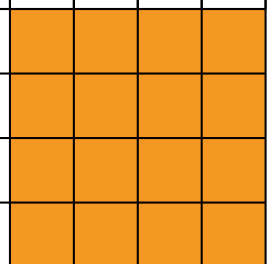
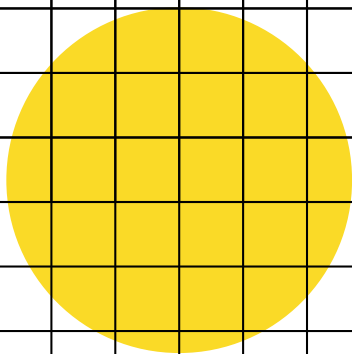
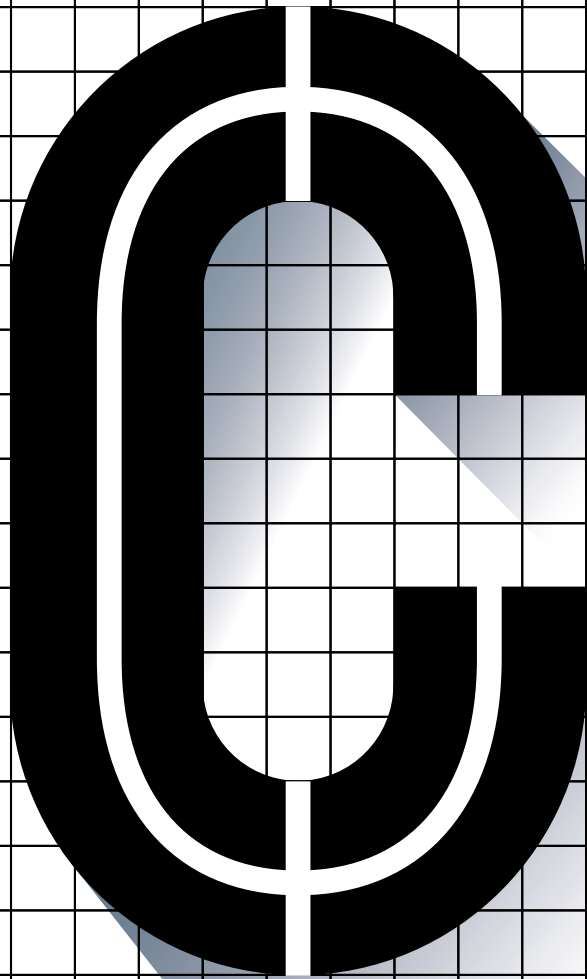
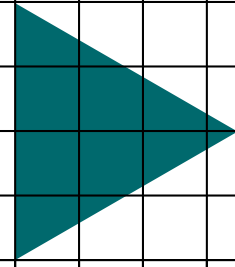


# Concept

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Product Design

# PRODUCT DESIGN AND BIOMIMETICS.

## RESEARCH AND DEVELOPMENT OF A WATER RESOURCE IN HARMONY WITH ARCHITECTURE

Illustration - Psychology - Video Game - Stress - Concept Art

**Abstract.** Building professionals face urgent and complex challenges related to climate change adaptation and biodiversity loss. It is essential to restructure and upgrade cities to promote ecological and social health rather than damage it. The application of biomimetics emerges as a solution where whole ecosystems and their functions are mimicked to significantly improve the ecological performance of buildings and urban environments. It contributes to some of the United Nations global Sustainable Development Goals such as “Goal 6: Ensure availability and sustainable management of water and sanitation for all”; “Goal 11: Make cities inclusive, safe, resilient and sustainable”; “Goal 12: Ensure sustainable consumption and production patterns”; “Goal 13: Take urgent action to combat climate change and its impacts”; and “Goal 15: Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss”.

The aim is to link research with practical development, sharing the hypothesis that in the future buildings and cities can be active contributors in socio-ecological systems, through strategic and technological approaches.

A building has been designed in Granada that integrates with ecosystem services to address water stress and apply regenerative design principles. Extensive research covers the topics mentioned above, as well as important elements for future practical applications. The result is a building with a cyclic rainwater harvesting, purification and reuse system that meets the established objectives. Rainwater and humidity collecting blades are used, taking advantage of the non-potable resource obtained.

