Report

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Acknowledgement

To be written once our work has been concluded.

Glossary

Across the text of our report, multiple abbreviations are about to be used. **Table 1** provides a handy summary of all of them and serves as a reference material to whoever is to read through our work.

Table 1: Glossary

Abbreviation	Description
DIY	Do It Yourself
EPS	European Project Semester
EU	European Union
IoT	Internet of Things
ISEP	Instituto Superior de Engenharia do Porto
LED	Light emitting diode
N/A	Not applicable

Abbreviation	Description
NDA	No data available
PAR	Parabolic Aluminized Reflector
PPT	Microsoft PowerPoint presentation, commonly as per .ppt file format used
PVC	Polyvinyl chloride
USB	Universal Serial Bus
EMC	Electromagnetic compatibility
LVD	Low Voltage Directive
RED	Radio Equipment Directive
ROHSEEE	Restriction of Hazardous Substances in Electrical and Electronic Equipment

1 Introduction

The following report serves as a summary of all the work done by the 1st appointed team of the Erasmus Project Semester programme at Instituto Superior de Engenharia do Porto in the spring semester of the academic year 2017/2018. The team consisting of six European students worked in the interdisciplinary, multicultural environment, for the whole semester investing their efforts into development of an innovative solution to a problem of the team's preference out of a list presented at the very beginning of the semester.

In the report, the full spectrum of the labour and research is about to be covered, from the introduction to the team, the task and the expectations toward the project, through recognition of the problem's state in the environment and the community at the time of writing, further toward analysis of the issue in the context of multiple different fields - management of work, marketing and media, efficient and sustainable development, and even any concerns of ethics it may rise.

That research being covered any progress, conflict, or problem made and encountered during the project's development will be introduced and summarised in order to present the path leading to the final state the project assumed by the end of the semester.

As an afterword, any and all of the unfulfilled ideas which could contribute to the further development of the project - should that ever happen - will be left for consideration, alongside conclusions drawn by the team and its members from the experience gained during the programme.

As the team, we grant our regards to anyone about to acquaint themselves with our work and would like to thank them for their time and consideration.

1.1 Team Presentation

Table 2: Introduction of the team members

Name	**Anastasia Sevastiadou**	**Andres Luts**	**Audrey Pretot**	**Mile Trendafiloski**	**Rodrigo Basurto**	**Szymon Błaszczyk**	**Leon the Chameleon**
Nationality	Greek	Estonian	French	Macedonian	Spanish	Polish	Portuguese
Speciality	Environmental and Geotechnical Engineering	Electrical Engineering	Packaging Engineering	Computer Science and Engineering	Mechanical Engineering	Telecommunications and Computer Science	Being awesome

Belbin® role [1]	Monitor Evaluator	Resource Investigator	Complete Finisher	Complete Finisher	Implementer	Implementer	Team Mascot
Jonied EPS to…	… to have the opportunity to meet and work with people from all over Europe and get out of my comfort zone	… to get out of my comfort zone and enjoy different culture	… to have a team project with unknown people in foreign langue out of my country, new experience, new challenge, Let's do it!	… to participate in a project in an international environment	… to improve my language skills and my teamwork skills and I found the EPS the best option to do it	… to work on an interesting project unlike these I could participate in at my home university	… to help us develop a great project!

Table 2 introduces the members of the team one by one. As a whole, the team has at first been assembled as “Team 1” of the EPS program at ISEP, Porto in the academic year 2017/2018. After getting to know each other, the group decided to assume the name “SAMARA”, which consists of the first letter of the name of each of the team's members:

- **S**zymon
- **A**udrey
- **M**ile
- **A**nastasia
- **R**odrigo
- **A**ndres

Each of the team's six members comes from a different country and from a variety of fields, different yet complement each other - with a noticeable emphasis put on the electrical aspect of the project, having three members carrying out studies in related fields. As a Belbin® composition, the group carries a small risk of struggling to set itself in motion, with multiple people dedicated to project execution but slightly missing on ideas creation and work coordination. Nevertheless, just as the world is not black and white, the Belbin® roles are not definitive and the SAMARA team carries out its work with good spirits and high morale.

1.2 Motivation

The team chose the topic of “Vertical farming”. This is due to the fact that vertical farming is considered to be the future of farming, eliminating a lot of space and making herbal products easier to access to the average person. In addition, we believe that vertical farming, as well as farming in general, should be more automated and the average person should produce goods with relative ease. Furthermore, the team is well prepared in tackling this task because each member can contribute to this project using their skills in the specific field which they study.

1.3 Problem

Traditional farming can take up a lot of areas and is very climate specific. This is due to the fact that some crops may grow in one climate but fail to produce the same results in a different one. Also, farming can be a difficult process that requires a lot of money spent on working and maintaining the

soil and the plants. Additionally, toxic pesticides are used during the traditional farming process to prevent the crops to decay due to animal factor. While the pesticides are useful in repelling insects and other parasites on animals, they are toxic also to humans and to domestic animals so they should be avoided.

We believe that using our module, most of the problems mentioned above will be greatly diminished.

1.4 Objectives

The goal is to create a Vertical farming module that will reduce the space of traditional farming and it will make it easier for the average people to incorporate farming into their daily lives.

We will achieve the goal by making a modular product which will contain several crops inside. It will be aquaponic so that we will eliminate the need of using soil and we will grow the crops using water and fertilizers alone. Additionally, we will create an automated system using electronics so that we will simulate the climate that will be able to grow the specific crop.

Finally, all of the automation will be controlled by an android application so that the user that owns the product will be able to select and monitor which plant is being grown into the specific module.

1.5 Requirements

The solution we are to propose has been appointed a set of requirements to meet in order for it to be positively evaluated:

- Propose a modular solution, as in (one or both):
    - Made of simple, highly compatible independent modules
    - Having highly gradual control over well-separated sections
- Make the design adaptable to different size areas

Following the above, an array of common ground objectives standing before all EPS projects is:

- Restrict our spending to a budget of 100.00 €
- Use high-sustainability materials and solutions
- Use open source software
- Adopt the International System of Units **[2]**
- Comply with the EU rules and regulations:
    - Machine Directive **[3]**
    - Electromagnetic Compatibility Directive **[4]**
    - Low Voltage Directive **[5]**
    - Radio Equipment Directive **[6]**
    - Restriction of Hazardous Substances (ROHS) in Electrical and Electronic Equipment Directive **[7]**

1.6 Functional Tests

For the project to be evaluated technically, expectations for its performance have to be set well in advance. Moreover, the prototype's first run obviously cannot take place during the final presentation

- and so functional tests will have to be carried out.

Working with living organisms - either animals or plans - is always complicated. These cannot be taken apart and separately tried out under different aspects and in different fields. For a plant to grow its environment has to support its development as a whole. Nevertheless, some basic principles of operation for maintaining this environment can be predicted - and so our device should:

- Provide water and nutrition, in appropriate amounts and at appropriate intervals
- Provide lightning, of appropriate intensity and at the appropriate time of the day
- Offer space for the roots and the shoot of the plant to grow and develop

Besides that, the products should offer certain functionalities to its users, therefore being able to:

- Fall silent and turn off the lights at nighttime, not to disturb the owner with its operation
- Offer reminders about any maintenance operations necessary to keep it operational

Further, as an appliance connected to the electricity mains, the prototype should:

- Be properly grounded, not to risk electroshocking the user
- Keep the electric components safe from any moisture

Finally, an integrated test simulating real-life performance shall be carried - supporting an actual plant living in our device for an extended period of time.

1.7 Project Planning

Having our work unorganised could easily lead to a major workflow crisis - some tasks could be left unattended while others would have too many people focusing on them at once. In order to avoid such situations, a division of tasks to be performed throughout the project has been conducted, its results being summarised in **Table 3**.

Table 3: Task and the responsibility division within the team

Task	**Responsible**	**Involved**
Research	**Audrey, Szymon, Mile and Anastasia**	**Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon**
Technical Research	Szymon and Mile	Andres, Mile, Rodrigo and Szymon
Marketing Research	Audrey	Audrey and Mile
Design Research	Audrey	Andres, Audrey, Rodrigo and Szymon
Ethical Research	Anastasia	Anastasia
Sustainability Research	Anastasia	Anastasia
Task identification & Problem Definition	**Mile and Audrey**	**Andres, Audrey, Mile, Rodrigo and Szymon**
Roles and Division	Mile and Szymon	Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon
Gantt	Mile	Audrey and Mile
Schematics	**Anastasia, Andres, Rodrigo and Szymon**	**Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon**
Drafts	Rodrigo and Szymon	Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon

Task	Responsible	Involved
Research	**Audrey, Szymon, Mile and Anastasia**	**Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon**
3D Drafts	Rodrigo	Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon
Draft ethics	Anastasia	Anastasia
Materials	**Audrey**	**Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon**
List	Audrey	Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon
Providers	Audrey	Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon
Assembly	**Andres, Mile, Rodrigo and Szymon**	**Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon**
System Design	Andres, Mile, Rodrigo and Szymon	Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon
Building the Mechanics	Rodrigo	Rodrigo
Building the Electronics	Andres and Szymon	Andres and Szymon
Programming the Electronics	Mile and Szymon	Andres, Mile and Szymon
Programming the Application	Mile and Szymon	Mile and Szymon
Testing	Andres, Mile, Rodrigo and Szymon	Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon
Communication	**Anastasia, Audrey and Mile**	**Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon**
Flyer	Anastasia and Audrey	Anastasia and Audrey
Wiki	Mile	Mile
Video	Mile	Mile
Report	Audrey	Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon
Manual	Audrey	Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon
PPT	Audrey	Audrey and Szymon
Interim Presentation	**Anastasia, Audrey and Szymon**	**Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon**
Content	Anastasia, Audrey and Szymon	Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon
Visuals	Audrey and Szymon	Audrey and Szymon
Execution	Anastasia and Szymon	Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon
Refined Interim Presentation	**Anastasia, Audrey and Szymon**	**Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon**
Content	Anastasia, Audrey and Szymon	Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon
Visuals	Audrey and Szymon	Audrey and Szymon
Execution	Anastasia and Szymon	Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon
Final Report	**Anastasia, Audrey and Szymon**	**Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon**

Task	Responsible	Involved
Research	**Audrey, Szymon, Mile and Anastasia**	**Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon**
Content	Anastasia, Audrey and Szymon	Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon
Visuals	Audrey and Szymon	Audrey and Szymon
Execution	Anastasia and Szymon	Anastasia and Szymon
Wiki Presentation	**Mile**	**Mile**
Video to Wiki	Mile	Mile
Poster to Wiki	Mile	Mile
Paper to Wiki	Mile	Mile
Manual to Wiki	Mile	Mile
Final Presentation	**Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon**	**Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon**
Content	Anastasia, Audrey and Szymon	Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon
Visuals	Audrey and Szymon	Audrey and Szymon
Execution	Anastasia and Szymon	Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon

1.8 Report Structure

This report is separated into several chapters, each associated with a distinctive field of our research and work. **Table 4** outlines the underlying purpose of each section.

Table 4: Structure of the report

Chapter	Title	Purpose
1	Introduction	to introduce the team's composition and motives, define the topic undertook with requirements regarding it to be met, and outline our expectations for the project's outcomes and workflow
2	State of the Art	to analyse the current state of the market to be entered, identify a niche to be fulfilled among existing competitors, and present a selection of the most promising solutions and components to be employed in project development
3	Project Management	to establish the scope of the project, identify resources available, and to allocate them accordingly and efficiently to the tasks contributing to project solution
4	Marketing Plan	to try to identify the main target group of our product, recognise all internal or external factors possibly influencing our progress, and to estimate a long-term strategy to be applied for the introduction of our solution to the market
5	Eco-efficiency Measures for Sustainability	to identify the key aspects of the project that impinge on the ecological footprint and the precautious steps to be taken in order to maximise to the overall sustainability of our project toward the planet and the society

Chapter	Title	Purpose
6	Ethical and Deontological Concerns	to comment on any concerns and ambiguities regarding our project from the point of view of engineering, social, market and environmental ethics
7	Project Development	to present the advancements of the actual project developments, walk through the steps taken by the team, including any problems expected or not with solutions applied, and to present the final outcome of our work in the form of an operational prototype/proof of concept - including results of basic functional tests carried out on the device
8	Conclusions	to conclude our work, summarise the achievements of the project, and to share any of our afterthoughts and possible visions for further development

2 State of the Art

2.1 Introduction

In this section, the current state of the market we would like to introduce our solution to shall be discussed. As the problem of the ineffectiveness of conventional farming - both acreage- and resource-wise - has long been recognized, numerous approaches to addressing it have been already presented, many of them already made available for use by the general public. Examples stretch wide in scale and complexity. Huge installations are placed in public spaces, akin to the example of a green wall of CaixaForum building in Madrid, Spain pictured in **Figure 1**. At the same time, DYI solutions are springing in some unexpected forms and places. An aesthetic green wall can be found at the entrance to a minor grocery store in Barcelona, Spain, one made from repurposed clothing organizer as depicted in **Figure 2**. Through careful scrutiny of these solutions, we will be able to acquire an overview of the customers' needs and expectations to be met in order to successfully enter the competition. Understanding the benefits offered by our to-be competitors should help us tailor an offer making us stand out from the crowd - or hopefully allow us to find a market niche yet to be claimed, one in which our solution could flourish.

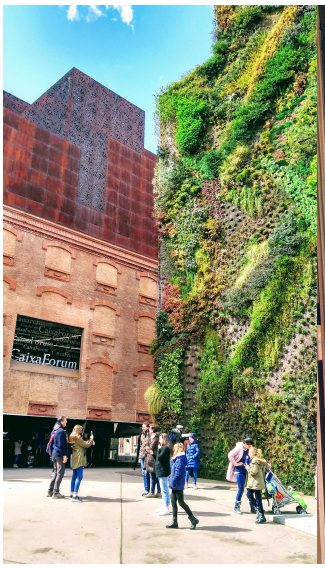

Figure 1: CaixaForum building in Madrid, Spain
(Photo by: Szymon Błaszczyk)

Figure 2: Vertical farming solution in the shop entrance in Barcelona, Spain
(Photo by: Szymon Błaszczyk)

Vertical farming is the practice of planting and growing various types of plants, usable for food

or medicine manufacturing, in a vertical manner. This can come in different forms such as:

- vertically stacked layers
- vertically inclined surfaces
- integrated structures

Today, most vertical farming products and projects evolve into indoor vertical farming. By moving the process indoors, all the environmental aspects such as humidity, light, water supply, etc. can be controlled with fine-grain precision in this way or another. It can be done using artificial light to mimic sunlight, customized water piping system suited for watering the plants, and usually employs electronic hardware and dedicated software to observe and control the water supply, humidity, temperature, etc.

