. To achieve the continuous improvement of tools tailored in T4.3, during the execution of ULLs they will be refined according to feedback from stakeholders. This task outputs M4.2, D4.2 and D4.6, and contributes to D3.3 UAV leads this task and advises ENG in the development of front-end software for SDST. ENG develops the user interface (front-end software) for the SDST.					
Participants	Piersaverio Spinnato, Peter Roebeling, Ricardo Martins, Rita Mendonça, Ana Ascenso, Ruben Mendes, Bruno Augusto, Carole Bodilis, Pierre Kil					
Comments						

V	Date	Authors	Description
0.1	2018-09-13	ENG	Table of Contents shared for contributions
0.2	2018-10-05	ENG	First draft shared for contributions
0.3	2018-11-09	ENG	New contributed version shared with partner
0.4	2018-11-12	UAV	Comments and contributes shared with partner
0.8	2018-11-14	ENG	Contributes merged and final version shared for internal check
1.0	2018-11-19	ENG	Final version sent to cross-WP check
1.0	2018-11-23	ERRIN	Cross check completed
1.0	2018-11-29	Sami Kazi	Final version ready to submit to EC

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About UNaLab

UNaLab will develop, via co-creation with stakeholders and implementation of ‘living lab’ demonstration areas, a robust evidence base and European framework of innovative, replicable, and locally-attuned nature based solutions (NBS) to enhance the climate and water resilience of cities. UNaLab focuses on urban ecological water management, accompanied by urban greening measures and innovative and inclusive urban design. The UNaLab partners aim to develop smarter, more inclusive, more resilient and more sustainable local societies through nature based innovation jointly created with and for stakeholders and citizens. UNaLab’s three front runner cities: Tampere, Eindhoven and Genova, all have experience implementing smart and citizen driven solutions for sustainable development. They support seven follower cities: Stavanger, Prague, Castellón, Cannes, Başakşehir, Hong Kong and Buenos Aires. UNaLab cities will actively share experiences with observer cities of Guangzhou and municipalities belonging to the Brazilian Network of Intelligent Cities. As a result, UNaLab project outcomes are expect to have beneficial impacts for cities of diverse size with different urban socio-economic realities, unique water- and climate-related challenges and diverse climatic conditions. In order to create an EU reference demonstration and go-to-market environment for NBS, UNaLab will use and further develop the European Network of Living Labs (ENoLL) Urban Living Lab model, and the European Awareness Scenario Workshop method for the co-creation of innovative, inclusive nature based solutions. A validated roadmapping approach will be employed and further refined to create a suite of urban planning and management tools for NBS.

Partners

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1. Executive Summary

This report describes the digital system expected under the task T4.3 as the deliverable D4.2 NBS Impact Simulation and Monitor.
Chapter 2 introduces the purpose of the tool, the contributions from the partners, an overview of the main concept and the relationship with the other project activities.
Chapter 3 describes how the tool will support the Urban Living Lab co-creation activities and the benefits it will provide.
Chapter 4 describes the reference architecture of the tool, indicating the functional and technological requirements to be addressed and the use cases to be supported. In addition, a set of mock-ups will be reported as indications of the possible look and feel and the user interaction approaches.
Chapter 5 describes the reference implementation of the Nature Based Solution Impact Simulation and Monitor, providing detailed specifications about the sub-components and the exploited models.
Finally, chapter 6 describes the main functionalities and the instructions to install and use the tool properly.

2. Introduction

2.1 Purpose and target group

This report provides a public description of the technical aspects and the functionalities supported by the deliverable D4.2 NBS Impact Simulation and Monitor. This information will be particularly useful for technical users that will be in charge of improving and maintaining the tool on a long-term basis. In addition, this report describes the use scenario and the user manuals in order to get the stakeholders (Urban Living Lab users and the decision makers) aware about the benefits derived by the use of the tool on evaluating, ex-ante, the implementation of Nature Based Solutions (NBS) in the city.

2.2 Contributions of partners

ENG and UAV collaborated in defining this deliverable D4.2 NBS Impact Simulation and Monitor. In detail, ENGINEERING took into account all the requirements coming from WP2 and WP3, defined the reference architecture of the tool in compliance with the T4.1 ICT framework and developed the reference implementation of the prototype. UAV provided the geodatabase containing the simulation results generated by the Systemic Decision Support Tool (SDST), while providing recommendations and sketches on the desired architecture, design, functionalities and user experience of the front end.

2.3 Systemic Decision Support Tool concepts

UNaLab will co-implement a systemic decision support tool (SDST) for state-of-the-art heat, flood and pollution risk adaptation planning and management at the city/landscape scale. The SDST structure, disciplinary component models and their integration as well as the scenario simulations and output data organisation are developed under T3.2. The corresponding geodatabase and SDST user interface, namely the NBS Simulation Visualisation Tool (NBS-SVT), are developed under T4.3.

The SDST user interface will be applied using interactive touch tables/screens to provide powerful geo-visualisation tools for participatory planning – allowing stakeholders to visualise and discuss the potential direct and indirect environmental, social and economic impacts of no-action as compared to implementation of selected nature-based solutions (NBS) in scenarios without (2015) or with (2030 and 2050) climate change and/or population growth.

Following the NBS co-creation process (defined under the T2.3), during the Urban Living Lab sessions, the SDST will allow stakeholders to evaluate, ex-ante, expected impacts, costs, benefits and co-benefits derived by the proposed NBS measures (individual NBS) and strategies (suites of NBS) as well as enable feedbacks and comments about the alternatives and opportunities.

2.4 Relations to other activities

This deliverable is related to the ICT framework technical and architectural aspects defined under T4.1. It is also related to the criteria adopted by the UNaLab Knowledge Base on managing the data defined under T4.4. The deliverable also meets the requirements and inputs related to the SDST simulation models defined under T3.2. Finally, the functional aspects are mainly related to the Urban Living Lab (ULL) activities and NBS Co-creation process, defined under T2.3.

3. NBS Impact Simulation and monitor use scenario

This section describes the typical use scenario for the NBS Impact Simulation and monitor, subsequently referred to as the NBS Simulation Visualisation Tool (NBS-SVT). As described in D4.1, the NBS SVT is the web application included in the UNaLab ICT framework. The NBS-SVT constitutes the user-interface of the SDST, which is a powerful tool for participatory planning, enabling stakeholders to visualise and discuss potential direct and indirect environmental, social and economic impacts of NBS strategies in the face of global change. It provides technicians with detailed simulation results on the multiple direct and indirect impacts of NBS in one single platform. Similarly, according to the NBS co-creation process (T2.3), it provides stakeholders in participatory planning with summary, indicator-based, simulation results on multiple direct and indirect impacts of NBS.

The underlying principle of the SDST is that NBS are co-created in a transparent, transdisciplinary, multi-stakeholder and participatory context as well as systematically incorporated into urban landscape planning. It aims to facilitate the participatory planning process and public discussion by improving stakeholder awareness about the multiple direct and indirect impacts of NBS. Hence, the SDST enriches the public discussion, adds transparency and increases public benefits.

The following topic describes a possible use scenario of the NBS-SVT during the NBS co-creation process.

Co-experience phase: Identification and initial evaluation of the social/territorial issue

Under a Living Lab session in Genova, Mario (a citizen) uses the UNaLab Open Nature Innovation Arena to report the problem of landslides in the city. Several other people support the problem submitted by Mario, because due to heavy rains in autumn, debris from the nearby mountains fall into the streets of the city and cause damage to cars, homes and injuries to people.

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Considering the relevance of this problem, the Eindhoven ULL manager dedicates a working session to co-evaluate the available resources (i.e. documents, maps, photos posted by users, etc) and assess the condition of the urban areas affected by the problem.

During the co-experience phase, the NBS-SVT supports the participatory process, providing a platform for discussion between decision makers and ULL users and raise awareness of the problem of landslides in the city. Indeed, it represents the current situation in Genova through a set of intuitive dashboards, maps, charts and tables. In addition, the tool provides interactive functionalities like zoom in/out, area selectors, searchable tables, informative pop-ups and useful links.

Co-definition phase: Assessment and selection of the possible co-created NBS

Following the initial evaluation of the current condition in urban areas, the NBS-SVT facilitates stakeholders to evaluate the expected impacts, costs and (co-) benefits of NBS measures (individual NBS) and strategies (suites of NBS) as compared to no action. Several interactive maps, charts, and tables allow the stakeholders to assess impacts for a specific city area and/or group of indicators. Based on the visualised results, stakeholders can discuss and re-define NBS scenarios – tentatively converging to one or more commonly accepted NBS strategies. To foster the ULL collaborative activities and involve additional stakeholders, the ULL manager takes the screenshots of the scenario evaluated and shares it on the related challenge page defined on the Open Nature Innovation Arena.

Finally, after the evaluation of the possible impacts and feedback from the wider community, decision makers and ULL stakeholders agree on the NBS strategy to be adopted to solve the problem of landslides, as expressed by Mario.

Co-implementation and Co-monitoring phase: continuous evaluation and monitoring

The NBS-based idea submitted by the ULL users is approved by the municipality. During the co-implementation phase, through the NBS-SVT, the working group periodically evaluates the implementing idea, in order to check if the requirements need to be reconsidered. In the long term, when the implemented solution will be operative in real environment, the ULL users will use the NBS-SVT to compare the impacts, costs and (co-) benefits, compared to the performance indicators. If something goes in wrong direction, the stakeholders can restart the NBS co-creation process to evaluate the possibility of implementing another NBS.

4. REFERENCE ARCHITECTURE

This chapter describes the functional and technical requirements to be addressed during the implementation of the NBS SVT.

4.1 Functional requirements

According to the usage scenario described in section 2 and the main requirements derived from the UNaLab ICT framework, the NBS SVT is the ideal tool able to represent the NBS simulation scenario models generated by the SDST in a graphic and intelligible way.

Roles of the users appointed to interact with the functionalities are:

- NBS SVT User:
    - Urban Living Lab (ULL) user, as participant to the ULL activities, he/she will be allowed to use the interactive GUIs.
    - ULL manager, as decision maker and manager of the activities in the LL, he/she will be allowed also to set the GUIs and the scenario data.

The NBS SVT should support the SVT users (i.e. decision makers and citizens) on comparing the potential social, environmental and economic impacts of non-action against the implementation of possible NBSs in the city.

In particular, the ULL users should be able to:

- visualise and compare NBS simulation scenarios;
- evaluate alternatives, opportunities and feedback;
- identify future strategical objectives;
- visualise geographical models.

Taking into consideration the requirements detailed above, the NBS SVT should offer the following functionalities:

- Visualise an NBS scenario data on map;
- Visualise the data model associated with the scenario in a table;
- Export scenario dashboard in PDF and data format;
- View the scenario details (i.e. name, description and additional information);
- Choose a map type to be visualised (point map, areas map, charts, etc);
- Show one or more indicators;
- Search and filters.

The following table describes the macro-requirements of the NBS SVT.

ID	NAME	DESCRIPTION
SVT.1	Visualise a NBS scenario on a map.	For each NBS scenario, the user should be able to visualise the simulation data on a map. Details and indicators should be associated the areas according to the scenario models.

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SVT.2	Visualise in tabular format the datasets associated to the scenario.	For each NBS scenario, the user should be able to visualise tables containing data models.
SVT.3	Export a dashboard as PDF	Each NBS scenario could be exported as PDF file.
SVT.4	View the information associated to the NBS scenario	For each NBS scenario the user should be able to consult the details, as example name, source, type of NBS and description.
SVT.5	Choose and configure a type of map to be visualised	Each NBS scenario could be visualised on a zone map, or on a point map or on a chart map.
SVT.6	Select what indicators to show on the map.	The user should be able to select one or more indicators to be shown on the map.
SVT.7	Set one or more filters to show/hide areas on the map.	The user should be able to set one or more filters to show some information on map and to hide other information.
SVT.8	Provide feedback and comments	The user should be able to provide some feedbacks and comments on a NBS scenario in order to facilitate the assessment of several NBS scenarios.

Table 1 – NBS SVT functional requirements

4.2 Use case models

The following figure depicts the NBS SVT use cases diagram.

Figure 1 – NBS SVT Use cases model

In the following tables, details of the NBS SVT are described.

ID	UC_SVT_01
Name	View simulation
Description	The user views the simulation on a map.
Pre Conditions	The user is logged in the platform.
Post Conditions	The user is allowed to view the required urban area on a map.
Trigger event	The user chooses to view a simulation of an urban area
Primary flow	The user requires to view a simulation interesting for it: 1. The system redirects the user to the map view 2. The system shows the simulation in the requested area.
Alternative flow	-
Exception flow	-

ID	UC_SVT_02
Name	Assess NBS scenario impact
Description	The ULL user compare several simulations and assess scenario impact.
Pre Conditions	The NBS scenario simulation to be evaluated is already defined in the platform. At least one scenario is defined.
Post Conditions	The impact of NBS simulation scenario is evaluated.
Trigger event	The user chooses to evaluate the impact of NBS simulation scenario.
Primary flow	The user requires to evaluate a scenario: 1. The system shows several simulations 2. The user compares the simulations. 3. The user assesses the impact of the scenario
Alternative flow	-
Exception flow	-

ID	UC_SVT_03
Name	Set scenario
Description	The ULL manager sets NBS scenario GUIs
Pre Conditions	The ULL manager is logged in the platform.
Post Conditions	A new NBS simulation scenario is set.

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Trigger event	The user chooses to define a new scenario.
Primary flow	The user requires to create a scenario: 1. The system shows the creation page. 2. The user inserts the required information to set the scenario.
Alternative flow	-
Exception flow	-

ID	UC_SVT_04
Name	Export simulation report
Description	The user exports a simulation report in order to evaluate it offline.
Pre Conditions	At least one simulation has been performed.
Post Conditions	The simulation report is exported.
Trigger event	The user selects the functionality of simulation report export.
Primary flow	The user requires to export a simulation report: 1. The system generates the required report. 2. The report is available for the user that can be exported it.
Alternative flow	-
Exception flow	-

ID	UC_SVT_ 05
Name	View simulation charts
Description	The user views charts generated from simulation
Pre Conditions	At least one simulation has been created.
Post Conditions	Charts are shown to the user
Trigger event	The user chooses to view charts.
Primary flow	The user requires to view the charts : 1. The system shows the required charts
Alternative flow	-
Exception flow	-

ID	UC_SVT_ 06
Name	Set Map
Description	The user acts on map by activating filters or performs zoom in or zoom out on an urban area.

Pre Conditions	The user is allowed to view the required urban area on a map.
Post Conditions	The user sets the map.
Trigger event	The user chooses to apply filters on a map or zoom in an area on the map.
Primary flow	The user requires to apply a filter on a map: 1. The system shows the map according to the filter applied by the user
Alternative flow	The user zooms in on a map: 1. The system show the zoomed area required by the user.
Exception flow	-

ID	UC_SVT_ 07
Name	Make screenshot
Description	The user views the simulation on a map and decided to make a screenshot to share it with other users.
Pre Conditions	The user is viewing a simulation scenario.
Post Conditions	The user is allowed to share its screenshot to other users.
Trigger event	The user chooses to make a screenshot
Primary flow	The user requires to make a screenshot of a simulation that it is viewing: 1. The system allows the user to make the screenshot 2. The user shares the screenshot to the other users through social networks.
Alternative flow	-
Exception flow	-

ID	UC_SVT_ 08
Name	View dataset associated to a NBS scenario
Description	For each NBS scenario, the user views the preview of the dataset associated to it.
Pre Conditions	At least one NBS scenario is present in the application
Post Conditions	The dataset preview is shown in a tabular view
Trigger event	The user selects one scenario among the available ones.
Primary flow	1. The scenario simulation appears on the map. 2. The user clicks on dataset icon to view the dataset preview.
Alternative flow	-

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Exception flow	-

ID	UC_SVT_09
Name	Select indicators
Description	Each NBS scenario has a set of information related to it. The user views this information.
Pre Conditions	At least one NBS scenario is present in the application.
Post Conditions	The user consults the information
Trigger event	The user selects one scenario among the available ones.
Primary flow	1. The scenario simulation appears on the map. 2. The user select a set of indicators.
Alternative flow	-
Exception flow	-

ID	UC_SVT_USER_10
Name	Set filters
Description	The user selects filters to be applied to the data to be shown.
Pre Conditions	At least one NBS scenario is present in the application.
Post Conditions	The scenario simulation is filtered and shown on the map.
Trigger event	The user selects one scenario among the available ones.
Primary flow	1. The scenario simulation appears on the map. 2. The user select a set of filters.
Alternative flow	-
Exception flow	-

ID	UC_SVT_USER_11
Name	Provide feedbacks and comments
Description	The user provides feedbacks and comments about the NBS simulation scenario.
Pre Conditions	At least one NBS scenario is present in the application.
Post Conditions	Feedbacks and comments are useful to evaluate the scenario.
Trigger event	The user selects one scenario among the available ones.
Primary flow	1. The scenario simulation appears on the map. 2. The user provides feedbacks and comments about the scenario.

Alternative flow	-
Exception flow	-

4.3 Technological requirements

The NBS SVT inherits the requirements defined for the ICT framework described in the deliverable D4.1. In addition, this section describes further requirements.

a) Standardisation and Interoperability

The tool must adopt standard data format and transportation protocols in order to ensure interoperability with the other components included in the ICT Framework architecture. In particular, it is necessary to adopt the data format GeoJSON (RFC7946) to describe the simulation models provided by the SDST.

b) Security and Privacy

In compliance with the security-by-design, the tool must protect its feature adopting architectural solutions and authorisation mechanisms to avoid fraudulent accesses to the data models, logs and configuration features.

c) Programmatic interaction

The NBS SVT must provide the proper interaction points (e.g. RESTful API or architectural solution) to allow the interaction with the ICT framework components.

d) Scalability

The NBS SVT must ensure the possibility to improve the performances in term of computational capability. Therefore, the tool has to be structured as a collection of modular and scalable containers deployable independently in performing environments.

e) Maintenance

The NBS SVT must ensure the possibility to maintain and evolve the features long-term. This is why it is necessary to develop the solution according to the no city lockin and no vendor lockin principle and adopt open source components.

4.4 Interoperability demands

As part of the UNaLab ICT framework, the NBS SVT interoperability demands have been listed in deliverable D4.1. Here they are reported with the related sequence diagrams.

- **SVT.INT.1:** the NBS SVT reads and writes Geo-data through the UNaLab Knowledge Base.

Figure 2 represents the sequence diagram for the interaction SVT.INT.1.