**Resumen.** Los profesionales de la construcción se enfrentan a desafíos urgentes y complejos con la adaptación al cambio climático y la pérdida de biodiversidad. Es esencial reestructurar y actualizar las ciudades para promover la salud ecológica y social en lugar de dañarla. La biomimética surge como una solución donde se imitan ecosistemas completos para mejorar de manera significativa el rendimiento ecológico de los edificios y entornos urbanos. Contribuye con algunos de los Objetivos globales de Desarrollo Sostenible de las Naciones Unidas como el “obj. 6: Garantizar la disponibilidad de agua y su gestión sostenible y el saneamiento para todos”; el “obj. 11: lograr que las ciudades sean inclusivas, seguras, resilientes y sostenibles”; el “obj. 12: Garantizar modalidades de consumo y producción sostenibles”; el “obj. 13: Adoptar medidas urgentes para combatir el cambio climático y sus efectos”; y el “obj. 15: Gestionar sosteniblemente los bosques, luchar contra la desertificación, detener e invertir la degradación de las tierras, detener la pérdida de biodiversidad”.

El presente trabajo une la investigación con el desarrollo práctico, compartiendo la hipótesis de que en el futuro los edificios y las ciudades pueden ser contribuyentes activos en los sistemas socioecológicos, mediante enfoques estratégicos y tecnológicos. Para ello se ha diseñado un edificio en Granada que se integra con los servicios ecosistémicos que aborden el estrés hídrico y aplique principios de diseño regenerativo. La investigación exhaustiva abarca los temas mencionados anteriormente, así como elementos importantes para futuras aplicaciones prácticas. El resultado es un edificio con sistema cíclico de captación, depuración y reutilización de agua pluvial, que cumple los objetivos establecidos. Se utilizan aspas recolectoras de agua pluvial y humedad, aprovechando el recurso no potable obtenido.

# 1. INTRODUCTION AND OBJECTIVES

This research paper is based on a project developed from Katharina Hetch's research "Biomimicry for Regenerative Built Environments: Mapping Design Strategies for the Production of Ecosystem Services" (Zari & Hecht, 2020), with her authorization and collaboration. This article investigates the creation of a qualitative relational diagram in an interactive way, relating ecosystem services concepts to design strategies and other information in a format for professional environmental purposes. Its conclusion is the hope that buildings and cities will be active contributors to social-ecological systems, as there is currently a possibility for this at both the technological and strategic levels.

The main objective of this project is to extend and apply the theoretical concepts of his original research in the practical development of a product. The research is divided into two main parts: the theoretical part, which covers various aspects related to the growth of the Spanish population (INE - Spanish Statistical Office, n. d.), the use of water in the city of Granada (Diputación de Granada, n. d.), the canalization of drinking water (Plan of Granada with the main water distribution pipes by

Alvarez de Toledo 1889 | Histocarto, n. d.), regenerative urban design and biomimetics and relevant legislation. In addition, the exploration of materials and innovative elements that are considered relevant for the development of the product and the practical part, where the possible solution to the problem proposed in the document is developed in the field of product design.

As the research has been carried out, several proposals have been designed for the case study, which have been evaluated and discarded until a viable proposal has been found that meets the requirements of regenerative design and is based on the ecosystem services identified in the project on which we are relying.

In order to visualize and place the products of the selected proposal in a spatial context, a scale model showing this element has been created.

Through this research and practical development, we seek to contribute to the field of biomimetics applied to regenerative urban design, focusing on the optimization of water use in the city of Granada. This study provides innovative and sustainable solutions that promote a more efficient use of natural resources and contributes to the improvement of the urban environment and the quality of life of its inhabitants. The solutions proposed as a

