HYDROMIXT

The Solution!

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Entry to the Stockholm Junior Water Prize 2026:

“Design and Development of an Efficient Irrigation System for Urban Gardens: Economic and Feasibility Study”

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PRELIMINARY MATTERS

Short bios of participants

Laura Pont: I'm a student at the Carles Vallbona Institute in Granollers, currently in the first year of the Science A-Level programme. Responsible for the scientific and technological aspects of the project. I consider myself to be an ambitious, dedicated and friendly person.

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The project was carried out collaboratively, each member working within their respective areas of expertise, with guidance from our supervisor; in many cases, it involved self-directed learning. AI tools were used to address Arduino programming errors during the creation of the *HydroMixt* application.

Abstract

Peripheral agricultural areas face two major pressures: industrial and urban. Palou (Granollers, Barcelona) is no exception. Similarly, many areas suffer or have suffered irrigation restrictions due to drought, impacting crops. These two variables, physical space and water scarcity, were the main reasons for the *HydroMixt* project. Designed through an interdisciplinary approach, a system has been created that combines two types of irrigation (drip irrigation in solid substrate and hydroponics) with potential savings in space, water consumption, and energy (it can be powered by a battery and solar panel). All of this is regulated by sensors and a dedicated app. Given the need for a viable product, the aim is for it to adhere to the circular economy model, be autonomous and easy to assemble, and feature a modular structure with 3D-printed parts so that users are not required to purchase the entire product, thus extending its lifespan. Various socioeconomic variables have been studied to ultimately determine its viability.
It is currently a functional prototype. In a meeting with local and regional businesses, farmers from the study area, and the Granollers City Council, interest in the proposal was confirmed. This interest does not preclude its implementation, primarily focused on small urban gardens and/or greenhouses. The complete project can be accessed through the *HydroMixt* website (QR#8).
Keywords: HydroMixt, sustainability, circular economy, irrigation, innovation, agriculture.

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List of abbreviations and acronyms used in the report

No list of abbreviations is required, as all technical terms and acronyms are explained within the text.

Acknowledgments

Throughout this work, we would like to thank the various institutions and individuals who have collaborated in many ways on its completion. First and foremost, we thank our supervisor, Ivan Nadal, for his unwavering support throughout the years the project has been underway. We also thank Aaron and Sara for their contributions to the project during the 2024/25 academic year. We thank the Business and Entrepreneurship Service of the Granollers City Council for listening to us and providing advice for its improvement. We also thank all the business community members who listened to us at the Vallbona-Empresa Conference and who expressed interest in the project and with whom we will be in contact soon, as previously agreed. Finally, we thank our families for their patience and support over these three years of work, through ups and downs, doubts, and unwavering convictions about its continuation. Thank you all very much.

THE WRITTEN PROJECT

1. Introduction

To what extent do the people surveyed have sufficient knowledge of the subject matter of this work, that is, of climate issues and hydroponic irrigation? Which plant is best suited for this type of hydroponic cultivation? Can the construction of the planned system save water and space? Which nutrients will be best for the plants in the hydroponic system? To what extent can a project originating in a school expand and be implemented? Hydroponics itself, in the context of soilless agriculture, is a method for growing plants using mineral solutions. A hybrid hydroponic system incorporates a traditional crop, from which leachate is collected and pumped through the hydroponic system, creating a closed loop.

According to Resh (1998), efficient agricultural systems have a high cost, making economic viability difficult. In response to this, the option of hydroponics, modern for its time, is presented, and its advantages and disadvantages compared to traditional cultivation are explained ([1]). Cuevas (2021) indicates that new cultivation methods are being invented every day, gradually replacing traditional agriculture, but the most effective to date is hydroponics. He states that it offers benefits both in terms of water conservation and harvesting, since the nutrients added to the water promote plant growth ([2]). Carmona (2022) indicates that the demand for food will continue to increase due to overpopulation; therefore, he poses the challenge of producing more resources sustainably using less space. His solution is hydroponics, a soilless system already being implemented in Africa and Asia ([3]). Finally, Ibujés and Alcibar (2023) explain that hydroponics is a viable system for urban life, beneficial for saving space ([4]).

In a second context, all economic processes have been carried out since the completion of the prototype design presented in this work. The aspects most considered were packaging, cost, advertising, contact with potentially interested parties and entities, as well as distribution and sales. According to the Emprendedores.es website, in a 2017 article ([5]), when creating a new product, such as ours, a series of potential pitfalls must be taken into account. This necessitates a rethink focused on strategic reorganization. According to the report on packaging industry trends in 2026 published by Barcelona Packaging Hub([6]), product

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[1] Resch, H.M. (2002). **Los cultivos hidropónicos**: https://www.scribd.com/document/427473674/Cultivos-Hidroponicos-Resh-HM-Libro-en-espanol-pdf

[2] Cuevas (2021). **Diseño y construcción de un sistema hidropónico Nutrient Film Technique; como alternativa sustentable de cultivo, producción y consumo de hortalizas, para el beneficio de los habitantes del Islote Pardito en Baja California Sur:** https://posgrado.lapaz.tecnm.mx/uploads/archivos/TESIS_CARLOS_EMMANUEL_CUEVAS_CASTILLO_MPEDR.pdf

[3] Carmona, J. (2022). **Mejora en la producción y calidad de lechuga mediante la optimización de las condiciones de cultivo en sistemas hidropónicos bajo invernadero**: https://digitum.um.es/digitum/handle/10201/122274

[4] Alcivar, T.A. & Ibujés, N.T. (2023) **Desarrollo de un sistema hidropónico mecanizado para zonas urbanas**: https://dspace.ups.edu.ec/bitstream/123456789/25781/1/UPS-GT004506.pdf

[5] Emprendedores.es (2017). **Si cometes estos errores, el lanzamiento de tu producto será un fracaso seguro**: https://emprendedores.es/gestion/crear-una-empresa/hundir-lanzamiento-producto-errores/

[6] Barcelona Packaging Hub (2026). **Tendencias clave que marcarán el sector del packaging en 2026**: https://barcelona-packaging-hub.com/tendencias-sector-packaging-2026/

packaging has ceased to be a simple protective element and has become a fundamental component that influences competitiveness, production efficiency, and regulatory compliance. Launching a new product involves planning and managing the costs associated with all its stages, from initial concept to commercialization. According to the Catalonian Open University (2023) ([7]), a product launch plan must consider the costs of development, design, production, distribution, marketing, and sales, ensuring an accurate financial estimate that guarantees the project's economic viability. Based on information from the report by the Ministry of Agriculture, Fisheries, and Food, published in 2023 ([8]), several key elements stand out as relevant for planning the marketing of agricultural products. These include appropriate distribution channels, logistical optimization, and the importance of quality and sustainability criteria in the transport process, among others.