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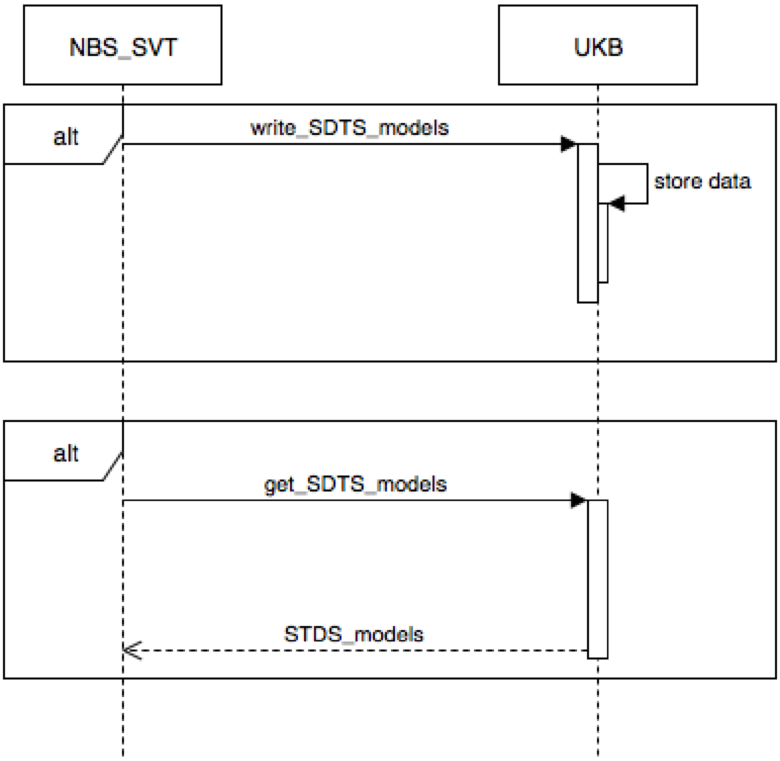

Figure 2 – SVT.INT.1 sequence diagram

- **SVT.INT.2:** The NBS SVT receives inputs from City Performance Monitor (CPM) to set the scenario to be shown. It returns the acknowledgement.

Figure 3 represents the sequence diagram for the interaction SVT.INT.2.

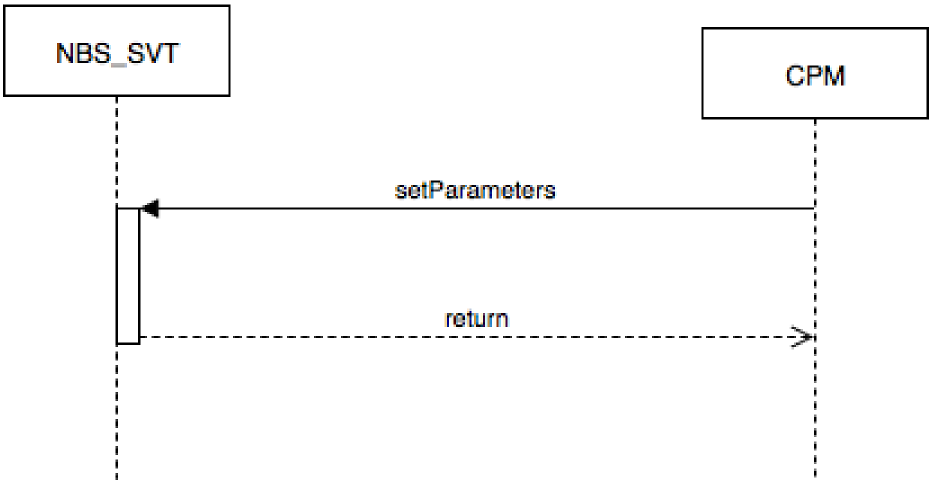

Figure 3 – SVT.INT.2 sequence diagram

4.5 Reference architecture

According to the functional and not functional requirements and in line with the technical specification derived by the UNaLab ICT framework, the reference architecture of the NBS

SVT is characterised by the decoupling of the data management from the components related to the front-end interaction.

Figure 4 represents the NBS SVT reference architecture.

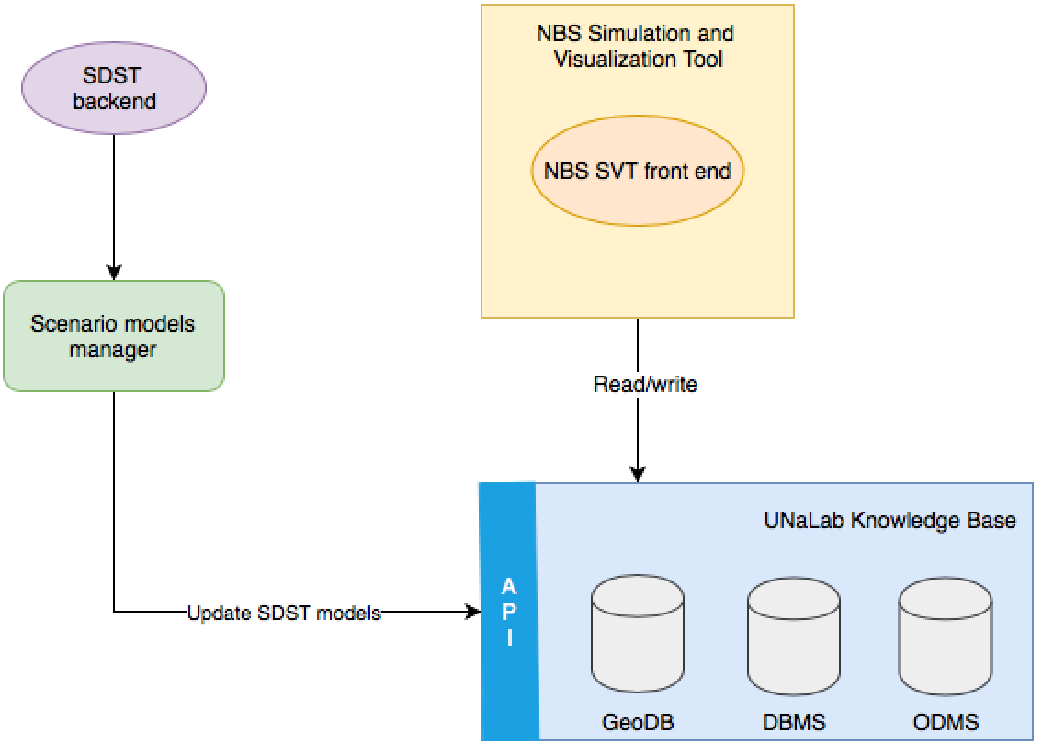

Figure 4 – NBS SVT Reference Architecture

The Scenario Models Manager will support the uploading of the SDST results models on the GeoDB. The GeoDB, logically included in the UNaLab Knowledge Base, will be the component in charge of the persistence and management of the NBS scenario impact indicators and any other related information.

The NBS SVT will interact with the UKB to retrieve the geodata models to be shown through the front-end user interfaces.

4.6 Graphical User Interface mockups

Below, a set of mockups of the NBS SVT interface are shown. During the implementation of the final GUIs these mockups have been taken into account as indication of a possible look and feel for the application and the expected user experience.

Figure 5 represents a dashboard, providing several functionalities to enable users to select the city, the year and the type of NBS to be evaluated. The simulation results are provided thorought interactive maps and tables.

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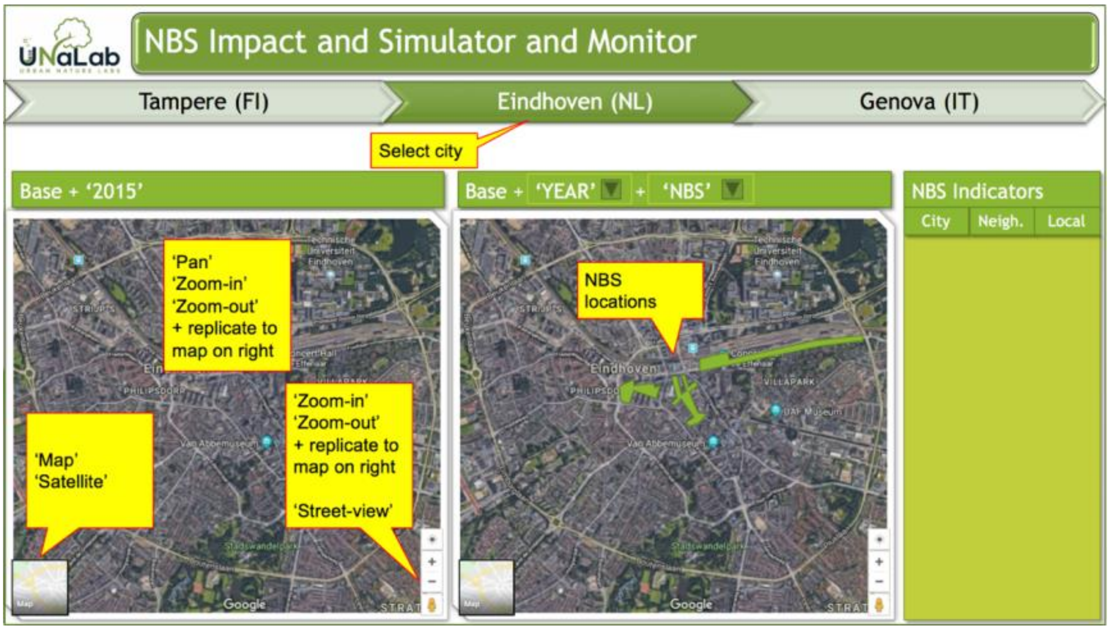

Figure 5 – Map based visualisation and features

Figure 6 represents the map where the areas selected identify the areas directly affected by the implementation of NBS described in the box.

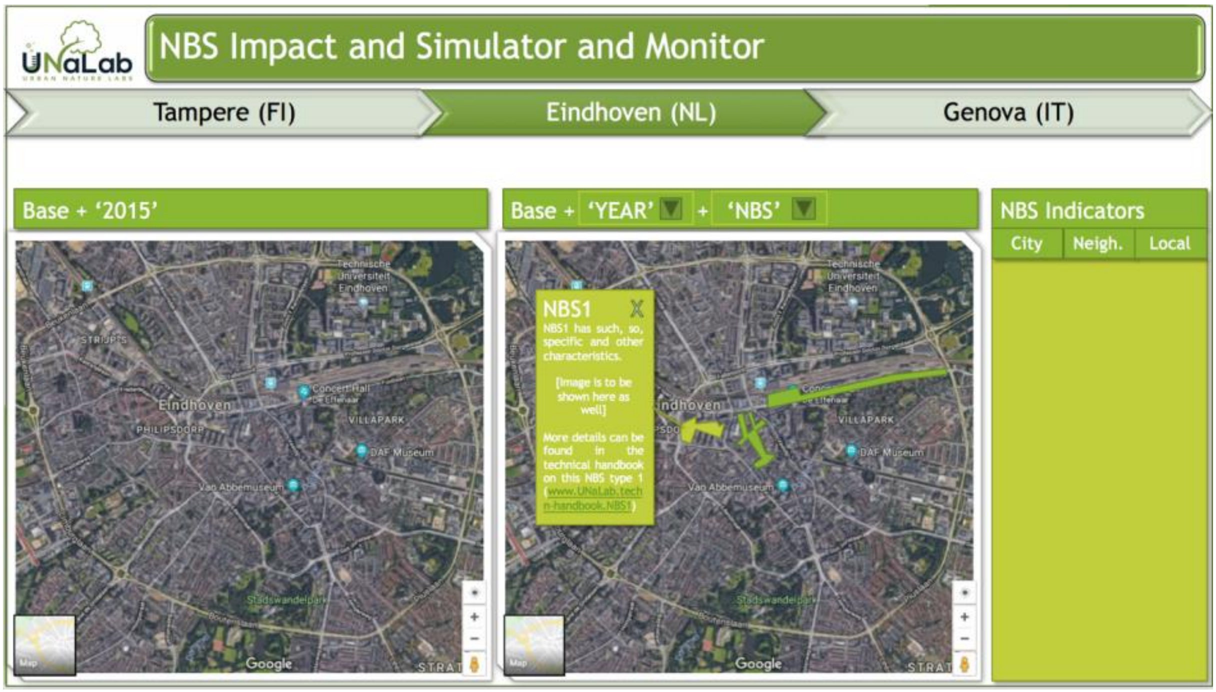

Figure 6 – View NBS description

Figure 7 represents the selection tool that enables users to select the year to evaluate.

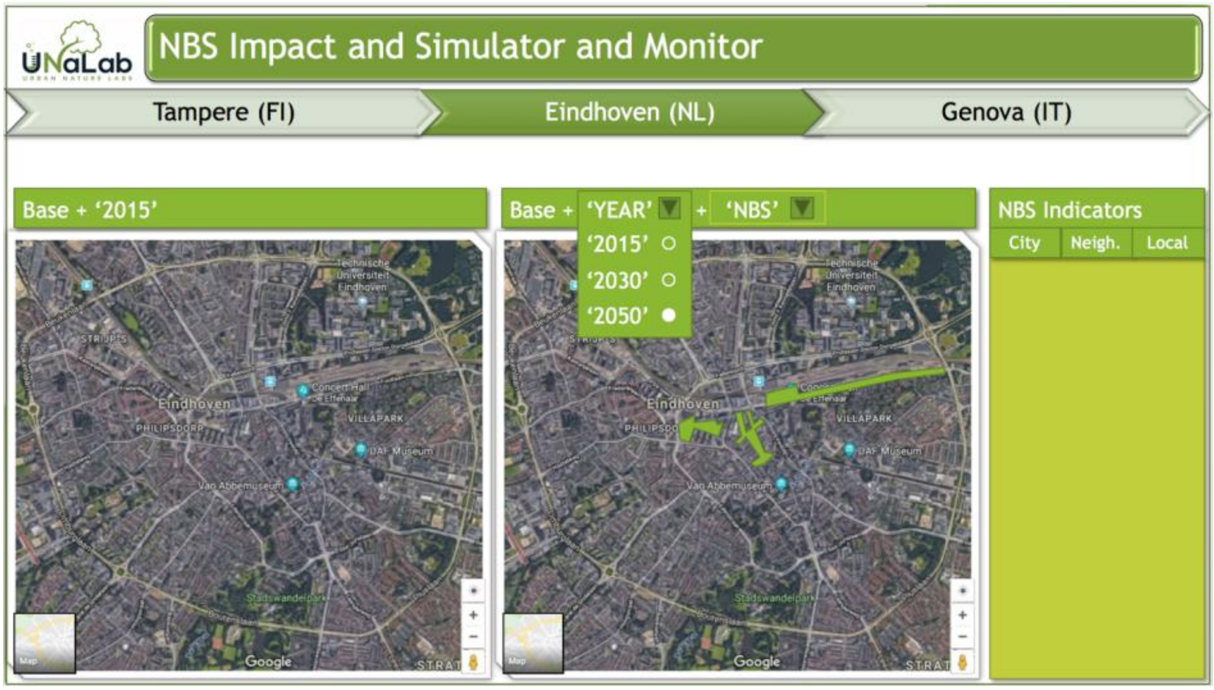

Figure 7- Year selectors

Figure 8 represents the selection tool that enables users to select the NBS to evaluate.

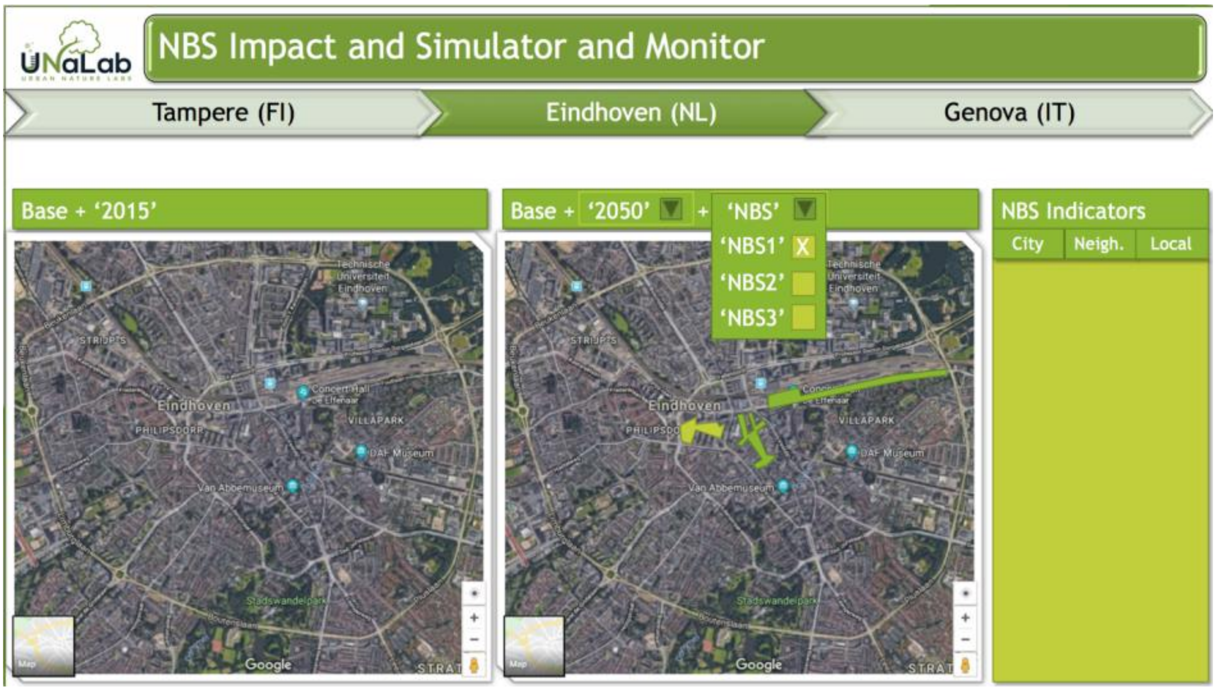

Figure 8 – NBS scenario selectors

Figure 9 represents the interactive areas,where users will be able to select the scale of the indicators (i.e. City, Local, Neighbourhood) and the mode (table or graph), and switch between absolute and difference values.

