

A BIM-GIS VALUATION MODEL OF URBAN GREEN INFRASTRUCTURE PROJECT

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Abstract

The main aim of the thesis is to develop a toolkit for assessing eco-systemic benefits related to the design of green infrastructure in urban areas. After a review of the literature concerning the valuation of green infrastructure in urban areas, existing instruments defining their limits and advantages are considered. The point of view assumed in setting the toolkit is to bring out an assessment of costs and benefits of architectural design which goal is to assess the 'Total Economic Value' of the project. The toolkit uses different tools based on BIM and GIS software proprietary and open source, beginning to investigate their interoperability. The toolkit developed considers the benefits according to different thematic areas: Climate change adaptation and mitigation, Flood alleviation and water management, Health and well-being, Land and property values and Landscape. The thematic Climate change adaptation and mitigation in the specific area is relative to the influence of vegetation on the area temperature, carbon dioxide absorbed by the plants and to the mitigation of the wind velocity which affects the decrease of energy expenditure for heating and cooling buildings that overlook the tree lined. Regarding the area Flood alleviation and water management, it is made by GIS analysis of the permeability of the soil, with the aim of quantifying the volume of water not absorbed, since the input of the verification of the sewerage system. The quantification of the benefits associated with health (Health and well-being) has been developed by applying the results of a World Health Organization study, the Health Economic Assessment Tool (HEAT), which allows you to calculate, based on the average statistical value of life in each European country, the value of a new bicycle and pedestrian path. It's been studied the increase of real estate value of the apartments (Land and property values) with a view of the new green infrastructure, by studies in literature. The method adopted by the toolkit is based on the analysis of case studies from which can emerge through statistical combinations results in monetary terms. It's evident as the price of the same "architecture" in proximity of a green infrastructure increases. Through cost-benefit analysis it's possible quantify how much is this added value, linked to the presence and proximity of green infrastructure. Then for the Landscape area indicators of quality-complexity landscaping are analysed: distribution of landscape attributes, spatial organization of landscape attributes, variation and the contrast. The landscape has been assessed according to the subcategories of visual and sound perception. Regarding the Soundscape are analysed decibel levels of noise pollution by the NoiseTube tool. The goals it's to demonstrate the strong correlation that exists between the architectural and urban design, and bring the benefits of

green infrastructure plan, not only in terms of aesthetics, but also in terms of health, climate, social and economic. The toolkit is tested to evaluate the benefits produced by the creation of a park in the city of Rotterdam. In the case study, it's also applied a traditional financial valuation model to test the toolkit by a private and public operator.

1. Introduction

The Millennium Ecosystem Assessment – MA - (2001–2005) prepared a state-of-the-art scientific appraisal of the condition and trends in the world's ecosystems and the services they provide. MA recognises four main categories of service:

- supporting services are processes that maintain the integrity, function or resilience of ecosystems and thus are crucial in the delivery of other services (including primary production and long term nutrient cycling);
- provisioning services represent the extractible/gained goods and services derived from ecosystems and include food, water, fibre, fuel and genetic material;
- regulating services represent the benefits derived from ecosystem functions such as the regulation of flows of water, soil formation and health, air quality and climate; and
- cultural services which are the social benefits derived from natural systems, including recreation, tourism, enjoyment of aesthetically pleasing features, and spiritual and artistic inspiration.

More recently, The Economics of Ecosystems and Biodiversity (TEEB), a major international study, drew attention to the global economic benefits of biodiversity, and highlighted the growing costs of biodiversity loss and ecosystem degradation. In 2010, the world's governments adopted a new strategic plan (2011–2020) for addressing biodiversity loss, through the Convention on Biological Diversity (CBD) with 20 targets, including a number that relate to ecosystem services. In 2012, the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), a new global mechanism to support Governments and Multilateral Environmental Agreements like the CBD, is established, with the aim of bringing information together on biodiversity and ecosystem services to inform decision-making. The ES concept is also popular in national and international policy processes, including national ecosystem assessments, the Aichi Biodiversity Targets of the United Nations Convention on Biological Diversity (CBD), the Work Plan of the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), and the Biodiversity Strategy of the European Union (Forster et al. 2015).

As trade-offs in land-use decisions affect values from ecosystem services and biodiversity at the local level (Goldstein et al. 2012, Polasky et al. 2011), so the architect's work should take account of multiple objectives in a

changing environment and the balance between the built and the green infrastructure.

An initial analysis demonstrates the outcome of conventional land-use decision-making, which emphasizes market values (for example, agricultural produce) and ignores nonmarket ecosystem services (Bateman 2013).

Ecosystem services contribute to economic welfare in two ways – through contributions to the generation of income and wellbeing and through the prevention of damages that inflict costs on society. Both types of benefits should be accounted for in project appraisal. Starting from the concept of Total Economic Value and the MA framework for categorising ecosystem services, the research examines the valuation models applicable to existing urban ecosystems, and to those of the project.

The study identified a number of tools that offer pre-packaged systems for the calculation of ecosystem benefits starting from the amount of existing or planned green infrastructure. Some of them are based on GIS software can define a set of spatial relationships between green infrastructure and territory.

To make closely related the work of the designer and the preliminary ecosystem assessment of the project, we have decided to adapt it to the BIM assessment tool that increasingly tends to be the data model for the project, and its management - even during construction time. In this way, the valuation starts at the early stage of the design (i.e. when it can be most effective because some design choices have not yet been defined).

Therefore, the thesis after the first phase of analysis has the main purpose to build a valuation tool can highlight ecosystem benefits in monetary way (compared to costs), capable of interfacing with the BIM of the project, and able to define spatial relationships with the main components of the territory. This necessarily meant to address the issue of BIM / GIS Interoperability. The structure of the proposed evaluation tool is as follows:

- Ecosystem functions and services identification for green infrastructure urban project to identify the key functions and services provided by the system;
- Defining the relationship between the territory and the project identifying the tools by which represent them;
- Ecosystem services assessment through quantification of the services in biophysical terms;

- Economic valuation expressing the services in a monetary value by 'benefit transfer' method;
- Assessing the costs and benefits of land use change analysing the impacts of changes in the landscape on ecosystem services supply.

2. Ecosystem services valuation Tool

The concept of ecosystem service is the core of the natural capital¹ enhancement process and a "strong" reason for the conservation of nature and biodiversity. In systemic terms, such services can be considered as the flows provided by natural capital stock and most of them are essential to human life and nature itself. Ecosystem services (ES) consist of flows of matter, energy and information coming from the stock of natural capital, which are combined with the services of anthropogenic artefacts to generate well-being and quality of life. The nature is the foundation of life on our planet. Its complexity and its extraordinary capacity for transformation and adaptation allow it to support many interdependent forms of life and to ensure the resilience of ecosystems and the services delivered to humanity. Nature provides essential services procurement, food, water, timber, medicinal substances, etc.; adjustment, the climate, the water cycle, precipitation, etc.; support, photosynthesis, soil formation, air purification and water etc. and is home to key activities, such as culture and education.

It therefore produces, consumes and gives work according to its own mode that man is not able to replace, if not to a limited extent. It is therefore substantial part of each economy and any failure in its fundamental performance translates into reduction of the possibility of generating value. The analyses conducted globally report a dangerous drop in productivity of ecosystems in terms of services rendered. To stop this phenomenon must first analyse this rigorous survey, allowing identifying possible interventions in each territory, making clear the extent of the problem to decision-makers and citizens.

The ecosystem assessment provides the connection between environmental issues and people. Assessments play numerous roles in the decision-making process, including responding to decision-makers' needs for information, highlighting trade-off between decision options, and modelling future prospect to avoid unforeseen long-term consequences (Ash et al. 2010).

Modelling individual ecosystem functions is not novel and there are countless models of functions in the scientific literature. For example, water regulation and water movement can be described by a myriad of hydrological models such as SWAT, INCA, TOPmodel, SHE (Vigerstol and Aukema, 2011). There are also a significant number of soil process models that

¹ Defined by the Natural Capital committee as "... the elements of nature that produce value or benefits to people (directly and indirectly)", but also incorporating capacity to produce ecosystem goods and services now and into the future (e.g. Turner and Daily, 2008).

describe nutrients, soil formation and indirectly climate regulation through carbon sequestration, such as CENTURY and RothC. These models can be captured in a Geographic Information System (GIS) environment and their outputs aggregated (i.e. some weighted averaging or addition of the different services for a given area; e.g. carbon sequestration + water storage + biodiversity) to generate an assessment of the current state of ecosystem services delivery. InVEST is a GIS-based project that uses land use/cover patterns to estimate levels and economic values of multiple ecosystem services, biodiversity conservation, and the market value of the commodities provided by the landscape (Nelson et al. 2009).

Such expert knowledge-based modelling approaches include ARIES and MIMES. The advantage of such an approach is that it can be based on sparse data and relatively simple models, and therefore can readily give estimates of ecosystem goods and services delivery in most situations. The disadvantage is that it is ultimately based on opinion, and is therefore less scientifically robust.

Monetary valuation tools reveal values given in financial currency. The main advance of monetary valuation is that outcomes are given in a common metric, which allows the user to derive 'net' benefits and costs (Fish et al. 2011). Significantly, not all ecosystem services and their attributes can be valued in monetary terms particularly cultural ecosystem services and non-use values (Atkinson et al. 2012). Therefore, the combination of monetary and non-monetary valuation tools can be highly beneficial.

3. As to the interoperability BIM - GIS

Building information models (BIMs) are rich and intelligent digital repositories of building information and use an object-oriented (OO) approach to describe the characteristics (semantics and geometry) and behaviour of each building assembly as well as its relationships with others (Eastman et al. 2011). BIM is the process to create, store, and manage the information related to buildings throughout their whole life cycle (Eastman et al. 2008). Information from GIS can facilitate BIM applications such as site selection and onsite material layout, allowing the environmental performance of the project. It has been shown in previous studies that the BIM domain and the GIS domain have mutual need of information from each other (Deng et al. 2014). As BIM technology is mainly centred on indoor environments, GIS can extend the benefits and applicability of existing building models to the outdoor environment. Industry Foundation Classes (IFC) and City Geography Markup Language (CityGML) were chosen as the key schemas due to their wide applications in the BIM domain and the GIS domain, respectively (M. El-Mekawy 2008). However, it is not an easy task to transfer data from BIM to GIS or vice versa without consideration of data format and meaning (Karan et al. 2015). IFC is an integrated model schema that describes construction information. It uses an object-oriented method to integrate information required by the relevant stakeholders in a project. It is the Data Exchange Format of BIM. It is an open data format, public and independent of any software company and, therefore, you can exchange the artefact information simply exchanging files in ".ifc" between the various applications.