With the highly controllable environment comes high efficiency in resource management. Crops harvested through the means of vertical farming can use numerous times less water and energy than their conventionally farmed counterparts.

2.2 Scale recognition

Just like for the past decades edible plants and fragrant herbs could have been found both on immense fields attended by an army of workers and in handcrafted backyard gardens, the revolution of vertical farming comes in different sizes - from gigantic and complex systems filling up whole workshops and suitable for commercial application, through school-sized glasshouse DYI projects helping to plant healthy lifestyle in pupils' heads, up to household-sized solutions treated as personal investment into one's health and well-being.

Extensive research which would cover all the aforementioned spectrum of cases and applications would be overly time-consuming. The team decided therefore in advance to focus on just a single branch of these devices' development. Once a whole array of factors - limited budget, set of skills at hand, room for creative freedom, target group, personal preferences of the team members, and others - have been discussed, the team SAMARA decided to put its efforts into a project able to cover needs of a single family or a small, well defined community - like a class of students, start-up company or neighbours sharing the same staircase.

Among arguments in favour of this approach were given:

- Small scale more suitable for limited budget of ours
- Use case giving huge odds for the device to be placed indoors, in a steady and safe environment
- More familiar and easier to reproduce marketing process addressing individuals, not huge businesses or city authorities
- Greater creative freedom for innovative functionalities, when compared to industrial-grade

solutions focused mainly on efficiency

That being established, the following chapter is about to cover our research in the field of private-use indoor farming solutions currently available on the customer market.

2.3 Products on the market

2.3.1 Minigarden Vertical

This vertical farming solution originating from Lisbon, Portugal promises to contribute to an *Urban Green Revolution* **[8]**, bringing a simple and scalable solution for introducing self-grown edible plants to the urban areas. Their concept is an affordable, straightforward system for creation of green walls, big or small, outdoors or indoors[minigardenVertical], helping to reconnect with Mother Nature.

Minigarden Vertical set of three modules, shown operational **[13]**

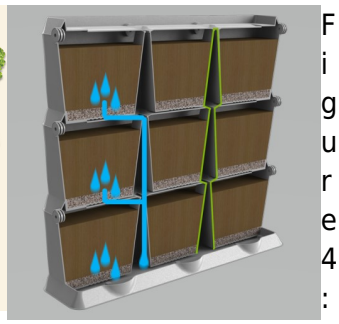

Figure 4: Irrigation system across multiple Minigarden Vartical modules **[14]**

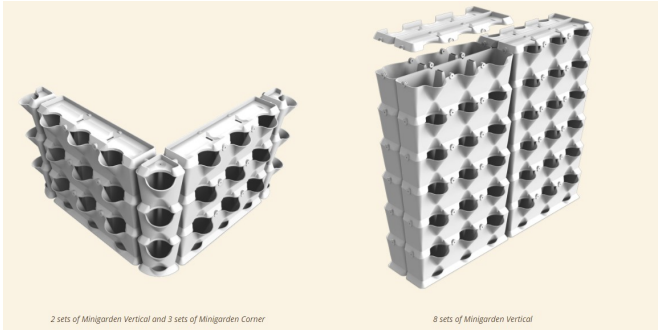

Figure 5: Multiple Minigarden Vertical modules being used to create bigger, complex structures **[15]**

Minigarden Vertical is a highly modular solution with building modules designed to fit each other vertically, horizontally, and back-to-back. This is expected to provide freedom of attuning the system to the needs and possibilities of one's living space.

Modules are built of high-strength polypropylene copolymer and contain additives that provide UV protection. This is done so that Minigarden Vertical is capable of withstanding extreme weather conditions such as solar radiation and extreme temperature **[9]**. At the same time, the materials used are promised to be 100% recyclable and to comply with appropriate EU directives regarding materials intended to come in contact with food **[10]**. A single building module provides space for three separate plants to grow. Plants are grown in soil - each module is to be filled with clay and earth upon setup.

Minigarden's modularity is extended through various supporting pieces - bottom tray collects any runoff of drainage water. Top lid encloses the head of the build when no more modules are to be added vertically. Together with three basic modules, these can be bought as a set, as seen in **Figure 3**. Further widening the offer available are Minigarden Corner modules, allowing build of L-shaped turns and complex structures, as seen in **Figure 5**, wall-support hangers, and irrigation

kits centralising the water flow through the system as seen in **Figure 4**, and allowing its connection to the water mains or e.g. gardening water dispenser.

Albeit of irrigation kits being part of the offer, plant watering cannot be said to be automated. It is up to the user to water the plants regularly or to create themselves a solution to supply the irrigation net appropriately. No proprietary lightning solution is proposed - the product is fully mechanical and contains no electrically powered elements.

Table 5 briefly summarises the specification of this product.

Table 5: Technical and functional summary of Minigarden Vertical product (given per single pre-defined set) **[11]**

Attribute	Comment
Dimensions	57 x 64,6 x 19 cm (HxWxD)
Weight	3,35 kg
Farming technique	Soil-based farming
Max. plant capacity	9
Expandability	Yes, huge possibilities of expansion through stacking and connecting additional modules
Automated watering	No, although key elements required for an appropriate system are available
Automated lightning	No artificial lightning
IoT aspects	N/A
Water consumption	NDA
Power consumption	N/A
Price	**39.99 € [12]**

2.3.2 Click & Grow

Based in Tallinn, Estonia, Click & Grow startup established in 2010 sets itself up with a mission of making the essential, fresh, and healthy food free for all the people of Earth. In order to achieve this admirable objective, Click & Grow

offers high-quality indoor gardens and food growing systems bringing large and self-sustainable farms to locations in greatest need of them **[16]**.

2.3.2.1 Smart Garden 3 / Smart Garden 9

The idea behind the Smart Garden products originates from Click & Grow founder's inspiration with work of NASA regarding farming solutions for manned space missions to Mars **[17]**. The key feature of all Click & Grow products is a coffee-machine-like model of compatible plants distribution - they are being sold in capsules compatible with the device. Each capsule hosts a seed embedded in an advanced nanotech growing material, labelled as Smart Soil. It is promised that Smart Soil on its own addresses the issues of proper irrigation, oxidation, and nutrition of plant's roots, without any use of GMO or pesticides, leading to naturally grown greens **[18]**. Smart Soil is finely attuned to individual needs of each type of plant in Click & Grow's offer, providing the very environment needed for the optimal growth. The company claims that their technology cuts overall ongoing costs of farming by 70%, water usage by astonishing 95% while offering 30% faster growth of the plants **[19]**.

Figure 6: Smart Garden 9 product, shown operational **[27]**

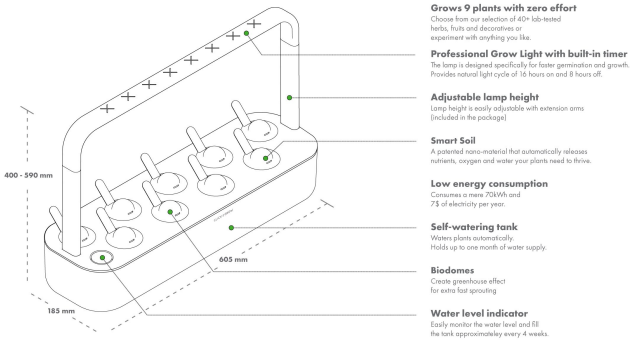

Figure 7: Smart Garden 9's key features **[28]**

The Smart Garden 9 unit seen in **Figure 6** is a self-growing indoor garden designed to serve as a growing platform for a wide variety of plants: fruits, vegetables, herbs, salads, and flowers. User input required is minimal and limited to installation of the plant capsules and attending to the water level within the device - with the reservoir holding up to a month of operation worth of water **[20]**. The water is not pumped anyhow but slowly soaked in instead by the Smart Soil capsules. Above growth area, there is an LED bar providing proprietary, automated lighting to plant-inhabitants, with a mixture of red and blue LEDs for the optimal colour spectrum **[21]**.

The device functions as a household appliance similar to a food processor or a coffee machine - with an all-in-one build and foolproof refills all it takes is to place the Smart Garden in a

convenient point and plug it to electric mains. Also in the company's offer is a smaller model o the device suitable for up to 3 separate plants **[22]**, suitable for households with more limited space and/or smaller demand for fresh self-grown greens.

It is worth to notice that Smart Garden line of products does not satisfy the term of a vertical farming solution - all plants are grown in the same vertical space. Leaving aside the manner of an effective use of space, these devices do fulfil the mission of providing their owners with a steady supply of fresh and healthy plants using highly sustainable and ecological methods, and so they will pose as a direct competition to any device which offers the same benefits via means of vertical farming.

Table 6 and **Figure 7** briefly summarise the specification of this product.

Table 6: Technical and functional summary of Smart Garden 3 and Smart Garden 9 products **[23] [24]**

Attribute	Smart Garden 3	Smart Garden 9
Dimensions	22,7 x 31,5 x 13 cm (HxWxD)	40 x 60,5 x 18,5 cm (HxWxD)
Weight	1,77 kg	2,43 kg
Farming technique	Soil-based farming	
Max. plant capacity	3	9
Expandability	No, comes as an all-in-one standalone device of limited capacity	
Automated watering	Yes, with a need for monthly refills	
Automated lightning	Yes, with LEDs of 10.000 lux, operational 16 h a day	
IoT aspects	Mobile App available, with no impact on device's operation, providing tips, recipes, and social media features	
Water consumption	0.3 l / week	0.9 l / week

Attribute	Smart Garden 3	Smart Garden 9
Power consumption	0.7 kWh / week	2.4 kWh / week
Price	**99.95 € [25]**	**199.95 € [26]**

2.3.2.2 Wall Farm / Wall Farm Mini

Click & Grow's offer does not end at the coffee-machine-sized, kitchen-countertop-fitting, automated indoor plant stations. Recognising the spacial limitations of non-vertical solutions and to provide a higher capacity solution to customers unsatisfied with the vision of acquiring multiple Smart Garden devices described in the Section 2.3.2.1, the company has introduced Wall Farm line of products. These made of wood wardrobe sized constructs are extending the idea behind Smart Farm products, by increasing the total capacity of the device, also through utilising the third, vertical dimension for plants allocation. While dimensions being amped up, the *modus operandi* remains the same, with plants being hosted in individual Smart Soil capsules supplying themselves with water stored in the reservoirs beneath them.

Figure 8: Wall Farm product, shown operational **[37]**

Wall Farm products are indoor vertical gardens that grow fresh herbs, fruits and leafy greens all year round and hyper-locally **[29]**. With this line, Click & Grow reinforce their concept of coffee-machine inspired distribution, with a monthly subscription of additional plant refills being added automatically to each Wall Farm order **[30]**.

Although being advertised as *truly affordable indoor food production system* **[31]**, with a selling point of more than a dozen hundred of euros for the Wall Farm unit **[32]** this product might be more suitable for restaurants, schools, and shops than for individual households.

Table 7 briefly summarises the details behind Wall Farm products.

Table 7: Technical and functional summary of Wall Farm Mini and Wall Farm products [33] [34]

Attribute	Wall Farm	Wall Farm Mini
Dimensions	202 x 135 x 40 cm (HxWxD)	148 x 135 x 25 cm (HxWxD)
Weight	70 kg	50 kg
Farming technique	Soil-based farming	
Max. plant capacity	51	34
Expandability	No, comes as an all-in-one standalone device of limited capacity	
Automated watering	Yes, with a need for monthly refills	
Automated lightning	Yes, with LEDs of 10.000 lux, operational 16 h a day	
IoT aspects	Mobile App available, with no impact on device's operation, providing tips, recipes, and social media features	
Water consumption	8.75 l / week	3.5 l / week
Power consumption	14.4 kWh / week	9.6 kWh / week
Price	**1299.00 € [35]**	**899.00 € [36]**

2.3.3 ZipGrow FarmWall

ZipGrow is a Canadian company specialising in commercial scale, modular vertical gardening systems. Recognising the current interest of the market in household-fitting, small-to-medium scale solutions, the company has attuned their systems to a wall-mounted, self-sustainable device.

According to the authors, ZipGrow's FarmWall is designed to provide a low maintenance, high yield hydroponic farming system that is modular and automated. The authors suggest that the product is easy to use and using it, customers

have a very efficient vertical farming product. [38]

The Wall is made of food-safe PVC that hold towers in place. The main base can contain five 152 cm towers. Each tower has an opening in the middle where you can put plants inside. There is not an exact number of plants that you can put inside, you can put plants as long as you have more space in the tower. There are two gutters, a lower gutter, and a higher gutter. The lower gutter holds the water, nutrients and the pump of the system, while the higher gutter holds the plumbing and the drip emitters. A fully installed kit can be seen in **Figure 9**.

The towers can be easily removed from the base which makes it easier for harvesting, planting and organizing space. Additionally, the wall has rear-mounted brackets that can easily clip into the provided wall mounts. [39]

In **Table 8** technical details regarding the ZipGrow's product have been summarised.

Figure 9: ZipGrow wallfarm, shown operational [45]

Table 8: 4 Tower FarmWall specifications[40]

Attribute	Comment
Dimensions	170 x 106 x 45 cm [41] (HxWxD)
Weight	Up to 105 kg
Farming technique	Hydroponics
Max. plant capacity	N/A, depending on the size of the plants
Expandability	No, the base can only accomodate limited amount of towers
Automated watering	Additional equipment required to establish daily cycles [42]
Automated lightning	Additional equipment required to establish daily cycles [43]
IoT aspects	N/A
Water consumption	NDA
Power consumption	N/A
Price	**1,199.00 $ ~ 969.00 € [44]**

2.3.4 Conclusions

With an overview of the current market situation we have noticed a major niche looming in the field of small-scale self-sustainable indoor farms - namely, none of the highly automated solutions comes as a scalable, expandable system.

Minigarden Vertical's modularity described in Section 2.3.1, one that helps it adapt to various spaces and applications, comes at a price of low independence. For the plants to thrive the system has to have access to direct sunlight - or be placed in an otherwise illuminated area. Without any subsidiary investments, the watering process would call for approaching every single plant with a watering can. Even with an irrigation set installed the plants won't be supplied with water without human interaction, unless one comes up with a DIY extension connecting Minigarden to the mains. To some potential buyers, the amount of labour this system is calling for may simply be repelling.

On the other hand, highly automated solutions like Click & Grow's Smart Garden from Section 2.3.2.1 or ZipGrow's FarmWall from Section 2.3.3 are offered at a relatively high selling point - what might be understandable having that they are almost “self-aware” smart devices - but at the very moment of purchase bound the customer with their limited capacity. If a person buys themselves a Smart Garden 3 unit in order to try out the idea of self-grown herbs and gets involved in it, there is no simple solution to increase the “farming area” available. A problem arises - whether to buy another small device and use both or upgrade to a bigger model, but try to place the predecessor on a second-hand market? Another answer would obviously be over-investing into a higher capacity-to-price-ratio device in the first place - but then again, not many will be willing to allocate their resources in an experimental purchase.