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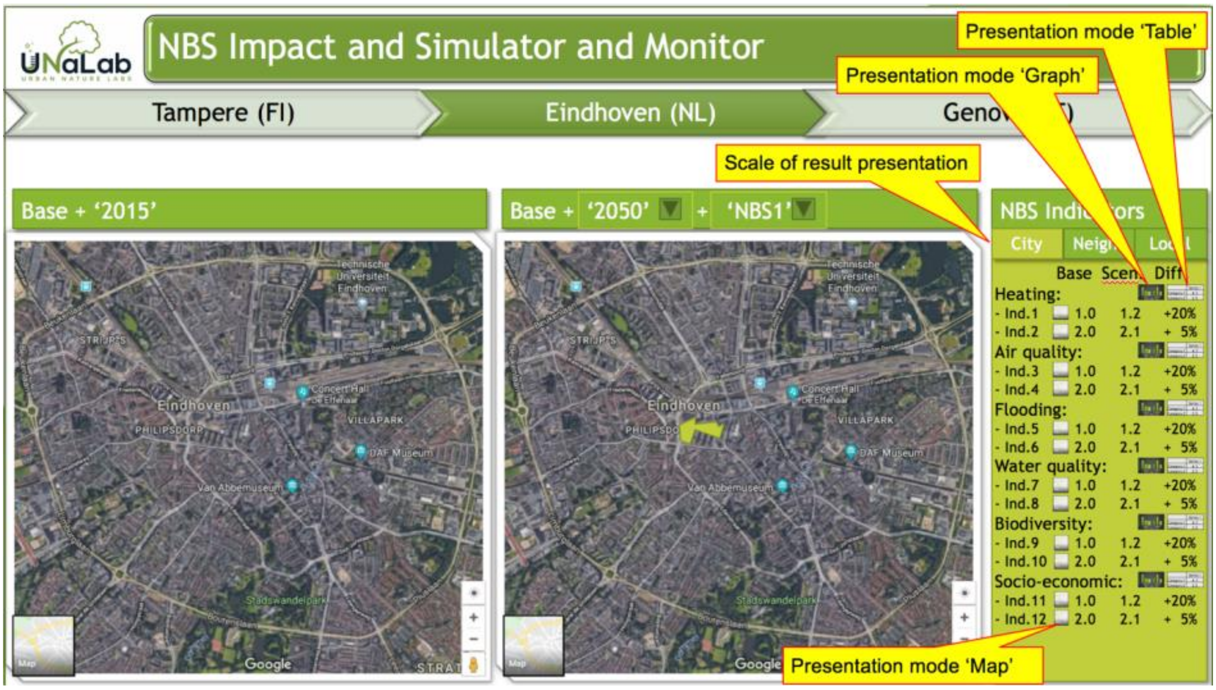

Figure 9 – Table and chart view selectors

Figure 10 represents the possibility to compare, at city scale, the base scenario against the likely scenario in 2050, if NBS1 is implemented. The menu on each map provides the color code adopted to represent the value of the selected indicator.

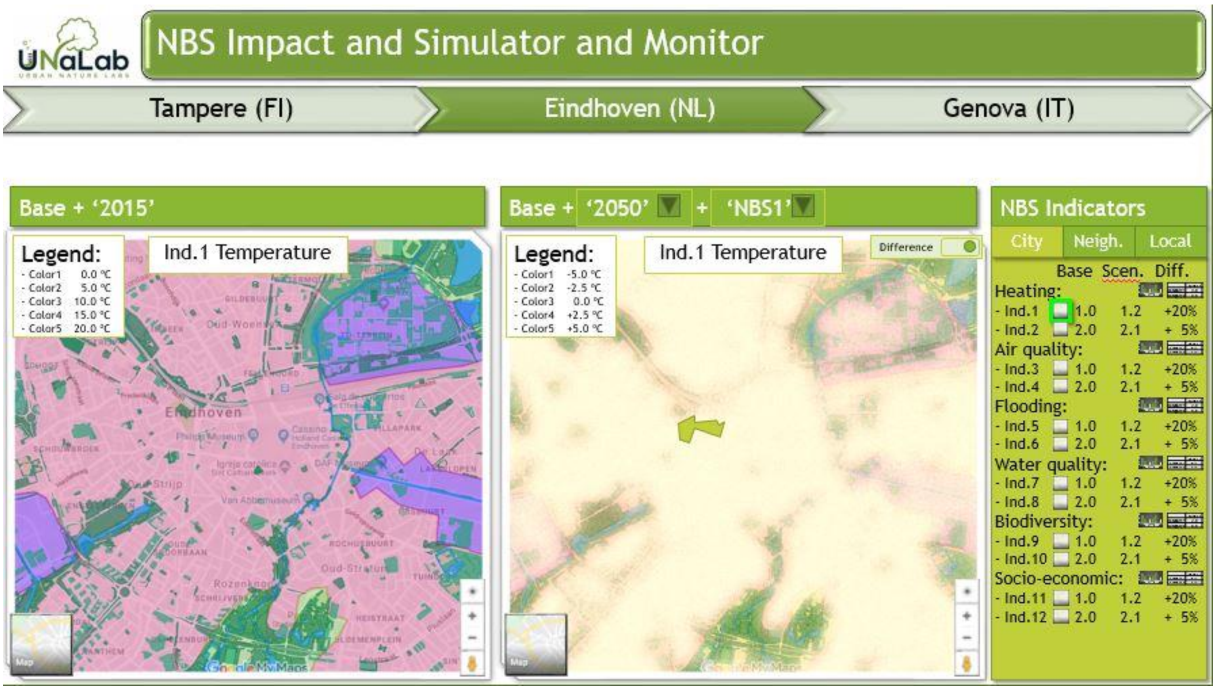

Figure 10 – Comparing the scenario data – city scale maps

Figure 11 shows the possibility to use the data in tables and graphs to improve comparison between the scenarios.

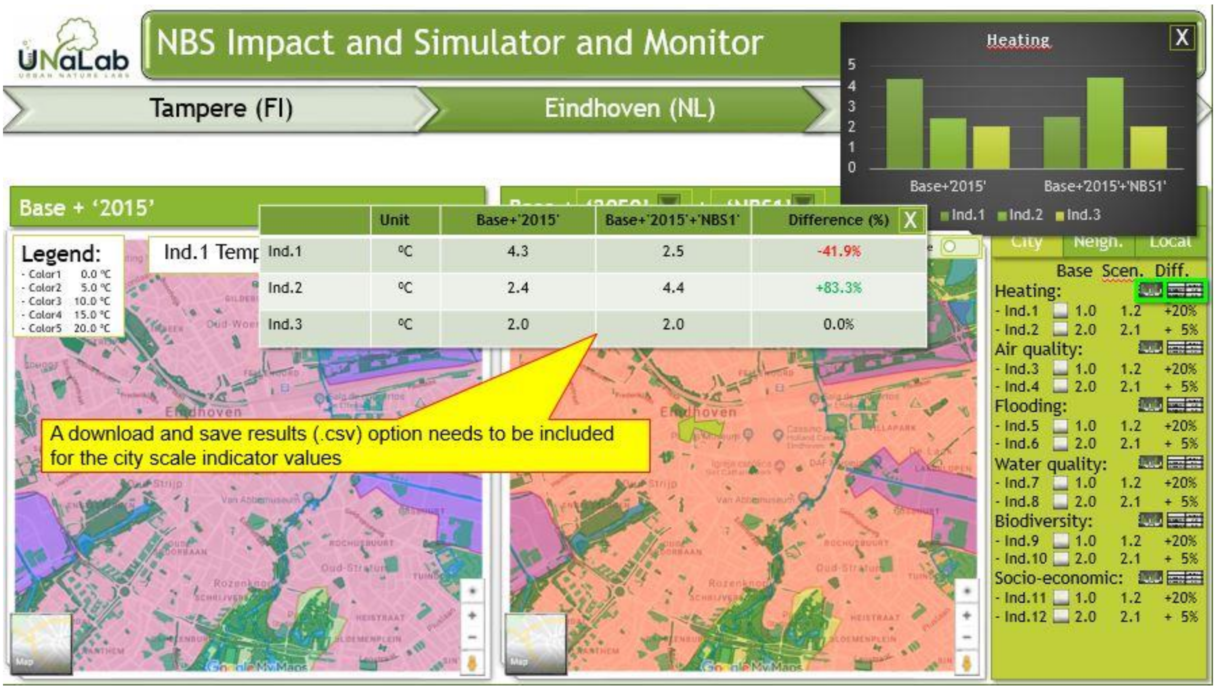

Figure 11 – Comparing the scenario data – city scale tables and graphs

Figure 12 depicts the possibility to compare the scenarios at neighbourhood scale. Each neighbourhood is depicted using a colour, indicating the value of selected indicator.

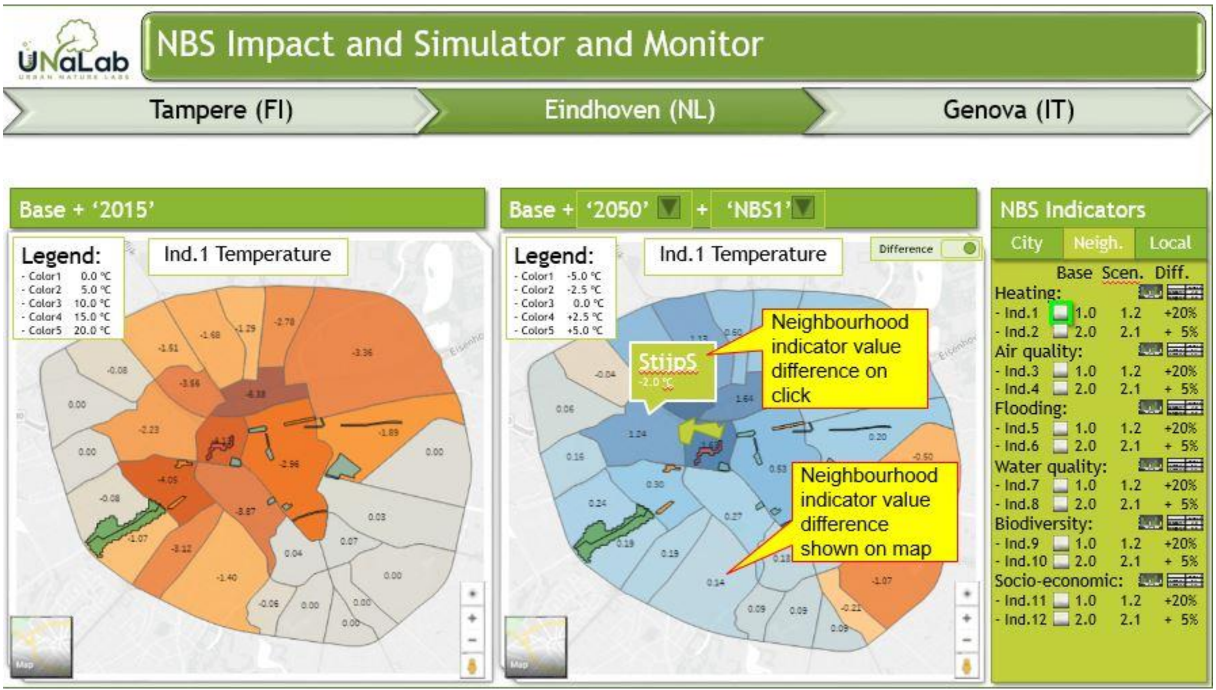

Figure 12 – Comparing the scenario data – neighbourhood scale maps

Figure 13 shows how the data drawn from tables and graphs can be used when comparing different scenarios . In addition, the download feature will allow additional elaboration of the datasets.

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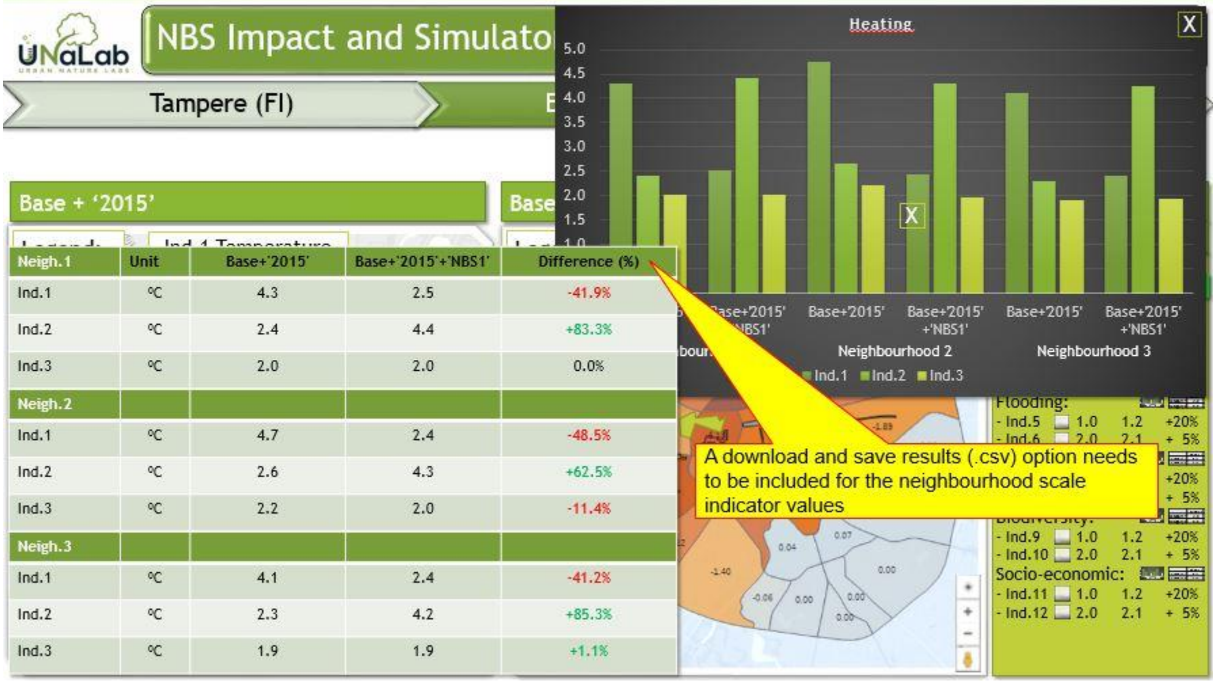

Figure 13 – Comparing the scenario data – neighbourhood scale tables and graphs

Figure 14 represents the possibility to compare the scenarios at local scale. Each cell represents a small area in the city and the colour indicates the value of the selected indicator.

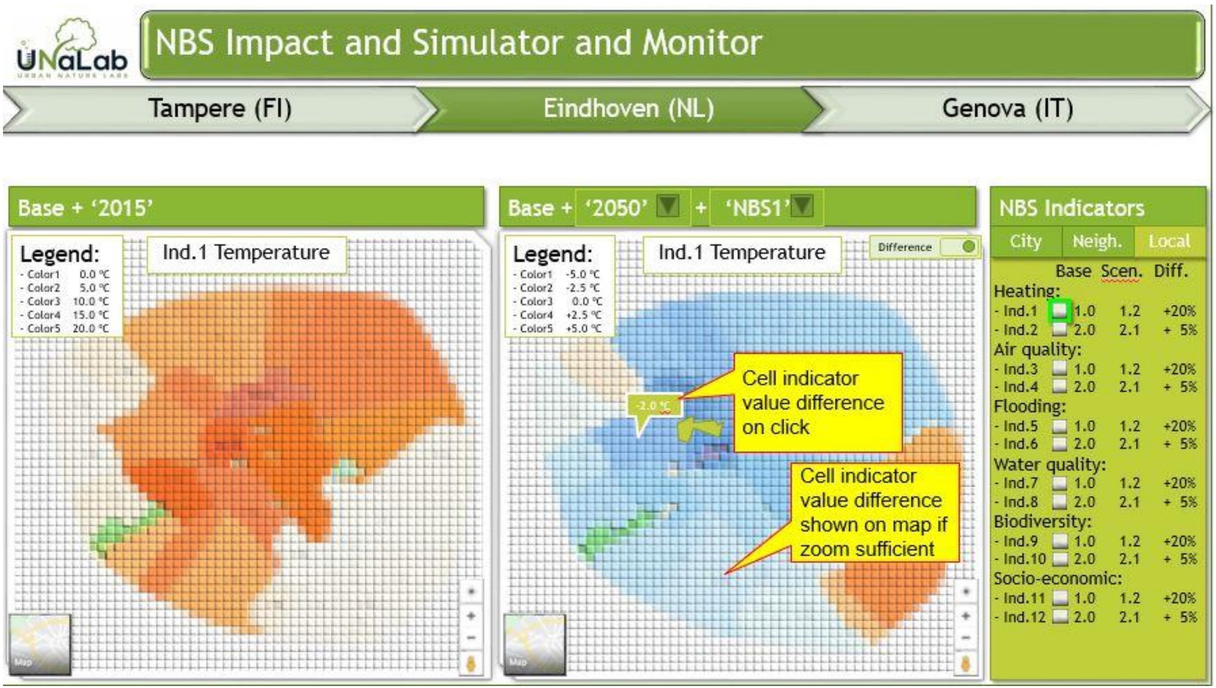

Figure 14 – Comparing the scenario data – local scale maps

5. Reference Implementation

This section describes the reference implementation of the NBS Impact Simulator and Monitor, i.e. the NBS Simulation and Visualisation Tool (NBS SVT), developed considering the requirements described in the reference architecture. Section 5.1 describes the criteria adopted by the SDST on defining the data models containing the simulation results (based on T3.2), and Section 5.2 provides the technological architecture and the deployment diagram will be represented and described.

5.1 SDST structure and data organization

This section describes the overall structure of the SDST, its disciplinary component models and their integration as well as the scenario simulation output data organisation.

a) Structure and disciplinary component model integration

The SDST integrates and builds upon data and information from disciplinary component models into a spatially-explicit framework at the landscape scale (following Bohnet, Roebeling, Williams, Holzworth & Van Grieken et al., 2011), to assess the direct (short-term) and indirect (medium to long-term) impacts of nature-based solutions (NBS) and strategies on urban heat and air quality, flooding and water quality, biodiversity, and sprawl, gentrification and real-estate valuation (see Figure 15). The SDST will be used to assess the potential direct and indirect impacts of NBS in front-runner cities (FRC) during the lifetime of the UNaLab project, as well as to evaluate the potential direct and indirect impacts of additional future NBS strategies at the local, neighbourhood and city scale beyond the lifetime of the project.

The SDST, and its disciplinary component models, share a common database, including meteorological and climate, land use, emission, air and water quality, biodiversity, demographic and socio-economic data (see Figure 15). A representative '2015' pre-NBS Baseline is established based on average 2012-2016 data, corresponding to long-term average temperature and precipitation data for the considered FRC. The corresponding baseline data are stored, visualized and downloadable through a Google Sites-based application (see https://sites.google.com/view/unalab/baseline-maps; Martins, Ascenso, Mendonça, Mendes & Roebeling et al., 2018).