The motivation that has led to the realization of this project lies in the importance of concern for climate problems. These include drought and the search for a solution applied to small spaces or with different limitations, such as water and space savings.

The project integrates geography, botany, technology, economics and citizenship education to address water scarcity and land-use pressures through a sustainable agricultural solution.

2. Background

The project itself originated two years ago (2022-2023 academic year) when, as part of the Research course in the second year of Secondary Education, Laura and two classmates designed a mixed cultivation system to explain the influence of nutrients in different types of substrate when introduced into a hydroponic system. The project was selected for E*xporecerca Jove*, one of the most nationally prominent young researchers' fairs. It was subsequently put on hold, although with the intention of continuing it in the future.

Two years later (2024-2025), the project was revived in the Research course (4th year of Secondary Education) with the addition of two students from the Commercial Activities with a Logistics Profile course within the Commerce and Marketing vocational training program (Aaron and Sara). This is facilitating greater interdisciplinarity in the work and its integration into the socioeconomic sphere. The center's commitment to cross-disciplinary projects has also enabled this step.

This year (2025-26), now in her first year of Baccalaureate, Laura continues with the science and technology track, while a new student, Alba (Vocational Training in Commercial Activities), has joined the socioeconomic track since Aaron and Sara left the institute.

[7] UOC (2023). **Plan de lanzamiento de productos nuevos II**: https://fp.uoc.fje.edu/es/estudios/blog-fp/plan-de-lanzamiento-de-productos-nuevos-ii
[8] Ministerio de Agricultura, Pesca y Alimentación (2023). **Distribución agroalimentaria**: https://www.mapa.gob.es/es/alimentacion/temas/consumo-tendencias/distribucion-agroalimentaria

On the other hand, the project has already been presented twice during its development. A meeting was held last July 2024 with the Business and Entrepreneurship Service of the Granollers City Council, where the idea was presented. It was well received and provided an impetus for its continuation. Similarly, at the 2nd Vallbona-Business Conference held at our institute last February 2025, we had the opportunity to briefly present it to businesspeople (**fig. 1**), also receiving a favorable reception, with some people even expressing interest. It was agreed that we would remain in contact once the system was completed. Finally, in March 2026, two meetings were held, one again with the Servei d'Empresa i Emprenedoria (**fig. 2**) and another with a farming family from the studied area (**fig. 3**, Palou, Granollers), with the aim of setting the future lines of the project.

3. Hypothesis and goals

3.1. General and specific hypotheses

Palou is an agricultural area on the outskirts of Granollers that is under considerable pressure from both an industrial and urban perspective. This necessitates a new approach to land use to prevent loss of biodiversity and crop productivity, enabling farmers to maintain their economic viability.

Therefore, the following hypotheses are proposed: implementing a combined drip irrigation and hydroponics system could save water; its two-story construction would maintain productivity and save space. Although this system might be more expensive than traditional drip irrigation, it could be viable in the long term and implemented in areas like the one studied.

Similarly, for each of the general objectives, the hypotheses are briefly explained (**CT** → Scientific and Technological studies; **SE** → Social and Economic studies):

CT: the surveyed individuals would have some interest in the proposal, given their awareness of issues related to water conservation and climate change. Studying the Palou area (land use, crops, etc.) would help design a more efficient system based on the observed needs. Ultimately, technology would facilitate the use and viability of the proposed system.

SE: Creating a high-quality, recyclable, and practical product would not only help people be more efficient but would also reduce costs by extending its lifespan through replaceable and customizable 3D-printed parts. Furthermore, it would promote sustainable consumption habits, encourage creativity in product use, and could generate economic and social benefits by collaborating with local producers, contributing to a more responsible and environmentally conscious community.

3.2. General and specific Goals

Regarding the proposed hypotheses, there is a dual ultimate goal. Firstly, to design and build a two-story hybrid drip irrigation and hydroponic system that saves water and cultivation space.

Secondly, to develop a business model that ensures the system's viability and appeal to potential users, based on the principles of the circular economy.

However, there are several specific objectives that complement the general ones, related to previous studies within the two main areas:

CT: First, to analyze the potential interest in the proposed system through a sociological study. Secondly, to understand the Palou area as an agricultural zone of interest, considering the dual pressures it faces (urban and industrial), to study its crops, to create fact sheets on some garden plants, and to assess their suitability for the proposed system. As a complement to this, to analyze nutrient leaching and the energy and water savings in the different operating cycles. Finally, to compare the yields of both crops by studying the products obtained.

SE: focuses on the design and creation of a practical, durable, and eco-friendly product that can be used in real life. The aim is for it to be easy to repair or customize through 3D design, promoting more responsible consumption and helping users save money. Furthermore, the goal is to minimize packaging, using recyclable materials to reduce waste and, whenever possible, support the community and local producers.

4. Methodological process

4.1. Materials

E01. Geographic: Bibliographic sources, *Google Maps*, *Google Slides*, and *GeoGebra*.

E02. Botanical and horticultural: Bibliographic sources and *Google Slides*.