In order to integrate fully GIS and BIM, there is a need to provide interoperability at the semantic level.

Interoperability is the ability to exchange data between applications by allowing to standardising workflows and tending to facilitate its automation. For a long time it feels need for dialogue between applications allocated for specific purposes but belonging to the same production chain (an example is the affirmation of the DXF format for transferring graphics data in vector format between applications of distinct software houses). The urgency of this requirement, however, becomes the primary importance in the case of BIM methodology, where the integration of different knowledge is the very essence of innovation. Also, the quality of the information to be exchanged goes far beyond the mere given graph, since the use of the objects allows the management and the transfer of information relating also to the materials, quantities, to costs, time, energy and structural analysis , etc.

The issue of data exchange, so, over time, has been the subject of great attention and efforts on the part of research institutions, associations of software developers, industries, etc. constituting a real technology in its own right, which has evolved with the evolution of software applications and their requirements.

To develop an assessment tool of ecosystem services of a project a critical question should be solved 'How do we match up the functionalities of BIM with Valuation tool requirements?' Developing this match up lays down the base for BIM/GIS integration because the GIS model are usually involved in ecosystem mapping and ecosystem services value estimation. An investigation regarding tool and application was conducted trying to make the integration more than a concept but a functioning mechanism.

A proper boundary for integration model is based on 'The green infrastructure valuation toolkit - The Mersey Forest' requirements matched up with available BIM solution in the market. Regarding GIS, open and proprietary applications were chosen. Implementation of BIM/GIS integration in a complete toolkit is in an early stage. For now the calculation of four areas of assessment has been developed: Climate change adaptation and mitigation, Flood alleviation and water management, Health and wellbeing, Land and property values.

4. Climate change adaptation and mitigation

Climate change is a statistically notable change both in average temperatures of both the changing nature of the climate, persisting for periods of time ranging from a few tens of millions of years. This could result in a change of the average climatic conditions, with a more frequent occurrence of extreme weather events.

For some ten years, the temperatures are rising globally.

By the term climate refers to the set of averages atmospheric conditions (temperature, humidity, wind pressure, precipitation) calculated in a certain geographical area for a period rather long (usually 30 years).

The climate is naturally variable, as demonstrated by the lack of regularity of the seasons from year to year.

This mutability is due to changing ocean currents, volcanoes activity, solar radiation and other components of the climate system that we are not yet able to understand fully. Sometimes our climate can manifest itself in extreme ways that can be devastating.

In recent years, many such events and as many studies on the subject have shown that global temperatures are higher and higher.

The Summary for Policymakers of the IPCC 5th report Dell' (Intergovernmental Panel on Climate Change), published in October 2013 states that: "Global warming is unequivocal and, since the '50s, many of the phenomena observed in recent decades they did not occur by hundreds, sometimes thousands, of years. The atmosphere and the oceans are heated, the snow and glaciers has decreased, the sea level has risen and the concentration of greenhouse gases has increased. "

Temperatures on Earth allow life because of a natural process called "greenhouse effect." When solar radiation reaches our atmosphere, some bounce back into space, while others will go through and are absorbed by the Earth. This causes the heating of the ground. The heat coming from the Earth is radiated outwards and absorbed by the gas present in the atmosphere, precisely known as "greenhouse gases." This process prevents the heat to dissipate, guaranteeing an average surface temperature of about + 15 ° C instead of -19 ° C.

There are several greenhouse gases responsible for a more intense warming: these are produced by humans. Most it comes from the burning of fossil fuels used by cars, industries and electricity producers. The gas most of all contributes to warming is CO₂. Other gases responsible are methane from landfills, agriculture and animal husbandry (especially from the digestive systems of grazing animals); nitrous oxide from fertilizers; the gas used for

refrigeration and industrial processes. Finally, the loss of forests, which store carbon dioxide to live, determines a lower CO₂ absorption.

Climate change is changing our economy, our health and the societies in which we live. Scientists warn that unless we slow down these changes effectively, the consequences will be dramatic. If the planet Earth were still overheated, which would happen:

- the level of the seas would tend to grow, because the water expands when its temperature increases and the oceans absorb more heat of the earth;
- sea levels would also increase due to the melting of ice sheets and sea ice;
- cities on the coasts would be submerged;
- the places where usually fall much rain and snow may become hot and dry;
- the lakes and the rivers could dry up;
- there would be droughts longer and more frequent, which makes the cultivation difficult;
- there would be less availability of water for drinking and washing, but also for agriculture and the food industry;
- many plants and animal species become extinct;
- hurricanes, tornadoes and other storms provoke changes in temperature and easy to evaporate water would be more intense.

Climate change is already underway and is expected to continue: temperatures are rising, rainfall patterns are changing, ice and snow are melting and the mean sea level is rising globally. It is very likely that the warming is, for the most part, due to the increase of greenhouse gas concentrations in the atmosphere due to anthropogenic emissions. To mitigate climate change, we need to reduce or avoid these emissions.

To avoid the worst consequences of climate change, the signatory countries of the United Nations Framework Convention on Climate Change (UNFCCC) agreed to limit to below 2 ° C increase in global surface mean temperature compared to pre-industrial times. To achieve this objective, global emissions of greenhouse gases must peak in the shortest possible time and then decrease rapidly. By 2050, global emissions must be reduced by 50% compared to 1990 levels, and reached, by the end of the century, carbon neutrality. The EU supports the objective of the UNFCCC and aims to reduce,

by 2050, its emissions of greenhouse gases by 80 - 95% compared to 1990. These elevated levels of reduction consider the lower rates reduction required by developing countries.

The greenhouse gases can be both natural and anthropogenic. The most important greenhouse gas, of natural origin, present in the atmosphere is water vapour. However, human activities release substantial amounts of other greenhouse gases, and increasing atmospheric concentrations, increase the greenhouse effect and global warming. The main sources of gas greenhouse effect caused by humans are:

- the combustion of fossil fuels (coal, oil and natural gas) due to the generation of electricity, to transport, to the civil and industrial sector (CO₂);
- agriculture (CH₄) and changes in soil destinations, such as deforestation (CO₂);
- landfills (CH₄);
- the use of fluorinated gases from industrial sources.

Several EU initiatives aim to reduce greenhouse gas emissions greenhouse. After reaching the targets under the Kyoto Protocol for the period 2008-2012, the EU has set itself the goal to be achieved by 2020, a 20% reduction in greenhouse gas emissions compared to levels 1990. to achieve this goal, however, a major part of the Europe 2020 strategy, the EU set up a system for the exchange of greenhouse gases (ETS) within the EU and, in ' scope of the proposed "effort-sharing" (effort sharing Decision -ESD), defined individual national targets for emissions in sectors not covered by that system. At the same time, the EU has adopted legislation to promote the use of renewable energies, such as wind, solar, hydro and biomass, as well as to improve the energy efficiency of a wide range of equipment and appliances. The EU also aims to support the development of carbon capture and storage technologies to trap and store the CO₂ emitted from power plants and other large plants.

As part of a policy framework on climate and energy, the EU is committed to reducing, by 2030, 40% of emissions compared to 1990. This is a binding target. The European Energy Union, which aims at ensuring secure, affordable and climate-friendly for the EU, has the same objective.

The green areas - whether public or private - positively affect the urban climate. Attenuate, for example, the daily temperature fluctuations of the air and the wind speed.

In addition, they locally occur refreshing effects through shadow zones and to a higher evaporation rate. This effect "oasis" takes place, however, only in the immediate vicinity of the green spaces or individual plants.

Gardens and large parks generate fresh air even outside of their area is therefore recommended to allow these air-flows are in the direction of the surrounding buildings and which are not hindered.

The importance of the number of green areas in cities is twofold: on the one hand, the more numerous are the green areas and the greater thanks to these air-cooling, on the other ensure filter and purify the air from the fine dust and from harmful substances.

Actually, it must bear in mind that the positive influence of the large green areas goes only up to a maximum distance of 200 meters.

For this reason, it is necessary to have a good connection between the different green areas so that the effectiveness of the result will be more extensive.

Green linear structures of variable height and depth can perform several functions: aesthetic, naturalistic, but also protects against the wind and reduction of the pollutants.

The effectiveness of these barriers plant is based on the ability to reduce wind speed and changes in air turbulence, contributing some great benefits on the filtration of pollutants.

A wide wooded band may represent a good barrier to the presence of wind. From investigations in the field, it has shown that the ability to filter the masses suckers reducing the speed is on average between 30 and 50%. Depending on the height of the plants on the forest edge, the air stream is deflected upward by preventing that the air passes through it internally. The edge of the forest act as a dense green windproof barrier.

After passing the green barrier, short distances from the leeward side of the forest the wind speed returns to normal again.

The effective area with wind decrease is relatively small.

The situation changed when it comes to a row of trees seldom or semi-infrequently (semirado). If the trees are of different height and type and, at least in part, planted at a certain distance, the possibility of air filtration are better than in the presence of a dense mass. In this case, the area where the wind speed is slowed down is much higher compared to a wood or a thick green windproof barrier. This means that impenetrable barriers to deflect wind of all the mass of air, while barriers sparser act as a filter.

As a rule of thumb, it can be said that the protected area behind a row of trees rarely is 15-20 times more than the height of the row of trees. Consequence of this state is that even the concentration of pollutants in this area is lower.

Based on these considerations, it is very important to the choice of the species, which make up a vegetable barrier: it is recommended to use deciduous broad-leaved, choose native tree and shrub species, multi-species in different bearing and with differentiated growth potential.