The following state-of-the-art disciplinary component models are integrated within the SDST to allow for the impact assessment of NBS without (2015) or with (2030 and 2050) climate change and/or population growth (see Figure 15):

- Urban heat and air quality are assessed using the coupled WRF-CHEM model (Grell, Peckham, Schmitz, McKeen & Frost et al., 2015; (see Section5.1.2a);
- Flooding and water quality are assessed using the InfoWORKS ICM (Innovyze, 2018) model (for Eindhoven; see Section 5.1.2b)) or the MIKE-Urban/Flood (DHI, 2007a, 2007b) model (for Tampere and Genova);
- Ecosystems and biodiversity are, potentially, assessed using the coupled CICES methodology (Haines-Young & Potschin, 2012) and InVEST (Sharp et al., 2016) and/or i-TREE (2018) model; and
- Sprawl, densification, gentrification, land use and real-estate valuation are assessed using the Sustainable Urbanising Landscape Development (SULD) model (Roebeling, Saraiva, Palla, Gnecco & Teotónio et al. 2017; (see Section 5.1.2c).

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Scenario simulations are performed for the reference scenario (2015) as well as for NBS and climate change and/or population growth scenarios (by 2030 and 2050). NBS scenarios and characteristics (e.g. NBS type, location and area, design and technical features), required by the disciplinary component models, are derived from local information as well as from the NBS Technical Handbook (Eisenberg & Polcher, 2018).

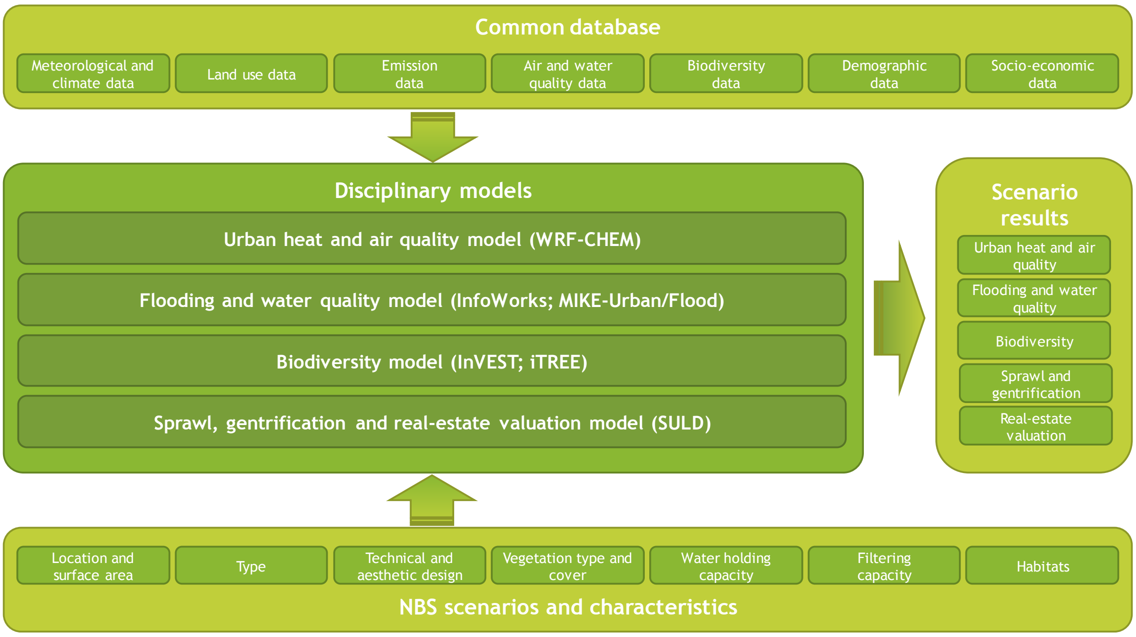

Figure 15 – SDST structure and disciplinary component models

b) Base and NBS scenario simulation output data organization

Output data is organised and stored in a geodatabase, containing simulation results for the Base and NBS scenarios in ‘2015’ (current climate and population conditions), ‘2030’ and ‘2050’ (future climate and/or population conditions) across spatial scales (city, neighbourhood and local). Simulation results comprise urban heat and air quality, flooding and water quality, biodiversity, and urban densification, gentrification, land use and real-estate valuation data that are, in turn, used to calculate corresponding performance and impact indicators.

The NBS Impact Simulator and Monitor allows for the end-user selection, simulation and visualisation of NBS scenarios in 2015, 2030 and 2050 and, hence, output data are systematically organised and stored in folders by Base/NBS scenario and, within, these, by year and spatial scale (see Figure 16).

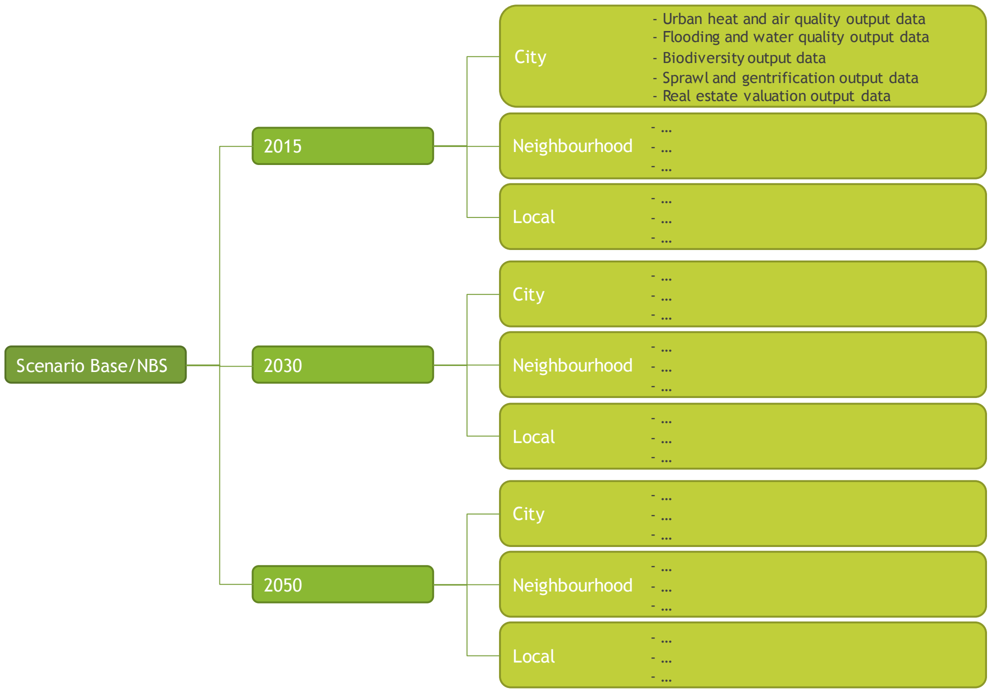

Figure 16 – SDST scenario simulation output data organization

This systematic output data organisation and storage allows the NBS Impact Simulator and Monitor to efficiently locate and retrieve data from the geodatabase server. Moreover, additional NBS scenarios are easily added and, in turn, located and retrieved by the NBS Impact Simulator and Monitor.

5.1.2 SDST disciplinary models

This section describes, in detail, the disciplinary models that comprise the SDST, focusing on input data requirements, model description and output data generation. Currently, the SDST comprises disciplinary component models on urban heat and air quality (Section 5.1.2a), flooding (Section 5.1.2b) and sprawl, gentrification and real estate valuations (Section 5.1.2c). Note that each of these disciplinary component models are parameterised, calibrated and validated using historical data (various databases) as well as observed data.

a) Heat and air pollution

This section describes the WRF-CHEM model (Grell, Peckham, Schmitz, McKeen & Frost et al., 2015) for assessing the impacts of NBS on urban heat island mitigation and air quality improvement. WRF-CHEM contains three components: (1) the *Inputs* component contains the data for the current situation as well as the scenario simulations; (2) the *Model* component contains the mathematical equations that transpose the physical processes into numerical results; and (3) the *Outputs* component presents the simulated results. The following sections provide a brief description for each of these components.

Input data

Required input data is obtained from stakeholders' and databases as well as any open source database. WRF-CHEM uses as inputs the anthropogenic emissions (EMEP inventory; Vestreng et al., 2005), biogenic emissions (MEGAN model; Guenther et al., 2006), initial and boundary conditions (MOZART model; Emmons et al., 2010), and orography and land use (USGS 33 classes database; Carvalho et al., 2016; Pineda et al., 2004). To represent the NBS, changes are applied to the land use accordingly.

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WRF-CHEM was forced by the Max Planck Institute Earth System Model – Low Resolution (MPI ESM-LR; Giorgetta, Jungclaus, Reick, Legutke, Bader et al. 2013), with a horizontal resolution of 1.9 degrees. The MPI-ESM-LR global climate model is used as it is considered one of the best models to simulate climate for Europe (Brands, Herrera, Fernández, & Gutiérrez 2013). The intermediate climate change scenario RCP4.5 (Thomson, Calvin, Smith, Kyle, Volke & Patel et al. 2011) is considered for future climate simulations, in alignment with the Paris Agreement (United Nations, 2015).

Model

WRF-CHEM is the Weather Research and Forecasting (WRF) model coupled with Chemistry. It is a fully coupled mesoscale "online" model developed by Grell, Peckham, Schmitz, McKeen & Frost et al. (2015) in which the air quality component is consistent with meteorological component. Both components use the same transport scheme (vertical and horizontal coordinates), physics schemes for sub-grid scale transport and the same time step, so that it doesn't need interpolation in space and time. The WRF dynamic solver integrates the compressible, non-hydrostatic Euler equations such that they are cast in flux form using variables that have conservation properties (Ooyama, 1990). Detailed information on the model structure and its underlying equations are available in Skamarock, Klemp, Dudhia, Gill & Barker et al. (2008).

For the UNaLab FRC, three online-nested domains with increasing resolution at a downscaling ratio of five are used – with the coarser domain of 25 km horizontal resolution covering Europe and part of the North Atlantic Ocean, and the innermost domain of 1 km horizontal resolution covering the area containing the FRC region.

Output data

WRF-CHEM output data are hourly three-dimensional fields that comprise a wide range of meteorological variables, including temperature and heat fluxes, as well as pollutant concentrations, such as ammonia (NH3), nitrogen oxides (NOX), ozone (O3), particle matter (PM), sulphur dioxide (SO2) and volatile organic compounds (VOC). Corresponding daily, weekly, monthly and annual meteorological variable and pollutant concentration values can be calculated.

b) Flooding

This section describes the InfoWORKS ICM (Innovyze, 2018) model, used in the Front Runner City Eindhoven, for assessing the impacts of NBS on the mitigation of urban floods. InfoWORKS ICM (Innovyze, 2018) model translates into computer code the mathematical and physical principles behind the physical process of fluid momentum and mass conservation given hydrostatic pressures. This is achieved using the well-known Shallow Water Equations (De Saint-Venant, 1871). InfoWORKS ICM contains three components: (1) the *Inputs* component contains the data for the current situation as well as the scenario simulations; (2) the *Model* component contains the mathematical equations that transpose the physical process into evaluable numerical results; and (3) the *Outputs* component presents the simulated results. The following sections provide a brief description for each of these components.

Input data

Required data is obtained from the stakeholders' input and databases as well as any open source databases. Flood simulations require the acquisition of data on historical precipitation, historical flood events, urban geometry, physical urban characteristics, man-made systems for water conveyance, natural streams/water bodies, and existing NBS solutions.

Model

The InfoWORKS ICM (Innovyze, 2018) model comprises two models and the linkage: A surface model, a sewer model, and the linkage between them.

The surface system modelling is based on the 2D SWE (Shallow Water Equations) derived by depth-integrating the three-dimensional RANS (Reynolds Averaged Navier-Stokes) equations (Martins, Leandro & Djordjevic, 2015), neglecting the vertical acceleration of water particles, and taking the pressure distribution to be hydrostatic (Nikolos & Delis, 2009). These are represented in its conservative form by:

$$\frac{\partial}{\partial t}h+\frac{\partial}{\partial x}(uh)+\frac{\partial}{\partial y}(vh)=0 \tag{1}$$

$$\frac{\partial}{\partial t}uh+\frac{\partial}{\partial x}u^2h+\frac{1}{2}\frac{\partial}{\partial x}gh^2+\frac{\partial}{\partial y}uvh=-gh\frac{\partial}{\partial x}B-\tau_{bx} \tag{2}$$

$$\frac{\partial}{\partial t}vh+\frac{\partial}{\partial x}uvh+\frac{\partial}{\partial y}v^2h+\frac{1}{2}\frac{\partial}{\partial y}gh^2=-gh\frac{\partial}{\partial y}B-\tau_{by} \tag{3}$$

where $h(x,y,t)$ is the height of the water, $u(x,y,t)$ and $v(x,y,t)$ are the velocity components according to the x and y direction respectively, g is the gravitational acceleration, $B(x,y)$ the topography relative height, τ_{bx} and τ_{by} are the bed friction stresses, and where n is the Mannings coefficient:

$$\tau_{bx}=u\frac{gn^2\sqrt{u^2+v^2}}{h^{\frac{1}{3}}},\tau_{by}=v\frac{gn^2\sqrt{u^2+v^2}}{h^{\frac{1}{3}}} \qquad (3)$$

Equation (1) is the continuity equation and represents the mass balance over the control volume, and Equations (2) and (3) represent the momentum equations and, therefore, the momentum quantity conservation.

The two-dimensional (2D) non-linear shallow water equations (SWE) are accepted to mathematically describe a wide variety of free-surface flows under the effect of gravity. They can be very useful for simulating long wave hydrodynamics when the vertical acceleration of water particles can be neglected, and the flow can be reasonably assumed to be nearly horizontal (Nikolos & Delis, 2009). Infoworks solves these equations explicitly using a Roe Riemann solver of second order (Neelz & Pender, 2012).

Sewer systems solve the 1D Saint-Venant equations:

$$\frac{\partial}{\partial t}A+\frac{\partial}{\partial x}Q=0 \tag{4}$$

$$\frac{\partial}{\partial t}Q+\frac{\partial}{\partial x}\frac{Q^2}{A}+gA\frac{\partial}{\partial x}H+gAS_f+gAh_L=0 \tag{5}$$

$$S_f=\frac{n^2V|V|}{k^2R^{\frac{4}{3}}},h_L=\frac{KV^2}{2gL} \tag{6}$$

where H is the hydraulic head and h_L the local energy losses, V is the flow velocity, L the conduit length, R the hydraulic radius and K is a local loss coefficient. A node continuity equation sometimes is added:

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$$\frac{\partial}{\partial t}H = \frac{\sum Q}{A_{Store} + \sum A_S} \tag{7}$$

where A_{Store} is the water surface area of the node, $\sum A_S$ the sum of the contribution from the water surface area in the pipes, and $\sum Q$ is the sum of all inflows and outflows into the node. These equations are solved implicitly using a four-point scheme (Preissmann, 1961).

Output data

The InfoWORKS ICM (Innovyze, 2018) model produces simulations results in the form of tables and maps, graphs, raw data, GIS compatible formats or images. Amongst the most commonly used outputs are the depth of water and the velocity, very relevant for the flood impact assessment as high velocities and depths usually imply larger flooding costs.

c) Sprawl, gentrification, land use and real estate valuation

This section describes the Sustainable Urbanizing Landscape Development (SULD) model (based on Roebeling, Fletcher, Hilbert & Udo, 2007; Roebeling, Teotónio, Alves, & Saraiva, 2014; Roebeling, Saraiva, Palla, Gnecco & Teotónio et al. 2017) for assessing the impacts of NBS on urban sprawl, gentrification and real estate values. SULD contains three components: (1) the *Inputs* component contains the data for the current situation as well as the scenario simulations; (2) the *Model* component contains the mathematical equations that transpose relevant input data into corresponding indicator values; and (3) the *Outputs* component presents the simulated results (indicator values) for the current situation and scenario simulations. The following sections provide a brief description for each of these components.

Input data

Required data is obtained from the stakeholders' input and databases as well as any open source database. SULD requires two areas to be defined: (1) the area to be shown/discussed with stakeholders (X by Y km); (2) a larger area (e.g. 1.25*X by 1.25*Y km) to be used in calculations so that amenities close to the study area, but not covered by it, can be considered.

Accordingly, the following spatial data for the model area is retrieved: land use, road network, environmental amenities, urban centres and population densities. Similarly, the following non-spatial data for the model area is retrieved: household types, property value, transport costs and construction costs.

Model

The SULD decision support tool is a hedonic pricing simulation model, developed to enhance the decision-making process regarding sustainable urban development and green/blue space management. It is a GIS-based optimization model, based on a classic urban-economic model with environmental amenities (Mills 1981; O'Sullivan 2000; Wu 2006; Wu & Plantinga 2003), that builds on hedonic pricing theory.

The **demand** side (Equation 8) is represented by households, considering their preferences regarding certain goods and services, as residential space *S*, other goods and services *Z*, and environmental amenities e. The utility obtained by households in each location depends on their preferences, distance to environmental amenities and income *y*. Hence, households aim to maximize their utility U at a certain location i, subject to the budget constraint *y*, that is spent on housing ($p_i^h S_i$), other goods and services (Z), and transportation between the residential area and the urban centre ($p_x x_i$):

$$\max_{S_i, Z_i} U_i(S_i, Z_i) = S_i^{\mu} Z_i^{1-\mu} e_i^{\varepsilon} \quad subject\ to\colon \quad y = p_i^h S_i + Z_i + p_x x_i \tag{8}$$

where p_i^h is the rental price of housing, p_x the commuting cost and x_i the road-network distance to the closest urban centre. Moreover, μ is the elasticity of demand for residential space (S_i) and ε is the elasticity of utility with respect to environmental amenities (e_i). The household's bid-rent price for housing p_i^{h*} is now given by:

$$p_i^{h*} = \left(\frac{\mu^\mu(1-\mu)^{1-\mu}e_i^\varepsilon(y-p_x x_i)}{u}\right)^{\frac{1}{\mu}} \quad (9)$$

where u is the utility level U. The above equation provides the household's maximum willingness to pay for housing (p_i^{h*}), representing the demand side of the real estate market.