E03. The prototype: Divided into the mechanical and electronic components. *Arduino IDE* web environment. The complete list of materials used, with their cost, can be found at **Table 1**.

E04: Measuring tape, *TinkerCad* to design modules, printing material (PLA), and a 3D printer.

E05: Bibliographic sources and *Google Drive*.

E06: Cardboard boxes, paint, adhesives, various office supplies, and a printer. *Flipbook Widget* web environment for presenting the instruction manual.

E07: Bibliographic sources and *Google Slides*.

4.2. Methodology

4.2.1. The project from a Scientific and Technological Perspective

E01. Geographic (fig. 4): The current land use in the Palou area (Granollers) was analyzed using aerial photographs. *Google Maps* was used to define the area. Subsequently, using *GeoGebra Classic*, the areas of the orthophotomaps consulted on by the Catalonian Cartographic Institute (from the 1970s to now) were defined, and the agricultural area of each was measured (1975 to 2025). To confirm the data, the land use map of the Department of Agriculture, Livestock, Fisheries and Food of the Government of Catalonia was consulted ([9]).

[9] Generalitat de Catalunya (2025). **Departament d'Agricultura, Ramaderia, Pesca i Alimentació. Bases cartogràfiques d'usos i cobertes del sòl**: https://agricultura.gencat.cat/ca/serveis/cartografia-sig//usos-sol/index.html

Urban and industrial uses present in the area, as well as infrastructure, were taken into account. Finally, a spreadsheet was created with the percentage values for each of these.

E02. Botanical and horticultural (fig. 5): To identify the horticultural plants in the Palou area, information was gathered from the websites of the Vallès Oriental Delegation of the Catalan Chamber of Commerce ([10]) and the Granollers City Council ([11]). Individuals with ties to the area were also contacted. Subsequently, double-sided fact sheets were created, including information such as common and scientific names, external descriptions, cultivation requirements, and other relevant details.

E03. The prototype: This is the central study and ultimate goal of the project. The proposed system, available in two models (non-modular and modular), features a vertical layout and combines traditional cultivation at its base with a double hydroponic level (expandable in the modular version). For the design of the non-modular structural part (**figs. 6 and 7**), a series of PVC pipes, 3 cm in diameter and 40 cm long, were used to construct the four vertical supports, divided into two tiers, and four transverse supports that connected the vertical elements to six other elements, 4 cm in diameter and 80 cm long, which held the hydroponic plants, each with its corresponding 5 cm diameter drainage holes (six per element). Once assembled, the other two elements of the system were constructed. First, a leachate collection tank, consisting of a transparent plastic container, and second, two 80 cm long planters for soil cultivation. Finally, a drip irrigation system was added, consisting of two parallel 6 mm diameter pipes, one for each planter. This is connected via elbows to a T-fitting (Ø6 mm) which, in turn, connects to a solenoid valve (¾″ threaded adapter to Ø6 mm) and, finally, to the main water inlet (laboratory tap with a ¾″ threaded adapter to a Ø15 mm garden hose). To separate the two planters, a U-shaped channel was constructed using three PVC rods (two L-shaped, attached to the planters and, in turn, to a central U-shaped rod), which, in reality, would represent a trench separating the two rows of plants.

The electronics consist of various components controlled by an *ESP32 DevKi*t board (ESP-WROOM-329) mounted on an *Arduino Screw Shield V2*. These include six *YL-69* relative humidity (RH%) sensors with an *HC-38 Arduino* module embedded in the ground and protected by 3D-printed covers, as well as two additional sensors (*XKC Y25 NPN*, 5-12V) mounted on the side wall of the tank to monitor the maximum and minimum water levels. A submersible water pump and a solenoid valve (**figs. 8-10**) have also been added to control the water inlet, both operating at 12V. The entire assembly is housed in a lockable metal enclosure (**fig. 11**) that can be opened with a key. A Wi-Fi sensor has also been included to connect the board to a web application. The current power supply is electrical (a relay has been added to

[10] Cambra de Comerç (2025). **Delegació al Vallès Oriental**: https://www.granollers.cat/promo-eco/cambra-comerc-VO

[11] Ajuntament de Granollers (2025). **Productes de Palou**. https://wp.granollers.cat/productesdepalou/

the *ESP32*'s power supply to allow it to control 12V loads), but it has been adapted for possible use with a solar-powered primary source (**fig. 12**). This source consists of a 40 cm x 40 cm panel which, using a *Steca* solar charge controller (*AKATEK* brand), stores energy in a battery that powers the entire system (this battery is not included due to its cost and maintenance).

The web application was programmed in the *Arduino IDE* environment (**fig. 13**). It pairs via internal Wi-Fi (its own IP address, without needing an internet connection) to the Wi-Fi module integrated into the board. The application was programmed in HTML, taking full advantage of the sensors' capabilities. To facilitate understanding of the program, it has been divided into a series of steps: 1. The *ESP32* creates a WiFi network *Hidromixt*. 2. The user connects with their mobile phone or computer. 3. They open the control website. 4. The website requests data every second. 5. The *ESP32* reads sensor data. 6. It calculates the average humidity. 7. It decides whether to activate the pump (only in auto mode). 8. It displays the information in the web app.

Finally, with the prototype working, two varieties of lettuce ("marvel" and "long") were planted, and their growth was monitored two to three times a week.

E04. Spare Parts: This study arose in response to a question that emerged during the development of the first prototype, aiming to address material shortages, wear and tear, or breakage, and to transform it into a fully modular system. To achieve this, all the parts (hydroponic system, planter, and leachate tank) were designed using *TinkerCad*, based on measurements taken from the non-modular model (**fig. 14**). These files were exported in .STL format to the 3D printing software *Creality Print* (**fig. 15**) and finally printed using a *Creality K1 Max* 3D printer with PLA (**fig. 16**). The printed files were then uploaded to a public *Google Drive* folder for easy access.