The barrier is most effective when located as close as possible to the settlements to be protected, near high-traffic areas. In this way are numerous positive effects generated by the barrier which will also act as an acoustic and air pollution reduction.

The ability to reduce air pollutants by plants is mainly linked to the air contact with the leaves. Even other plant organs, such as bark, twigs, serve as adequate impact surface to retain the pollutants.

This capacity is determined by physical characteristics of the plant, such as the roughness and porosity of the leaves or the presence of epicuticular waxes to which bind the pollutants.

Foliage porous, or transparent, they are better suited to the absorption of pollutants rather than foliage dense and impermeable. In fact, with sparse foliage, it is greater than the number of leaves that meet the air and participating in the purification process, including those positioned more internally to the crown.

The porosity of the green structures therefore influence the interaction between the deviation of the airflow and filtering of pollutants. Analysis carried out by Wesseling (2004) demonstrate that the concentration of dust particles of different sections is lowered depending on the wind force and close to the vegetation with a good porosity.

If the wooded area is rather dense, we observe an accumulation of dust particles on the leeward side and the filtration capacity is poor. The porosity is a measure widely used to estimate the amount of air, which passes through the foliage.

From a porosity of 50 - 70% are unable to ensure effective filtration, but at the same time it lowers the flow deviation.

Dutch research documents that the wind refraction effect caused by the foliage of deciduous trees in winter is lower by only 20% compared to summer. Although the filtration capacity and the "capture" of evergreens dust is higher, even plants with winter deciduous affect the flow field that makes possible other types of deposition.

They do not always determine the trees, on the spot, lower concentrations of pollutants. In the trees, whose lower branches were pruned but who have dense foliage, - for example, those of the classic avenues in the city - a large part of the polluted air passes under the crown and is not purified. This is

precisely the area in which there is passage of people. Where it is possible, under these trees, planting of shrubs should be able to filter and eliminate toxic substances where the trunks of trees without branches are not able to do so, or do so only to a very limited extent.

To avoid the so-called "tunnel effect" especially in large avenues should leave empty spaces between the trees, so to allow the exchange of air. The trees behind the filter road, but also to lower wind speeds.

The removal of PM10 is ineffective if the porosity of the green is less than 40%. The tunnel effect can then be resized through a proper design of the green areas. This is possible by choosing the right types of trees with sparse foliage sufficiently, or taking care to prune them and treat them in a targeted manner.

The tunnel effect occurs only within 100 - 150 m from the road, where the exhaust gases of vehicles have not yet been completely mixed with the surrounding air.

It can be estimated that the green elements intercept a maximum of 15 - 20% of fine dust (PM10) in normal weather conditions. A green structure, with the right porosity, can lower the concentration of nitrogen oxides to a maximum of 10% (Wesseling et al, 2004).

a. ENVIMET

ENVI-MET is a multidisciplinary modelling software that allows you to model the physical behaviour and microclimate of the buildings, the gardens and landscape, including applications for urban planning, climate adaptation, comfort and human health. The approach is holistic and considers the environment as a single organism. The simulation results can show the effects that the architectural solutions, sustainable technologies, the use of green and water, allow improving the microclimate outdoor conditions. ENVI-MET is the microclimate of the simulation tool outdoor chosen because it is an open software, free from licensing, with a solid base of calculation (equations Navier-Stokes, fluid dynamic model and turbulence, radiation and exchanges due evapotranspiration of plants, modelling sky-factor). With a simple, intuitive interface it is easy to use and allows you to get a result with all relevant information for the evaluation of the microclimate in the open spaces.

To create the file for the simulation of the case study of Rotterdam, you must select "ENVI-MET HEADQUARTER", click "ENVI-MET HEADQUARTER", then click OK. The screen "MANAGE WORKSPACE", select "Select workspace" and then the folder you created as the project database. This will define which folder will be saved the project. To create a new project, click on "Create New Project" in the "MANAGE WORKSPACE" window. You then need to fill out the table on the left ("PROJECT BASEDATA") with the project name and folder. The software will create a folder with the name of the project in which all data will be saved. Select the "DONE" button. After selecting "DONE", will appear the toolbar "ENVI-MET 4 HEADQUARTER". To define the geometric data and thermo-physical of project, select "SPACE". The screen in which you will place the data of the outdoor space project. The next steps are:

- insert the map
- insert geographical data
- insert thermal data of building, soil and green

To insert the map, you must select "SELECT BITMAP" and choose the BMP image of the study area. The image of the study area must be dimensioned in function of the grid chosen for the simulation, the greater is the number of grid cells the greater is the accuracy and the time required for the simulation. To define the grid and the number of cells in which it will be divided map,

select "BASIC SETTING, NEW AREA." You need using the "MODEL SAVE AS" button to save the database in the same folder as the case study. To build the 3D model as the simulation graphical input is necessary to fill the height of buildings in meters. Choose "VEGETATION" to enter vegetation and plants. You can choose the type of plant and then click on the map to place each plant. After placing the plants, you can choose the fields in "SIMPLE PLANTS". When the desired height of the building, you must draw on the map filling the checked grid. Selecting "SOIL AND SURFACE", you can choose the type of soil. For example, it is possible to reshape the surface by choosing the asphalt, water, sand and other types of soils. At this point, the modelling area of the case study is completed. It is therefore necessary to save the file and close to proceed with the compilation of climatic data for the area.

Entry of climate data set-point, go to "ENVIMET HEADQUARTERS" and select "CONFIGWIZARD". We must proceed by clicking the "NEW" button to create a new simulation file, and then select the setting file of the model case study in "AREA INPUT FILE". Proceed with the compilation of climate data using the "NEXT" button. In the "NAME AND FOLDER" you must specify the type of simulation that is going to do, in the specific case ANTE simulation exam. Proceed with the "NEXT" button. The window "TIME AND DATE, OUTPUT", in which you must specify the start time of the simulation, the simulation date and duration of the simulation. The duration refers to the output, for example the number of hours, for which you want to obtain the results. The actual duration of the calculation depends on the number of inserted elements, on the accuracy of the grid and on the characteristics and speed of the computer. Proceed with the "NEXT" button. In the "METEOROLOGY: BASIC SETTINGS" you need to specify the initial weather conditions. Proceeding with the button "NEXT" you reach the "METEOROLOGY: SIMPLE FORCING" window within which you can choose to enter the actual data hour by hour of temperature and relative humidity of the day chosen for the simulation.

Once the compilation of climatic data you can start the simulation by reopening the window "ENVI-MET 4 HEADQUARTERS". You need to choose the size of the grid for the simulation, in the dropdown menu "ENVIMET". The screen "ENVI-MET 4 DEFAULT CONF.", it is possible to start the simulation processing using the "LOAD SIMULATION" button. "CHECK" to see if the data work "SET-POINT". Click "Run" and wait. The first step of the simulation calculation will be that relating to the "3D VIEW FACTOR". The second step will instead be on the wind calculation. The third involves the simulation of the

temperature step by step. Once completed the processing of the simulation it is necessary to close the "ENVIMET V4 DEFAULT CONFIG" window.

It is time to proceed with the processing of output data, using the data setting with "BIOMET" (data relating to the subject, that is, data for the comfort of the simulation). You must open the TOOL "BIOMET," and look in the files related to the simulation of the project database folder. The simulation can be made for a single hour or all day. Select the hour or hours for which you want the simulation. Then select "CALCULATE PMV - PPD".

Once the simulation is completed can close the TOOL "BIOMET" window. You can below proceed with creating output maps as a reworking of the results. From the "ENVIMET4 HEADQUARTER", you select the TOOL "LEONARDO". From "LEONARDO" you must proceed by selecting the file for the day and time chosen for the map results, click the button "FILE SET A". You can proceed with the selection of the desired output. "LEONARDO" allows you to create maps for:

- OBJECTS
- FLOW U (m/s)
- FLOW V (m/s)
- FLOW W (m/s)
- WIND SPEED (m/s)
- WIND SPEED CHANGE (%)
- WIND DIRECTION (deg)
- PRESSURE PERTURBATION (Diff)
- AIR TEMPERATURE (°C)
- AIR TEMPERATURE DELTA (K)
- AIR TEMPERATURE CHANGE (K/h)
- SPEC. HUMIDITY (g/kg)
- RELATIVE HUMIDITY (%)
- TKE (m^2/m^3)
- DISSIPATION (m^3/m^3)
- VERTICAL EXCHANGE COEF. IMPULS (m^2/s)
- VEGETATION LAD (m^2/m^3)
- DIRECT SW RADIATION (W/m^2)
- DIFFUSE SW RADIATION (W/m^2)
- REFLECTED SW RADIATION (W/m^2)
- TEMPERATURE FLUX ($K*m/s$)
- VAPOUR FLUX ($g/kg*m/s$)

- WATER OF LEAFES (g/m²)
- LEAF TEMPERATURE (°C)
- LOCAL MIXING LENGTH (m)
- MEAN RADIANT TEMPERATURE (°C)
- TKE NORMALISED 1 D
- DISSIPATION NORMALISED 1 D
- KM NORMALISED 1 D
- TKE MECHANICAL TURBULENCE PROD.
- STOMATA RESISTANCE (s/m)
- CO₂ (mg/m³)
- CO₂ (ppm)
- PLANT CO₂ FLUX (mg/kg*m/s)
- DIV RLW TEMP CHANGE (K/h)
- BUILDING NUMBER

You can also choose the height of the map section. Once you configure the output options, you need to click the "EXTRACT2D" button. So, configured will appear on the map screen, with its legend and title, you can either leave it off. One can therefore proceed with the rescue of the output map, using the "SAVE MAP", or "MAP SAVE AS" button, and continue with the configuration of other output maps. You can save the .LEOX, aninteroperable with other software, exporting the data using an ASCII text file, which can be cleaned and processed with other programmes, including GIS software, ARCMAP and ARCSCENE.

b. GIS: ARCMAP

To create a data cloud ENVI-MET is necessary, when you export data, make a note of the height in meters of each layer and export the data in ASCII format. But we must not forget that the ENVI-MET exported files are not compatible and interoperable with GIS ARCMAP software, for this reason, before you import the data into ARCMAP, you need to clean them because as they are not ordered enough and you risk have problems to import them. The ASCII file is organized as if it were a table without the lines: the data that you would find on the same row of a table but in different boxes are all lined up one after the other, and to simulate a table structure is used spaces to align the columns. The aim is to clean them by eliminating data that do not serve, separating the data that are on the same row but in different boxes with a comma, and by replacing the commas separating the decimals with a point and by adding the values Z.