The **supply** side (Equation 10) is represented by real-estate developers, that aim to maximize their profit by trading off returns from housing development density D and associated development costs, that are subject to households' willingness to pay for housing. Hence, developers aim to maximize their profit (π_i), which is given by the difference between construction revenue ($p^h D$) and development costs ($l+D^\eta$):

$$\max_{D_i} \pi_i(D_i) = p_i^h D_i - \left(l_i + D_i^\eta\right) \quad with: \quad D_i = n_i S_i \quad (10)$$

where p_i^h is the rental price of housing, l_i the opportunity cost of land, D_i^η the construction cost function (with η the ratio of housing value to non-construction costs), n_i the household density and S_i the residential space. The developer's bid-price for land r_i^{**} is now given by:

$$r_i^{**} = \left(mp_i^{h**}\right)^{\frac{\eta}{\eta-1}} \quad (11)$$

where $m = [(\eta-1)^{\eta-1}/\eta]/\eta$. This equation determines the minimum rental price for housing the developer is willing to accept $\left(p_i^{h**}\right)$, thus representing the supply side of the housing market. This means that developers will only develop when residential land rents ($p_i^h D_i$) are larger than the opportunity cost of development ($l_i + D_i^\eta$), which corresponds to the foregone land rents (l_i) and investments in land conversion (D_i^η).

In **equilibrium** (Equation 12), supply for housing equals demand for housing (i.e. $p_i^{h*} = p_i^{h**}$). The land rent price r_i can now be derived using Eq. (2) and (4), and is given by:

$$r_i = \left(\frac{ke_i^\varepsilon(y-p_x x_i)}{u}\right)^{\frac{\eta}{\mu(\eta-1)}} \quad (12)$$

where $k = \mu m^\mu(1-\mu)^{1-\mu}$. The corresponding optimal household density n_i is given by:

$$n_i = \frac{D_i}{S_i} \quad (13)$$

with $S_i = \mu(y-p_x x_i)/p_i^{hx}$ the necessary condition for optimality U_i and with $D_i = (\eta-1)^{1/n}(r_i)^{1/n}$ the necessary condition for optimality of π_i, and where p_i^{h*} and r_i are given in Equations (9) and (12), respectively.

The **equilibrium** land rent price r_i and household density n_i are then derived, providing development patterns for a certain population size and composition and given the location of urban centres and environmental amenities location. SULD builds on a numerical application

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of the above-described model, using the General Algebraic Modelling System (GAMS 21.3; Brooke, Kendrick, Meeraus & Raman 1998). The objective function maximizes, for a given household population Q_t, the difference between benefits B from residential (L_i^{res}) and non-residential (L_i^{nres}) land uses and development costs ($l_i + D_i^{\eta}$), so that:

$$\max_{L_i} B(L_i) = \sum_i \left(l_i L_i^{nres} + \left(r_i - l_i - D_i^{\eta}\right) L_i^{res}\right) \tag{13}$$

with $Q_t = \sum_i n_i$ and $L_i^{res} + L_i^{nres} = \mathrm{a_i}$, and where l_i represents the opportunity cost of land, r_i is the land rent price and a_i corresponds to the grid-cell area. Land use conversion can happen between residential and non-residential land uses – all other land uses are fixed.

Output

The SULD model simulation outputs provide information on land use, population, housing quantity, development density, living space and real estate value. 'Land use' provides information on seven different types of land use in the study area (in ha). 'Population' gives the number of residents in the study area (in #), which are grouped in low-, middle- and high-income households. 'Housing quantity' provides information about the total built area (in m^2), 'Development density' refers to the total floor space (in m^2) and 'Living space' refers to the average living space (in m^2/hh) per household type. Finally, 'Real estate value' provides information on the annual rental value of living space (in €/m2/yr) per household type. Hence, SULD calculates the equilibrium price for housing as a function of demand and supply, it allows to assess the impact of location-specific green/blue spaces, infrastructure and socio-economic scenarios on the location of residential development, housing quantity, residential development density, population density, population composition, household living space and real estate values.

5.2 Technological view

Taking into account the requirements described in the reference architecture, the NBS SVT has been implemented exploiting both the results models generated by the SDST (Task 3.2), from data point of view, and the community edition of Knowage (Knowage community edition, 2018), for data visualization.

Knowage is the powerful open source tool provided by Engineering with several functionalities to ease the composition of applications devoted to data visualisation through:

- the dashboard modeller provides the functionalities to build self contained dashboards representing the data models through modular and interactive widgets, i.e. charts, histograms, maps, tables and so on.
- the data sources manager, eases to set and manage the data structures stored in several kind of data sources, e.g. RESTful web services and RDBMS as MySQL and PostgreSql.

For more details about Knowage see the official documentation (Knowage community edition, 2018).

According to these premises, the reference implementation of the NBS SVT consists of:

- Front-end Layer: it is a web application developed in HTML and JavaScript. It provides a step-by-step experience to lead the users to the pages containing dashboards, the small and self-contained interactive applications built in Knowage deputed to evaluate and compare the NBS simulation scenarios.

- Dashboards Layer, it is the web application supporting the dashboards composition and the SDST models management.
- Data layer (as geodatabase it is logically included in the UNaLab Knowledge Base):
    - MySQL version 5.5.62: it is the RDBMS ensuring the persistence of the SDST models.
    - NodeJS based web service, it exposes the RESTful APIs providing the SDST models in the structure expected by Knowage.

The following picture depicts the NBS SVT reference implementation.

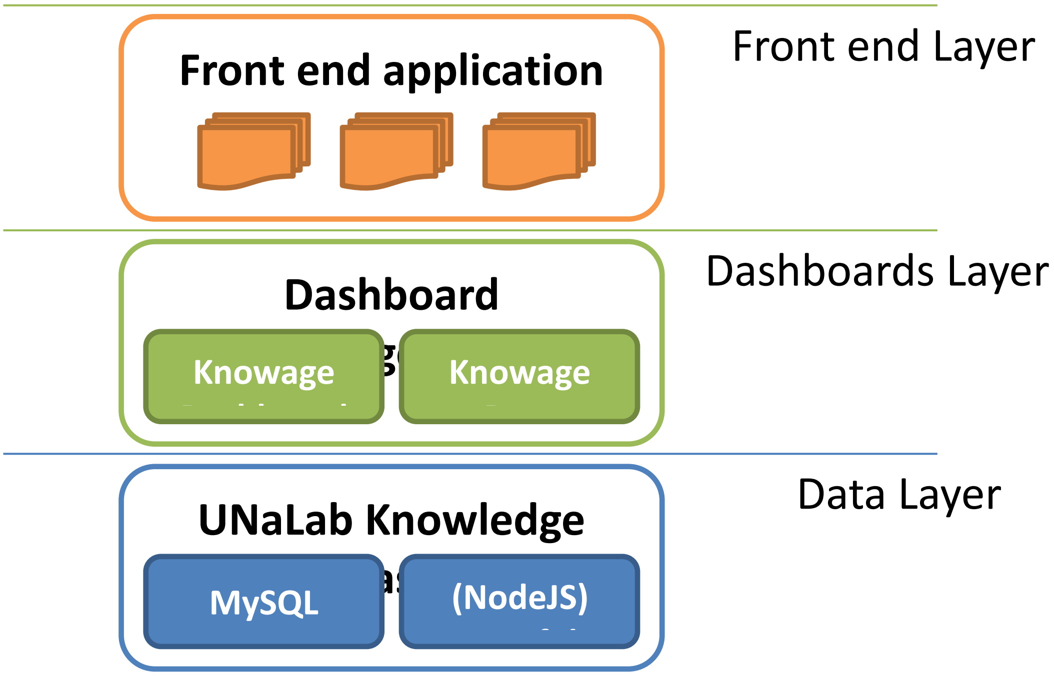

Figure 17 –Reference Implementation

5.3 Deployment Diagram

The following picture depicts the deployment diagram of the NBS Impact Simulation and Monitor components.

In compliance with the respective technical specifications, these components are deployed in Tomcat containers.

As the components of the overall ICT framework, these containers are hosted in a private cloud and not directly connected to Internet.

All the invocation have to be processed by a “reverse proxy” that acts as the front end component exposing and protecting the public interfaces.

All of these components will be maintained under the task T4.6.

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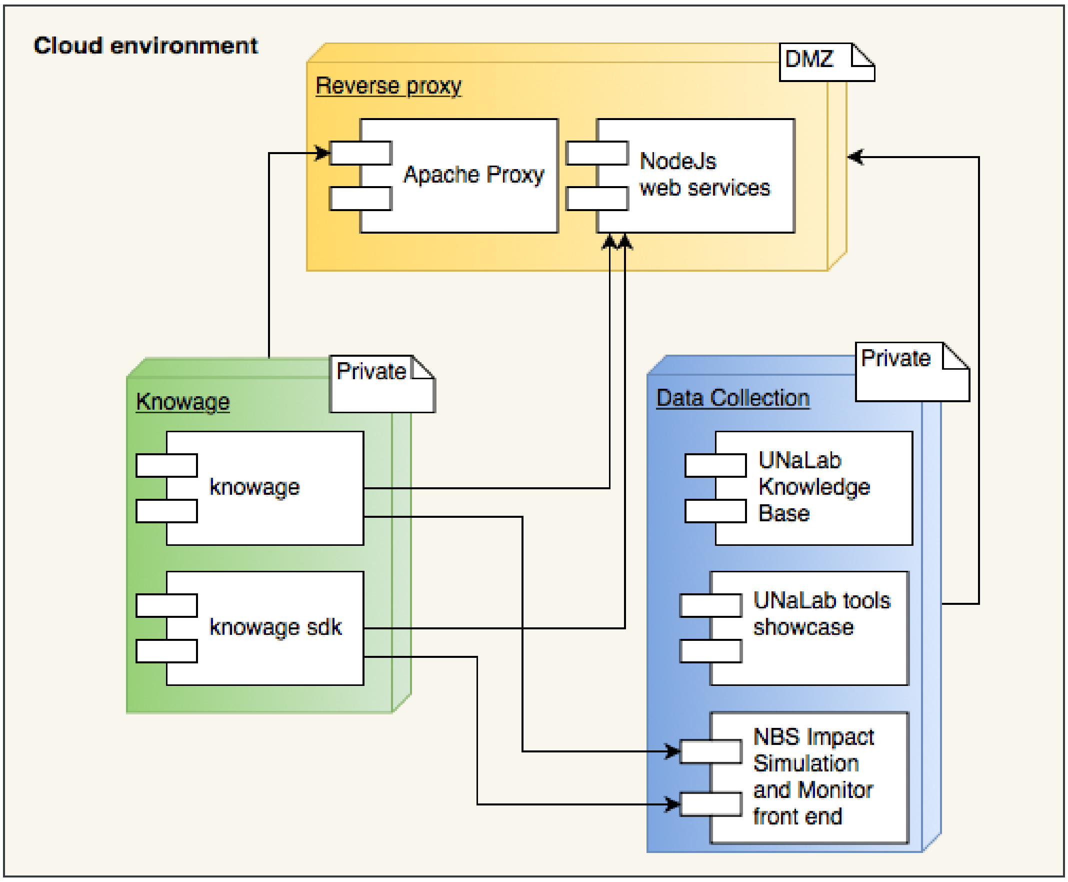

Figure 18 – NBS Impact Simulation and Monitor deployment diagram

6. USER MANUAL

6.1 Requirements

Follows the mandatory requirements to the proper interaction with the NBS SVT:

- To use Chrome as browser.
- To enable the cookies from third parties.
- To refresh the page in case of partial download of the dashboards.

Note:

- (at the time this deliverable is edited) according to the project work plan, the front end application is not integrated in the ICT framework yet.
- In case of the login will be required, refresh the page and it will work properly.

6.2 Installation and configuration manual

To install the Knowage community edition follow the online documentation (Knowage installation manual, 2018).

To install MySQL version 5.5.62 follow the online documentation (MySQL installation manual, 2018).

The NBS SVT front end is a simple HTML application hosted within a Tomcat 8 container.

To install the front-end application:

1. download the WAR package released on the UNaLab Bitbucket repository (Bitbucket UNaLab, 2018);
2. update the URL of the dashboards in the variable.js file included in the src/js folder;
3. deploy the WAR on Tomcat;

To enable the export of the dashboards in JPG e PDF format:

1. Login as administrator in the machine and run the following instruction:
   a. *sudo apt-get install libc6 libstdc++6 libgcc1 libgtk2.0-0 libasound2 libxrender1 xvfb*
2. logout from the machine

No additional configurations are required.

6.3 NBS SVT application User Manual

As anticipated, this deliverable describes the proof of concept of the graphical user interface devoted to represent the SDST geo data. This sub-section describes with screenshots and images the main functionalities provided by the application.

Texts and figures will change in the future as consequence of the improvements will be implemented to address the user request, feedbacks and suggestions. For the first release, the proof of concept of the tool presents the main Eindhoven city models. In this way, the users will have the opportunity to test the functionalities and begin familiar with the tool avoiding a vain overload of options.

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At the moment of defining this deliverable the NBS SVT application is available at the following URL:

- http://UNaLab.eng.it/CockpitSelection/

The following picture shows the main page of the NBS SVT.

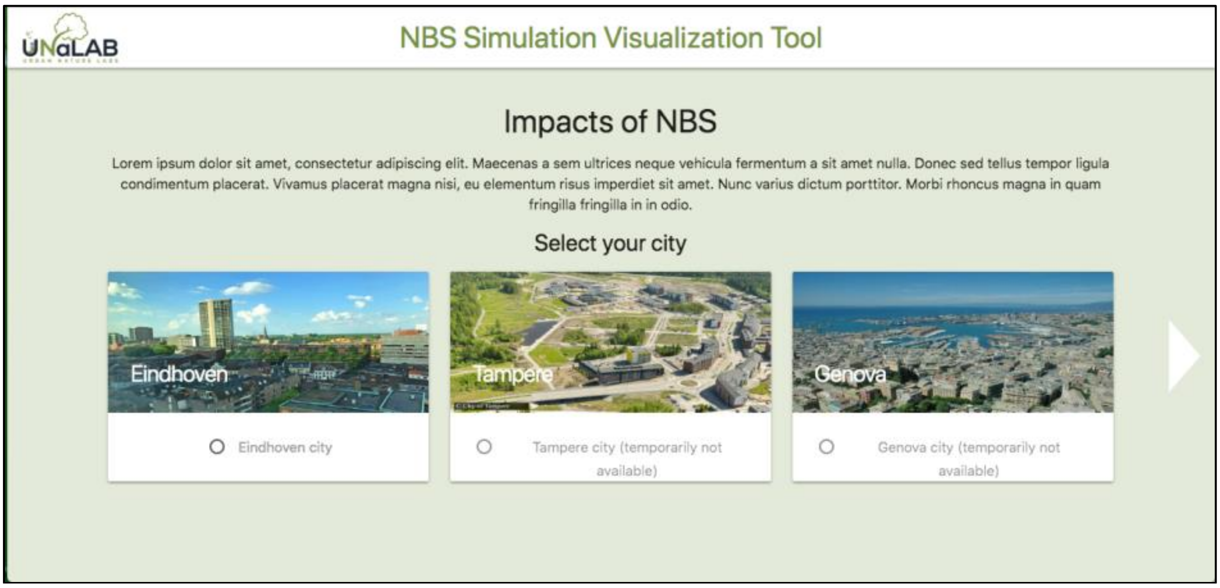

Figure 19 – NBS SVT main page

Starting form the main page the user can select its city.

After the selection of the city, the web application forward to a dashboard containing map and charts representing the current situation indicators.

By clicking on the map, the user can view the details related to that city area.

In addition, as depicted in Figure 20 each dashboard provides a menu to allow the users to:

- print the dashboard;
- export the dashboard (in PDF, XLS, JPG, XLSX formats);
- copy the dashboard link;
- get the html code to embed dashboard in an externnal HTML page.

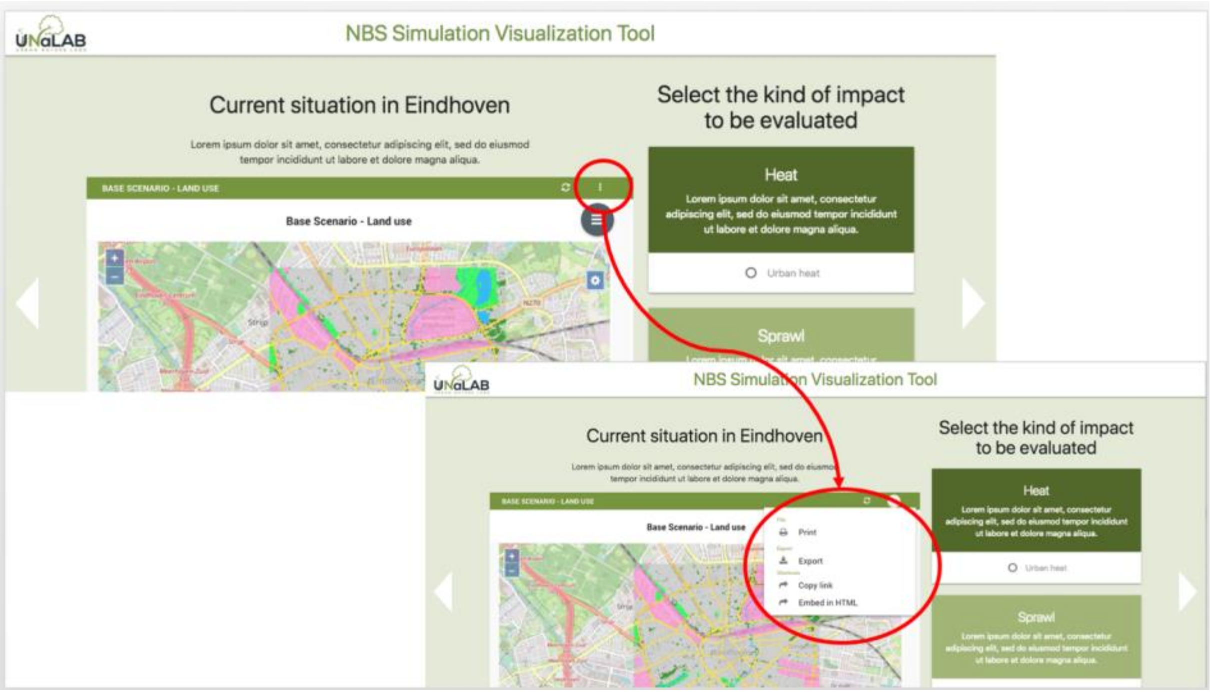

Figure 20 – Dashboard menu

As shown in Figure 21, from the ”Current situation” page the user can select the kind of impact to evaluate, e.g. ’Urban Heat’.