4.2.2. The Project from a Social and Economic Perspective

E05. Market Analysis: To carry out this work, we had to study the sector to which we intend to apply our product, analyzing the current state of sustainable agriculture and the problem of drought in Catalonia (2023-24). We also conducted research on the SDGs: SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action) to ensure that the project was aligned with current environmental challenges.

E06. Packaging Design: To ensure the product was transported safely and in good condition, we had to precisely measure all the components to adjust the packaging material (**fig. 17**). We then created a sketch with all the measurements (**fig. 18**) to develop a realistic concept and apply it to the final design. Subsequently, we assembled and decorated it according to the product's corporate image (**fig. 19**), as it not only serves as transport and protection but also allows us to reflect our business concept.

E07. Commercial Viability and Strategic Partnerships: To conduct the feasibility study, we analyzed all the necessary costs (**fig. 20**) to launch the project, such as materials, salaries, storage, and transport, with the aim of calculating its profitability. We also defined a pricing strategy adapted to the market and studied potential revenue streams (**fig. 21**), including different product models, as well as possible public aid or subsidies. Finally, we prepared an analysis of the main competitors in the sector (**fig. 22**), which allowed us to identify their characteristics, their market positioning, and the elements that differentiate our project.

5. Results

5.1. The Project from a Scientific and Technological Perspective

E01. Geographic: In the Palou area, a decrease in cultivated land can be observed over the 50 years studied (1975-2025) and in 10-year intervals, amounting to 6.85%, as shown in the sequence (**fig. 23**) obtained from the Institut Cartogràfic de Catalunya viewer. According to this land use data, the lost land is currently being used for housing and infrastructure. Small industries have also been established in recent years, but their landscape impact is minor. Furthermore, the Palou information sheet (**figs. 24 and 25**) includes a description of the area, a representative image, and its boundaries. Finally, the main crops have been identified, separated into cereals (wheat), vegetables (especially lettuce and tomatoes), and fruit trees (primarily peaches and pears).

E02. Botanical and Horticultural (figs. 26 and 27): A total of four fact sheets have been created on the most characteristic horticultural plants of the Palou area, specifically, radish, cabbage, lettuce, and artichoke. Each fact sheet includes the plant's name, a photograph, botanical information, and cultivation characteristics. Their initial objective is purely informational and to provide knowledge of plants that could potentially be used in the designed prototype. Therefore, their number and content may change as the project evolves.

E03. The prototype: aims to fulfill two objectives based on the climatic conditions of the Palou area in 2023 and 2024 (water conservation and efficient use of agricultural land). The circular operation would be as follows (**link**; *see QR#1 in the image appendix*): the main water intake could come from a reclaimed water pipeline near the Palou area (with a pending project for this area) or, as tested in the laboratory, from one of the general water taps (which is the one explained here as a model).

First, the water passes through a solenoid valve to the drip irrigation system of the soil-based crop. This valve closes when the water level in the leachate tank is between a minimum and maximum value (controlled by water level sensors; **fig. 28**), and opens when the level falls below this minimum.

Once the soil is saturated (the relative humidity is monitored by six sensors; **fig. 29**), the water percolates through the tank and, after filtration (in the prototype, fragments of mosquito netting placed in holes at the base of the planters), reaches the leachate tank. This nutrient-rich water is then pumped by a pump located in the tank to the second level of the hydroponic system. Finally, by gravity, once the hydroponic system is full, the water returns to the leachate tank, and the cycle begins again. The water would be consumed, the whole system being autonomous, until it reached the minimum level, where the solenoid valve would open again (automatic mode), allowing water to enter again from the main inlet system, starting the cycle again.

It could operate (**PDF**; *see QR#2 in the image appendix*) using electricity or solar power. Currently, the prototype is designed to run on electricity, as using solar power via a photovoltaic panel and battery would require the battery to be kept minimally charged at all times to prevent damage.

The electronic assembly (**fig. 30**) is protected in a lockable metal box, to which the sensors are connected (**fig. 31**). Inside, the following components are found (**fig. 32**):

Left: Steca (KATEK brand), a solar charge controller, which receives energy from a solar panel, charges a battery, and manages the output to the load.

Right: *ESP32 DevKit* microcontroller, mounted on an *Arduino Screw Shield V2*, which controls the entire system based on the programmed code.

Top center: Relay module, which allows the *ESP32* to control 12V loads. It activates the submersible pump, the solenoid valve, and the microcontroller.

Other: green spiral terminals to facilitate connections and *Wago* connectors to distribute power and make branches.

The system can be controlled directly, in manual or automatic mode and without a SIM card, from any computer or mobile device thanks to the *HydroMixt* web app programmed with a Wi-Fi connection (**figs. 33 and 34**). It was developed using HTML (web) programming in an Arduino environment (**PDF**; *see QR#3 in the image appendix*). From top to bottom, the following information can be viewed:

The Relative Humidity (RH%) percentage from each of the six sensors, as well as their arithmetic mean, is displayed as a horizontal bar. Based on these values, the user can define the Threshold Humidity (TH%) for each plant. If the value of each sensor is below this TH%, in automatic mode, the solenoid valve and pump are automatically activated to start the circuit and irrigate both the soil and hydroponic plants. If the value is above this TH%, in the same mode, it means the system has the appropriate (or minimum) RH%, keeping the circuit closed and thus saving water. In MAN MODE, the user directly opens the solenoid valve and pump.

The water level in the leachate tank is monitored by two level sensors (MIN / MAX) that define 3 states: empty (red; below MIN), half full (yellow, between MIN / MAX), and full (green; above MAX). In AUTO MODE, the system opens when empty; in MAN MODE, the user opens it.

Finally, there are ON/OFF buttons for the solenoid valve and pump, as well as a MAN/AUTO MODE button.

In the first phase (February-June, 2025), before the current electronic setup with sensors was installed, an initial planting of the "*Maravilla*" lettuce variety was carried out, and a first water consumption trial was conducted using manual irrigation (**fig. 35**). The average results indicated that for an average of 2 L of water used to irrigate the soil portion of the crop, the average return was 1.75 L when the soil was fully saturated.