Considering all of the above, the ideal solution appears to be a smart - possibly IoT enabled - device one can expand at least to a certain extent with time, alongside growing interest in the idea of indoor vertical farming. That is a niche in the market we as a team could try to claim introducing our product.

2.4 Selection of Technology

Soil indoor **(drip system)** is a method of growing plants in soil and nutrients solution is already added to soil, for plant whole lifespan. **[46]**

The soil was not an option because it is too frugal. That did not fit with our plan to monitor everything with an app, also was not innovative enough.

Hydroponics is a method of growing plants without soil, using mineral nutrient solutions in a water solvent. **[47]** Plant roots are in water constantly.

Hydroponics was our way to go for a long time until we managed to fit our budget to go for aeroponics. We had problems finding out how to keep hydroponics modular. But the decisive part for us was that we wanted more complex system.

Aquaponics refers to any system that combines conventional aquaculture (raising aquatic animals) in a symbiotic environment. Excretions from animals are being used as nutrients. **[48]** Plant roots are in water constantly. This type of indoor farm had already been done in past years, and we did not want to take the same path.

Aeroponics is the process of growing plants in an air or mist environment without the use of soil or an aggregate. **[49]**

Seems like a way to go for future, its most water efficient, the fastest growth rate for the plant. **[50]** Suitable for a big variety of different plants. For example, misting for Romaine salad lasts for 6 seconds every 4 minutes. For us it seemed like most perspective way to go since week 2, at first we had serious problems funding the budget and dropped the idea for a while.

Had to some concessions, for some valves etc, but the final prototype satisfies our eager minds.

2.5 Selection of Components

2.6 Conclusion

Based on the research done by the team on the topic of State of the Art, the team decided that the product should:

- Be modular and easy to use
- Use aeroponics/hydroponics
- Use some electronics that will monitor the plants' status
- Incorporate some form of automatization of growing the plants
- Use a mobile application for simple and effective use

We believe that by following these points we will create a product that will have a high market value and will be a strong competitor in the market and contribute highly to the future of vertical farming.

3 Project Management

3.1 Scope

Our team created a graph about the scope of the project. This is because we do not want to mix the responsibilities and we would like to have a good overview of what we need to do in our project and we can schedule the time much easier. The scope of our project looks like this:

- Initial Phase
  - Research
    - Technical
    - Marketing
    - Design
    - Ethical & Sustainability
  - Task identification and definition
    - Roles & Division
    - Gantt chart
- Design phase
  - Schematics
    - Draft
    - Detailed

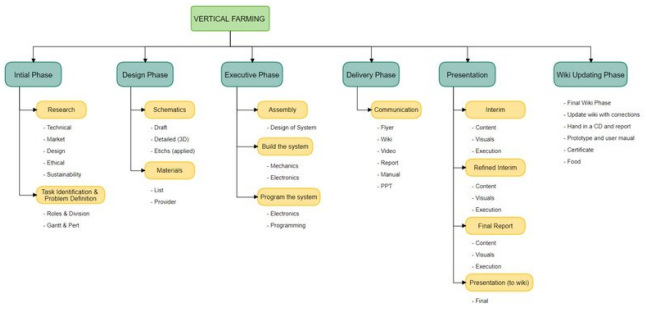

Figure 10: Scope of the project

        - Apply ethics to the schematics
    - Materials
        - List
        - Providers
- Execution phase
    - Assembly
        - Designing the system
    - Build the system
        - Mechanics part
        - Electronic part
    - Programming the system
        - Program the electronics
        - Program the android application
- Delivery phase
    - Communication
        - Flyer
        - Wiki
        - Video
        - Report
        - Manual
        - PPT
- Presentation
    - Interim
        - Content
        - Visuals
        - Execution
    - Refined interim
        - Content
        - Visuals
        - Execution
    - Final Report
        - Content
        - Visuals
        - Execution
    - Presentation
        - Final presentation(on wiki)
- Wiki updating phase
    - Final wiki phase
    - Update wiki with corrections
    - Hand in CD and report
    - Prototype and user manual
    - Get Certificate
    - Prepare food

3.2 Time

Using Microsoft Project, our team specified the Gantt chart for the time management of the project. This is because Microsoft Project is an excellent tool for Task management and allocating people and resources to each task. **Figure 11** shows the Gantt chart that is designed for our product.

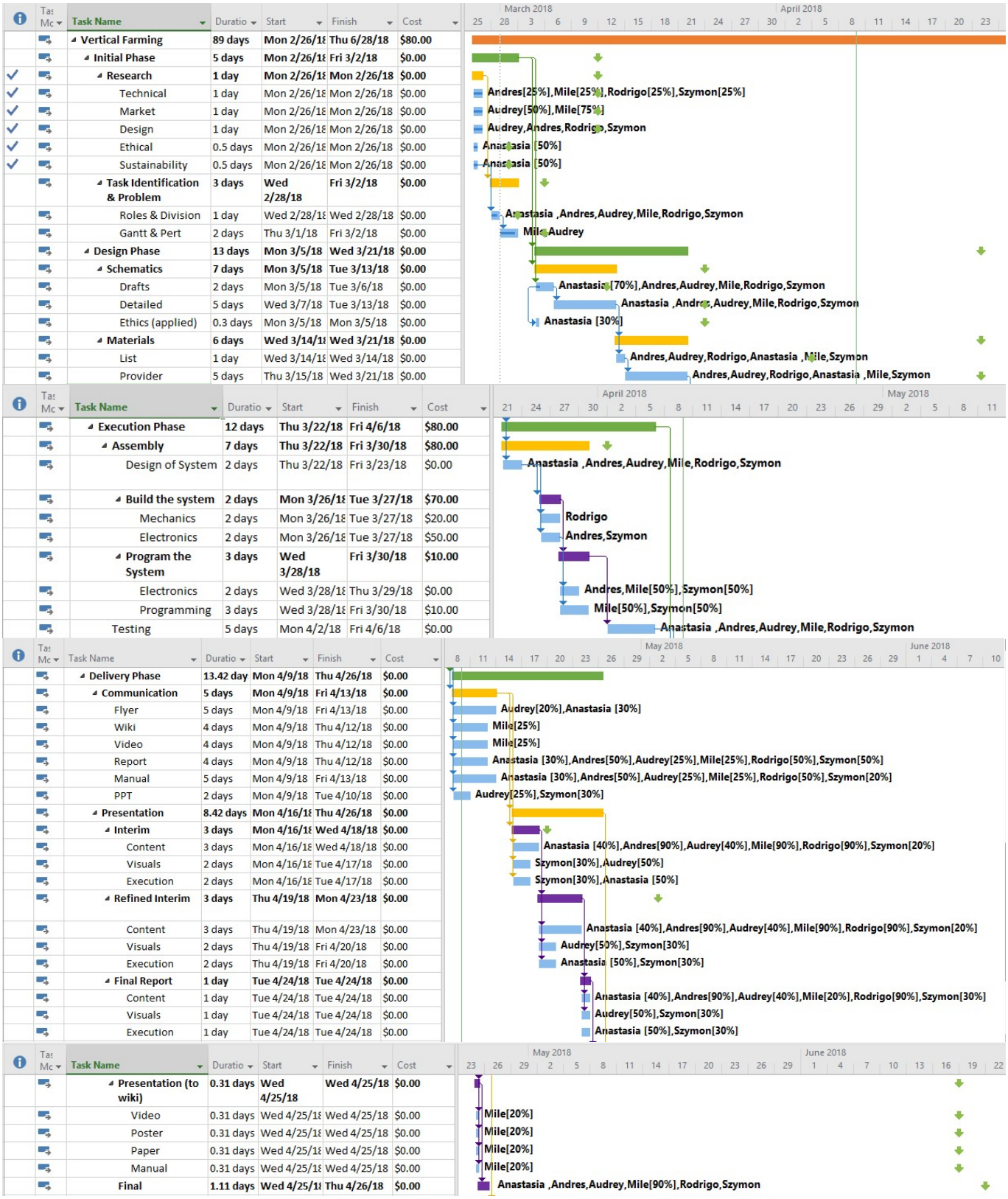

Figure 11: Gantt Chart

3.3 Cost

Another very important aspect of the Project Management phase is the cost distribution. Each resource can be a **work resource** or a **material resource** and has its own cost. The project manager has the obligation to allocate the work and material resources to be cost-effective. Table 9 and Figure 12 show the costs distributed on the work resources.

Table 9: Work resources

Name	Cost
Anastasia	3234.80 €
Andres	3697.50 €
Audrey	3485.50 €
Mile	3592.00 €
Rodrigo	3527.50 €
Szymon	3615.50 €
Total	**21152.80 €**

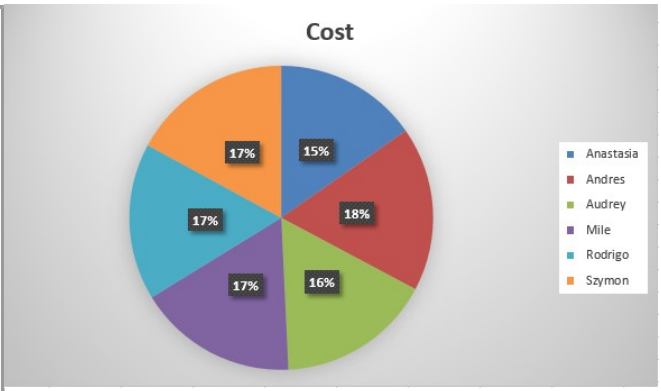

Figure 12: Work resources

As seen above, the work resources are equally distributed among the members of the team. Material resources are things that are not working for the product but are used to create and build the resource. The project manager had to distribute 100 € for the resources. **Table 10** shows the material resources used to build the project.

Component	Quantity	Comments	Usage	Est. Price	Est. Supplier
Case & Structural material					
Frame	1	Plywood chassis	Structural base of the device	2.50 €	Hardware Store (e.g. Leroy Merlin)
Water tank	1	Water tank	Reservoir for water in the device and environment for immersible pump	2.50 €	Hardware Store (e.g. Leroy Merlin)
Silicon tube	1	-	Distribution of water from the immersible pump	6.00 €	Hardware Store (e.g. Leroy Merlin)
Silicon tube connector	1	-	Connecting the pipes with the immersible pump	2.00 €	Hardware Store (e.g. Leroy Merlin)
Pipes	1 set	-	Collecting the excess water and transport to the reservoir tank	5.00 €	Hardware Store (e.g. Leroy Merlin)
Water Sprinklers	2	Simple, passive sprinklers	Evenly distributed water in the aeroponics system	3.00 €	Hardware Store (e.g. Leroy Merlin)
Electronic Components					
Wireless Microcontroller	1	ESP-12E NodeMcu	CPU-core of the device's control circuitry	9.90 €	“Bot'n'Roll” Online Store
LED element - plant illumination	2	3 LED Light Bar – White Light	Illumination of the plants inhabiting the device	7.20 €	“Bot'n'Roll” Online Store

Component	Quantity	Comments	Usage	Est. Price	Est. Supplier
Case & Structural material					
LED element - user feedback	1	RGB LED light	Displaying basic information about the state of the device to the user	1.10 €	Bot'n'Roll Online Store
LED Holder	1	2-pieces self-closing mechanism	Mounting the user feedback LED element appropriately	0.15 €	“Bot'n'Roll” Online Store
Voltage Regulator	1	12 V to 9 V step down	Safely and efficiently reducing the supply's voltage for some of the devices	4.90 €	“Bot'n'Roll” Online Store
Water pump	1	Immersible water pump	Pumping water to the roots of plant inhabitants	11.65 €	“Bot'n'Roll” Online Store
Protoboard	2	Medium-sized, 22 x 26 holes	Assembly of the electrical components	3.00 €	“Bot'n'Roll” Online Store
Water level sensors	1	Conduction-based unit	Keeping track of the water reserves in the tank	2.20 €	“Bot'n'Roll” Online Store
Illuminecence sensor	1	High-quality digital unit	Probing the ambient light level for efficient use of illumination LEDs	6.50 €	“Bot'n'Roll” Online Store
Jumper cables M/M	1	Pack of 10	Connections	2.00 €	“Bot'n'Roll” Online Store
Jumper cables M/F	1	Pack of 10	Connections	2.00 €	“Bot'n'Roll” Online Store
Jumper cables F/F	1	Pack of 10	Connections	2.00 €	“Bot'n'Roll” Online Store
Pin Headers	1	Pack of 40	Connections	0.60€	“Bot'n'Roll” Online Store
Transistor - bipolar NPN	4	2N2222 with H(rf) ~ 70	LED elements switching	0.60 €	“Bot'n'Roll” Online Store
Transistor - bipolar NPN	2	TIP120 with H(rf) ~ 1000	Water pump switching	0.98 €	“Electrofun” Online Store
Resistor - high valued	5	2.2 kOhm	Transistor Base isolation	0.25 €	“Electrofun” Online Store
Resistor - low valued	5	1 kOhm	RGB LED anode isolation	0.25 €	“Bot'n'Roll” Online Store
Diodes	2	1N4001 rectifying diode	Prevention of Immersible pump backward voltage spikes	0.20 €	“Bot'n'Roll” Online Store
Cable	1	Rigid core, 25 m roll	Connections	2.90 €	“Bot'n'Roll” Online Store

Component	Quantity	Comments	Usage	Est. Price	Est. Supplier
Case & Structural material					
Power source	1	12 V - 1 A unit	Supplying energy to the device from the standard household mains	6.00 €	“Bot'n'Roll” Online Store
Power source adapter connector	1	-	Connecting the Power source to the device without the necessity of damaging the source's cable	1.00 €	“Bot'n'Roll” Online Store
Project Box	1	Medium-sized box with 12 output sections	Organisation of electronic components and limiting contact with stray moisture	2.75 €	“Electrofun” Online Store
Shiping					
Botnroll	-	-	Free delivery over 50.00€	0 €	-
Leroy Merlin	-	-	Free pick up at the store	0 €	-
Electrofun	-	-	Free pick up at the store	0 €	-
TOTAL				**89.11 €**	

As seen above, the material resources do not exceed the limit of 100 €, which means that the project manager and the team did a good job with the material cost.

3.4 Quality

Quality is an important aspect of a project that strives to meet the needs of the customers. The team and the project manager should always strive to improve the quality of the product that will increase the market value of the product.

3.5 People

One of the most important aspects of Project Management is allocating tasks to people. This is done because each team member knows what to do at any given moment and it is easier to synchronize with the other team members because everyone knows who is responsible for the task. Additionally, if anything fails, the project manager can find out who is responsible for the failure and should act accordingly. **Table 11** presents the allocated tasks and the people that are responsible and involved in them.