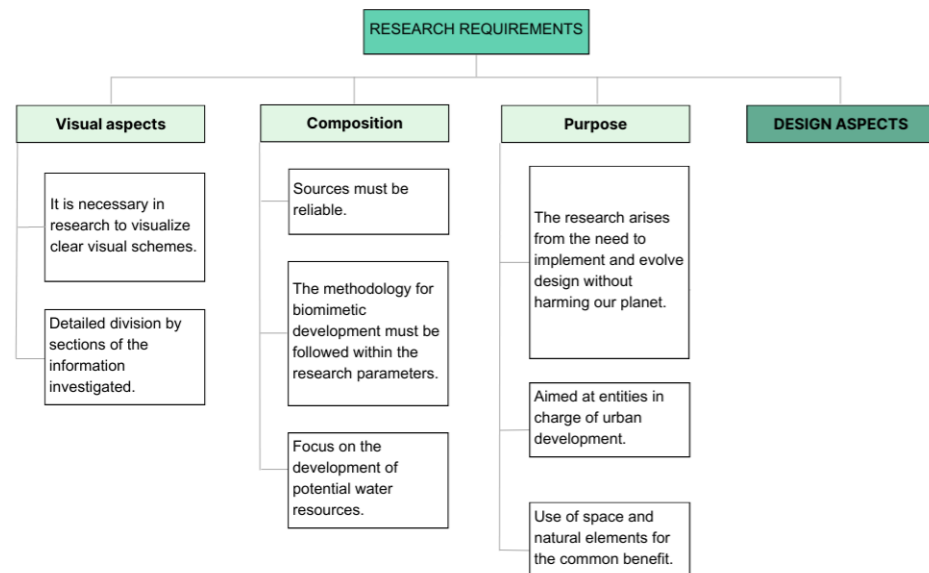


Image 1: Outline of research requirements (own elaboration)

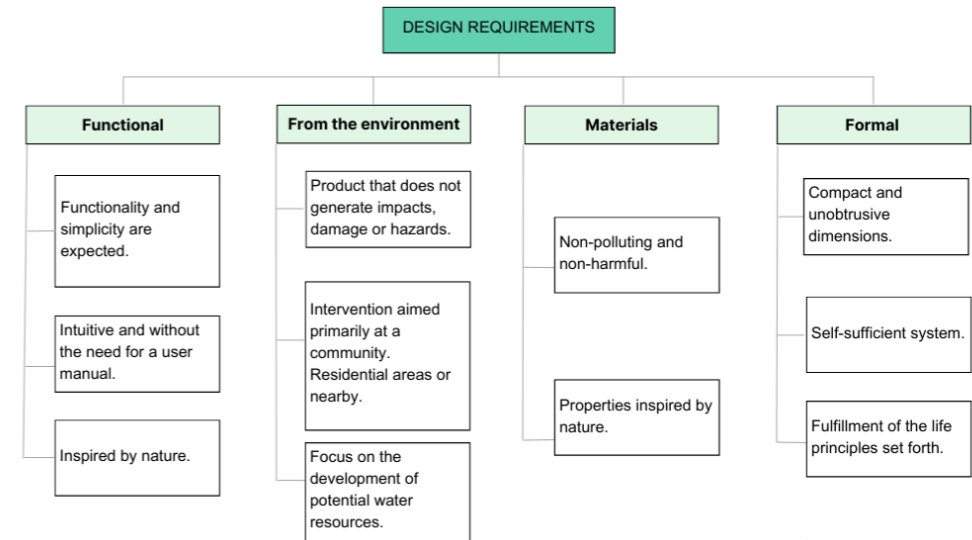


Image 2: Diagram of design requirements, prepared in-house (Own elaboration)

result of the research are graphically summarized in Figure 9.

The main and clear **objectives** of the project are:

1. **To understand** the concept of biomimetics in order to be able to apply the acquired knowledge in the practical development of the project.
2. **To investigate** possible applications of biomimetics in the design of products to develop water resources.
3. **Develop** a water resource that allows architectural improvements favoring the environment.
4. **Execute** a final physical product to demonstrate the viability of our main hypothesis.

Followed by **secondary objectives** such as:

1. **To create** an innovative and sustainable water resource that promotes ecological and social health in the city of Granada.
2. **To develop** water resources based on biomimicry.
3. **Contribute** to the water sustainability of the city, benefiting the environment and improving the quality of life.
4. **To show** the results of the project through a final physical product.

In addition to the objectives, research and design requirements are established that allow us to organize the research in a coherent manner in its different stages. These are shown in Figure 1 and Figure 2.