You must open the ASCII file with NOTEPAD ++, and delete data that do not serve. The data used are X, Y, and Z DATA (which will be added by the user who is not based on the data in the meter section, shown in ASCII file exported from ENVI-MET LEONARDO tool). You must put the cursor at the beginning of the column to remove the upper left corner. While holding down SHIFT + ALT, click your mouse at the end of the column at the bottom right. The text will be selected as if it were organized into a table itself. With the DELETE button, you can delete all. This procedure with NOTEPAD ++ also allows you to create a vertical slider as high as the height of all rows of the column that you have selected that flashes as a normal cursor, but relative to a greater number of rows. If you write something, write the cursor on all lines. You must put a comma to separate the data on the same line: X, Y, Z, DATA. Are then replace all the commas with points (decimal separators), using the same trick vertical selection and cursor up, you can select all the decimal points that are in the "DATA" column and replace them with a point. You must separate the data on the same line with a comma. The columns X and Y are already separated by a comma. Then you must select again in the vertical space between the "Y" column and the "DATA" column (being careful not to take in data from other columns) and put a comma separator of the four data in the column, as if they were 4 columns in a table (X, Y, Z, DATA).

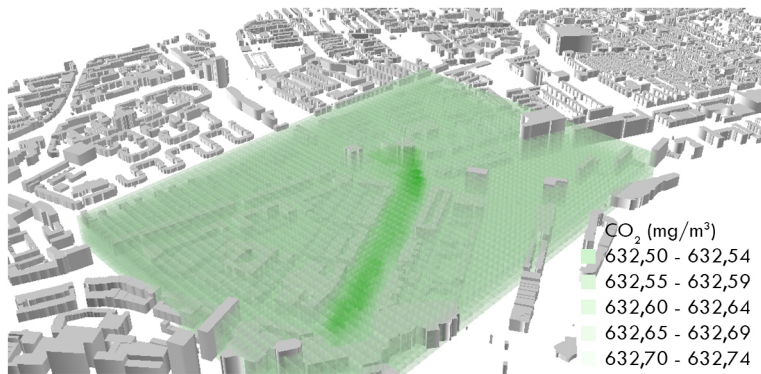
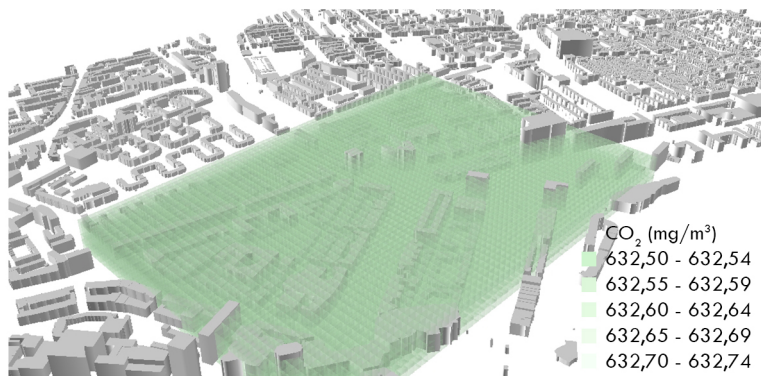
It must add the fourth column and Z data by selecting in a vertical space after the end of "DATA" column and adding a comma and the given height (writing with the cursor up vertically so writes on all rows in the fourth column). The units used for the sections of the output of the Rotterdam study case are 1.5 m, 13.5 m, 37.5 m, 52.5 m, or whatever the height of which you wrote down when you exported ASCII files from ENVI-MET. Within each ASCII file

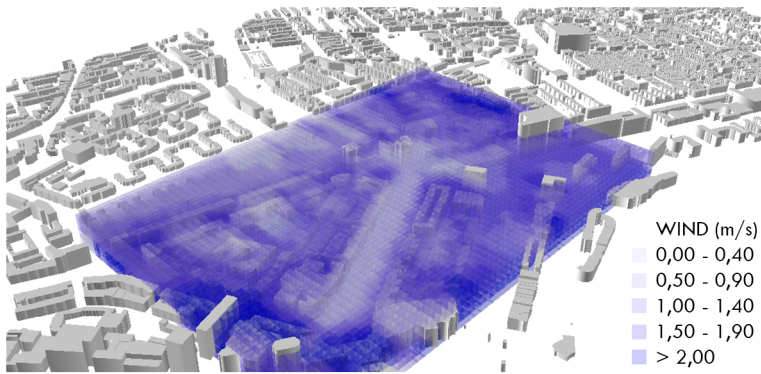
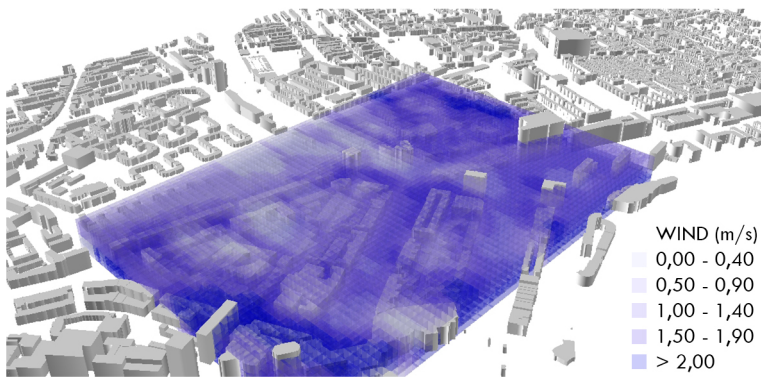
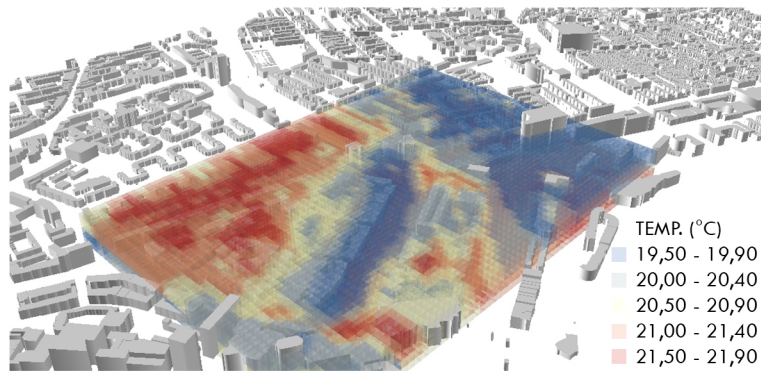
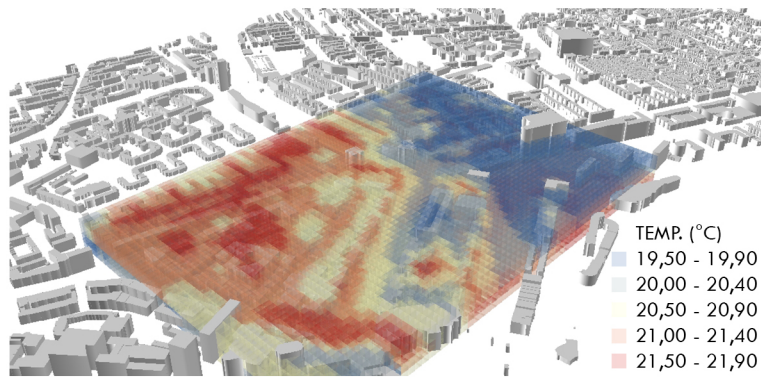
is the same Z value (because each ASCII file is a layer, and then all the points are at the same height), but every ASCII file must have a different Z value. At the top where there are the titles of the columns, add a comma and "Z". You can clean the file by deleting all spaces with SEARCH > REPLACE (or CTRL + H). This is not necessary because it does not consider ARCGIS spaces when making the data import. This cleaning process must be done for each ASCII file that has been exported from ENVI-MET. Once you have all been cleaned, you must copy and paste to get all the data in one file. The column titles should never be repeated, serving them only once at the top, with in all the sorted data of all ASCII files, or of all the layers. At this point processing, you can import the data into ARCMAP. To import the data into the GIS ARCMAP software, in a project of ARCMAP, FILE > ADD DATE > XY ADD DATE > [select ASCII files] > assign fields for X, Y and Z. You should see all the dots. For each dot, there are 4 superimposed, one for each layer 1.5 m, 13.5 m, 37.5 m, 52.5 m.

ARCMAP displays only to see them in 2D then 3D should open in ARCSCENE but before they go geo-referenced. For the geo-referencing of dots must open the other shapefile of temperature that has already been georeferenced dots (the dots are a little 'bias, are not a grid at right angles). EDITOR a call, and the other called SPATIAL ADJUSTMENT, using the drop-down menu CUSTOMIZE > TOOLBARS > EDITOR, then again CUSTOMIZE > TOOLBARS > SPATIAL ADJUSTMENT For geo-referencing of dots must be opened by ARCMAP two toolbars. You must start an editing session with EDITOR > START EDITING. In the toolbar of the SPATIAL ADJUSTMENT > set ADJUST DATE > ALL THESE FEATURES IN LAYERS > (select only the dots layer that is being geo-referencing). Using the tool from the toolbar SPATIAL ADJUSTMENT, creates links before clicking on the new layer of dots and then the dots of the reference layer. To see the different layers, you need to click the right button on the layer you want to display > ZOOM TO LAYER. When they have made enough link, it will become coloured the ADJUST option. Clicking that option will move the dots. You must save everything with EDITOR > SAVE EDITS and then close the editing session with EDITOR > STOP EDITING. It is very important to define the coordinate system in the right box "SEARCH" is basic search tool called the "DEFINE PROJECTION". This allows you to define the coordinate system of a DATASET, in this case the point cloud just created. You must put as input the point cloud on which you are working, and how to select the coordinate system PROJECTED COORDINATE SYSTEMS > NATIONAL GRIDS > EUROPE > NEW RD.

c. GIS: ARCSCE

To see the points in 3D geo-referenced and righteous, we must open them in ARCSCE. To ensure they are fair, it must also open the MULTIPATCH buildings and the other point cloud - should fit all.





d. BIM: REVIT- FORMIT 360 - DYNAMO STUDIO - INSIGHT 360

INSIGHT is a BIM software that can be of significant help for decisions on how to design. It is known as BIM software dot enlargement of the focus, even out of pure design, optimizing the "AS BUILT" for later use (commercial or facility management). This objective is perfectly in line with what the market and new regulations require a solution capable of managing the built "in all its life stages" (lifecycle management) just since there can be superior design if there is no planning in advance of the intention design.