Table 11: Management of people

Task	**Responsible**	**Involved**
Research	**Audrey, Szymon, Mile and Anastasia**	**Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon**
Technical Research	Szymon and Mile	Andres, Mile, Rodrigo and Szymon
Marketing Research	Audrey	Audrey and Mile
Design Research	Audrey	Andres, Audrey, Rodrigo and Szymon
Ethical Research	Anastasia	Anastasia
Sustainability Research	Anastasia	Anastasia
Task identification & Problem Definition	**Mile and Audrey**	**Andres, Audrey , Mile, Rodrigo and Szymon**
Roles and Division	Mile and Szymon	Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon
Gantt	Mile	Audrey and Mile
Schematics	**Anastasia, Andres, Rodrigo and Szymon**	**Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon**
Drafts	Rodrigo and Szymon	Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon
3D Drafts	Rodrigo	Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon
Draft ethics	Anastasia	Anastasia
Materials	**Audrey**	**Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon**
List	Audrey	Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon
Providers	Audrey	Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon
Assembly	**Andres, Mile, Rodrigo and Szymon**	**Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon**
System Design	Andres, Mile, Rodrigo and Szymon	Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon
Building the Mechanics	Rodrigo	Rodrigo
Building the Electronics	Andres and Szymon	Andres and Szymon
Programming the Electronics	Mile and Szymon	Andres, Mile and Szymon
Programming the Application	Mile and Szymon	Mile and Szymon
Testing	Andres, Mile, Rodrigo and Szymon	Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon
Communication	**Anastasia, Audrey and Mile**	**Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon**
Flyer	Anastasia and Audrey	Anastasia and Audrey
Wiki	Mile	Mile
Video	Mile	Mile
Report	Audrey	Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon
Manual	Audrey	Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon
PPT	Audrey	Audrey and Szymon

Task	Responsible	Involved
Interim Presentation	**Anastasia, Audrey and Szymon**	**Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon**
Content	Anastasia, Audrey and Szymon	Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon
Visuals	Audrey and Szymon	Audrey and Szymon
Execution	Anastasia and Szymon	Anastasia and Szymon
Refined Interim Presentation	**Anastasia, Audrey and Szymon**	**Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon**
Content	Anastasia, Audrey and Szymon	Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon
Visuals	Audrey and Szymon	Audrey and Szymon
Execution	Anastasia and Szymon	Anastasia and Szymon
Final Report	**Anastasia, Audrey and Szymon**	**Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon**
Content	Anastasia, Audrey and Szymon	Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon
Visuals	Audrey and Szymon	Audrey and Szymon
Execution	Anastasia and Szymon	Anastasia and Szymon
Wiki Presentation	**Mile**	**Mile**
Video to Wiki	Mile	Mile
Poster to Wiki	Mile	Mile
Paper to Wiki	Mile	Mile
Manual to Wiki	Mile	Mile
Final Presentation	**Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon**	**Anastasia, Andres, Audrey, Mile, Rodrigo and Szymon**

3.6 Communications

An essential asset of a good working team is having good communication between the members of that team. The project manager needs to establish a good communication channel that is accepted by every team member. Below you can see the table and figure about the communication used in the team.

Table 12: Communication Table

Medium	Percentage
WhatsApp	30%
Facebook	20%
Oral	45%
Other(E-mail, Google Drive, etc)	5%

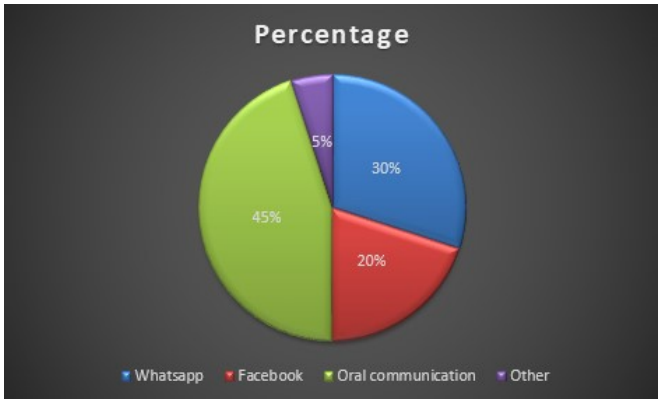

Figure 13: Communication pie chart

As seen from **Figure 13** and **Table 12** mostly, the team communicated orally, using WhatsApp and Facebook group to schedule meetings. The team also uses Google Drive and e-mails to share materials with each other. **Table 13** shows a detailed overview of the communication between the members of the team.

Table 13: Communication matrix

What	Who	Why	When	How
Deliverables	Mile/Szymon	To not miss the deadline	Before the deadline	Upload the wiki
Scheduling team meetings	Everyone	To schedule a team meeting	Once a week	WhatsApp
Holding team meetings	Everyone	To decide next steps/brainstorm/work on the project	Once a week	Face to face
Agenda	Everyone	To inform the agenda to the supervisors	The day before the meeting(usually every Wednesday)	Upload to Wiki
Meeting with the supervisors	Everyone	To inform the supervisors about the current state of the project	Every Thursday	Face to face
Interim presentation	Everyone	To get feedback from the supervisors for the first part of the project	19-04-2018	Face to face
Share researched materials	Everyone	To show the materials that have been researched	Whenever possible	Mail/Google Drive

3.7 Risk

The team has thought about the risks involved in the process of developing and maintaining the product. To combat this problem and for a general overview of the risks involved in the project, the team set up a table as seen below in **Table 14**.

Table 14: Risk table

Description	Trigger	Responsible	Probability	Impact	Importance	Strategies	Status
Component malfunction	Faulty item delivered	Seller/Manufacturer	Unlikely	Reorder/Replacement	Major	Buy duplicates/backup design	Open

Description	Trigger	Responsible	Probability	Impact	Importance	Strategies	Status
Overlapping with competitors	Product with same/similar name	Team leader	Likely	Rename/Revamp product	Major	Proper research beforehand	Active
Overestimating our capabilities	Lack of research	Research manager	Unlikely	Force to change	Major	Proper research/multiple propositions	Active
Team member missing	Irresponsibility/accident/sick team member	Project manager/Team member that is missing	Likely	Work not done/lack of communication/lost time	Moderate	Increase communication/Multiple workers per task	Active
Seller out of stock	Lack of experience	Team leader	Unlikely	Unable to deliver the promised results	Major	Designing a less complex solution	Open
Plants getting improper treatment	Huge demand	Seller	Unlikely	Delay of project/redo the budget	Extreme	Anticipate/find multiple suppliers/find backup design	Open
Lack of safety measures	Creating a wrong environment for the plant/underbudgeted/poor design	Engineer/Budget/Team leader	Unlikely	Possibly dangerous product	Extreme	Carefully design and implement the product	Active
Quarrel between team members	Misunderstanding/Personal problems	Team members involved	Unlikely	Project may suffer/bad work atmosphere	Extreme	Maintain correctness/good relations	Open
Customer misusing the product	Customer making a mistake when picking a plant to grow in the application/Customer not understanding the manual	Customer	Likely	Plant may not grow as intended	Major	Proper documentation/manual	Open
Natural disaster	Flooding/Earthquake/Lightning etc...	Nature	Very unlikely	Product may be partially or totally destroyed	Very extreme	Accept, nothing can be done	Closed

3.8 Procurement

3.9 Stakeholders management

3.10 Conclusion

As a conclusion, for the project to be successful, it has to be managed thoroughly and strategically. That does not only include management of people but even more: risk, quality, cost and stakeholders. The essentials to succeed in the project management is to keep up with the principles. It is a key part of the project, with great impact on whether or not the project will succeed or not. This study allowed the team to define specific criteria and also succeed with most optimal management solution.

4 Marketing Plan

4.1 Introduction

Many people think narrow-minded that marketing means only “selling” or “advertising.” It is partially true but marketing is much more. It is a lot of activities that create a link between the brand and the consumer. The marketing approach of a successful company is to understand and fulfil consumer needs. Indeed, marketing is a wide management field in applications and content. The client needs are

Figure 14: Maslow's hierarchy of needs [51]

the heart of all of this approach.

Do not forget that the marketing does not create new needs but answers existing ones. This raises a desire for a product/service which would answer one or more of basic human needs/desires (according to Maslow's pyramid, as seen in **Figure 14**). Desires are limitless and the more a product answers then the more the wider market will be.

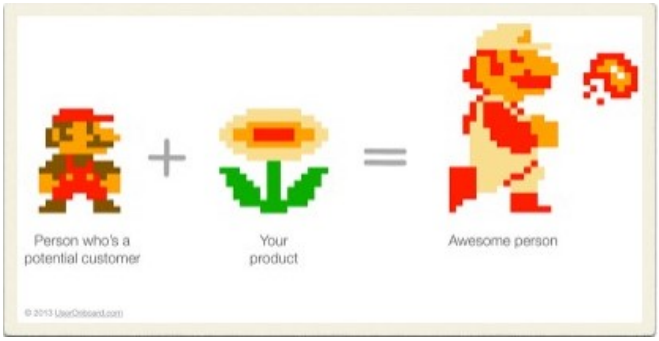

Figure 15: Pop culture image explaining why people buy products **[52]**

"People don't buy products, they buy product benefits" - Luis Lopes

"People don't buy products, they buy better versions of themselves"

This report part is to provide a proper marketing plan for our product while taking into account the actual market to achieve the marketing objectives. Our analysis is firstly about the market and customers, then about the target, price, product, and promotion will be discussed to establish a suitable strategy for the product launching.

4.2 Market Analysis

Before we start the market analysis, it will be necessary to determine the problem statement. Indeed this preliminary analysis will be used to understand what will be our work environment, the current market, and it will permit us to be positioned on this one. This study is essential to know during the project and in the future, how to face this possibles threats/opportunities with our own weakness/strength thanks to a strong strategy previously made.

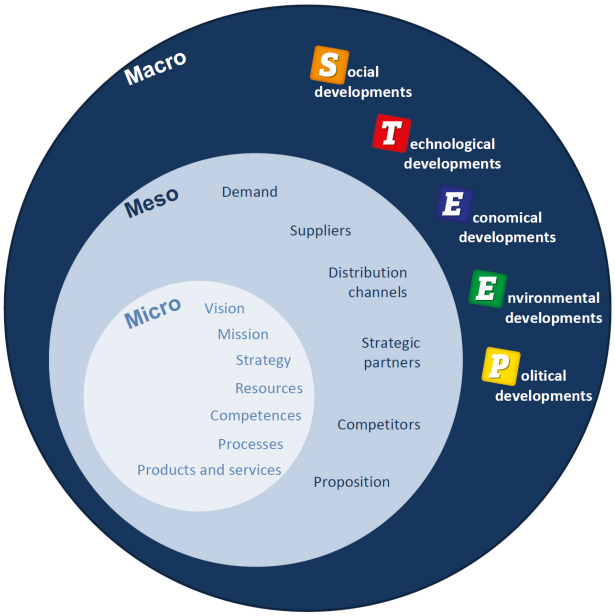

Figure 16: Macro, Meso, Micro scale **[53]**

The whole market analysis can be cut in 3 parts:

- The macro-environment
- The meso-environment (not analyzed here)
- The micro-environment (defined afterward).

Problem statement

- **As a private customer,** I don't have an

easy access to supply of fresh herbs and vegetables for my use without going to a shop/market and spending money on a regular basis.
- **As a health-aware customer,** I don't trust the quality of herbs and vegetables available on the market and I am afraid a lot of unhealthy/toxic chemicals might have been used to grow them.
- **As a private customer who would like to grow my own supplies,** it would only be possible to do so provided I have big enough outdoor area available to me to change into a garden.
- **As a private customer who owns their own garden,** the process of growing my own supplies takes loads of my free time and energy.

4.2.1 Macro-environment

First of all, the macro-environment is the market by the scale view of the whole world. That means all the factors that we cannot be able to manage but which will influence our product and affected the performance and the decisions of the team.

All these uncontrollable factors are gathered by the PESTEL analysis:

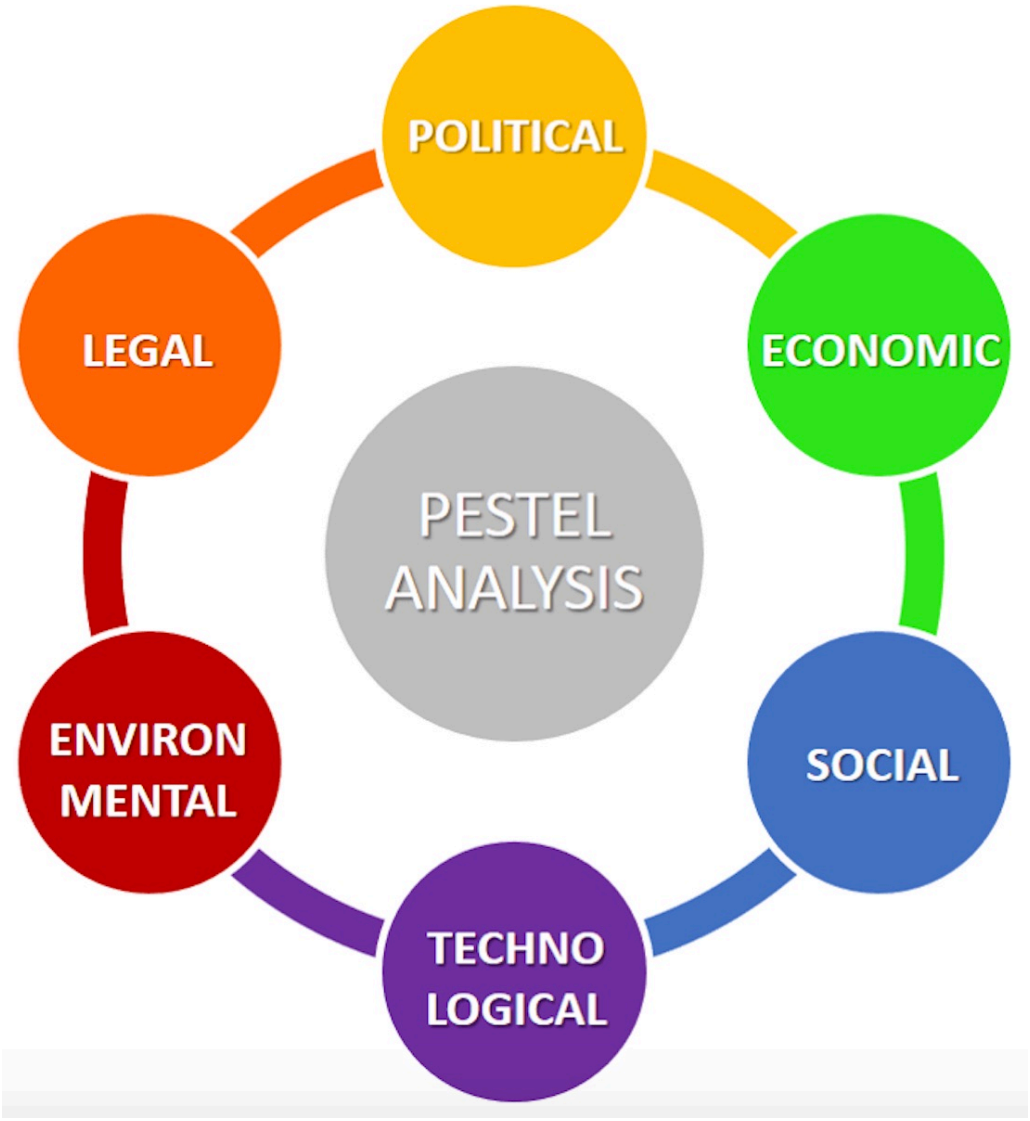

Figure 17: PESTEL analysis **[54]**

POLITICAL/LEGAL ASPECT is in the case of vertical farming, it has no law against the self-growing, taxes on neither.