Currently (April-June 2026), with the electronic system now operational, preliminary results (12 measurements collected between April and early June 2026) suggest that lettuce grown in substrate reached maximum heights approximately 1.7–2 times greater than those observed in the hydroponic section, with maximum heights of 27.44 cm and 15.95 cm, respectively. On the other hand, there is a moderate negative association between lettuce growth in substrate and the substrate's relative humidity (%RH) (Pearson: $r=-0.477$) (**fig. 36**). Finally, the association between growth and water consumption in the leachate tank (**fig. 37**) is positive but weak, with no significant differences between the two cultivation methods, substrate *vs*. hydroponics (Pearson: $r=0.355$ and $r=0.354$, respectively).

E04. Spare Parts: All the parts that make up the hydroponic system have been designed in *TinkerCad* (**fig. 38**) and 3D printed (**fig. 39**) so that those interested in the system can always have spare parts (assuming that 3D printers are widely available) in case of breakage or wear, making it a modular system. The complete set of files can be downloaded in .stl format (printing standard) from the link (**PDF**; *see QR#4 in the image appendix*).

5.2. The project from a Social and Economic Perspective

The proposed and complete context in the socio-economic field can be consulted in the document (**PDF**; *see QR#5 in the image appendix*) produced over these two years.

E05. Market Analysis: The study has shown a greater need for more sustainable and effective cultivation systems (**fig. 40**) due to drought and a lack of arable land. This analysis has allowed us to define the main potential clients, such as local farmers, public administrations, and individuals interested in ecological solutions. Furthermore, studying the competition has revealed that while hydroponic systems are still available on the market, few combine soil cultivation with hydroponics. This presents an opportunity to differentiate the project.

E06. Packaging design: The product is inside a box. Internally, the components are organized modularly with more compact boxes that have inside the different 3D-printed parts of the hydroponic system (**fig. 41**), as well as the electronic system. Likewise, the tank and the two planters have been placed vertically (**unboxing**; *see QR#6 in the image appendix*). Externally, it is painted white, for better design capacity, with the product logo, two blue horizontal borders, as well as four holes with gripping systems and 8 for fixing the lid, recycled from the original product that had the two boxes used (**fig. 42**). Likewise, a user manual is included (**triptych**; *see QR#7 in the image appendix*) that can be consulted.

E07. Commercial Viability and Strategic Partnerships: The study revealed that the project has potential for application in the local agricultural environment. The feasibility plan (**fig. 43**) shows that *HydroMixt* offers a mixed cultivation system designed for farmers in the Palou area, with the aim of saving water and optimizing cultivation space. Furthermore, although the business may raise concerns in the first years of implementation, the projected balance of assets and liabilities aims to balance income and expenses to facilitate this viability (**fig. 44**). The various interviews conducted (**fig. 45**) indicate that its use could be viable for small urban gardens or greenhouses, while it would be less viable in open fields or large agricultural areas.

6. Conclusions

Although initially designed for small spaces (private gardens), the proposal explained in this report facilitates the efficient use of irrigation water and cultivation space, especially in areas with greater urban development pressure. The results suggest that it could also be a valid system for larger cultivation areas, such as community gardens with a supply of treated or reclaimed water.

A project has been conceived from scratch, with a clear interdisciplinary approach, based on an idea informed by the opinions and knowledge of various individuals. It optimizes water use thanks to different sensors and the application of technology in its operation. Likewise, the entire process, from product development to public sale, including costs, company creation, viability, advertising, and packaging, has been addressed and presented on a **website** (*QR#8 in the image appendix*). Even so, the experimental results obtained, while interesting, do not clearly establish a relationship between some parameters that define lettuce growth, as the values of the coefficients of determination (r^2) obtained do not clearly explain the relationships between the variables studied. The correlation analyses show, therefore, that neither soil moisture nor water consumption alone explains growth.

Results indicate that *HydroMixt* may reduce water demand while increasing productive use of limited cultivation space. The modular design, sensor-based control system and circular economy approach support its potential application in urban gardens and small greenhouses. Furthermore, its alignment with SDGs 11, 12, 13, and 17 could open doors to European funding opportunities such as *Horizon Europe*, among others. Even so, the project also contributes indirectly to SDG 6 (Clean Water and Sanitation), particularly through improved water-use efficiency. For its implementation, several expenses must be considered, such as construction materials, installation and labor, operational costs, and finally, administrative costs and permits.

Final Conclusion and Future Proposals

Many obstacles and improvements remain to be made in a project that began at a time when water conservation was a fundamental need and with an agricultural area in mind that, although known for the quality of its products, is increasingly under human pressure. The aim is to contribute to the social, technological and business improvement of society.

Some of the improvements are listed below (CT: Scientific-Technological field; SE: Socio-economic field):

Underway:

CT1: The experimental testing period is to be extended, as the system has only been evaluated for one month so far.

CT2: Water consumption is being quantified based on volume measurements, considering the tank as a prism. Evaporation has not been taken into account since it could not be measured.

CT3: The growing container (currently the two planters) and the leachate collection tank are being designed in 3D to be modular. These will be added to the existing .stl files. Furthermore, they will be stacked one on top of the other, without gaps (**fig. 46**): this reduces water evaporation and prevents mosquitoes. Printing will be done with PETG, which is more resistant and suitable for use with water and soil.

SE1: A more realistic and detailed economic analysis is being developed to assess the project's commercial viability.

SE2: The product's differentiating values compared to existing products are being classified and detailed.

SE3: Contacts have been made with companies in the water and irrigation industry (AGBAR, IRTA, Riegos Iberia, Fluidra, etc.), and meetings have been scheduled to evaluate the project and its feasibility.

Coming soon:

CT1: Analyze the water in the leachate tank, as this could become a problem, especially due to the accumulation of toxic substances. Therefore, the aim is to study control mechanisms, purge systems, and establish maximum usage times. New sensors could be added.