This part is extremely complex because it must consider both the performance of the building, the aesthetic form, volumes, its shadows, analysis of light.

It is the combination of software like FORMIT 360, and INSIGHT 360 DYNAMO STUDIO enables drill these analyses simultaneously and not too time-consuming, which in conceptual stage is a valuable resource.

You can in fact use DYNAMO STUDIO to create a form modulated as desired by means of computational modelling, publish it in cloud script and insert it in FORMIT 360, in order to evaluate the simplest aspects such as shading, areas and volumes. Then push the analysis up to the energy detail exporting the model of INSIGHT 360, where they are analysed all the potential savings variables taken individually to assess how impacts every single choice (orientation, the stratigraphy, doors and windows) on the final costs.

To obtain an energy simulation of detail with the INSIGHT 360 software, is sufficient to model a mass in FORMIT 360 PRO or alternatively a mass (or a complete building or even a mix of masses and structural elements) in REVIT, set the geographic coordinates, launch the energy analysis and access to the portal CLOUD INSIGHT 360 to test the impact of all possible variants.

INSIGHT 360, which makes it easy to understand the functioning of the building in terms of performance, otherwise complex to be processed and program.

INSIGHT 360 is connected to a concept of sustainability LEED.

INSIGHT 360 can handle a vast number of variables (it is estimated that the turning point in cloud optimization in a handful of minutes can be carried out manually in a year of man-hours).

Thus, INSIGHT 360 does not have the purpose of "certify", but of make the best choices possible, defined boundary conditions.

In fact, usually we tend to "certify" a work already done, when you no longer can intervene or correct the substantially building: exactly the opposite of what happens with conceptual tools such as cloud-based INSIGHT 360 and FORMIT 360.

5. Flood alleviation and water management

Green infrastructure can help store and intercept rainwater, and facilitate natural drainage. Relevant types of green spaces and features – all trees, plants and green infrastructure, but functional benefits from:

- elements of sustainable urban drainage systems (SUDS)
- green roofs in urban areas.

Creating, reinstating or protecting natural drainage systems can reduce flood risk as well as demand on sewers and the wastewater treatment network:

- trees and other plants process rainwater, through interception, evaporation and transpiration
- green space allows natural infiltration of surface water
- Sustainable Urban Drainage Systems (SUDs) include elements of green infrastructure - culverts, ditches and swales
- reed beds can be used to treat wastewater
- wash lands and wetlands can store water and provide a buffer against flooding
- woodland and forests can help regulate watersheds, reducing river flow speeds, the frequency and severity of flooding and soil erosion, and conserving nutrients.

Measuring the impact of green infrastructure on improved water management and reduced flood requires detailed knowledge of:

- the hydrology of an area
- existing water infrastructure
- the area and permeability of surfaces (natural and built)
- climatic conditions.

a. GIS: ARCMAP

For the purposes of permeability, you should create a shapefile polygons. This procedure will need to draw the areas before and after the project and give each area a value of permeability. You can create a shapefile from the "CATALOG" window on the left, right click on GEODATABASE where you want to create the new shapefile > NEW > FEATURE CLASS. As the coordinate system must be set RD New. For all other screens, you should go on until the end. You must open the new FEATURE CLASS in the project. In the "TABLE OF CONTENTS" left > right click on the layer > OPEN ATTRIBUTE TABLE. Then, create a new field from the attribute table. "ADD FIELD" is an operation that is not possible if you are in an edit session.

It is appropriate to draw polygons in open editing session and assign the values of permeability to everyone. EDITING You should start a session. ARCMAP > CUSTOMIZE > TOOLBARS > EDITOR. EDITOR > START EDITING. You must select the layer "PERMEABILITY".

With the "CREATE FEATURES" button opens a panel that lets you choose which shapefile you want to change and shape you want to draw. Then select the "PERMEABILITY" layer and the type of shape you want to draw.

Whenever you draw a polygon, results in the Attribute Table of layer "PERMEABILITY". You can enter by ATTRIBUTE TABLE permeability data. To facilitate the subsequent steps (for example, the creation of the raster for the calculation of the accumulation of water), the permeability values must be on the contrary, as if it were a value of permeability. That is, if permeability is 0% (asphalt type), you should give it a value of 100. If the permeability is 90% (such as trees, grass) you need to give a value of 10, and so on. In this way, you go to give a value that indicates how much water is made to slide away on the surface, instead of how much water is absorbed from the surface. At the end, it is the same thing, but for the accumulation of water need to know how much water flows and not how much water is absorbed.

If you want to cut out the polygons of the areas by the large rectangle area, you must use the "UNION" tool (ANALYSIS). You do not need the large rectangle, and all the other small areas in two different shapefiles - may be the same. You should be sure to remove small non-significant areas that may arise at the intersection of two polygons.

If you want to copy and paste the shapefile starting to alter it and create the second scenario, you can right-click on the shapefile in the "CATALOG" right > COPY. Then, still in the "CATALOG", right click on the destination

folder > PASTE. This works only from folder to folder or geodatabase from a geodatabase.

Once you designed all the polygons that you want, and you have entered all the data permeability (on the contrary) must close the editing session with EDITOR > SAVE EDITS and then EDITOR > STOP EDITING.

For conversion from raster polygon must use the "Polygon to Raster" tool and convert the polygon dataset with permeability values in a raster dataset that maintains the permeability values for each zone.

It must indicate:

INPUT FEATURES: the shapefile polygons with permeability.

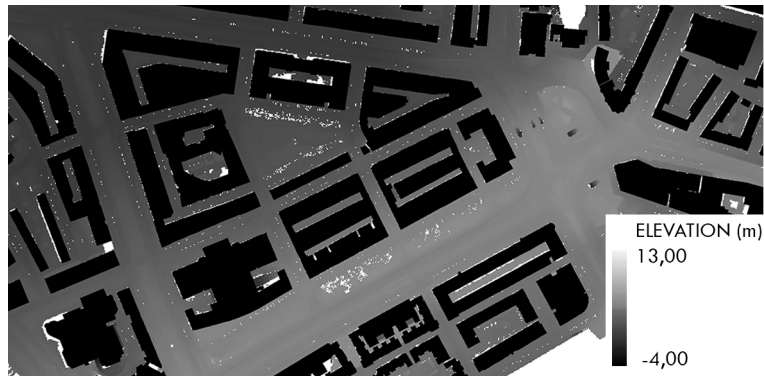
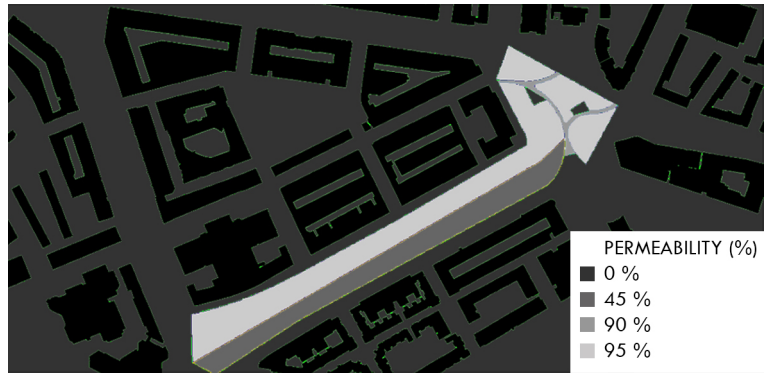
VALUE FIELD: the field from which the values will be assigned to the raster cells, so you should specify the field values of permeability.

CELLSIZE: use the raster with the heights because then you will be using together so it must have the same cell size.

You have to repeat this process in order to have two raster: one with the current situation permeability zones, and one with the permeability zones of the situation after the construction of the project.

For the analysis of water storage, the data required to start are:

- Raster elevation
- Raster water-flow direction
- Raster weight permeability



6. Health and well being

To facilitate evidence-based decision-making, WHO has developed, in collaboration with experts. It is an online tool to estimate the value of reduced mortality resulting from regular walking or cycling.

The health and economic assessment tool (HEAT) for cycling and walking:

- is intended to be part of comprehensive cost–benefit analyses of transport interventions or infrastructure projects;
- complements existing tools for economic valuations of transport interventions, for example on emissions or congestion;
- can also be used to assess the current situation or past investment;
- is based on best available evidence, with parameters that can be adapted to fit specific situations. Default parameters are valid for the European context.

HEAT calculates the answer to the following question: if x people cycle or walk y distance on most days, what is the economic value of mortality rate improvements?

A guidance book and summary address practitioners and experts, focusing on approaches to the economic valuation of positive health effects related to cycling and walking.

HEAT can be applied in many situations, for example:

- to plan a new piece of cycling or walking infrastructure: it models the impact of various levels of cycling or walking, and attaches a value to the estimated level when the new infrastructure is in place;
- to value the mortality benefits from current levels of cycling or walking, such as benefits from cycling or walking to a specific workplace, across a city or in a country;
- to provide input into more comprehensive cost–benefit analyses, or prospective health impact assessments: for instance, to estimate the mortality benefits from achieving national targets to increase cycling or walking, or to illustrate potential cost consequences of a decline in current levels of cycling or walking.