Opportunities:

- Our compliance with the environmental ethic. To be irreproachable on the recyclable part and in agreement with environmental legislation of the European Union, all the used materials will be recyclable. That contributes to reducing consumption of energy and new raw materials and production of greenhouse gases and, air and water pollution. Moreover, our product will have a high lifetime.

Threats: Nothing relevant

ECONOMIC ASPECT is the influence of the consumer quality of life.

Opportunities:

- The price of our product can be a threat but the price of biological vegetable can be an opportunity to promote the “own growing”.

Threats:

- Indeed, the incomes are really different on one side of Europe and the other (Greece and Switzerland) so the link the sale price will differ from country to country. Moreover, the differents incomes of the differents social economic classes can be a threat to the sales of our product.
- The cost of electricity can increase and our product isn’t autonomous, that can be a brake of buying if this energy becomes too expensive for consumers.

SOCIAL ASPECT represent for our product the opportunity of the biological and healthy trend.

Opportunities:

- Currently, more and more people live in cities (rural exodus), meaning fewer and fewer places are designated to a garden, and the food is less and less biological, which means less and less healthy. Nowadays, customers feel more involved and touched by ethics, sustainability, biology, recyclability, pollution, etc. and a vertical farm can provide an answer at this wish;
- More and more people are affect by the recyclability and the sustainability of products, with your own plant there is no need to drive to the supermarket (less gas used), no package thrown in the trash, no toxic products used to grow your plants, more involvement in the earth protection with benefit for your lifestyle.

Threats: Nothing relevant

TECHNOLOGICAL ASPECT involve all the technologies which can impact our product.

Opportunities:

- More and more people are connected to social media and disconnected from mother nature. In this way, to turn this threat into an opportunity we have decided to create an application available on a smartphone connected with our vertical farm.

Threats: Nothing relevant because the technological gap between countries doesn't really exist anymore

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ENVIRONMENTAL ASPECT: The most important one for our project because of our choice to be sustainable,

Opportunities:

- No wastes will be produced and our product will use an aeroponic system which uses less water than soil farm, that responds to the need of saving pure water.
- In some country without a lot of sunshine and with harsh temperature, the weather can become an opportunity for our application, allowing growth of some crops that normally do not grow in that climate.
- The electricity is more and more reap by sustainability way like with the water with hydraulic pump), the wind turbine and the photovoltaic pannels. So our only need resource is now

renewable.

Threats:

- The weather can be a threat in some country where it is really easy to grow a lot of kinds of vegetables, with a lot of sunny days.

4.2.2 Microenvironment

Then, the microenvironment is the actual market by the scale view of the company. Microenvironment means all the actors in an immediate area of operations that influence the performance and decisions of the team.

These actors can be analyzed by the 5 PORTER's forces:

Figure 18: Five PORTER's forces analysis **[55]**

CUSTOMERS and more exactly the power of clients, the pressure they can exert over the market. On the vertical farming market, the pressure from customers come to their trends. That means if the trend of biological change our product can become old-fashion even if is useful. That means to grow your plants can become a real way of life too. All these factors can influence the price of our product through the sales, that’s why we need to create and hold the desire to have the own indoor garden. With advertising, innovation and development/update of our application, and of course highlight the benefits of “Vereatable”. Currently, the number of rural people wanting biological food at a low price is increasing that limited their negotiating power. Moreover, our vertical garden will solve the problem of the place and time, place because is vertical and time because it’s autonomous and connected with

an application, that will increase again the number of our possible customers, so decrease their negotiating power.

SUPPLIERS' power is about all the materials we need but we can't provide. In fact, have several suppliers can solve some problems but is not easy enough because in some field they are only a few suppliers. Currently, suppliers can have a deal between them, an agreement to have room for maneuver. If suppliers are organized, they are controlling the market and play with the rivalry between them become impossible. Actually, our suppliers are an electrical component shop, they are a lot everywhere, then their negotiating power is limited. The raw material shop (wood, metals, etc.) are also a lot, so their negotiation is limited too. The only supplier with a significant negotiating power is the application hoster like IOS and Android.

THREATS OF NEW ENTRANTS in the vertical farming market is largely because of the increasing demand. Indeed as we said before people are more and more concerned by biological food, sustainability, recyclability, no waste, environment, etc. and as people are more and more rural the vertical farming is the solution. The market is currently in a boom for only a few years that's why it is possible to make a way for us yet. COMPETITORS: Rivalry

RIVALRY IN THE INDUSTRY (ie. state of the art) of vertical farming

Name:	IKEA		MiniGarden		Click & Grow			AeroGarden				Arduino Vertical Farming	ZipGrow	Tower garden	SAMARA
Device:	Krydda	Krydda + Vaxer	MiniGarden Vertical	MiniGarden Kitchen	Small Garden 9	Wall Farm Mini	Wall Farm	Sprout	Harvest	Bounty	Farm	RUFS	tower farm	tower garden	Vereatable
Price (€):	29	111	55	156	199	899	1299	80	186	308	567		73	440	75
Width x Length x Height [cm]:	44 x 25 x 80		64 x 19 x 60	64 x 19 x 160	60 x 18 x 59	135 x 25 x 148	135 x40 x 202	13 x 28 x 40	27 x 19 x 43	44 x 29 x 87	91 x 30 x 87	152 x 152 x 152	10 x 10 x 152	76 x 76 x 157,5	60 x 60 x 60
Levels:	2	2	3	8	1	2	3	1	1	1	1	8	5	4	3
Weight [kg]:	8.1	10.6	3.03	8.08	2.4	50	70	2.25	3.44	6.35	9.97	N/A	4,3 kg		10
Max. plants [pcs]:	16	16	9	24	9	34	51	3	6	9	24	160	10	20	9
Max. plant height [cm]:	30	30	N/A	N/A	40	30	30	25	30	60	60	Depending on the pipes	N/A	N/A	N/A
Materials used:	Steel, PET plastic	Steel, PET plastic, PP plastic, Acrylic plastic, Polycarbonate plastic	Polypropylene Moplen with UV protection	Polypropylene Moplen with UV protection	N/N	N/N	N/N	N/N	N/N	N/N	N/N	Detailed in the link	Non-woven polyester, 100% rigid PVC	plastics	Plasctics and steel
Plant growing technique:	Hydroponics	Hydroponics	Soil based	Soil based	Soil based	Soil based	Soil based	Hydroponics	Hydroponics	Hydroponics	Hydroponics	Hydroponics	hydroponie, aquaponie	Aeroponic	Aeroponic
Automated water distribution?	No	No	Possible, once appropriate kit is bought and installed, if connected to central water system		yes	yes	yes	yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Integrated lights?	No	Yes	No	No	yes	yes	yes	yes	Yes	Yes	Yes	Yes	No	No	Yes
Automated lights?	No	No	No	No	yes	yes	yes	yes	Yes	Yes	Yes	Yes	No	No	Yes
Independent modules?	Yes, because of the simplicity of the system	Yes, because of the simplicity of the system	No	No	no	no	no	no	no	no	Two independed trays	Yes	Yes	Yes	Yes
Expandable via modules?	No	No	Yes	Yes	no	no	no	no	no	no	Yes, devices can be stacked	Yes	No	Yes, piece of 5 plants can be added on the top	Yes
Mobile app?	No	No	No	No	Yes, although not controlling the functionallities of the device			no	Yes, in the WiFi variant			No(innovation perspective)	No	No	Yes
Design variants:	1	1	5	5	3	1	1	3	4	4	2	1	1	1	3
Power Consumption [kWh / week]:	N/A	2.24	N/A	N/A	1.35	9.6	14.4	1.68	4.48	6.72	15.67	N/A	N/N	N/N	1,1
Water consumption [L / week]:	4	4	N/N	N/N	1	3.5	6	N/N	N/N	N/N	N/N	N/A	N/N	N/N	2

Figure 19: Rivalry in the vertical farming industry

In the current market, our product stands out from the competition by the smartphone connectivity with an application, the light automated and movable system and the water aeroponic system with automated distribution. The price is suitable for all the functions fulfilled and the size is good for the number of possible plants inside. We can get to the market with some way of pressure on the rivalry.

THREATS OF SUBSTITUTES GOODS

	Bio market	city garden	vertical farm
advantage	- in every shops - always available	- security - at home - cheap	- security - at home - cheap - inside you home (embellishment)
disadvantage	- not at home - trust of market - expensive - packaging waste	- sometimes far from your house or take a lot of place from the garden - depending of the weather - water consumer - time to grow - subject of water, soil & air pollution	- time to grow but it's autonomous, you just organize your menu - place but not a lot because it's vertical
availability	everywhere, a lot of suppliers (internet, shops, etc.)	rare in city center	Internet
price/month (€)	40	10 (location) 0 (outdoor garden)	3 (water & electricity)

Figure 20: analysis of substitutes goods

Finally, the solution of a vertical farm is cheaper, easier available and the security for bio food is better than the supermarket. As the own garden, time is necessary to grow your plants but the difference is in the distance from your home and the place that take. The vertical farming is a great option for nature lover and biological concerned person living in city.

4.3 SWOT Analysis

Table 15: SWOT analysis

	Positives (for the objective)	Negatives (for the objective)
Internal (the team)	**Strengths**	**Weaknesses**
	Sense of sustainable & ecological responsibility	New brand, Zero notoriety
	The app innovation	Electricity needs
	Quality of our product	Deadlines
	Team with different background fields	Limited Budget
	Competent teachers	Foreign language communication (misunderstanding)

	Positives (for the objective)	Negatives (for the objective)
External (environment)	**Opportunities**	**Threats**
	The emerging market	Fierce industry competition
	The connectivity asking of customers	Fluctuation in the currency
	Growing segment of the biological food	The prices drop in the biological market
	Increase in the number of the customers asking for homemade fresh food	Cost of electricity consumption

The SWOT analysis allow us to be conscious of team weaknesses so be carful about that. Indeed, weaknesses and strenghts are intern of the team, that's why we must used our strenghts to balance our weaknesses.

This analysis is very useful to have a large point of view of the environment's threats and opportunity, what is possible and what is risky or complicated. To see where are our opportunity and be irreproachable and strong on theses ones, for after make a way on the actual market and perhaps create a brand notoriety.

4.4 Strategic Objectives

The SMART method is the way to define and explain exactly your objectives in order to make it easier and successful. Over time SMART evolved in SMARTER to define always better your goals for being feasible.

Figure 21: Smarter objectives **[56]**

Specific & **S**imple: The goal must be easy, clear, exact and understandable easily by everyone. If it is not the case, we must decompose it in several shorters. Our main objective is to be competitive in the vertical farming market. Not really specific objective, that is why we can decompose it (ie. project planning)

- Analyses what is a vertical farm and the needs characteristics to fulfill them and build a real vertical farm. In our case water and light distribution and take less place as possible for as much as possible of plants.
- Analyse perfectly the rivalry on the actual market to be competitive on the market. What added value can we create ? in our case the smartphone application and the aeroponic système
- Define our target customers. Rural and hurry people wanted a garden but without have the time to work in. Nature lovers, biological and health affected and connected users.

- Define how to answer to this clients. with an autonomous system linked by a smartphone application and growing plants at home without toxic product. A decorative way to eat healthily.

Measurable: It is said that a measurable goal can be quantified or qualified, to define if the objective is complete or not with simple calculate/measure.

- Electric power use/week (less than 4 kWh for 9 plants)
- Quantity of water use/week (less than 2L for 9 plants)
- Can connect more than 4 modules together
- Win 3% of vertical farm market share
- Create a long-life system (more than 10 years)

Attainable: You must find a goal that is big enough to be daring, challenging, and motivating. But it must be small enough to remain attainable and attainable.

- aeroponic system so few water consumption (Electrical Engineer)
- sustainable materials (Packaging and Environmental Engineer)
- smartphone application (Telecommunications and Computer Science Engineer)
- few electrical power consumption (Electrical Engineer)

Relevant: Nowadays we find a way to encourage people to save place, eat biological and healthy with only few water and electricity is a real challenge but a relevant one.

Timely: In the context of EPS program, we have deadlines to respect (ie. Gantt chart). That is why our first real model will be ready and operational at the end of June.

- Date of actual market research' end
- Date of marketing/ethic/sustainability research's end
- Define the technologic model/system
- Define the design
- Beginning of production

Evaluate: In this kind of big project, it is necessary to evaluate your progress and quality after each task. Only because if you missed a mistake makes at the beginning you can spoil all your project. For example, our team must create an aeroponic system, but before to do that we must test all the received components. After all, components are truly good we can build the system who will be tested before to put it into the "box" and tested on plants. We will do the same for the smartphone application, we must test it after each forward steps.

Reward: This final step consists to reconsider your objectives, take a different point of view, being critical to see a possible another way. For example at the beginning our team wanted to create an aquaponic system, this way was really complicated and not in the "theme" vertical farming. So we just change the system for another also autonomous but easier. Then the system chose was hydroponic, already much present on the market and more expensive for us, so finally we change the aeroponic system.

4.5 Segmentation

Segmentation is the action of dividing a population into homogeneous groups according to different criteria. This is known as market segmentation or customer segmentation depending on the context. It makes it possible to create differentiated marketing actions as functions of the segments and to

possibly propose a product offer specific to each segment while taking care to avoid possible segment conflicts. It is also possible to choose to address only one market segment, that is our case.