CT2: More precisely quantify the water savings obtained compared to other cultivation systems.

CT4: Measure the luminosity of the different areas of the prototype, as the lower part of the system may receive less sunlight. This could be presented s an added value of the product, since it could be used to cultivate species that require less light than others in that area.

CT5: The aim is to increase the efficiency of the irrigation circuit by adding a new solenoid valve and a non-return valve to separate the water that returns to the leachate storage tank from the drip irrigation system (**fig. 47A/B**).

CT6: Analyze some basic nutrients for plant growth, both in the substrate and in the leachate, to best adapt to the type of plant to be cultivated.

SE1: Incorporate estimates on costs, potential benefits, and market positioning. How much can be earned with each? How many units need to be sold to generate a profit?

SE3: With the help of professionals, an attempt will be made to define the approximate size of the usable areas, in square meters or hectares, where the product can be applied, as well as the cost and the economic benefit that would be generated (area/cost/benefit ratio).

7. Biography and Webgraphy

Given the pagination limitations of this project, the complete bibliography used for its preparation (including citations and supplementary sources) can be found in the following **document** (PDF). The bibliography used in this report was:

(4) Alcivar, T. & Ibujés, N. (2023). **Development of a mechanized hydroponic system for urban areas.** Salesian Polytechnic University, Ecuador [Accessed October 22, 2024]. Electronic document available at: https://dspace.ups.edu.ec/bitstream/1/UPS-GT004506.pdf

(6) Barcelona Packaging Hub (2026). **Key trends that will shape the packaging sector in 2026** [Accessed October 23, 2025] Available at: https://barcelona-packaging-hub.com/tendencias-sector-packaging-2026/

(10) Cambra de Comerç (2025). **Vallès Oriental Delegation** [Accessed November 3, 2024] Available at: https://www.granollers.cat/prom-eco/ca-co-VO

(5) Emprendedores.es (2017). **If you make these mistakes, your product launch will be a sure failure** [Accessed April 15, 2025] Available at: https://emprendedores.es/gestion/crear-empresa/hundir-lanzam-prod-errores/

(9) Government of Catalonia (2025). **Department of Agriculture, Livestock, Fisheries and Food. Land Use and Land Cover Cartographic Bases** [Accessed January 24, 2025] Available at: https://agricultura.gencat.cat/ca/serveis/cartografia-sig//usos-sol/index.html

(8) Ministry of Agriculture, Fisheries and Food (2023). **Agri-food distribution** [Accessed December 14, 2024] Available at: https://www.mapa.gob.es/es/alimentacion/temas/consumo/distrib-agroalimentaria

(7) UOC (2023). **New product launch plan II** [Accessed October 18, 2025] Available at: https://fp.uoc.fje.edu/est/bl-fp/lanz-prod-nuevos-ii

Appendix: Figures, photos and tables

2. Background

Segona jornada de Formacions Professionals al Carles Vallbona

Granollers L'Institut Carles Vallbona ha realitzat la segona jornada Vallbona Empresa, que va enfocada a les Formacions Professionals. La jornada, que va comptar amb representants del centre educatiu i del teixit empresarial, va servir per crear un espai de diàleg i col·laboració per establir sinergies futures entre el món laboral i l'educatiu. Aquesta relació, segons apunta el Vallbona, és fonamental per fomentar una relació més estreta entre les empreses i l'institut. Aquest fet beneficia la preparació dels futurs professionals, ja que van poder compartir idees i experiències per adaptar-se a les demandes del mercat laboral.

Fig. 1. Article in the Som Granollers newspaper about a project presented at the 2nd Vallbona-Business Conference. Source: https://www.somgranollers.cat/

Fig. 2. Meeting with Mr. Planas (Granollers City Council); March 2026.

Fig. 3. Meeting with the Puntí family, farmers from Palou (Granollers); March 2026.

4. Methodological process

4.2. Methodology

4.2.1. The project from a Scientific and Technological Perspective

E01. Geographical / E02. Horticultural

Fig. 4(l). Creating the Palou data sheet.

Fig. 5(r). Creating the plant data sheets.

E03. The prototype

Fig. 6(l). Assembling the hydroponic system (1st version).

Fig. 7(r). Assembled hydroponic system, with the leachate collection tank (bottom; 1st version; non-modular prototype).

Fig. 8(l). Assembling the water inlet system in the circuit.

Fig. 9(r). Detail of the main water inlet solenoid valve (left) to the drip irrigation system (right).

Fig. 10 (l). Working with the solenoid valve.

Fig. 11 (r). Mounting the sensors in the enclosure.

Fig. 12(l). Detail of the solar panel.

Fig. 13(r). Working on the programming of the irrigation control system.

E04. Spare parts

Fig. 14. Working with TinkerCad.

Fig. 15. Preparing for printing.

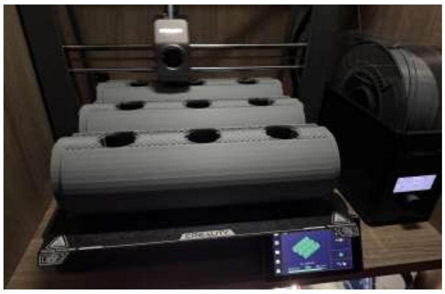


Fig. 16. Printing the designed parts.

4.2.2. The project from a Social and Economic Perspective

E06. Packaging Design

Fig. 17. Measuring the product to create the packaging.

Fig. 18. Packaging sketch.

Fig. 19. Final packaging design.

Fig. 20. Prototype cost analysis.

Fig. 21. Revenue stream analysis.

Fig. 22. Competitive analysis to define the points that differentiate the project from the rest of the market.