# 2. HYPOTHESIS

A fundamental hypothesis has been formulated that will guide our exploration and analysis. This hypothesis holds the following:

1. New construction can be active contributors to socio-ecological systems.
- We present secondary hypotheses that complement the main hypothesis:

1. Effective dissemination of the benefits of biomimetics in urban design and visual presentation of the results will increase public awareness of sustainable solutions and encourage them in future projects.
2. The application of biomimetic principles in the development of a water resource integrated into urban architecture will improve water use and promote environmental sustainability in Granada.
3. The review of previous projects with biomimetic applications in the design of water resources will facilitate the development of a water resource in Granada.

Based on these hypotheses, our research focuses on exploring potential advances in regenerative urban design in the city of Granada. This involves the study of possible applications of biomimetics or biomimicry in building facades, taking into account a number of factors, including environmental, ecological, social and structural aspects of the city that will allow us to know the feasibility of the proposal.

### 3. METHODOLOGY

As the theoretical phase of the research is carried out, several design proposals are simultaneously generated in relation to the construction of galleries and canalizations for the handling of non-potable water, which are evaluated and discarded due to their complexity when intervening in the historic center of Granada, until finally a viable proposal is proposed for its development in the field of product design, where the intervention is on the facades of buildings and new buildings. In the latter, the different elements involved in the design have been proposed based on research and corroboration of their performance, as in the case of fog-catching meshes (Pascual, J. A., Naranjo, M. F., Payano, R., & Medrano, O., 2011).

For the development of the theoretical part of the research, different methodologies have been used (Sosa Compeán, Liliana Beatriz (2010)). For the theoretical part, the methodology of the design school Hochschule für Gestaltung, better known as the Ulm, has been used, demonstrating an active search for previous knowledge and relevant approaches. The “Literature Review” technique is used. This technique involves researching and analyzing existing literature related to the topic of study. The decision of this technique is paramount in the research, as it lays the theoretical foundation and provides an in-depth understanding of the topic of study.

Throughout the research we found elements studied with this approach, such as the materials to be used, serving as an example Aquaporin (A selective membrane inspired by aquaporin channels filters and purifies water - Innovation - AskNature, n. d.), climatic values or reference projects such as ‘The Sponge City’ (Lagos et al., 2022).

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Below is a table of the project phases into which the research has been divided and their contents.

#### 3.1. CHRONOGRAM

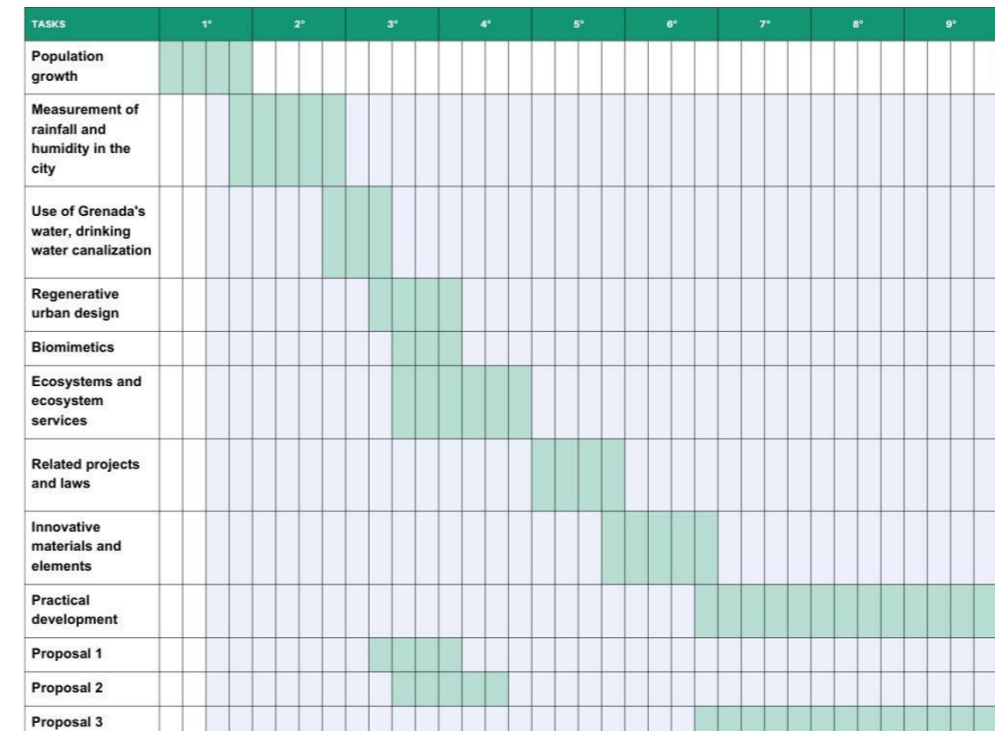
The sections to be investigated have been recorded in a Gantt Chart (Figure 4), organized in order of priority according to their influence on the investigation.