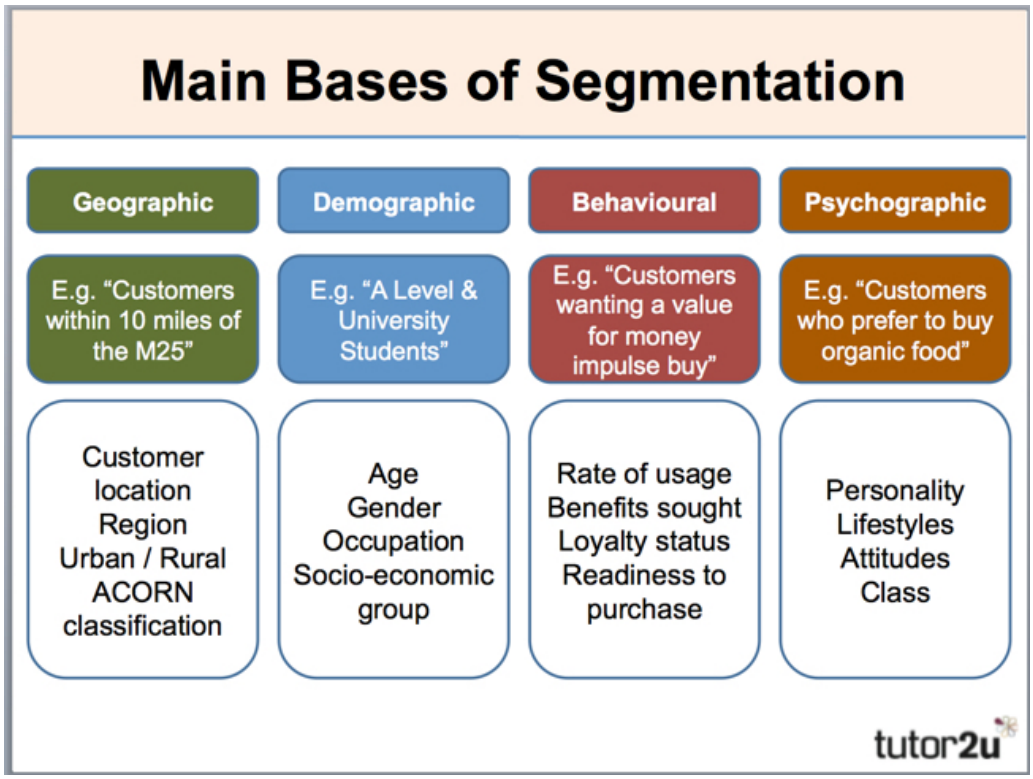

Figure 22: Main bases of segmentation **[57]**

4.5.1 Geographic

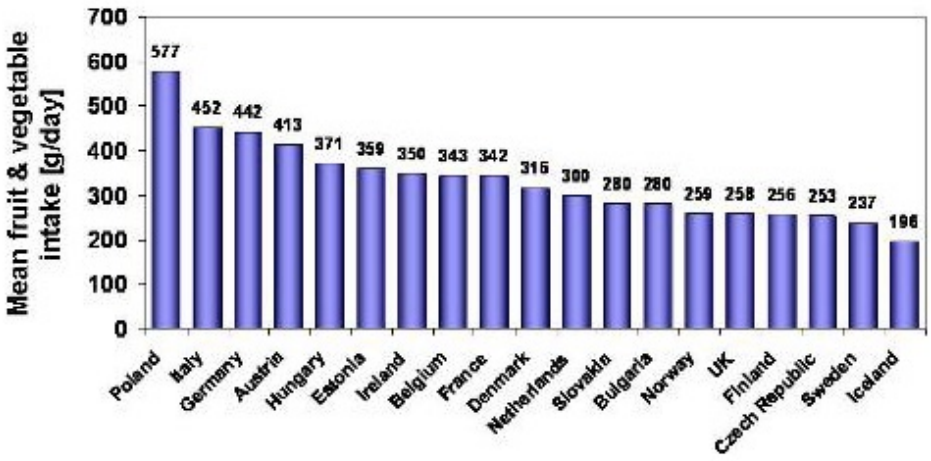

Figure 23: Geographical segmentation**[58]**

As we can see America and Europe are the biggest fruits and vegetables, eaters.

North of Europe & US: Vereatble is created to answer to this country with sometimes a cold weather, without a lot of sun per years. With our product, their garden will be indoor and the light will be controlled by a captor and LED automatized if during the day plants did not have enough sun.

South of Europe & South America: In theses country plants needs a lot of water, thanks to our aeroponic system this quantity can be reduced. In this kind of country they are a lot of suns, maybe we will develop a Vereatbale with the LED system.

Moreover, with Vereatable, no more need of soil and a lot of space neither, it will be very useful for big cities.

4.5.2 Demographic

Life situation of our target customers:

Gender: Men & Women

Age: 24-50

Family situation: Single / Couple / With children

Occupation: Workers

Interest: Health food & Nature

Income: Average or High

4.5.3 Behavioural

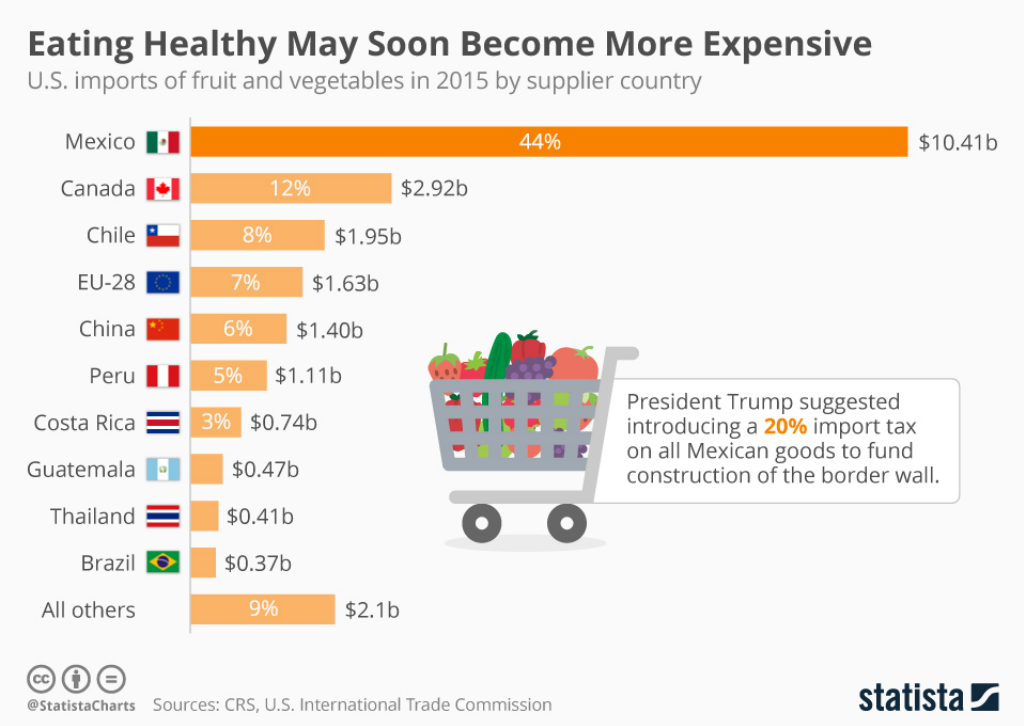

Figure 24: Behavioral segmentation **[59]**

The biological market boom increase the fruit & vegetable price everywhere in the world. All the usual biological food consumers can be easily attracted by Vereatable because of the small price, and the fact that our product is really autonomous. Moreover, no matter if you are a busy worker and if you do not have enough time to give to your garden, Vereatable is totally autonomous without use a lot of electricity. Our product allows you to have a veritable indoor garden, you can educate your children to grow fruits and vegetables, and most importantly to eat healthily. If you are a connected person you have a smartphone application where you can control light water and know what you grow, where and since when.

4.5.4 Psychographic

Our psychologic target is people feeling concerned by sustainability & renewable energy because our product has been done to consume as less as possible electric power and water. They are environmental & nature lovers to buy a recyclable product with long-life term product. Have a vertical garden at home enable you to reduce your wastes because you will not buy any more fruits and vegetable in a supermarket. Our product is for rural lovers who have to live in the city for their work. They can have a little garden indoor even if they do not have a lot of space. Our consumers will be biological food eaters.

4.6 Positioning strategy of brand

A brand is defined by its identity (Vereatable), its market (vertical farming) and its public(target customers). All this aspect of a brand contributes to establishing the strategy to adopt.

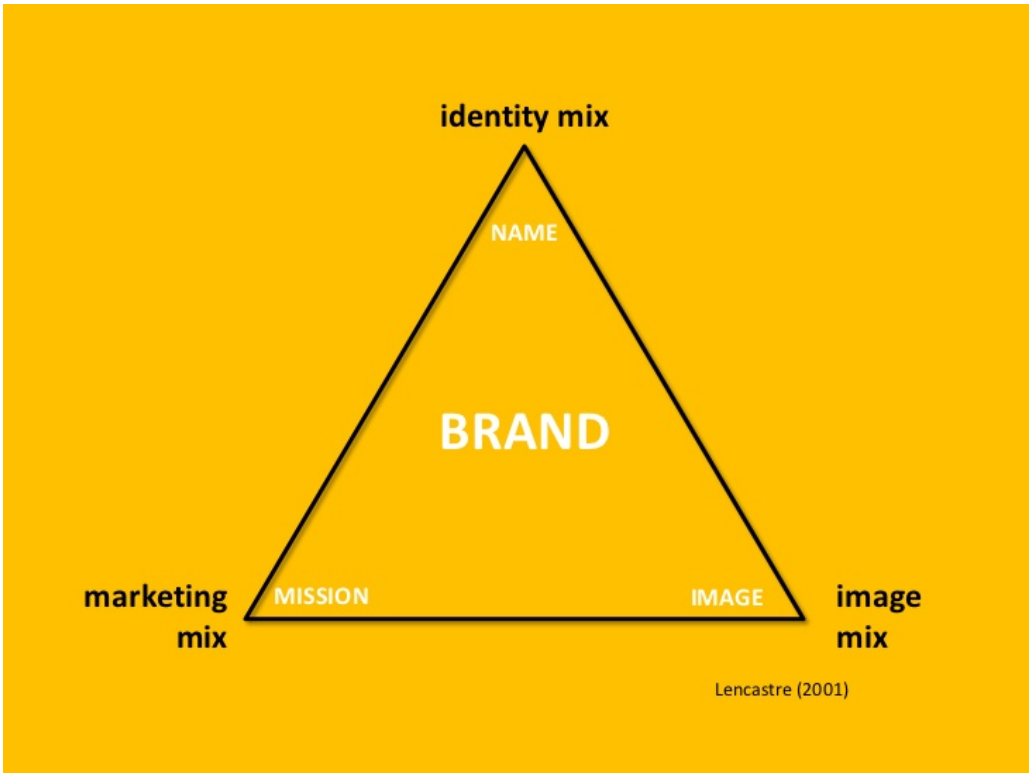

Figure 25: Branding strategy **[60]**

4.6.1 Identity-Mix

Distinguish yourself from the others brands is really important to have a room in the market and most important in the people/clients mind. That is why our team chose a really important name with a lot of significations and simplicity.

Figure 26: Product identity

The “Vereatable” name is a pun for veritable which mean truly, really. For our team, that means transparency, sincerity and something real without bad surprises. Eatable, because of the food, biological and healthy that you can grow with your vertical garden. And the whole word means food truly eatable, truly healthy and good for you and your family.

We wanted to make out “VER” for two reasons: - VER is the beginning of vertical for a vertical garden and - VER(T) in french mean green

The bands on the top of “eatable” are for the modularity of our product, because you can gather several modules to have a really big vertical garden. And because of the connectivity with our smartphone application.

Finally “indoor garden” because it will be your own little garden, where you can grow your fruits, vegetables, plants or flower, whatever you want, at home. A truly decorative inside garden.

4.6.2 Marketing-Mix

4P: The 4P model is the first one but also the less specific. This model gives us a vague idea about our product.

- **Product:** Vertical farming, autonomous system of distribution (water, light), smartphone connected, low consumption of water and electricity power.
- **Place:** garden and vegetal shops, e-market (Amazon, eBay, official website)
- **Promotion:** flyers and leaflet in the vegetal shops, word of mouth, social media, press-paper
- **Price:** 50-75 €

4C: The 4C model is more specific than the 4P. Because this model gives us more explanation, it pushes our team to ask the good questions, and give some rights answers.

- **Customer need:**

- Vertical farming: to allow rural people to have a real garden indoor. A vertical farm saves more place than a simple garden, moreover, you can put your vertical garden indoor so it is not sudden the weather. The most important is that the food you will grow with Vereatable will be biological without toxical products. No more excuses to eat healthily, not it will not be expensive and far neither because it will be at home just next to you.

- Autonomous system of distribution (water, light): As we now our customers' target are rural and hurry workers. That is why our product will be totally autonomous with some captor this system is

possible. Your plants' needs will be fulfilled perfectly. Water needs thanks to an aeroponic system and light needs thanks to a LED. The only thing you will have to do is to come and harvest your food.

- Few consumption of water and electricity power: The word “garden” has something ecological inside. That is the reason why we wanted our product as much as possible respectful of the environment. Thanks to the aeroponic system your plants will not consume a lot of water, so less than a traditional farm. And thanks to the automatic light LED system, these LED will be turned on only when it is necessary for your plants, and as we know LEDs do not consume a lot of electricity. Moreover, the materials we chose for the outside “box” is really resistant (long-life term) and recyclable. smartphone connected

- **Convenience of Buying:**

Our product will be available everywhere where nature lovers can find it. You want a *Vereatable indoor garden*? you can have it easily. You can search on the internet, directly on our website or Amazon, eBay, etc. or if want to see our product you can go in your garden shop.

- **Communication:**

As we are anew brand the communication is really important. At the beginning make some '“sales” can be effective. Fulfill a customer book to send e-mails with advantages or newsletters. Vereatable is a real quality product so the word of mouth will participate in our promotion. With our smartphone application we want to touch the connected generations so launch advertising on social media as facebook, twitter, Pinterest and Instagram is a really big part of our communication because it is here we will touch our biggest part of possible clients. And finally the press-paper like a newspaper, magazines, flyer in the streets, and leafleter in shops.

- **Cost to satisfy:**

Eat biological and healthy is an everyday concern. That is the reason we do not make a lot of money, the reason why our product is not really expensive, around the cost price for us. Moreover, the consumption of electricity is really low.

4.6.3 Public-Mix

4E: Now that our target public is defined we must think about how can we touch them?

- **Emotion:** pride of own biological production, no more guilty about the environment
- **Experience:** urban farming, biological and homemade
- **Exclusivity:** modulation of the size, adaptable for each kind of plant
- **Engagement:** simplicity, efficiency & ecological

4.7 Budget

To be competitive in a new market we must be present on the media to catch the attention of our possible customers, we must communicate with them. The advertising part is really important to make people know our brand and our product, to share our values.