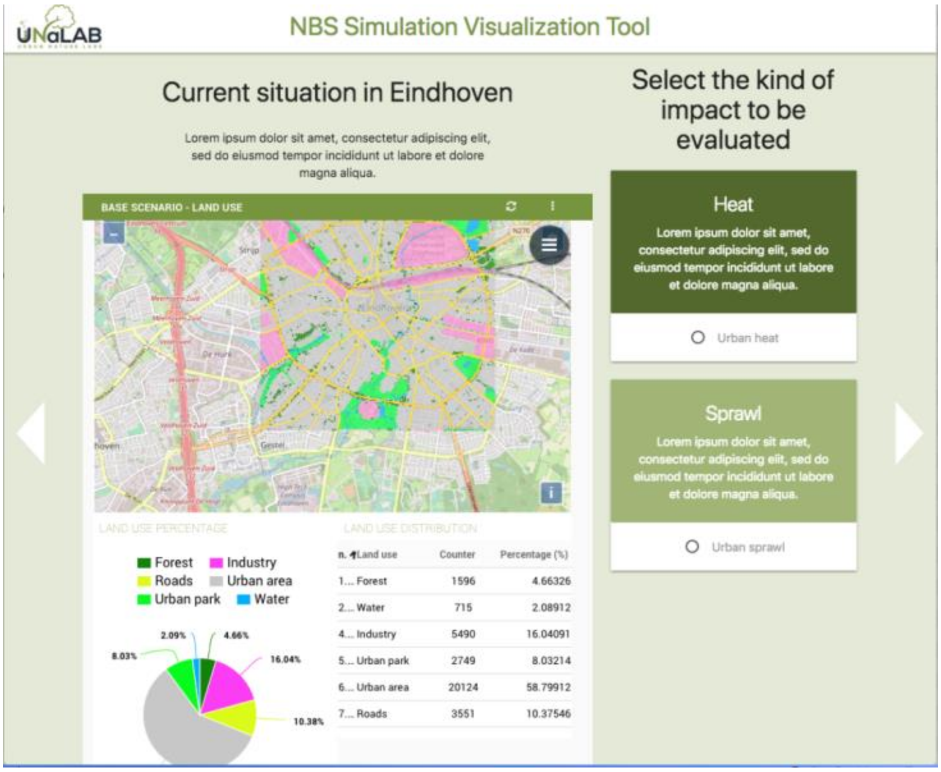

Figure 21 – Current situation and Impact selection

After the user has selected the impact to be evaluated, the options for the scale to evaluate (local or neighbourhood scale) is provided.

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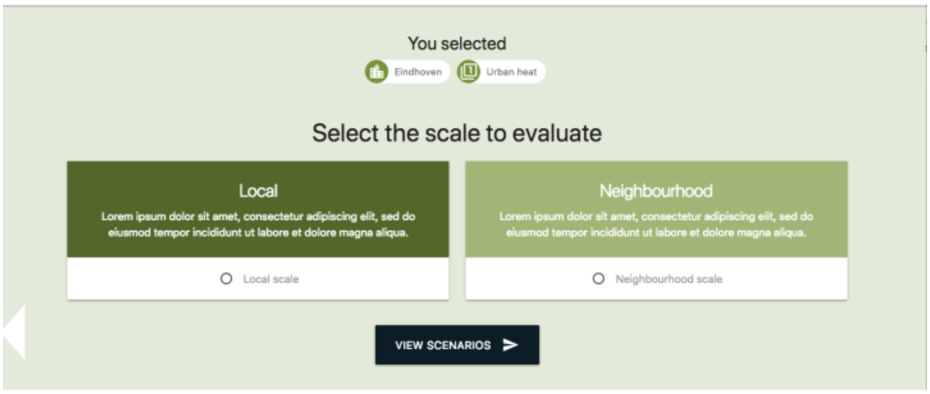

Figure 22 – Evaluation scale selection

To avoid the overload of information, the tool adopted a tab-based approach to organize the information to be represented in separated tabs. As depicted in the Figure 23, the page for the Urban Heat indicators at 'Local scale' contains four tabs:

- Map View: an interactive map based dashboard to represent the impact indicators,
- Table View: a table based representation of the indicators description;
- Scenario Data: a table based representation of the whole dataset;
- City Data: a table based representation of the dataset related to the city indicators.

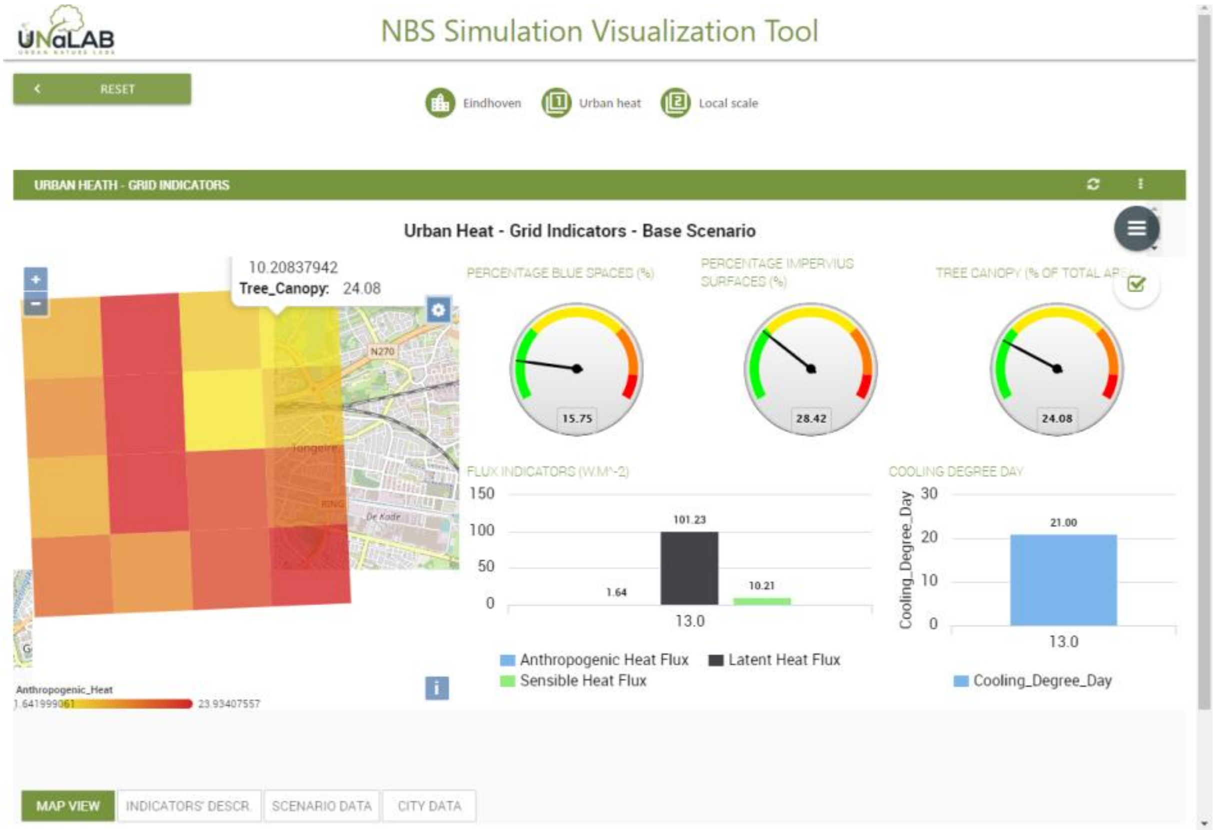

Figure 23 – Urban Heat – Grid Indicators dashboard

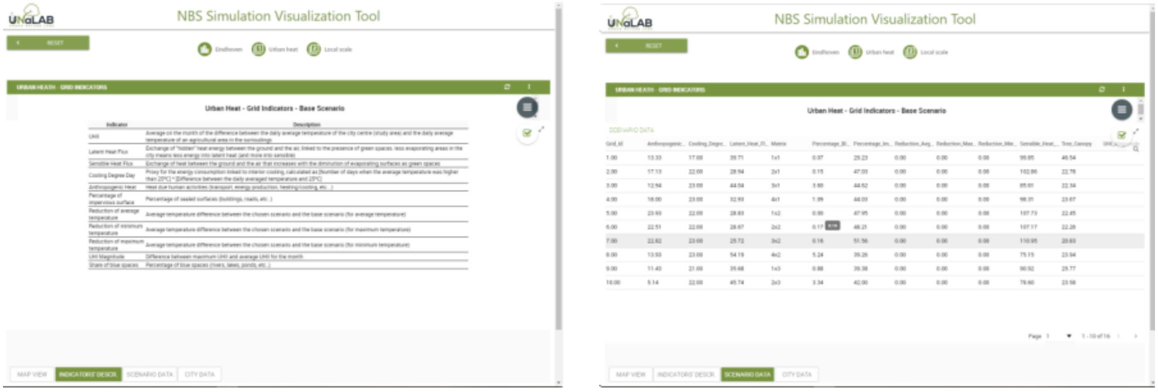

Figure 24 – Urban Heat – Grid Indicators dashboard-

Indicators description and Scenario data tabs

In the Map view tab, it is possible to click on a point of the map to update the charts with the information related to the selected area. In addition, as depicted in Figure 25, each dashboard provides a toggle menu icon to change the indicator represented on the map.

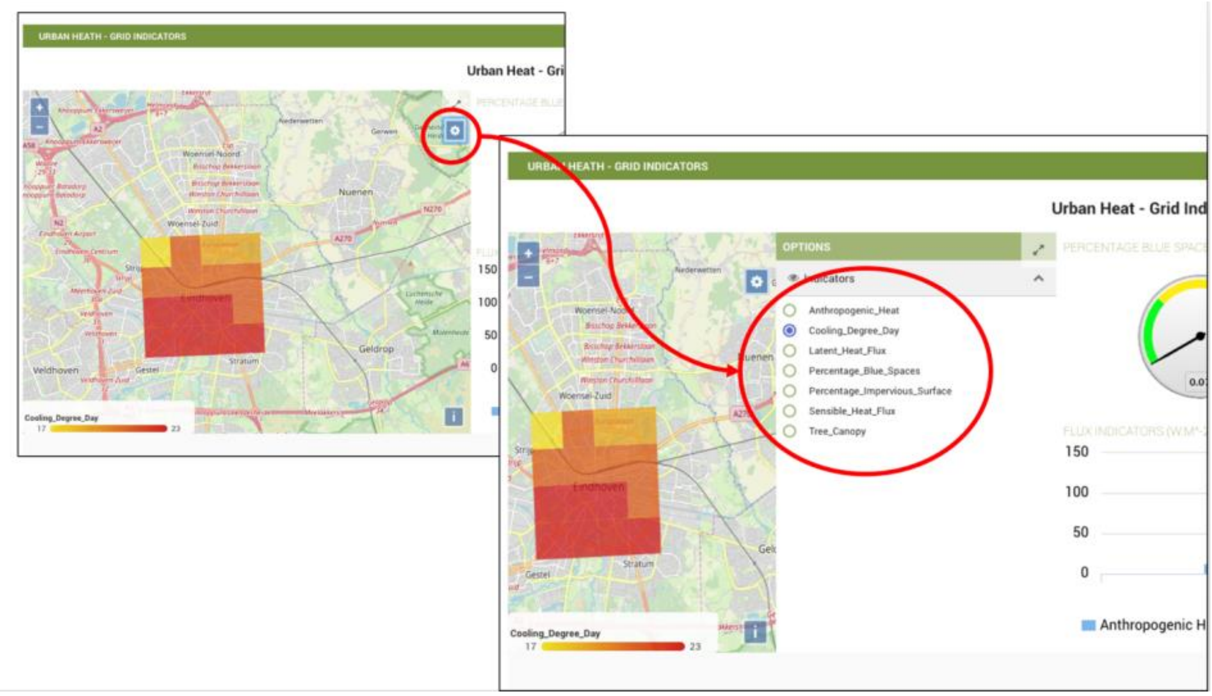

Figure 25 – Toggle menu options

The Figure 26 depicts the dashboard for the ”Urban Heat” scenario at ’Neighbourhood scale’.

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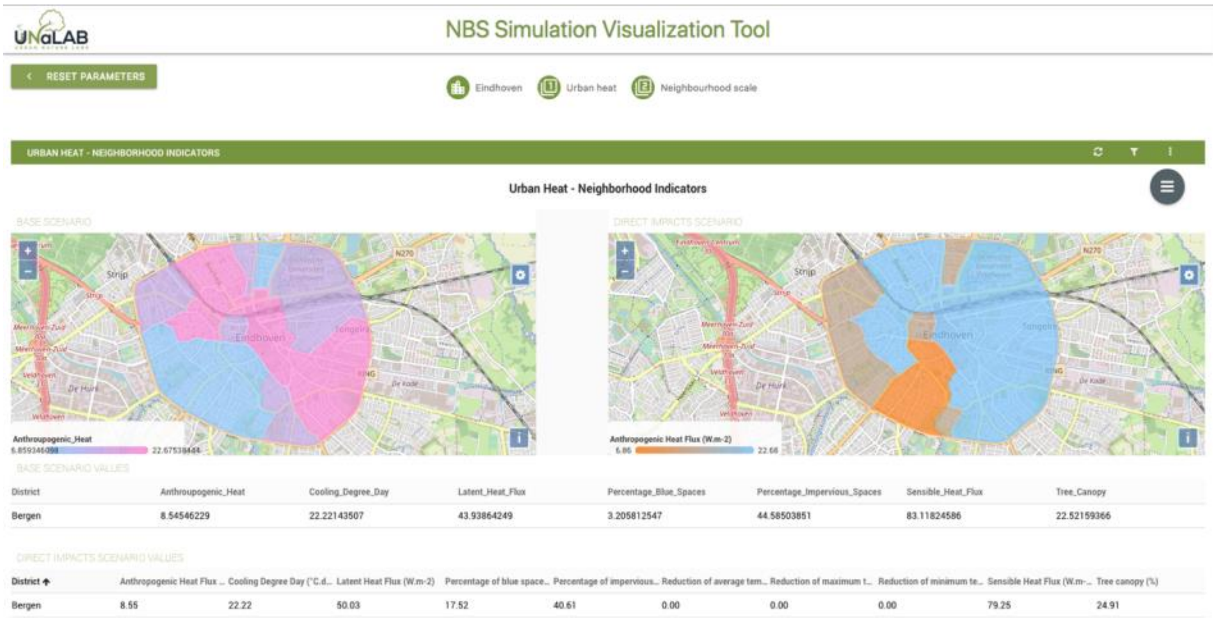

Figure 26 – Urban Heat – Neighbourhood Indicators dashboard

As depicted in the figure below, this dashboard make the users able to compare the possible changes derived by the implementation of the NBS in the city selecting the scenario to be represented: Direct impact, Indirect impact, Direct and indirect impacts scenario.

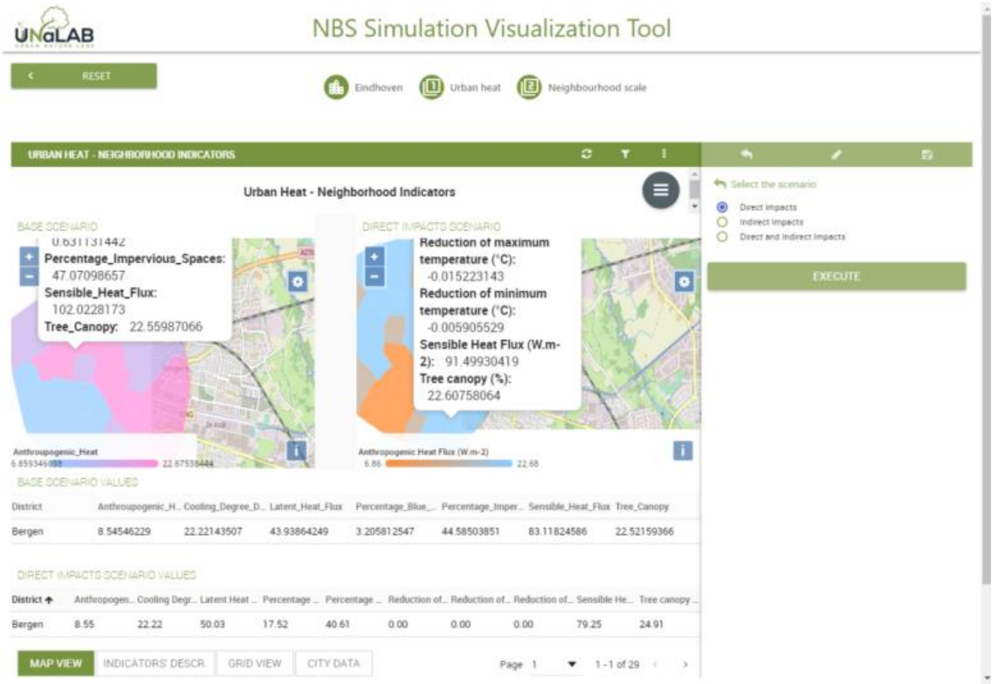

Figure 27 – Urban Heat – Neighbourhood Indicators dashboard – Impact scenario selection

6.4 Dataset and Dashboard creation manual

At the moment of editing this deliverable, the instance of Knowage customized for UNaLab is publicly reachable at the following URL:

- http://UNaLab.eng.it/knowage

The following picture shows the Knowage main page after login providing two badges linked to the main functional sections: Dashboard Management and Dataset Management.

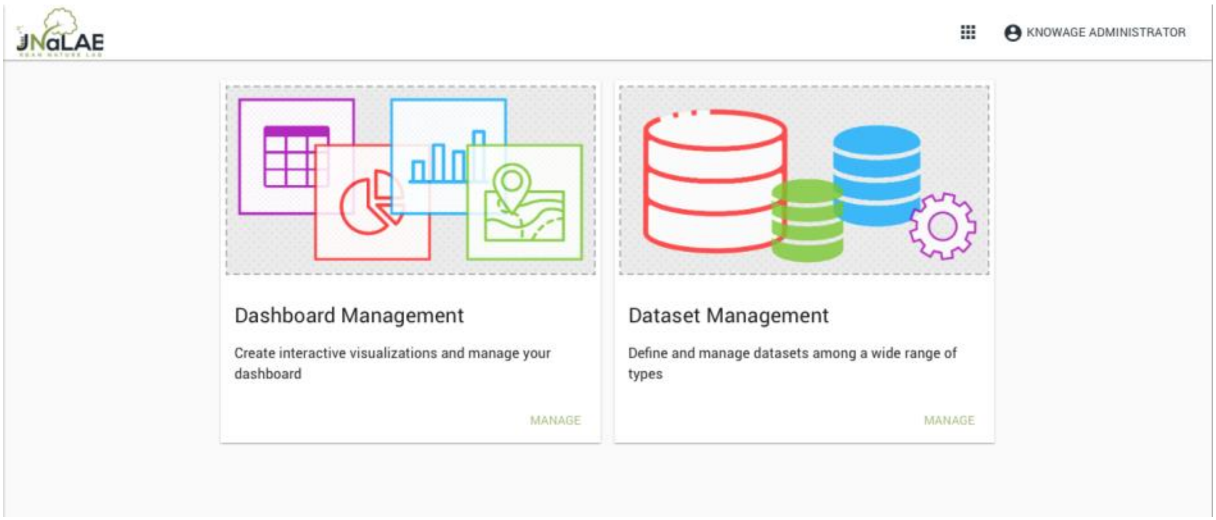

Figure 28 – Knowage main page

The following sections describe the steps required to create and manage both the datasets and the dashboards.

