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GREEN ROOF TECHNOLOGY ASSESSMENT

THE ROLE OF GREEN ROOF IN THE PROVISION OF ECOSYSTEM SERVICES: THE CASE OF THE LINGOTTO IN TURIN.

Executive summary

The Green roof Technology Assessment (GreenTA) project investigated the cost and benefits arising from the installation of green roofs, while developing a user-friendly evaluation tool to quantify said benefits. As the awareness of sustainability's importance for humanity's future grows, so does the interest in urban ecosystem services – the benefits that humans can gain from interacting with the urban environment. It is known that mankind is increasingly choosing life in the city, and roofs are a fundamental element of the built environment – in Italy for example, roofs account for 20-25% of the urban surfaces.

The role of green roofs is therefore fundamental in cultivating a sustainable future. Despite their importance, however, existing literature reveals that the current scenario for green roof evaluation lacks tools that consider a variety of benefits at once, a gap that the GreenTA project sought to understand and bridge.

The tool considers green roof benefits from a multidisciplinary point of view through environmental, economic, and social perspectives, with its primary users being designers and policy-makers. The tool not only helps these actors to reach better decision-making concearning green roofs but can also be vital in increasing the awareness of their benefits, helping the diffusion of this type of technology, and reducing the human footprint on Earth.

The work was divided into different phases, with the first months being dedicated to analysis and research in order to understand green roof technology and its current assessment in the existing literature. While defining the indicators applied in the tool, the GreenTA team had the opportunity to develop and publish a literature review gathering the main findings, titled "Green Roof Benefits and Technology Assessment. A Literature Review", publish with Springer.

The remaining time was dedicated to developing the tool in Excel, providing quantifications and monetary values of the green roof's benefits. The four categories of benefits measured are outdoor air quality, water management, energy consumption reduction, and social aspects.

Key Words

Green Roof, Evaluation, Multi-Dimensional Performances, Sustainability

Image 1: Green roof in the Lingotto building, Turin.