Table 16: Marketing, Communication and

Promotion budget

Incomes	price (€)
budgeted money	+ 2 000
Sponsors	+ 2 000
Expenses	**price (€)**
Flyer (10 000)	- 100
Leaflet (5 000)	- 200
Social media advertising (instagram, facebook, twitter, pinterest)	- 1 000
Official Website	- 1 000
Radio	- 200
Televisor	- 800
Newspaper/magazines	- 600
Total	**+100**

Figure 27: Vereatable flyer

4.8 Strategy Control

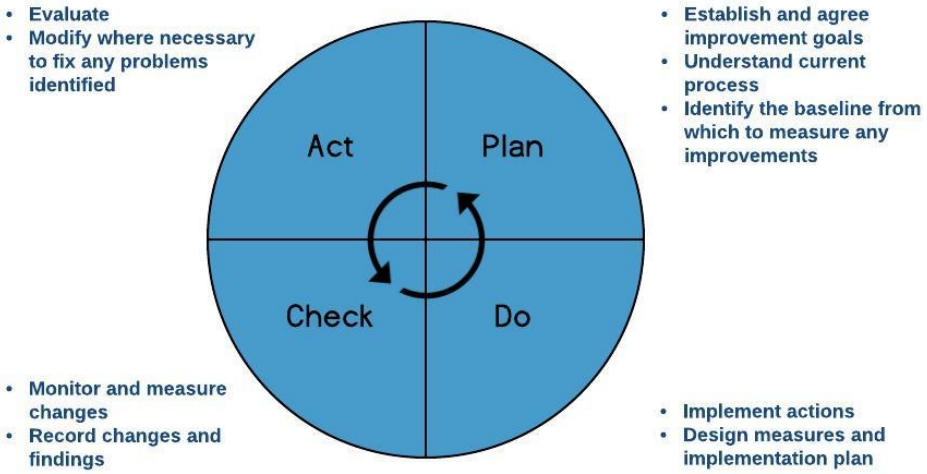

Figure 28: Plan Do Check Act **[61]**

PDCA (Plan Do Check Act) by Deming

Plan:

Do & Develop:

Check & Control:

Act & Adjust:

ie. Evaluate and Reward from SMARTER method

4.9 Conclusion

Here are two elevator pitches to summarize this study:

Table 17: Elevator pitch from standpoint vs. traditional farming

For	A private customer living in an urban area
Who	Is health-aware and wants to grow his/her own supplies
The	Vereatable - Indoor Farm
Is a	Household-friendly, self-sustainable, and modular farming solution
That	Provides a steady supply of fresh vegetables, fruits, and herbs right at your home without major time and effort investment
Unlike	The food supply available in the big city stores
Our	Guarantees healthy, toxic-hazard-free crops and is available for you fresh and ready all year round

Table 18: Elevator pitch from standpoint vs. other vertical farming

For	A connected customer living in an urban area
Who	Is health-aware and wants to grow their his/her supplies without being keeping busy
The	Vereatable - Indoor Farm
Is a	Household-friendly, self-sustainable, and modular farming solution
That	Provides a steady supply of fresh vegetables, fruits, and herbs right at your home without major time and effort investment
Unlike	Vertical farming products without the possibility of modularity and without automated application
Our	Guarantees healthy, toxic-hazard-free crops and is available for you fresh and ready all year round

To conclude, we can say the vertical market and our place inside it have been well study. Our product can be really competitive on this one because of his numerous innovations and concerns. Indeed, an autonomous lihgt and water distribution systeme allow us to touch workers, the smartphone application allow us to touch the connected generation (25-50 ans), the aeroponic and LED system allw us to touch environmental lovers because of the few ressources needed and globally the vertical garden is the whole community of biological, healthy food user (or just flower) but living in city without place and time neither to grow it.

5 Eco-efficiency Measures for Sustainability

5.1 Introduction

Current agricultural systems are not as effective or sustainable as they should or could be. Agricultural agriculture is a promising solution to the disadvantages of traditional agriculture. Compared to traditional farming, vertical crops use 70 to 95 percent less water and over 90 percent less land and harvest 80 percent more per unit area. The Vertical Farming Association, a two-year, nonprofit organization focused on promoting the industry, says vertical farming allows people to produce crops throughout the year because all environmental factors are controlled. It produces healthier and higher yields faster than traditional agriculture and is resistant to climate change. In addition, as the world's population becomes more urbanized, vertical farms can help meet the

growing demand for fresh local produce. **[62] [63]**

5.2 Environmental

For cultivation of plants, Aeroponics, which is already successfully used in greenhouses, is proposed as the most suitable method. Aeroponics is the process of growing plants in an air or mist environment without the use of soil or an aggregate medium. The basic principle of aeroponic growing is to grow plants suspended in a closed or semi-closed environment by spraying the plant's dangling roots and lower stem with an atomized or sprayed, nutrient-rich water solution The advantages of this technique are, on the one hand, that it makes it unnecessary to use herbicides due to the absence of fungi, and on the other hand that it recycles the nutrient solution, which is re-used in fertilization. It is sometimes considered a type of hydroponics since water is used in aeroponics to transmit nutrients. Vertical farms are distinguished for the minimal use of water, as they manage to use their irrigation system in a reasonable and fully controlled manner and drastically reduce the unnecessary use of water The vertical form of this type of farms allows the formation of many parallel crops in a smaller space - compared to the cultivations in a traditional field. Thus, several land areas remain untouched by the human hand, protecting and preserving soil quality. Growing plants in such an environment are constantly exposed to radiation, allowing them to grow more rapidly and perform more, as they do not have to wait for the sun to reappear in order to benefit from its beneficial properties. In addition, leaving a smaller impact on the environment. **[64] [65]**

5.3 Economical

Sustainable economy by general definition is the one that does not use natural sources more quickly than nature can replenish. A sustainable economy is built, in our opinion, based on ethical values, innovation, investment and sound financial bases, using available resources to make better use of us. The aim is to use these resources in a way that is efficient, responsible and can yield long-term benefits as well as continuous profit. Sustainability principles, centered on the environment and society, are a strategic factor for economic growth and maximum but also long-term corporate performance. We came to the conclusion that Sustainability is not limited to spending cuts. In the first years, the sustainability principles do not bring profit for companies as they are called upon to invest funds for their implementation throughout their financial cycle. It is not an automatic process, but an investment and only the companies that adapt to the principles of sustainable development will stay in time. **[66] [67]**

- Physical capital (natural resources)
- Human capital (including skills and motivation)
- Social capital (social networks, trust, social standards)
- Technological capital (tools, technology, machinery, buildings, infrastructure)
- The financial capital (the production power of the other four types of capital)

5.4 Social

Although Social sustainability is an often overlooked aspect of sustainability, is extremely crucial if you want to attain the most sustainable outcome possible. ISO 26000, the Guiding Pattern for Social Responsibility, is probably the most comprehensive tool that can help businesses integrate the principles of social responsibility into everyday business ventures. It should be clear that there is no

single guide to applying the principles of Social Responsibility that can be used in every business. The issue is, unfortunately, more complex and the details of the implementation of the basic principles of viability depend on the type of business and the place where it operates. The basic pillars of the standard are clearly explained within the model itself: **[68] [69]**

- Human rights
- Work practices
- Fair business practices
- Consumer issues
- Social participation and social development

5.5 Life Cycle Analysis

Life Cycle Analysis (LCA) is a set of research tools for assessing all the environmental impacts associated with the entire lifecycle of a product. The objective of the life cycle analysis is to seek and quantify the environmental degradation resulting from the production of a product or a production process. This is possible through monitoring the product from its “birth” to “burial”, from the extraction of raw materials, production, use up to its final disposal. Through this process, it is possible to identify those activities that cause the most serious environmental burdens. Producers can, therefore, focus on specific sectors to reduce or even minimize pressures on the environment from their production processes. **[70] [71]**

Regarding the life of our vertical farm we tried to accomplish the most sustainable choice as possible.

- Vereatable, indoor garden its re-usable.
- After purchasing it is up to the consumer to re-filled the water tank and the needed nutritians necessary to sustain the plants of choice.

5.6 Conclusion

To conclude this chapter, after penalizing the three areas of the sustainability report, Environmental, the Economic and the Social areas, the team chose to use environmentally friendly materials, and produce a re-usable indoor vertical farming. It was very important for the team to make a product that is respectful to the environment by not only during the manufacture but only during its life course. With Vereatable, the indoor garden we provide an eco-friendly solution and a greener way of life.

6 Ethical and Deontological Concerns

6.1 Introduction

Ethics and deontological concerns are an important pillar of any company's core. These principles play a big role in the way a company works but also in its public image. The Ethical and Deontological Concerns varies depending on the area, but all of them are based on an agreed common code. Because of the variation of areas in our team we believe that the ethical behavior and deontological concern should be inherited in each field. **[72] [73]**

6.2 Engineering Ethics

The profession of an engineer is particularly important, given that it is generally accepted that, as long as this profession is concerned, there is a work that has a direct and positive impact on the quality of life of all human beings. By analogy, the services offered by the engineers require honesty, objectivity, fairness and impartiality and must be effective in the protection of public health, security and publicity. When practicing their profession, engineers must follow a professional attitude that has the highest ethical standards of behavior towards the public, customers, employers, and the profession of engineering itself.

Every country has its own organization which describes ethical guidelines for engineers. The society of NSPE, National Society of Professional Engineers, has a list of rules which is the perfect example of what an engineer should apply to his moral code.

I. Fundamental Canons

II. Rules of Practice

III. Professional Obligations

The team decided to support and work between the lines of the NSPE code of ethics. **[74] [75]**

6.3 Sales and Marketing Ethics

Our team decided to support and work within the guidelines of the ICC/ESOMAR International Code on Market and Social Research, the Code is based on 8 key fundamentals. The team have decided to behave ethically and shall do anything that might damage our market reputation. Our biggest priority is the consumers and as a result, we shall not do anything which might damage our reputation such as misleading, information about the general purpose and nature of the project. We will conform to all relevant national and international laws and we will ensure that the project is designed, carried out, reported and documented accurately, transparently and objectively. **[76] [77]**

6.4 Environmental Ethics

The more aspects of the ecological crisis are perceived and felt, the more pressing is the task of re-aligning our moral values and visions towards directions for taking into account and integrating the nonhuman beings of our planet as well as the corporations. Global ecological problems require us to establish such moral relationships that until now have not studied in a structured way. The environmental impasse in which today' s societies have been driven, as well as the increasing awareness of the acute environmental problem facing the whole of mankind, fatally affect our quality of life and lead to a redefinition of the relationship between today' s man and his natural environment, the need for new moral values. And this is what we are trying to accomplish with our project, Vertical farming. Our goal is to figure out the most effective way not only to have a smaller impact on the environment by the means of sustainability and efficiency but also healthier, insecticide-free products and the opportunity of a greener way of life for our consumers. **[78] [79]**

6.5 Liability

Our first concern revolves around testing that the product works properly and making sure that all of the materials that were used are from certified suppliers. We need to make sure that the application is fully factual and the instructions on how to use it are concluded, before putting our product available on the market. The European Union's requirements of Machinery Legislation must also be applied:

- Machine Directive (2006/42/CE 2006-05-17); **[80]**
- Electromagnetic Compatibility Directive (2004/108/EC 2004 12 15); **[81]**
- Low Voltage Directive (2014/35/EU 2016-04-20); **[82]**
- Radio Equipment Directive (2014/53/EU 2014-04-16); **[83]**
- Restriction of Hazardous Substances (ROHS) in Electrical and Electronic Equipment Directive (2002/95/EC 2003-01-27); **[84]**

6.6 Conclusion

To conclude the ethical and deontological analysis, the team has decided to be honest, objective, fair and impartial though out the life of the project and always try to find the best solutions especially regarding the environmental ethics. Because we believe that through our project on vertical farming we entering a field with great opportunities to change today's agricultures impact on the environment and provide a more greener and sustainable way of life.

7 Project Development

7.1 Introduction

In this paragraph, we show basics of our Aeroponics system. There is an overview of the proposed design, components, functionalities, electronic schematic, testing and final results. Once the tests are carried out on the prototype, final conclusions will be drawn and scheme for further development may be proposed. The specifications of indoor Aeroponics system are:

- Energy efficient
- Modular
- User-friendly
- Wi-Fi compatible
- Appealing design
- Cost effective

7.2 Architecture

During a brainstorming session dedicated to gathering innovative solutions to stand out of the market of vertical farming, the team has chosen the functionalities that they found mandatory for the project. Water level sensor for monitoring, and ambient light sensor to increase sustainability. After that, the first drafts were made as shown in **Figure 29**, which shows our initial concept and the black box diagram.