The tool has already been applied in several countries.

This tool is designed to help you conduct an economic assessment of the health benefits of walking or cycling by estimating the value of reduced mortality that results from specified amounts of walking or cycling.

The tool can be used in several different situations, for example:

- when planning a new piece of cycling or walking infrastructure. HEAT attaches a value to the estimated level of cycling or walking when the new infrastructure is in place. This can be compared to the costs of implementing different interventions to produce a benefit–cost ratio (and help to make the case for investment)
- to value the reduced mortality from past and/or current levels of cycling or walking, such as to a specific workplace, across a city or in a country. It can also be used to illustrate economic consequences from a potential future change in levels of cycling or walking.
- to provide input into more comprehensive economic appraisal exercises, or prospective health impact assessments.

For example, to estimate the mortality benefits from achieving targets to increase cycling or walking, or from the results of an intervention project.

a. WHO: HEAT walking



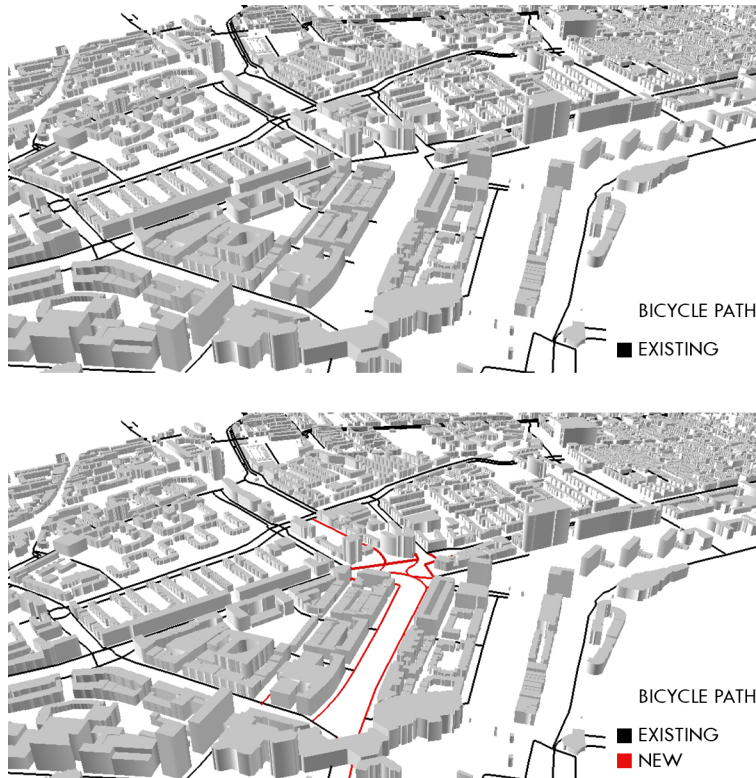
HEAT is to be used for assessments at the population level for groups of people and not for individuals. This tool considers habitual behaviour, such as walking for commuting or regular leisure time activities.

Do not use it for the evaluation of one-day events or competitions (such as walking days etc.), since they are unlikely to reflect long-term average activity behaviour. HEAT is meant to be applied for walking of at least moderate pace (i.e. about 3 miles/hour or 4.8 km/hour). Walking at this speed requires an energy expenditure that is necessary for health benefits.

HEAT is designed for adult populations (aged approximately 20-74 years). This is the age range, for which the used relative risk estimate is applicable (see box “more information on the relative risk estimate used”). Information on the relative risk in younger or older populations is insufficient for inclusion. If the age distribution in the assessed population is significantly different (much younger, much older) HEAT may over or under estimate the resulting benefits. In such cases, it is important to adjust the mortality rate, which depends strongly on the age of the assessed population. However, HEAT should not be applied to populations of children, very young adults, or older people, since the relative risk used by HEAT does not include these age groups.

Studies on the benefits of physical activity for decreasing premature mortality have typically been conducted in the general population where very high average levels of physical activity are uncommon. Thus, the exact shape of the dose-response curve is uncertain but it seems to level off above physical activity levels that are the equivalent of perhaps 2 hours of brisk walking per day. Therefore, the tool may not be suited for populations with very high average levels of walking (i.e. about 2 hours per day or more, e.g. mail personnel) which go beyond activity levels common in an average adult population. Caution also should be applied when using the tool in predominantly sedentary populations, since the underlying risk estimates were derived from populations with a broad distribution of activity levels. HEAT could therefore slightly underestimate the effect in very sedentary population groups.

b. WHO: HEAT cycling



HEAT is to be applied for assessments on a population level, i.e. in groups of people, not in individuals.

This tool considers habitual behaviour, such as walking for commuting or regular leisure time activities.

Do not use it for the evaluation of one-day events or competitions (such as cycling days etc.), since they are unlikely to reflect long-term average activity behaviour.

HEAT is meant to be applied for an average cycling speed of about 14km/h (see also box for more information).

HEAT is designed for adult populations (aged approximately 20-64 years). This is the age range, for which the used relative risk estimate is applicable (see box “more information on the relative risk estimate used”). Information on the relative risk in younger or older populations is insufficient for inclusion. If the age distribution in the assessed population is significantly different (much younger, much older) HEAT may over or under estimate the resulting benefits. In such cases, it is important to adjust the mortality rate, which depends strongly on the age of the assessed population. However, HEAT should not be applied to populations of children, very young adults, or older people, since the relative risk used by HEAT does not include these age groups.

Studies on the benefits of physical activity for decreasing premature mortality have typically been conducted in the general population where very high average levels of physical activity are uncommon. Thus, the exact shape of the dose-response curve is uncertain but seems to level off above physical activity levels that are the equivalent of perhaps 1 hour of cycling per day. Therefore, the tool may not be suited for populations with very high average levels of cycling (i.e. about 1.5 hours per day or more, e.g. bicycle couriers) which go beyond activity levels common in an average adult population.

Knowledge of the health effects of cycling is evolving rapidly. These projects represent first important steps towards an agreed harmonized methodology. In developing these tools, on several occasions the advisory group made expert judgements based on the best available information and evidence. Therefore, the accuracy of results of the HEAT calculations should be understood as estimates of the order of magnitude, much like many other economic assessments of health effects. Further improvements will be made as new knowledge becomes available.

HEAT is composed of 16 questions in total; depending on the route you take, some questions will be skipped.



7. Land and property values



The existence of trees and green spaces within urban and semi-urban areas can increase land and property values. Relevant types of green spaces and features – primarily planned urban green infrastructure aimed at enhancing the urban environment, providing a setting for investment and improving quality of life. This includes:

- amenity green space
- civic squares and spaces
- allotments
- community gardens and urban farms
- parks and public gardens
- community woodland.

Land and property values are a useful proxy measure for the relative prosperity and attractiveness of a community, neighbourhood or place. Property values reflect a basket of factors – for example transport links, proximity to employment and local services, as well as environmental quality.

Several studies have tried to isolate the impact of green infrastructure, including trees, parks and community woodland on neighbouring property

prices, particularly in a residential context. The magnitude of the suggested impact on value varies significantly between the studies.



a. GIS: ARCMAP

This real-property value box allows you to view the real-property value of homes. The WOZ value box is designed for individual consulting individual dwellings.

The displayed real-property values are formally WOZ values set by the relevant municipality. The municipality is responsible for the real-property value.

The shown object attributes such as built and usable area are from the Key Registers addresses and buildings.

In this counter are shown the real-property values such as the municipality that has made to the National Facility WOZ (LV WOZ). When a municipality has not yet been connected to the LV WOZ, then from this municipality, the real-property values are not visible in this counter.

Using the value of every residential building in the area, was created a database with the software GIS ARCMAP. In the "TABLE OF CONTENTS" left > right click on the layer > OPEN ATTRIBUTE TABLE. Then, create a new field from the attribute table. "ADD FIELD" is an operation that is not possible if you are in an edit session. Opening the attribute table, it's possible to add a column, for the value of the property, then another column where the previous value is directly multiplied by the number of floor in that building, data took from the cadastre. The is possible to consider the plus-value, caused by the proximity to the new park projected, or every urban green infrastructure, considering an increase of 12% to the value. Then it is possible to create several kinds of maps, showing the square metre value, and the increasing of the value.

8. Landscape

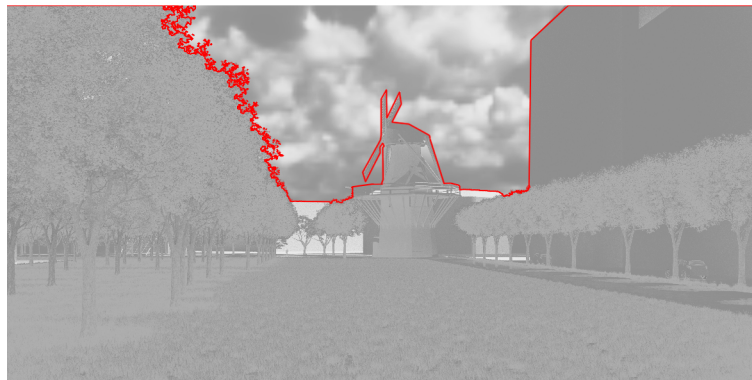
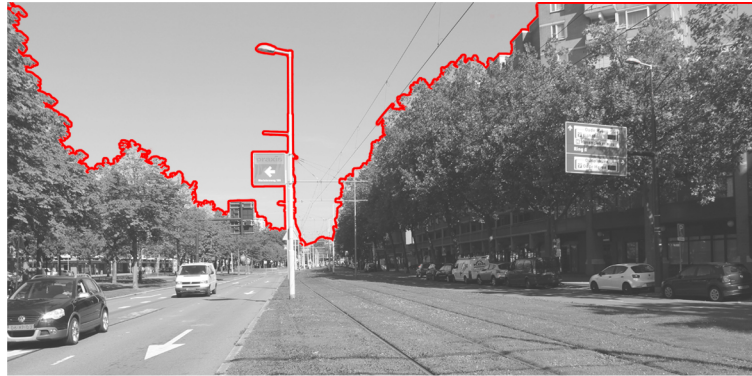
The European Landscape Convention (ELC)¹ definition of “landscape” is: “an area, as perceived by people, whose character is the result of the action and interaction of natural and - or human factors.”