6.4.1 Dataset creation

A “dataset” is a formal description of a specific SDST GeoJSON model.

The Dataset Sources Manager ease the exploitation of data sources at Data Layer and implement a flexible and transparent approach on persisting the datasets.

To make the dashboards able to represent the SDST models it is necessary to register it as dataset.

In order to upload a new model as a REST dataset in Knowage, the logged in user:

1. Clicks on dataset management
2. Clicks on plus icon to add a new dataset

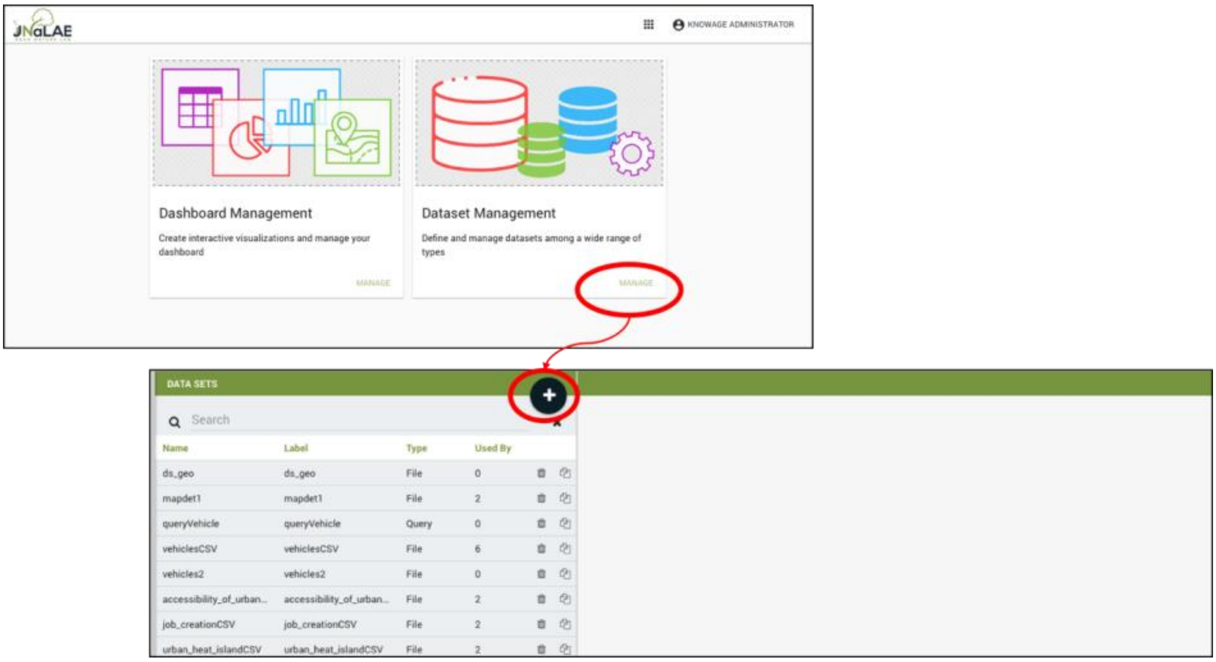

Figure 29 – Dataset creation

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The user must add the required information about the dataset to be created.

In the ”Detail” tab as shown in the Figure 30 user is able to add:

- A label, a name and a description for the new dataset;
- The scope (‘Enterprise’);
- The category (’Default Dataset Category’).

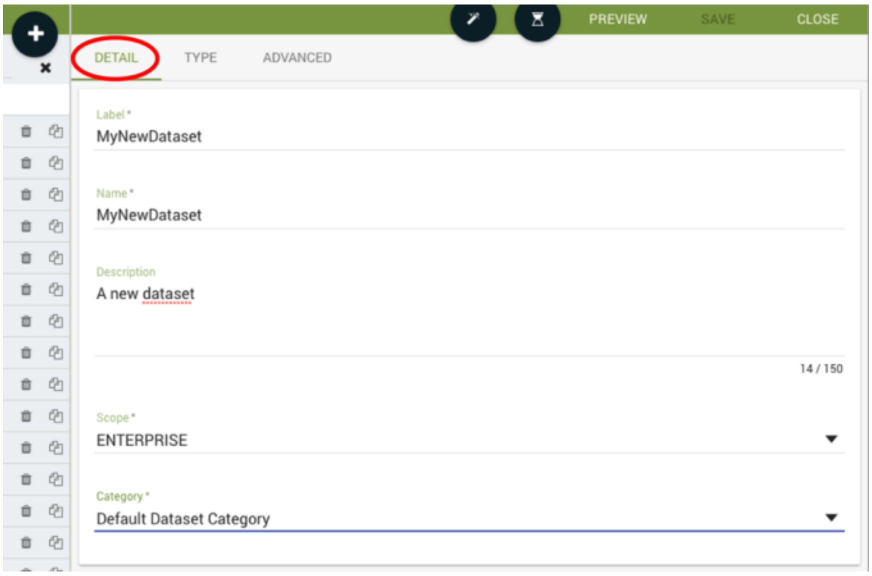

Figure 30 – Detail tab in the dataset creation

In the “type” tab, the user selects the dataset type (in this case, ‘REST’ is selected)

After the selection, other information is required:

- Address: the interaction point exposed by the NodeJS based web service;
- HTTP methods: the method to invoke the REST dataset (GET)
- JSON pattern: $.*;
- Check on “Use direct JSON attribute”.

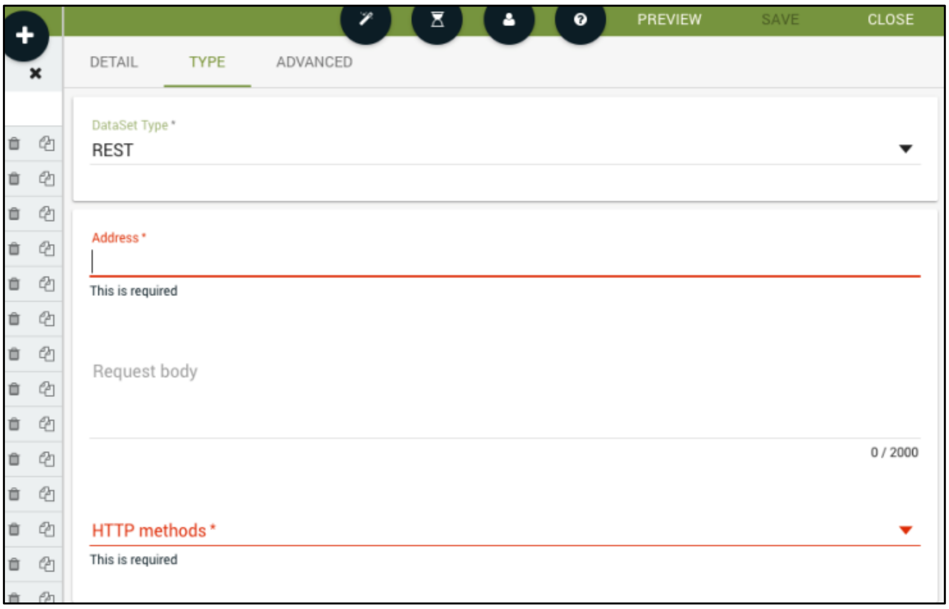

Figure 31 – REST dataset information

In the “Advanced” tab, the user can persist the dataset to be created in the Knowage database, by checking “Persist” and adding the desired table name.

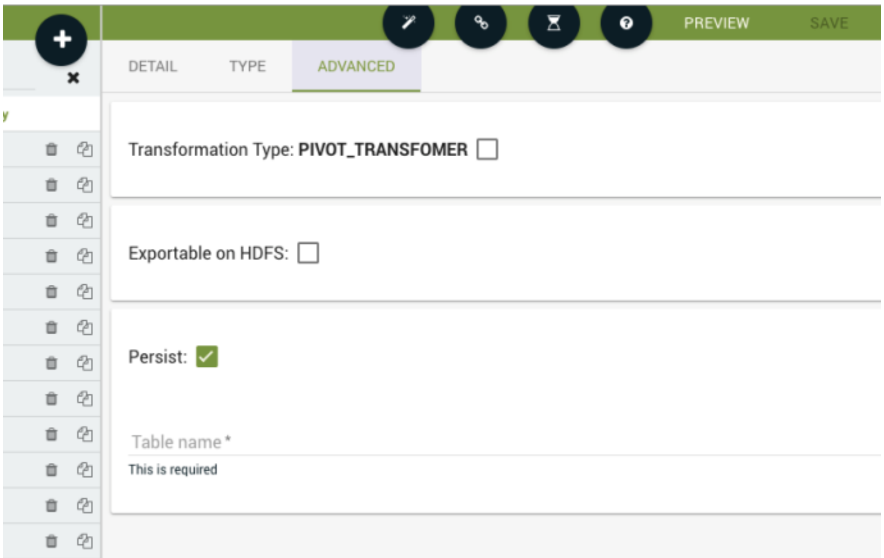

Figure 32 – Persisting dataset into the database

Then, the user clicks on SAVE.

After this, the user can click on the “magic wonder” button to set the metadata:

- Spatial Attribute: the field containing the location coordinates
- Attribute: the field containing the ID
- Measure: the field to be represented in the charts

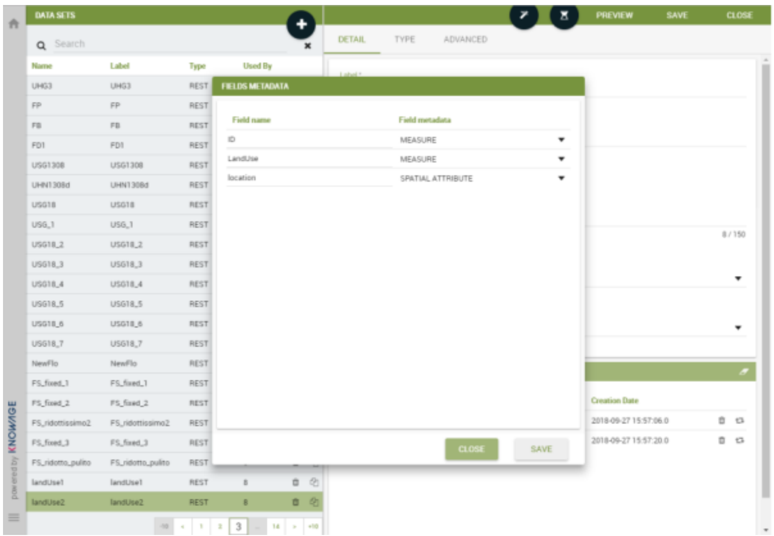

Figure 33 –Dataset creation – metadata dialog

6.4.2 Dashboard creation

To create a new dashboard:

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1. In the main page click on ‘Manage’ button in ‘Dashboard Management’ card
2. Click on Create
3. The dashboard editor will be provided

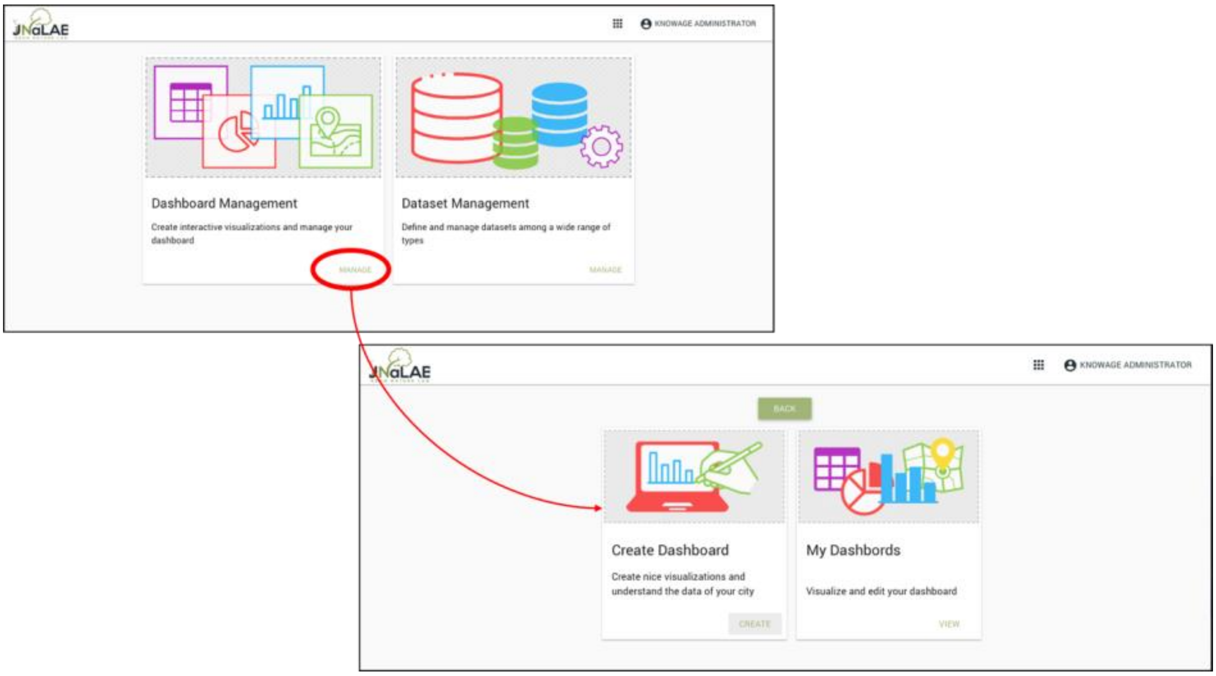

Figure 34 – Dashboard creation

(From the dashboard editor) to select a dataset to be associated to the dashboard:

1. Click on the database icon in the cockpit menu
2. Click on plus icon
3. Select a dataset among listed alternatives
4. The editor will be provided as a black working area

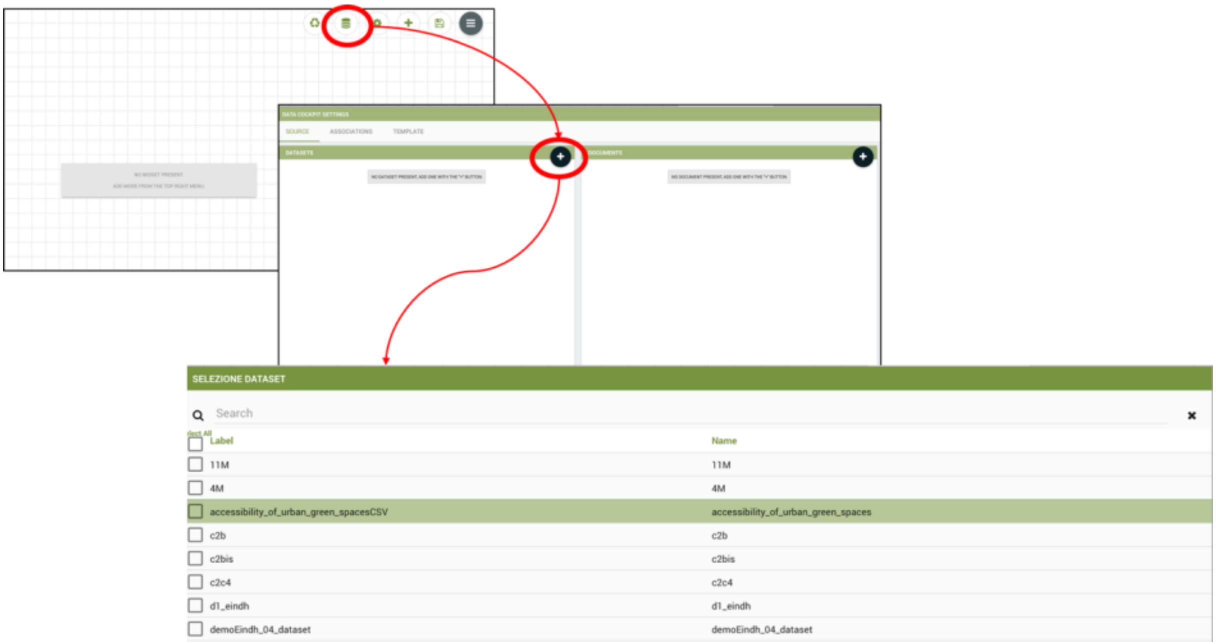

Figure 35 – Dataset selection

(From the dashboard) to add widgets:

1. Click on the cockpit menu

2. Click on Add Widget
3. Choose a widget type
4. Set data source and configure styling parameters

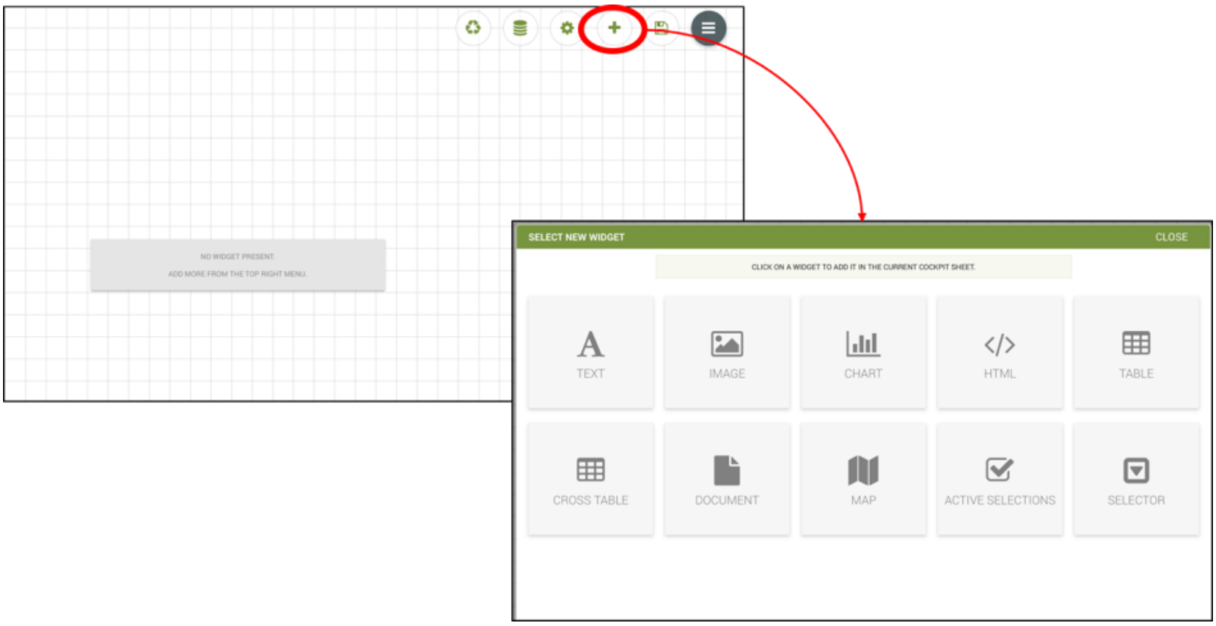

Figure 36 – Adding a widget in the dashboard

To create a map widget:

1. Register the dataset through the dataset management feature, see Figure 37
2. Add a map widget
3. Click on ‘Add Layer’
4. Select the already registered data sets to be represented on the map as layers
5. Selected layers have been added to the map widget.