### 4. RESULTS AND/OR CONCLUSIONS

Thanks to the use of the literature review technique, the biomimetic principles have been understood for the practical development of the project and its application in product design. In addition to raising proposals for biomimetic applications in product design for water resources and developing one of them, complying with the established characteristics, identifying opportunities and designing sustainable and innovative solutions. Reflecting the results of this research in a physical prototype. This ful

**Table 1:** phases of the project, prepared by the company. (Own realization)

|                                      |   |
|--------------------------------------|---|
| <b>PART I</b><br>Justification       | - Summary of research and results.<br>- Hypothesis.<br>- State of the art and related works.<br>[Analysis of the specific problem. Specification of the life principles to be covered].                                 |
| <b>PART II</b><br>Objectives         | - Demarcation and specification of the problem.<br>- Project objectives.  |
| <b>PART III</b><br>Methodology       | - Project methodology.<br>- Project development and description.  |
| <b>PART IV</b><br>Development        | - Development of the research.<br>- Practical development of the proposal.<br>- Incidents detected.<br>- Data collection.<br>[Biomimetic applications to products. Brainstorming. Product development with biomimicry]. |
| <b>PART V</b><br>Critical evaluation | - Critical evaluation of product development.<br>- Confirmation or not of the initial hypothesis.<br>- Evaluation of the fulfillment of objectives.<br>- Conclusions and personal assessment.                           |
| <b>PART VI</b><br>Bibliography       | - Bibliography.<br>- Sources of information.  |



**Image 3:** Gantt chart according to priority and order of research. (Own realization)

fills the four primary objectives of the research.

The secondary objectives have also been fulfilled since a clear proposal for an innovative and sustainable water resource based on biomimetics has been reached, applied mainly on the facades of buildings in the city of Granada, promoting ecological and social health and contributing to the water sustainability of the city. Showing these results through the physical prototype and facilitating the understanding of the proposal.

Through this information, we can ensure that the approach for new constructions can be active contributors to the socio-ecological systems, considering the results of the research for its development, such as: the ecosystem in which to intervene, suitable materials that meet the established characteristics, aesthetics and structure of the current buildings of the city in question or the climatic values of the area.

The main data of interest obtained for the realization of the project have been: -Obtaining the humidity and amount of annual rainwater in the city of Granada. -Similar projects or projects with a shared purpose and objectives.

- -Situation of the levels of ecological design (Wahl, 2018).
- -Biomimetic applications (The Top 10 real world Examples of Biomimicry in architecture, n. d.).

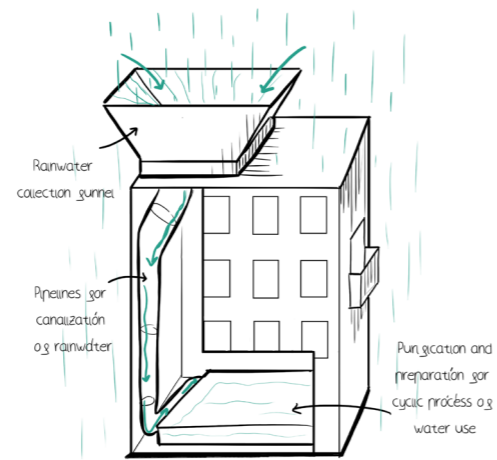
Images of the final project proposal will be shown through the initial sketches (Figure 4),

the approach to the operation of the blades (Figure 5 and 6) and the scale model (Figure 7), a positive result of the practical implementation of the theoretical research.