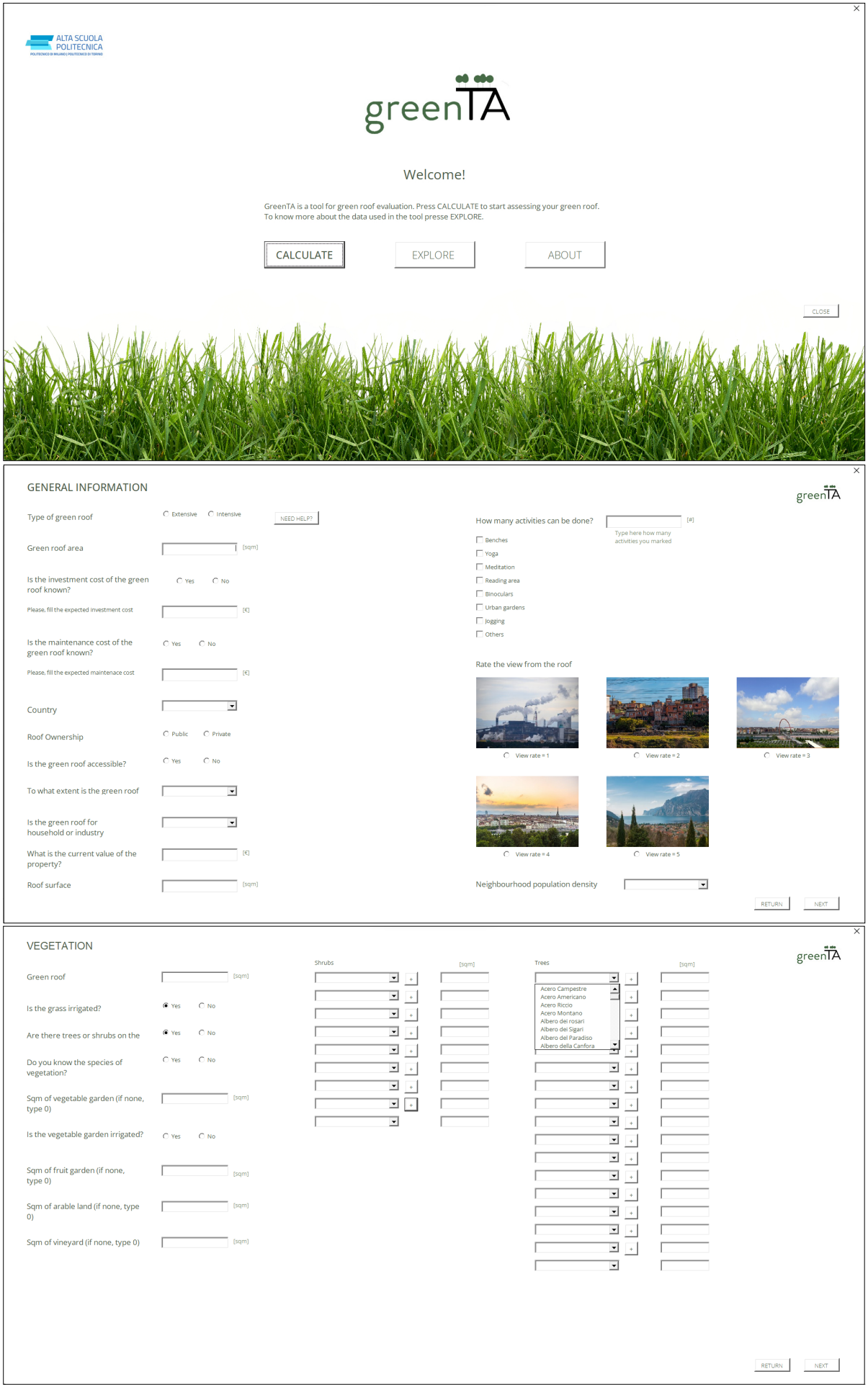

Image 2: GreenTA tool interface.

Project description written by the Principal Academic Tutor

The project investigates the topic of ecosystem services and their benefits provided by built and natural environments. Starting from a real case study related to the green roof installation on the Lingotto building (Turin), the research will explore the integration of different evaluation methods in order to have an overall assessment of ecosystem benefits considering multiple and (often) conflicting dimensions. In the project, innovative models in the domain of energy passive solutions, economic and biophysical assessment, urban health, and socio-cultural values will be investigated in relation to the planned scenario of transformation, with the aim of creating a transdisciplinary approach. The combination of cost-based and value-based techniques will constitute a novelty in the context of green infrastructure development and its assessment. Practitioners, developers, and policymakers are the main beneficiaries of the research, as they must adapt projects and policies in the provision of urban green infrastructures by considering the results of the evaluation framework and opinions expressed by the population in the different stages of the assessment. Given the structure of the multidisciplinary research, a cost-optimal perspective will be proposed in order to avoid wasting economic resources and achieve high sustainable standards.

Team description by skill

The GreenTA team is composed of six members:

- 3 managment engineering students
- 2 civil engineering students
- 1 architecture student

Since the work dealt with constructive and economic aspects of green roofs, the variety of skills was fundamental, and also guided the division of the tasks in the different phases of the project.

During the phase of elaboration of the tool, the group subdivided itself according to each member's strengths. It is important to note that the tool is composed of four "segments" of aspects analyzed: outdoor air quality, water management, energy consumption reduction, and social aspects. Since all aspects have to also be analyzed from a monetary point of view, the final work subdivision was established as follows:

- Outdoor air quality + social aspects: 1 management engineer + 1 architect
- Water management: 1 management engineer + 1 civil engineer
- Energy consumption reduction: 1 management engineer + 1 civil engineer

This subdivision helped to cover both the constructive and monetary aspects of each part. It is important to note however that the frequent communications and meetings among the different subgroups allowed all students to understand and build the tool as a whole.

A variety of other soft skills were also explored, for example when the students presented the literature review at the "New Metropolitan Perspectives 2022" conference in Reggio Calabria in May 2022.

Goal

The aim of the project is to create a user-friendly tool for evaluating green roofs, considering a multiplicity of benefits simultaneously. More specifically, the tool finds its innovation in providing an assessment that touches upon environmental, economic, and social aspects, providing both quantitative and monetary results.