5. Results

5.1. The project from a Scientific and Technological Perspective

E01. Geographic

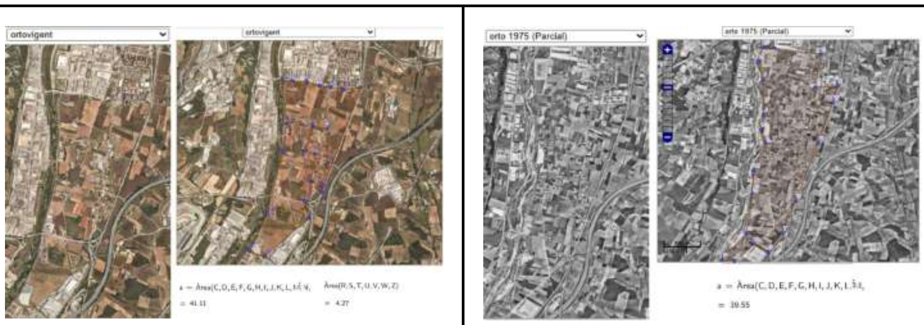


Fig. 23. Reduction of agricultural area between the most distant images in the studied time (1975-2025).

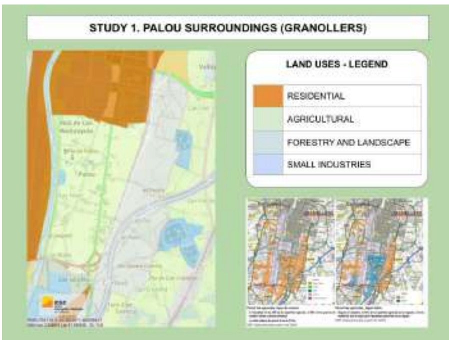
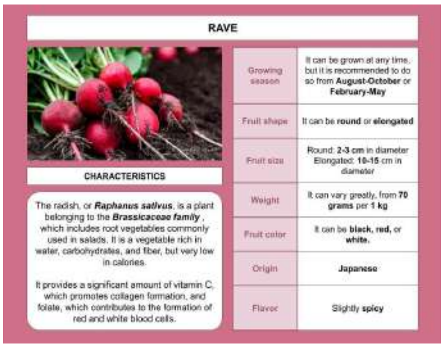
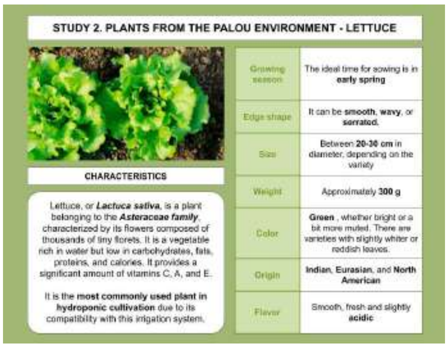


Fig. 24(l). Detail of the Palou fact sheet. Description of the area and crops.

Fig. 25(r). Detail of the Palou fact sheet. Land uses.

E02. Botanical and Horticultural





Figs. 26 and 27. Two of the fact sheets are designed on the most characteristic horticultural plants of the Palou area (Granollers).

E03. The Prototype

Fig. 28. Water inlet to the leachate tank, regulated by the tank's level sensors (m/m).

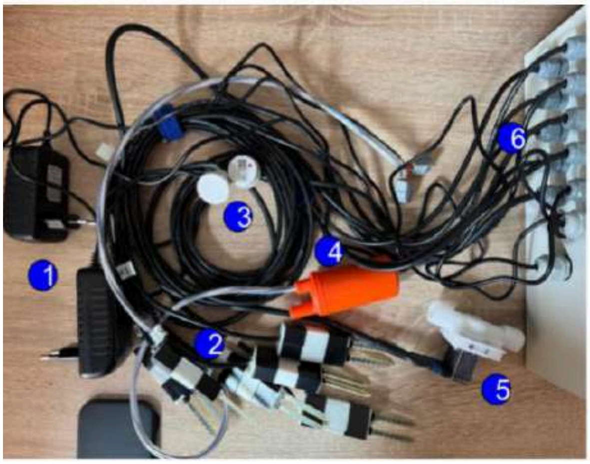
Fig. 29. Set of sensors located in the ground that monitor the soil's relative humidity (%).

Fig. 30. Connection details (from left to right: solenoid valve, watertight box, and wiring for the relative humidity (RH%) and water level sensors).

QR1(l). Video of HydroMixt *in operation (subtituled in Cat/Span/Eng).*

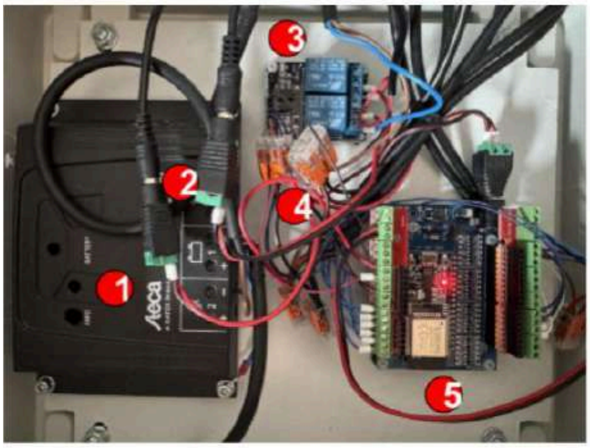
QR2(c). Diagram of HydroMixt*'s operation (solar/electrical).*

QR3(r). Arduino program (sensor control and creation of the HydroMixt *web app).*



NO.	NAME	FUNCTION
1	Feeding	It is used to power: ESP32, relays and pump
2	Soil moisture sensors	They measure the moisture in the soil.
3	Level sensor	Detects the water level in the tank.
4	Water pump	It pumps water into the irrigation system.
5	Solenoid valve	Open or close the water valve
6	Cable grommet of the box	They fit the cables into the box and protect the electronics.

Fig. 31. Sensor assembly (relative humidity and water level in the leachate tank).