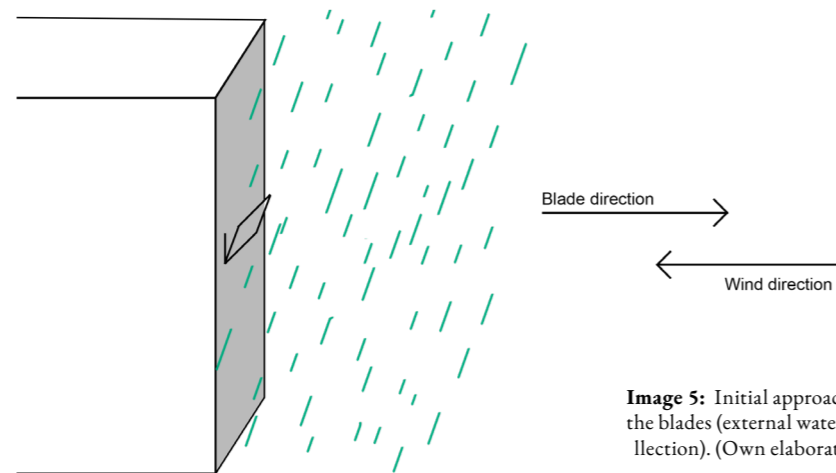
The following figure concisely presents the proposed elements of regenerative building design research, accompanied by a brief explanation of how they work:

**PERSONAL APPRAISAL**

The project has been carried out correctly but, in spite of the effort to complete the research until practically its total closure, new lines of

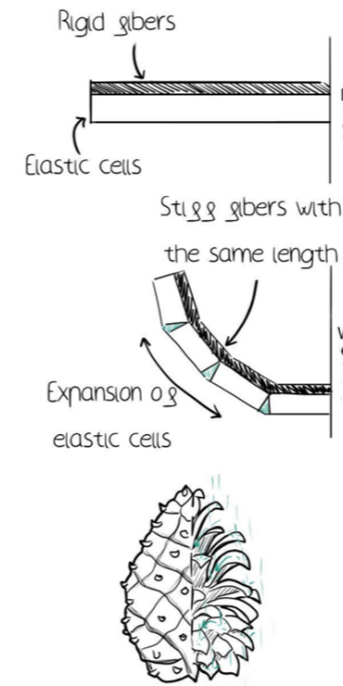


**Image 4:** Initial approach to the operation of the building. Rainwater and humidity collection by means of an "X" element. (Own elaboration)