The development toward the desired final tool was also accompanied by other intermediate goals:

- Understanding the current state of the art in green roof evaluation
- Gathering a solid database of indicators and formulas for evaluating green roofs, deriving from existing research

Considering the growing importance of ecosystem services - the benefits that humans can obtain from interacting with the surrounding environment - and their application in the urban context, the final step of the project aimed to apply the tool to a real case study: the Lingotto Building in Turin, understanding the impact of its recently built green roof.

Understanding the problem

The growing awareness about the finite resources on this planet has helped to raise evergrowing attention towards sustainability. In this context, Ecosystem Services have been gradually gaining importance, as they correspond to the benefits that humans can obtain from interacting with the environment. These benefits can be related to many aspects, from food to energy, or even leisure-related activities.
With the growing number of individuals choosing to live in the city, the discussion on Urban Ecosystem Services finds space to develop.
One important strategy for the provision of urban ecosystem services is the greening of cities. Considering that in Italy roofs account for 20-25% of the urban surfaces and 60-70% of the building's envelope (Mohajerani et al., 2017), green roofs can be a significant tool for building more sustainable cities.
Despite green roofs having many benefits, related to a plethora of disciplines - water, energy, air quality, social, etc - many of such benefits remain unknown to important decision-makers who have the power to promote green roofs in the city.
The goals of the GreenTA project and its final tool are therefore structured in fact that the promotion of green roofs can be limited by the lack of design tools helping to understand their positive outcomes (Thuring et al., 2010) and that there is currently a gap in existing tools that can provide such a multidisciplinary assessment.

Image 3: Lingotto building in the past.

Image 4: Lingotto building today.

Exploring the opportunities

Along the development of the project, intermediate deliverables allowed to shape the final tool, aiding in selecting indicators and formulas to be used. An initial case study analysis allowed to understand the main benefits of green roofs, while a stakeholder analysis helped to indicate the primary users of the tool, and some consequent requirements.
One of the most crucial moments in the project development was the writing and publishing of a literature review titled "Green Roof Benefits and Technology Assessment. A Literature Review". This paper not only allowed to have an overview of the current situation of green roof evaluation in literature, but also provided contact with many articles from which indicators and formulas were collected, and later selected to be applied in the tool. The literature review also highlighted two important gaps concearning evaluation tools that this work later aimed to overcome: the lack of tools providing assessments considering many benefits at once, and the challenge of providing a social evaluation.

Generating a solution

The conclusions drawn from the intermediate deliverables, especially the literature review, allowed to establish the main organization of the tool, which provides four main sectors of calculations:

- Outdoor Air Quality
- Water Management
- Energy consumption
- Social

Also from the development of the literature review came the selection of which indicators and formulas would be used in the tool. For this selection, a large table was compiled with calculations provided by the articles read, and the chosen formulas for the tool were selected based on their simplicity of calculation and inputs needed. The image below synthesizes the main benefits that are calculated for each sector.

Benefits evaluated by sector	
Social aspects	Increase of property value after the green roof installation
	Increase of property value due to the panoramic roof
	Recreational value
	Urban agriculture
Outdoor air quality	Air pollutants removed from the air
	Impact on the healthcare system due to improved air quality
Water management	Reduction of stormwater runoff
Energy consumption	Savings in energy used to provide heating and cooling

Image 5: Benefits evaluated by the GreenTA tool.

When opening the tool, the user is guided through four different pages where inputs about his green roof are required. For specific fields where inputs are possibly harder to be obtained by the user, predefined values are given to the user, based on other information previously provided. For example, a pre-defined value of the investment cost is given based on inputs about the green roof area and type (extensive /intensive). In the end, the user receives results both in quantitative and monetary terms.
The development of the tool was done in excel due to its simplicity of use and wide accessibility. After the students divided themselves to work on the four sectors, as described in the "Team description by skill", the team came together to integrate the different parts. The use of macros with basic notions of coding allowed to provide an interface that is clearer and more appealing to the user.
After its completion, the GreenTA tool was tested in a real case study, the Lingotto building in Turin, allowing to draw some conclusions about the benefits brought by this green roof, a recent project in what was once a test track for Fiat cars.

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