The landscapes are extremely important to human, they are part of the cultural heritage. Nowadays designer and planner offer an opportunity to provide a more harmonious link between man and the natural world, for the benefit of both. Sensitive, informed, and integrated approaches should help us all to conserve, enhance, restore and regenerate landscapes that are attractive, diverse and publicly valued, showing that environmental, social and economic benefits can go hand in hand.

The issue of landscape quality is central in many both national and European policies. The European Landscape Convention (Florence, 2000) requires that for any place of life, whether ordinary or outstanding, ‘landscape quality objectives’ can establish in relation to a precise definition of its users / clients (Faro Convention, 2005). Thus, unlike environmental assessment, which can more easily refer to universal conditions, determining landscape quality requires the recognition of the value attributed by the population (expected to change over time).

We consider the landscape quality through indicators that focus its attention on the visual quality and complexity, and the soundscape, which give more importance to the acoustic environment.

a. Visual qualities and complexity



In recent years, the visual qualities have become an essential element of landscape planning and management strategies. During the European Landscape Convention, it was promoted an integrated approach to landscape combining social, cultural and visual aspects with ecological functions. The result of this was the fact that the landscape indicators have become one of the priorities of landscape research and are increasingly used in the assessment of landscape quality. One of this landscape indicators is the visual complexity. It refers to the diversity and wealth of elements in the landscape and stress the fact that complexity is the source of content and exploration opportunities.

In the literature of the subject complexity is expressed as the diversity of elements in the form of the number and types of objects, land cover and pattern variability – the variety of forms of land use, as well as size and shape diversity. The description and approach to complexity depends to a considerable extent on the way output information is obtained.

The complexity indicators are the qualitative parameter that try to describe the complexity of landscape based on photographic images. In the studies the aspect of spatial distribution of individual landscape attributes is

completely overlooked. Consequently, an attempt at was made to describe the landscape as the contact point of various types and forms of use and land cover as well as a quantitative depiction of landscape complexity through the Horizontal complexity coefficient [Hcc], as the ratio of horizontal line length to sectional view length. The formula that corresponds to this coefficient is:

$$Hcc = hl/s$$

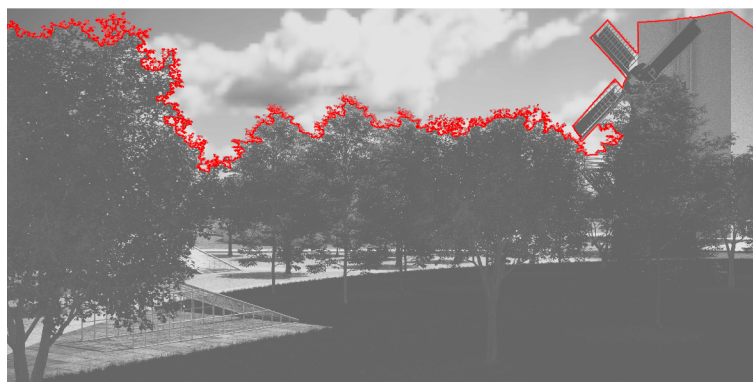
where:

Hcc – horizontal complexity coefficient,

hl – horizon line length,

s – sectional view length.

In the specific case of the project of Rotterdam two pictures of the project area were analysed according to the method described above. Then they were compared with two images of the state of art with the same angles and perspective. It is visible that the horizon line length is deeply changed and thus its complexity Horizontal coefficient. As the pictures show the presence of green space is improve and the windmill will be relocated in the site.



b. Soundscape

The soundscape is a key component of the landscape and it's composed by the acoustic environment that can be perceived by humans. By the European Landscape Convention, the soundscape was defined as "the acoustic properties of any landscape in relation to the specific perception of a species (...) is the result of events and physical dynamics (geofonie), biological (biofonie) and human (antropofonie)."

There is a varied history of the use of soundscape depending on discipline - ranging from urban design to wildlife ecology. An important distinction is to separate soundscape from the broader term acoustic environment. The acoustic environment is the combination of all the acoustic resources within a given area - natural sounds and human-caused sounds – as modified by the environment.

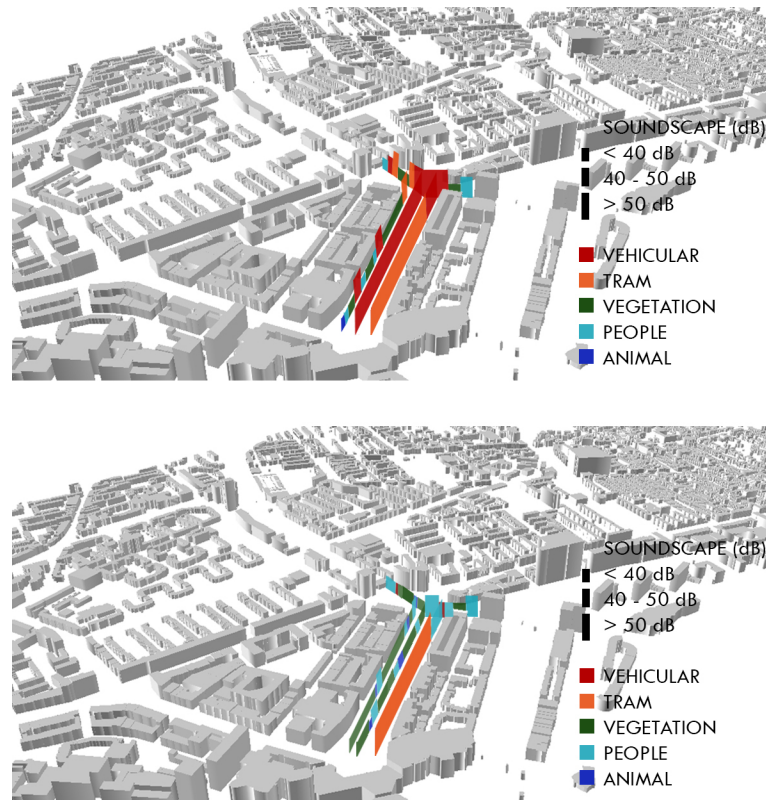
A soundscape is a sound or combination of sounds that forms or arises from an immersive environment. The study of soundscape is the subject of acoustic ecology.

The idea of soundscape refers to both the natural acoustic environment, consisting of natural sounds, including animal vocalizations and, for instance, the sounds of weather and other natural elements; and environmental sounds created by humans, through musical composition, sound design, and other ordinary human activities including conversation, work, and sounds of mechanical origin resulting from use of industrial technology. Crucially, the term soundscape also includes the listener's perception of sounds heard as an environment: "how that environment is understood by those living within it" and therefore mediates their relations. The disruption of these acoustic environments results in noise pollution.

The terms "soundscape" has been used for the first time since M. Southworth and in an even more foundational by R. Murray Schafer to define both the totality of the world of sounds, whether any recordings of a portion thereof, at the same manner in which it defines a visual landscape and a photograph that depicts a part.

Thanks to the design of a green infrastructure it is notable a huge change between the existing soundscape and the one audible after the planning of the park. To make a careful analysis it was used the app NoiseTube.

c. NOISETUBE



NoiseTube is a research project started in 2008 at the Sony Computer Science Lab in Paris, it proposes a participative approach for monitoring noise pollution by involving the public. The NoiseTube mobile app extends the current usage of mobile phones by turning them into noise sensors enabling citizens to measure the sound exposure in their everyday environment. Furthermore, each user can participate in creating a collective map of noise pollution by sharing geo-localized measurement data with the NoiseTube community.

By installing the free app on your smartphone, everyone will be able to measure the level of noise in dB(A), and tag the measurements obtained (e.g. subjective level of annoyance, source of sound, ...). When uploaded to the website everyone can check the sound trajectory of the recorded measurements on Google Maps. Thanks to this app was possible to understand how the noise pollution change after the design of the green infrastructure. Especially it was possible analysed the different decibel of noise and define from where source they come from (traffic, green, river, people, ...) and then compare the actual soundscape of the project area with the future possible one. To do this it was decided to analyse the soundscape in a park in Rotterdam to understand the possible improvement of the soundscape in the site.

9. Case study

a. Urban analysis



The case study is in the city of Rotterdam. This city is located in the South Holland, within the Rhine–Meuse–Scheldt river delta at the North Sea. It is home to Europe's largest port and has a population of 633'470, ranking second in the Netherlands, just behind Amsterdam. The Greater Rijnmond area is home to approximately 1.4 million people and the Rotterdam Den Hague Metropolitan Area makes for the 168th most populous urban area in the world. Rotterdam is part of the yet larger Randstad conurbation with a total population of 7.100.000.

The near-complete destruction of Rotterdam's city centre during World War II (known as the Rotterdam Blitz) has resulted in a varied architectural landscape including sky-scrappers, which are an uncommon sight in other Dutch cities.

The neighbourhood's reading shows the huge presence of the water in the whole city and in the same time shows some critical issues, the most important is related to the traffic levels, the other one is more relate to the lack of green area, close to the city centre.

The project area is close to the city centre and is an important gate to it. The buildings here located are most of them residential and commercial, are built between 1940 and 1960. The only one historical building lays close to the waterfront.

The Oostplein used to be the eastern welcome of the Rotterdam city centre. It was the remnant of the Renaissance fortification with its city gate. In the 19th Century it became the busy urban square, where everyone entered Rotterdam passing its monumental 35 m tall windmill and the ever-smoking chimney of the pump house, which brought the water from the deep polders into the river Maas right there. Due to the bombardment of the city at the Second World War, the loss of the windmill, the dominant traffic engineering and the realisation of the subway station, this place totally lost its spender as show the masterplan of the state of art. The area has within a small green space that is now unused and "close" to people as the pictures shown. The site is nowadays an example of discontinuity, fragmentation, danger and neglect.