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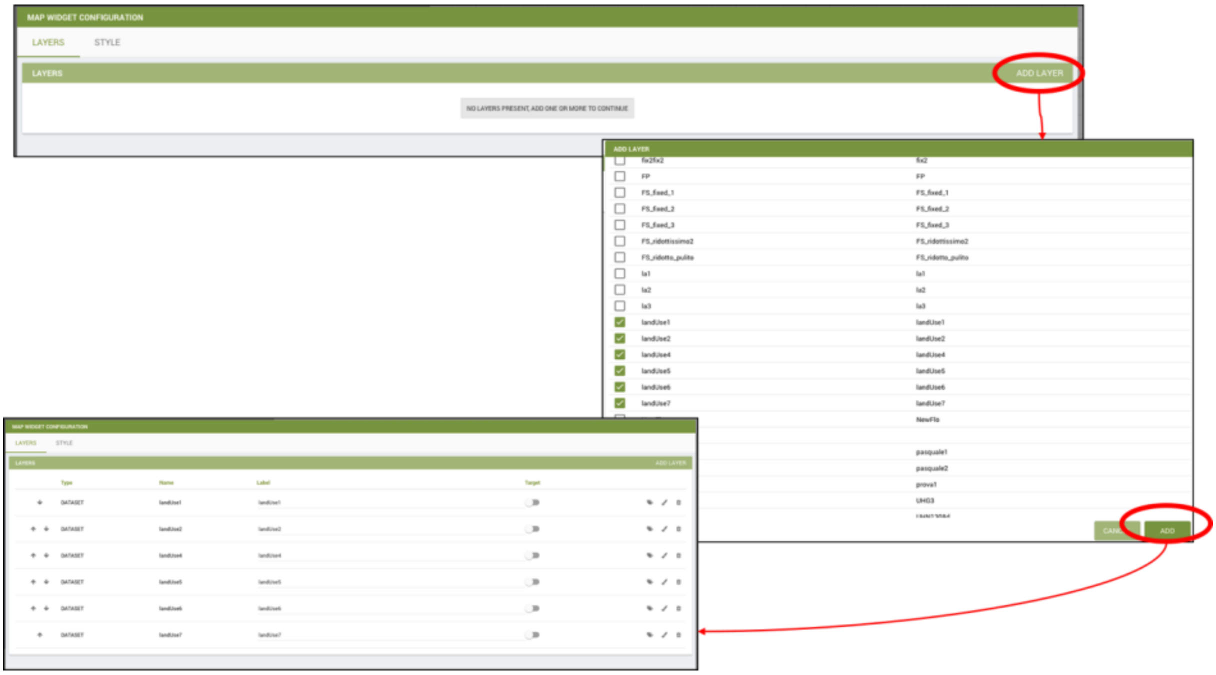

Figure 37 – Adding data layer to a map widget

6. For each added layer, click on ‘metadata’
7. Change the coordinates type from ‘string’ to ‘JSON’
8. Check ‘show on detail’ and ‘show on map’
9. Click on ‘Save’

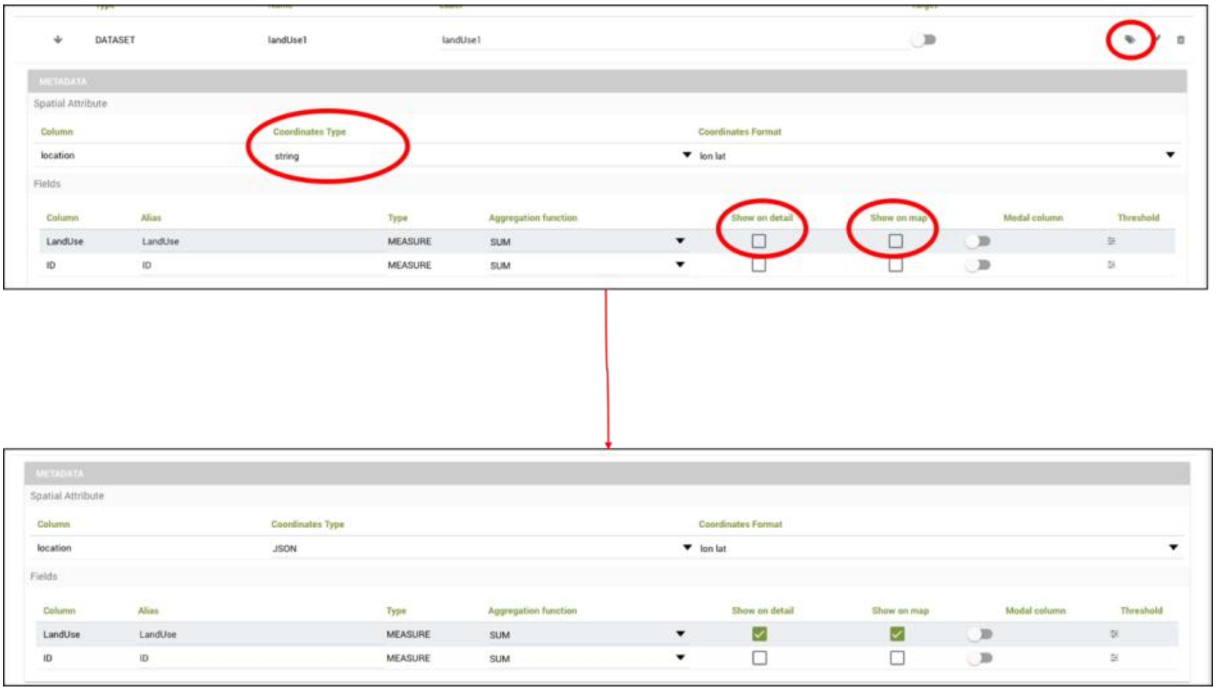

Figure 38 – Setting metadata

The selected layers are now shown on the map, as represented in Figure 39.

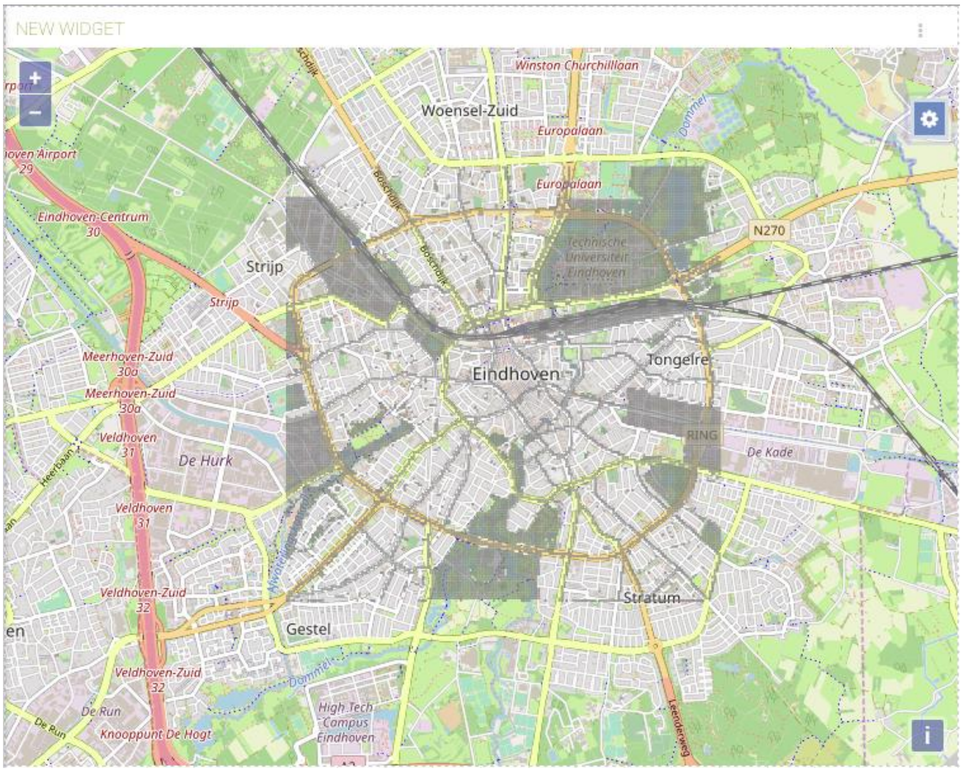

Figure 39 – Showing data layer on a map

The default colour of the layers is grey. In order to change it:

1. Click on settings menu of the map
2. Select the type of style colour to be adopted
3. Assign a colour for each layer, as represented in Figure 40.

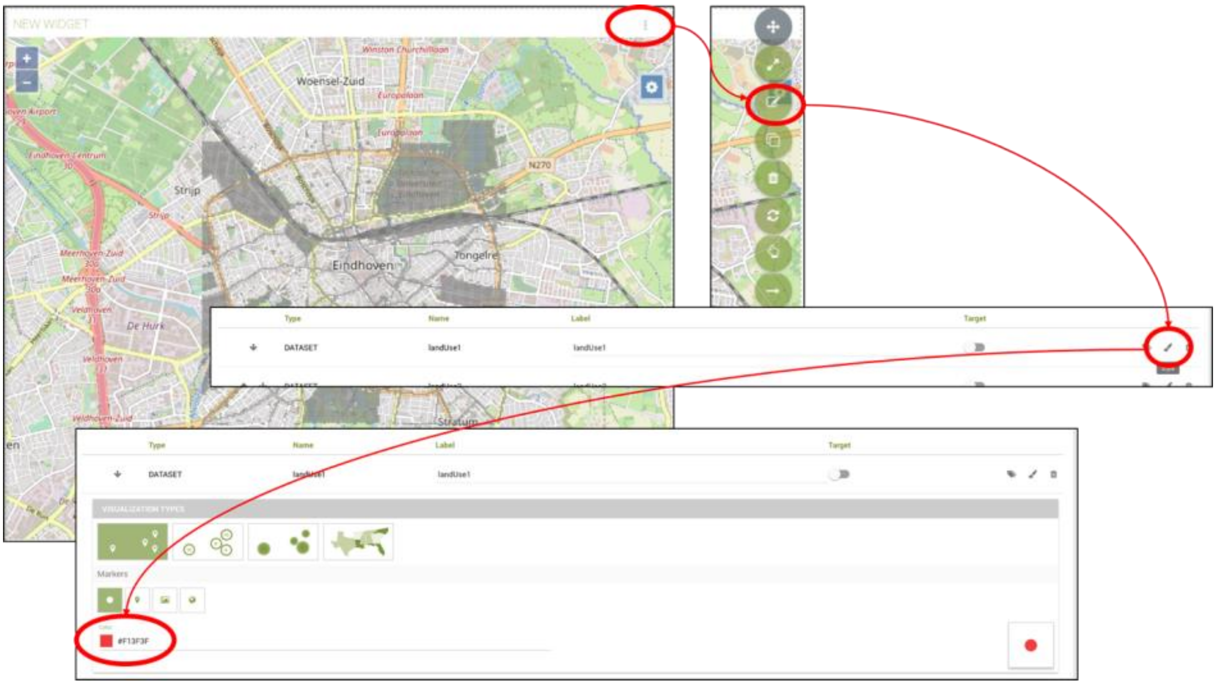

Figure 40 – Map colour settings

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When the customisation is completed, the final result is shown, as represented in Figure 41.

Figure 41 – Final result of map widget visualization

To hide show the map legend:

1. Add a HTML widget to the dashboard
2. Click on HTML widget configuration
3. Click on the CSS tab
4. Set the legend property as follows:

```
.kn-cockpit .cockpit-map-widget .mapWidgetLegend {
    display: none; //block to show
}
```

Another interesting widget is the Gauge. It represents the absolute or percentage data using a speedometer styled area. Default value are:

- Values: from 0 to 1
- Colors: none

To customize the value range as percentage:

1. Click on chart widget configuration button
2. Click on Structure tab
3. Click on the double check in the "Series" bar
4. Click on "Additional Parameter"
5. Indicate min and max values as 0 and 100
6. Click on Save and close the configuration

To customize the colors on the circle:

- Click on chart widget configuration button
- Click on Structure tab
- Click on the double check in the "Series" bar
- Click on Plotbands

- Add New button and indicate the range colors
- Click on Save and close the configuration

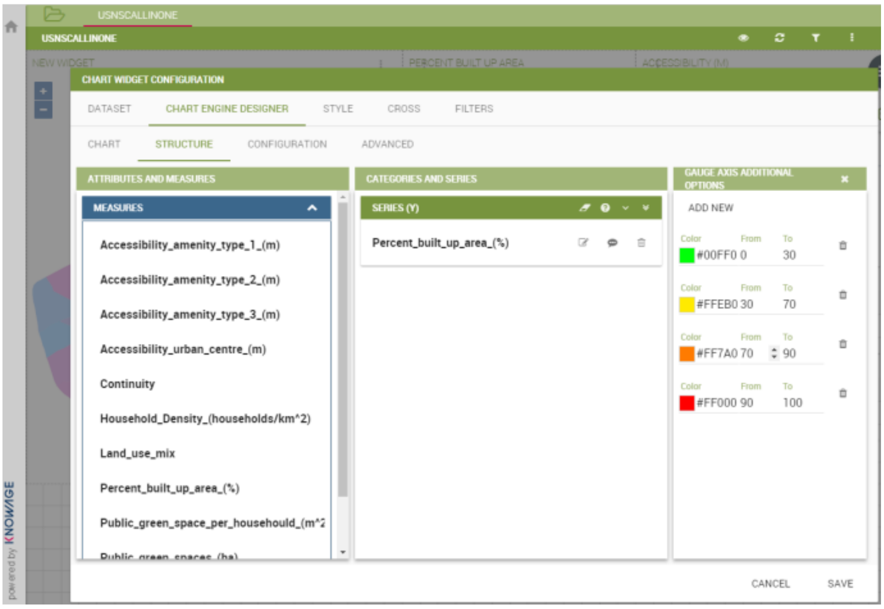

Figure 42– Gauge widget configuration page

Figure 43 represents the gauge widget configured to provide a set of coloured plotbands.

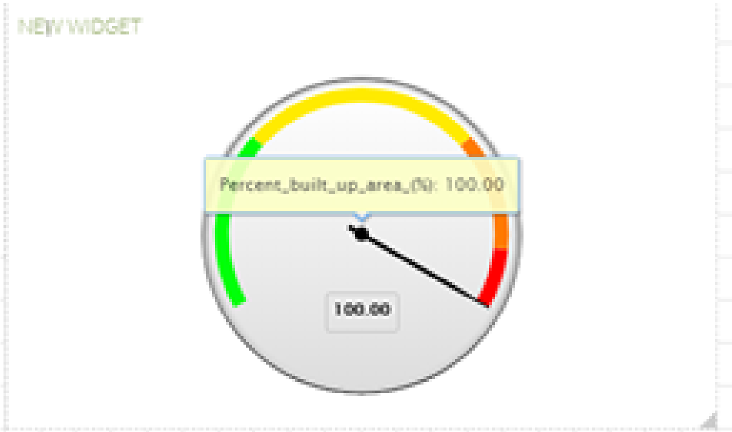

Figure 43 – Gauge widget

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7. CONCLUSIONS

This report described the digital service expected under the T4.3 as the deliverable D4.2 NBS Impact Simulation and Monitor. This tool is the proof of concept of the graphical user interface devoted to represent the SDST geo data.

According to the no-city lockin and no-vendor lockin principles, the tool has been defined and implemented adopting standard models and open source components. In this way, the tool will ensure high performance in terms of interoperability with the other ICT frameworks components and flexibility to changes. In particular, the technicians will have the opportunity to maintain the tool in long terms and evolve it in order to meet the requirements and user feedbacks will be gathered during the use in real life.

To ensure the independence of the SDST user interface and geo database from the specific reaquirements of FRCs, the tool adopted GeoJSON as the standard data format to serialize the SDST simulation results. In addition, the SDST disciplinary models have been defined on a set of parameterised algorithms. Both these choices will ease the generation of new models and dashboards reducing the effort required to make a new city (not FCR) able to exploit the benefits derived by the use of the tool.

At the moment of defining this report, the NBS Impact Simulation and Monitor components are deployed in the UNaLab cloud environment. The web application providing the user interface is publicly available to be tested by the users on http://unalab.eng.it/CockpitSelection/

Texts, figures and the interactive elements would change as consequence of the improvements will be implemented to address the requests, feedbacks and suggestions will be provided by the users. As the first release of the proof of concept of the tool, it presents the main models for Eindhoven city. In this way, the users have the opportunity to test the functionalities and begin familiar with the tool avoiding a vain overload of options. The models related to Tampere and Genova city will be published iteratively until the complete publication of the datasets.

8. ACRONYMS AND TERMS

ENG	Engineering
ERRIN	European Regions Research and Innovation Network
FRC	Front runner city
ICT	Information and Communications Technology
KII	Key impact indicator
KPI	Key performance indicator
NBS SVT	NBS Simulation and Visualization Tool
NBS	Nature-based solution
SDST	Systemic Decision Supporting Tool
UAV	Universidade de Aveiro
ULL	Urban Living Lab

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