NO.	NAME	FUNCTION
1	Solar controller	It regulates the charge between the solar panel and the battery.
2	DC jack adapter to terminal block	It allows you to connect the power supply to the board using cables.
3	Relay module	It allows you to activate higher power devices such as the pump or the solenoid valve.
4	WAGO Connectors	Used to distribute power and connections.
5	ESP32 with terminal board	Microcontroller that manages the entire system (reading sensors, pump and valve control, web server).

Fig. 32. Interior of the metal enclosure with all the electronic components.

Figs. 33 and 34. Web app developed for the visualization and control of the irrigation system (v1).

Fig. 35. Checking the irrigation system and the water in the tank.

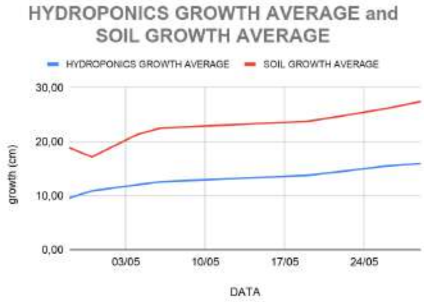


Fig. 36. Relationship between plant growth in substrate (cm) and substrate moisture (%RH)

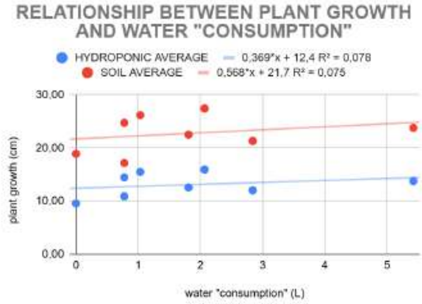


Fig. 37. Relationship between plant growth (hydroponics and substrate) and water consumption.

E04. Spare parts

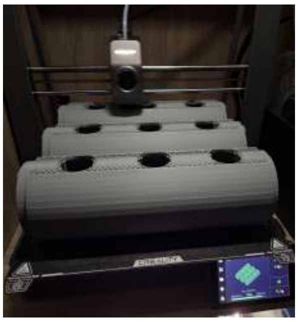


Fig. 38. Screenshot of one of the designs created with TinkerCad.

Fig. 39. Printout of the support for the hydroponic irrigation baskets.

QR#4 for the modules that make up the hydroponic part of the HydroMixt.

5.2. The project from a social and economic perspective

E05. Market analysis

Fig. 40(l). Statistics and evidence of market needs.

QR#5 for the socioeconomic context of the project.

E06. Packaging design

Fig. 41(l). One of the boxes with the printed parts.

Fig. 42(r). General exterior view of the box with the product.

QR Codes:

(l) QR#6. Product unboxing (subtitled in Catalan, Spanish, and English).

(r) QR#7. HydroMixt *Quick Start Guide and User Instructions.*

E07. Commercial viability and strategic partnerships

ASSETS	
A) NON-CURRENT ASSETS	3.000
I. Intangible fixed assets	0
II. Tangible fixed assets	3.000
Digital equipment (POS, Web...)	3.000
B) CURRENT ASSETS	-39.023
I. Inventory	0
Commercials	0
Products in progress	0
II. Trade debtors and other accounts receivable	0
Customers for sales and other services	0
Various debtors	0
Other loans with public administrations	0
III. Investments in group/associated companies CP	0
IV. Short-term financial investments	0
V. Short-term periodizations	0
VI. Cash and other equivalent liquid assets	-39.023
TOTAL ASSETS (A + B)	-36.023

NET WORTH + LIABILITIES	
A) NET WORTH	-36.023
A-1 EQUITY	-36.023
I. Capital	3.000
III. Reserves	0
VI. Other contributions from partners	0
VII. Result of the exercise	-39.023
VIII. Interim Dividend	0
A-2 GRANTS, DONATIONS AND LEGACIES	0
B) NON-CURRENT LIABILITY	0
I. Long-term provisions	0
II. Long-term debts	0
III. Debts with group companies and associates of LP	0
IV. Deferred tax liabilities	0
V. Long-term periodizations	0
C) CURRENT LIABILITY	0
I. Short-term provisions	0
II. Short-term debts	0
III. Debts with group companies and associates of CP	0
IV. Short-term creditors and other accounts payable	0
Short-term suppliers	0
Various creditors	0
Other debts to Public Administrations	0
Personnel (outstanding wages)	0
V. Short-term periodizations	0
TOTAL NET PURCHASE + LIABILITIES (A + B + C)	-36.023

Fig. 43(l). Proposed business feasibility plan.

Fig. 44(r). Projected balance sheet assets and liabilities.

Fig. 45. Summary of the proposal to improve product viability and create strategic partnerships.

6. Conclusions

Final conclusion and suggestions for improvement

QR#8 for the HydroMixt *website (in Spanish, Catalan, and English).*

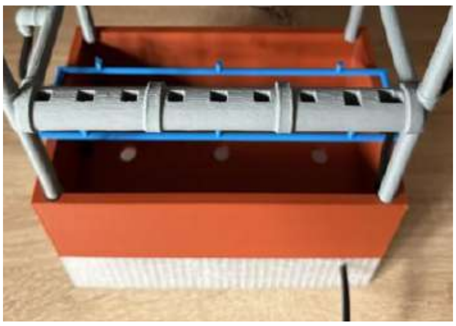


Fig. 46. Detail of the new proposed layout of the soil cultivation area (brown) and the leachate collection tank (white).

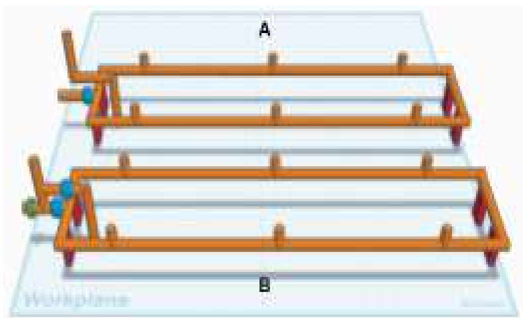


Fig. 47. Current circuit system (A) and new proposal (B) with a double solenoid valve (blue) and a non-return valve (green).