Rotterdam has a reputation on failing urban atmosphere and identity. People considered Rotterdam a harsh city short on parks. In this city, dubious interventions of modern urban planning cry for physical restoration and a redefinition of the urban tissue: hence a city park at the Oostplein. For this reason, the Mayor of Rotterdam wants the Oostplein to be the welcome of the city centre again, being a green urban meeting point, a park. Therefor Oostplein, Burgemeester van Walsumweg en de west queue of Het Balkengat need to be brought together into a coherent green space that can be park, space and esplanade in one. The main hope for this part of Rotterdam is the transformation of an unwelcome, traffic dominated Oostplein into a green urban park at the entrance of the Rotterdam city centre. For that, the Oostplein, the adjacent 'Burgemeester Van Walsumweg' and the waterfront need to be connected into an integrated park zone. Therefore, this new park layout should be contributing as an efficient and innovative urban design strategy.

The masterplan below shows the proposal design for the project area, where the green is become the main element. The viability has been completely modified, giving less importance to cars and more importance to pedestrians

and bicycle circulation, but also to the public transportation. In the square and the park all the material used have elevated level of permeability, even if some of them are partially permeable.

It was also done an analysis of the soil and on the existences plants to make the best choice for the new species of trees. It was tried to keep the bigger number of existences trees, removing just the sick one. The masterplan shows that have been used several types of trees for the forest while just one for the boulevard, that follow a linear scheme, opposite to the irregular scheme of the urban forest.

The project's aim is the requalification of the Oostplein area. In these diagram is visible the comparison between what is maintained and what is completely new. It's clear the different grade of density of vegetation in the area, following two different rules, one more linear, and the other one more aleatory. Also the pedestrian and cycle paths has a completely new design and importance in the site.

Instead the below diagrams show the different proportion of green and public space with the traffic area. Regarding the directions of the park they come from the pre-existing line.



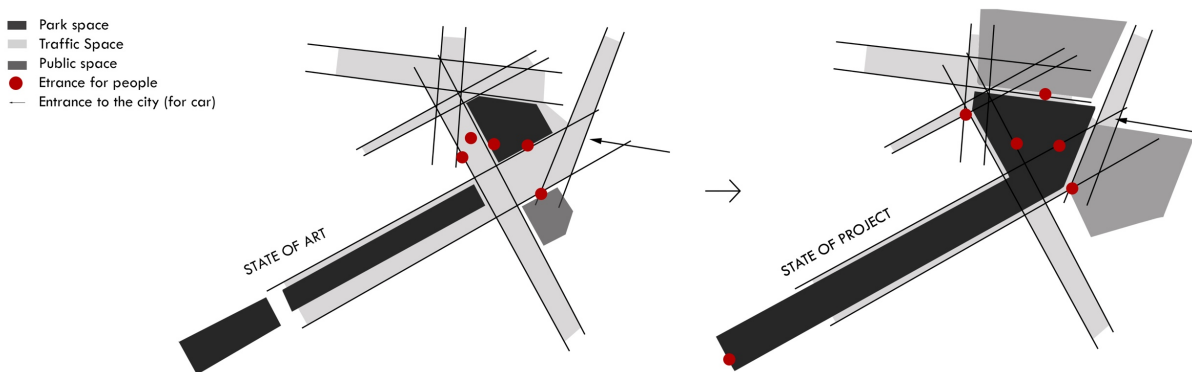
b. Masterplan



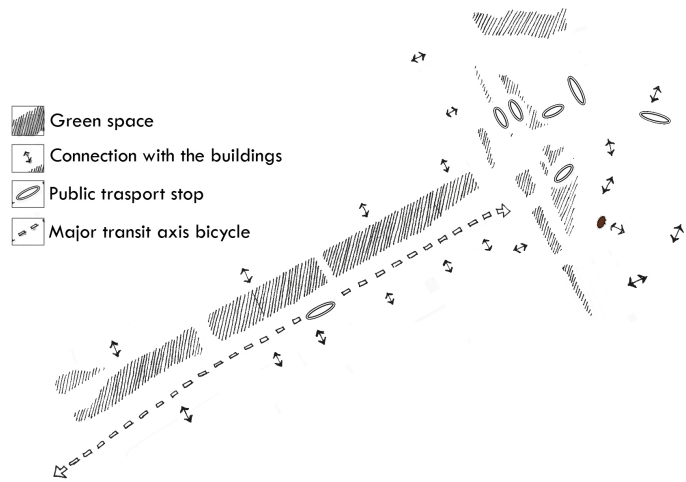
The idea of the project is to create an urban forest that can enhance the essential elements located in the area and create a new link with them, as the area behind the pump house, the waterfront with the marine's statue and the cube house. As the masterplan show, the connections between these points, however, they are treated differently. Between the central forest and

the cube house there is a green boulevard, instead between the forest and the pump house and the waterfront there are two squares.

At the same time restoring the lost identity rebuilding the windmill as a new element of junction and welcome for the city. The windmill could be in a strategic position in the topographically highest point and in a central position thus allowing a visual connection with the boulevard, but also the waterfront and the pump house. From here, the route enters in the forest and change their style, becoming more organic, and size, now 4 m while before 8 m. These routes linking the major points of importance in the district, HUSTRAAT the street parallel to the boulevard, the area behind the pump house and HUSTDAIK. It because is also essential that the project meets both the urban scale, and is therefore connected to the centre of the city, but also the local scale and then serving the surrounding districts.



One of the aim of the project is to solve the existence problem of vehicular traffic, going to modify traffic flows while maintaining public transport, as the tramway and metro. Regarding the metro station, the entries are keep in the same place. Two of them use exactly the space of the previous, instead the third one, in the middle of the urban forest and close to the tram stop, is make bigger. The other two entrances are instead delated to give more importance to the others. The style of the metro station is completely change, becoming a glassed prism.



Regarding the boulevard as already mentioned, this is composed of a large linear pedestrian cycle path, parallel to the tramline and a green boulevard composed of grass and by an ordered sequence of trees. The boulevard links the cube house with the windmill, located in the end of the pedestrian path.



About the waterfront square, the topographical difference is handled in two separate ways. In the part next to the historic building there is a slope where

are located the tables of the café in the building, while the second, as it is best shown in the 3D view, there is a wide staircase that comes right to the river and to the marine statue.

The presence of the windmill is also very strong because of the localisation across the road that separates the square from the forest.

For the subway entrance, the idea is to create a glass prism from which it was possible to see and feel part of the forest even from underground level and in the same time remain almost transparent in the forest.

c. Costs and benefits of project

From economic point of view, we consider to use the underground shops of Oostplein Metro Station for a coffee shop (with an online sales collection point as Amazon Locker or similar), a first aid medical centre and a Bike shop. This choice is based on quick market analysis (by GIS mapping).

Project cost

The costs are defined considering the construction stage and the operational stage, and the current prices on Rotterdam market (2016). The cost does not comprise the rebuilding of the windmill that has to request a bespoke appraisal. Windmill De Kameel in Schiedam (33 m height) rebuilding cost between 2008 and 2011 was for around 2.5 million euros. The government, concerned that one of the foremost symbols of the Netherlands was about to disappear out of neglect, approved an 60 million euro programme to build or restore 120 mills, of roughly 1,040 still standing. Therefore, we can consider the cost for windmill rebuilding from 500.000 to 2.500.000 €.

TREES	N°	UNIT PRICE (€/TREE)	TOT PRICE (€)
GLEDITSIA TRIACANTHOS SUNBURST	229	25	5.725
PLATANUS X HISPANICA	25	90	2.250
PINUS SYLVESTRIS	22	285	6.270
FAGUS SYLVATICA	12	20	240
CERCIDIPHYLLUM JAPONICUM	17	50	850
TOTAL (€)	-	-	15.335

FUNCTIONS	m ²	UNIT PRICE (€/m ²)	TOT PRICE (€)
PAVEMENT	25.970	30	779.100
GRASS	33.720	35	1.180.200
SUBWAY STATION 1	84	1.300	109.200
SUBWAY STATION 2	86	1.300	111.800
SUBWAY STATION 3	116	1.300	150.800
SUBWAY STATION 4	88	1.300	114.400
SUBWAY STATION 5	47	1.300	61.100
SUBWAY STATION 6	47	1.300	61.100
SUBWAY STATION 7	47	1.300	61.100
SUBWAY STATION 8	47	1.300	61.100
SUBWAY STATION 9	106	1.000	106.000
SUBWAY STATION 10	58	1.000	58.000
TOTAL (€)	-	-	2.853.900

We define the operational cost only related to maintenance cost and management cost of the facilities supplied at the underground level of metro station and inside the windmill. Regarding the green space of the project and the tramline, we consider maintenance and management cost in charge of municipality.

Project Benefits

The benefits are defined applying two different valuation method: The Ecosystem Services Value, on which is based the valuation toolkit and the traditional Discounted Cash Flow analysis.

Total Ecosystem Services Value are the following:

Land and Property Value: 15.160.080 €

Other Economic Value: 4.087.100 €/year

The Financial Benefit from DCFA is positive.

10. Results and discussion

The aim of the thesis is to define an ecosystem services valuation toolkit in the field of urban green infrastructure design. The starting point is a conceptually meaningful assessment model, but developed in excel, which classifies benefits into 11 thematic areas (climate change adaptation and mitigation, the reduction of the Flood and Water Management, Location and communities, health and wellness, land and property values, productivity investments Jobs, Tourism, Leisure and recreation, biodiversity, the management of the territory). We develop the first four valuation areas: climate change adaptation and mitigation, flood reduction and water management, health and welfare of the territory and of the value of real estate. We have also considered the 'landscape' assessment area in addition.

The analysis of existing tools and the need to find a model that uses the instruments connected to the project and the architect's working methods, brought the idea to focus successively on the BIM - GIS interoperability through which connect the two technologies and allow the correct relationship between design and territory model on which the project was dropped.

This allowed us to analyse more precisely than the starting toolkit benefits (in the fields defined) of green infrastructure designed and constructed to apply the model to a case study.

Regarding the model structure, we observe that there is no loss of information passing from one application to another, but there is still a loss of time in managing the data.

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