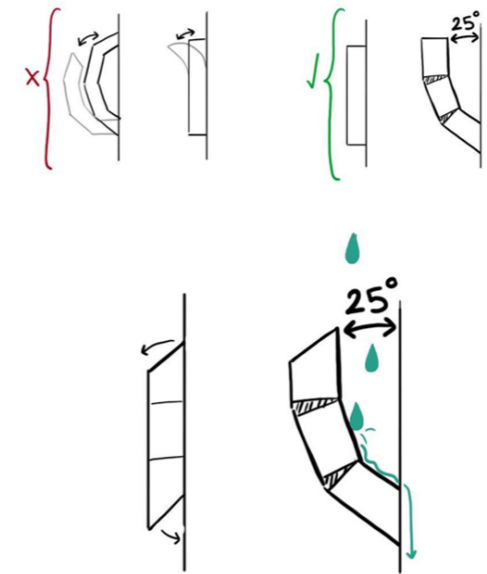


**Image 5:** Initial approach to the blades (external water collection). (Own elaboration)

**Operation of the pineapples**



**Initial product ratings**

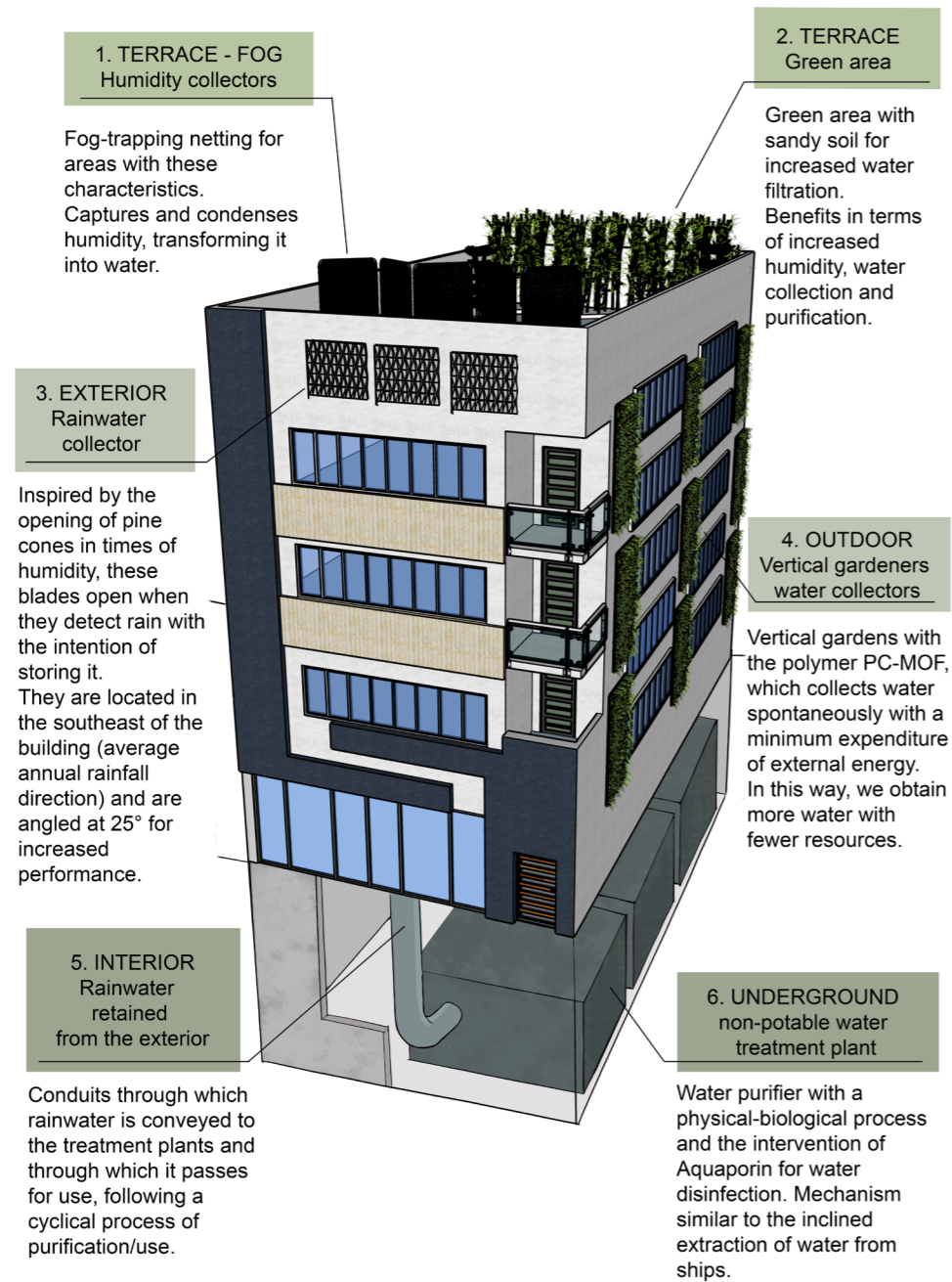


**Image 6:** Position of the blades with respect to the direction of the average annual rainfall. (Own elaboration)



**Image 7:** Image of the general view of the building with the blades (on the left). Scale model. (Own elaboration)

research have been left open on different topics that should be continued in the future to complete the functions proposed for new urban buildings:



**Image 8:** Elements of regenerative building and functions. (Own elaboration)

- Different types of vegetation in the green areas of the building according to the situation of the building.
- Continue with the formal development of the rainwater purifiers using Aquaporin Inside's product (aquaporin) and of the rainwater collecting blades on the facades. -To know the status of the development of the mixed polymer-MOF matrix (PC-MOF) in order to further develop its application in vertical gardens and, if the research is successful, to proceed to its testing (Yilmaz et al., 2020).
- As for the architectural branch, to develop the ideal distribution of the water conduits obtained from the exterior.

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