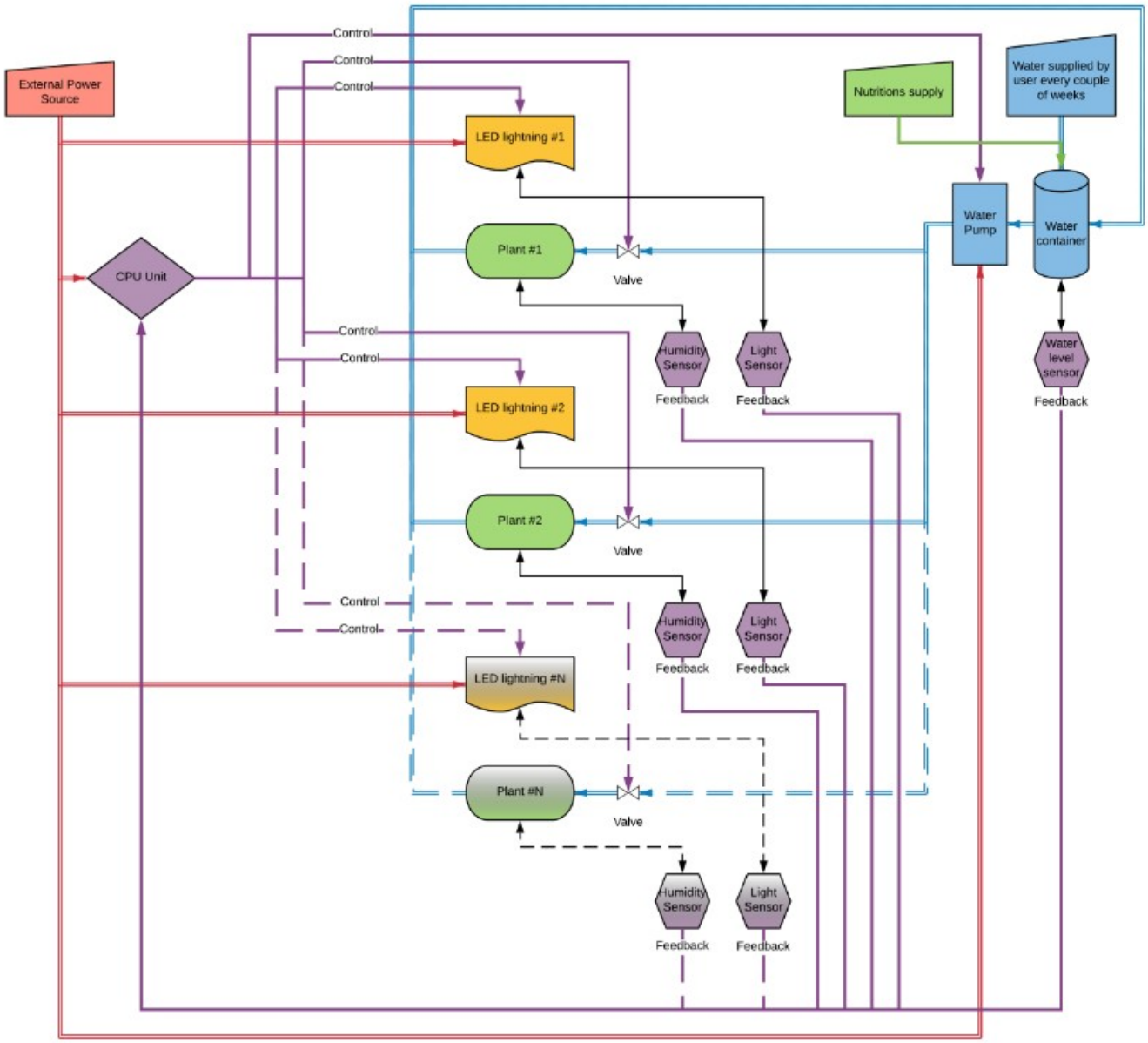

Figure 29: First blackbox diagram draft for the device

7.3 Schematics

The principles of operation as depicted in the previous section, albeit very likely valid for a commercial scale development prototype of the device, proved not to be compatible with our limited budget - for instance, having multiple solenoids valves depletes our money allocation almost instantly, with them being sold for an average of 10 € a piece. Not so complex and possibly slightly less functional solution - in the industry sometimes referred to as Minimum Viable Product - had to be assumed as a proof of concept, one that possibly could convince a sponsor or the crowdfunding community that the general idea is valid and the project should be expanded further based on this initial iteration.

The electrical schematics for such an MVP prototype is given in **Figure 30**, with a short legend of the colour-code applied to hard-wired connections summarised in **Table 19**.

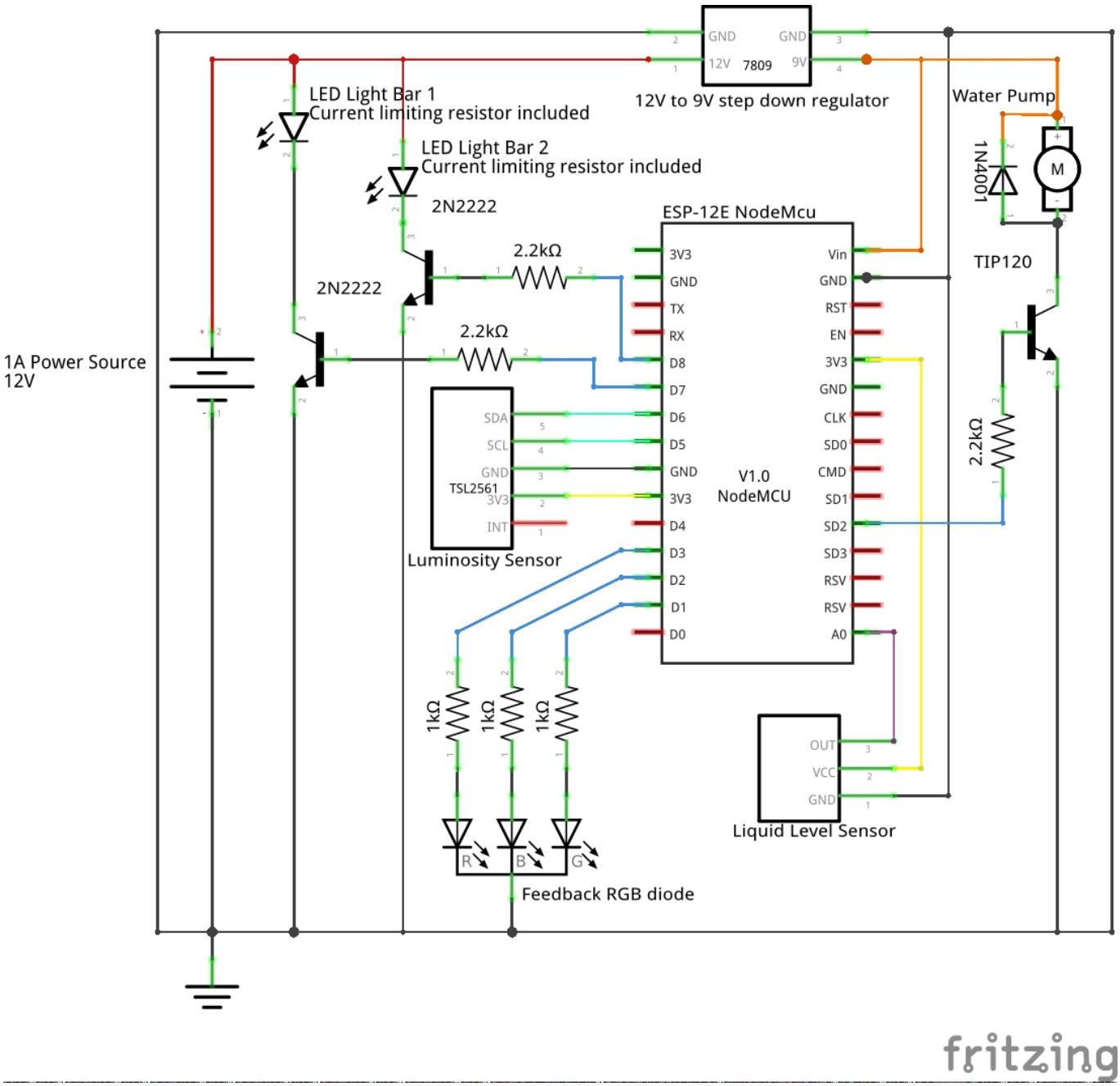

Figure 30: Electrical schematics for a Minimum Viable Product prototype

Table 19: Legend for the colour-code of electrical connections in electric schematics for a Minimum Viable Product prototype

Colour	Circuit	Comment
Red	12 V	12 V supply circuit for appropriate devices
Orange	9 V	9 V supply circuit for appropriate devices
Yellow	3.3 V	3.3 V supply circuit for appropriate devices
Purple	Analogue	Communication buses operating with analogue signals
Blue	PWM	Control buses operating with Pulse Width Modulation
Cyan	I2C	Serial Master-Slave communication buses
Black	GND	Circuit grounding and/or short elements interconnections

The final array of control-system functionalities contains, among others, modulating the intensity of work of both the water pump and the light-providing LED strips -including deactivation of the in-built lamps in the presence of high-intensity ambient light, control over the water level in the reservoir

tank, and simple feedback mechanism with an RGB LED diode available for machine-to-user communication, e.g. in case of power or communication failures.

Just like the financial aspect addressed further down this section of the Report, our resources - like electrical power - are limited. There is only so much energy delivered to the device that the components installed can utilise. **Table 20** presents the power budget for the Minimum Viable Product prototype.

Table 20: Power Budget of the Minimum Viable Product prototype

Component	Voltage	Current	Power
ESP-12E NodeMcu Microcontroller	9 V	200 mA	1.8 W
(2x) LED Light Bar	12 V	(2x) 30 mA	(2x) 0.36 W
RGB LED Diode	2 V	20 mA	0.04 W
Water Pump	9 V	500 mA	4.5 W
Waterlevel Sensor	3.3 V	20 mA	0.066 W
Iluminence sensor	3.3 V	1 mA	0.0033 W
Total			**6.7693 W**

7.4 Drawings

After basic drafting, the Team came up with an idea and drew a 3D model. We used NX for 3D modeling, it also includes real size components, shown as accurate as possible. Pictures below show the model from outside and also provide a detailed view from the model inside.

Figure 31 shows the product from the outside, how it will look to the customer

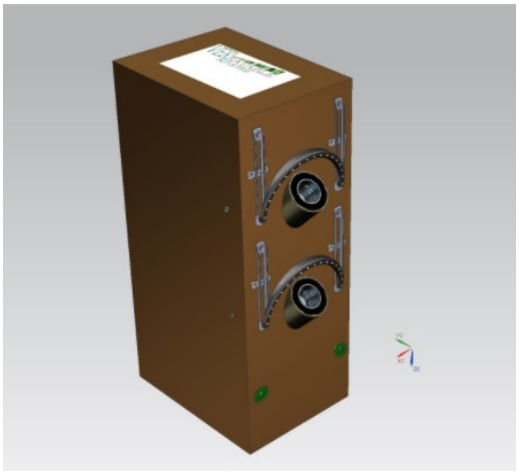

Figure 31: View of the model from the outside

Figure 32 shows the product from the back side to see how it fits the deposit with the pipes and joints.

Figure 32: Backside view

Figure 33 shows the product without the external part to show the connections and the parts with more detail.

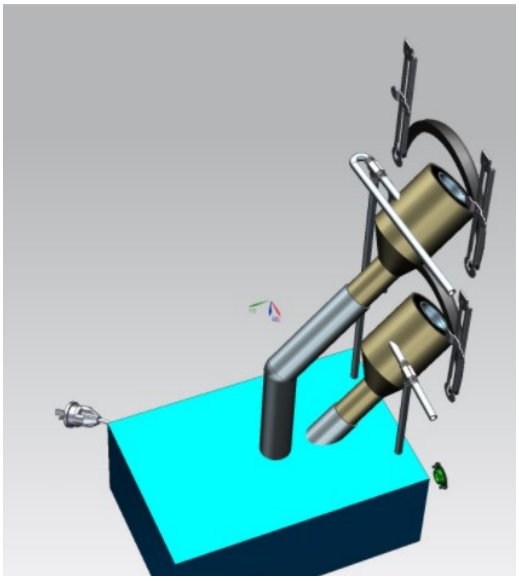

Figure 33: Water and pipe system

Figure 34 shows how the water is going to be spread with the sprinklers to the plant socket.

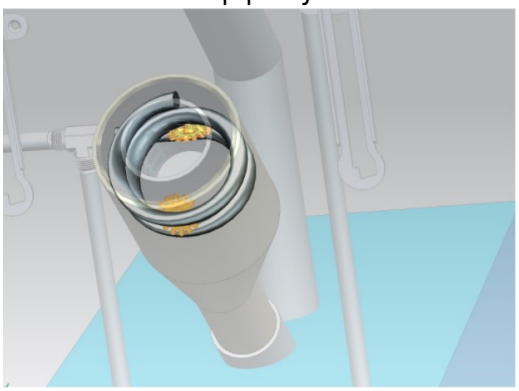

Figure 34: Empty plant socket

Figure 35 shows a detailed view of the plant socket ready to be used.

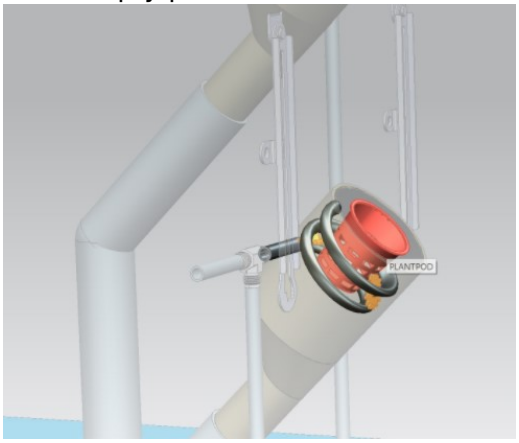

Figure 35: Detailed plant socket

7.5 Components

^ Component ^ Quantity ^ Comments ^ Usage ^ Est. Price ^ Est. Supplier ^

Case & Structural material					
Frame	1	Plywood chassis	Structural base of the device	2.50 €	Hardware Store (e.g. Leroy Merlin)
Water tank	1	Water tank	Reservoir for water in the device and environment for immersible pump	2.50 €	Hardware Store (e.g. Leroy Merlin)
Silicon tube	1	-	Distribution of water from the immersible pump	6.00 €	Hardware Store (e.g. Leroy Merlin)
Silicon tube connector	1	-	Connecting the pipes with the immersible pump	2.00 €	Hardware Store (e.g. Leroy Merlin)
Pipes	1 set	-	Collecting the excess water and transport to the reservoir tank	5.00 €	Hardware Store (e.g. Leroy Merlin)
Water Sprinklers	2	Simple, passive sprinklers	Evenly distributed water in the aeroponics system	3.00 €	Hardware Store (e.g. Leroy Merlin)
Electronic Components					
Wireless Microcontroller	1	ESP-12E NodeMcu	CPU-core of the device's control circuitry	9.90 €	“Bot'n'Roll” Online Store
LED element - plant illumination	2	3 LED Light Bar – White Light	Illumination of the plants inhabiting the device	7.20 €	“Bot'n'Roll” Online Store
LED element - user feedback	1	RGB LED light	Displaying basic information about the state of the device to the user	1.10 €	Bot'n'Roll Online Store
LED Holder	1	2-pieces self-closing mechanism	Mounting the user feedback LED element appropriately	0.15 €	“Bot'n'Roll” Online Store
Voltage Regulator	1	12 V to 9 V step down	Safely and efficiently reducing the supply's voltage for some of the devices	4.90 €	“Bot'n'Roll” Online Store
Water pump	1	Immersible water pump	Pumping water to the roots of plant inhabitants	11.65 €	“Bot'n'Roll” Online Store
Protoboard	2	Medium-sized, 22 x 26 holes	Assembly of the electrical components	3.00 €	“Bot'n'Roll” Online Store

Case & Structural material					
Water level sensors	1	Conduction-based unit	Keeping track of the water reserves in the tank	2.20 €	“Bot'n'Roll” Online Store
Illuminecence sensor	1	High-quality digital unit	Probing the ambient light level for efficient use of illumination LEDs	6.50 €	“Bot'n'Roll” Online Store
Jumper cables M/M	1	Pack of 10	Connections	2.00 €	“Bot'n'Roll” Online Store
Jumper cables M/F	1	Pack of 10	Connections	2.00 €	“Bot'n'Roll” Online Store
Jumper cables F/F	1	Pack of 10	Connections	2.00 €	“Bot'n'Roll” Online Store
Pin Headers	1	Pack of 40	Connections	0.60€	“Bot'n'Roll” Online Store
Transistor - bipolar NPN	4	2N2222 with H(rf) ~ 70	LED elements switching	0.60 €	“Bot'n'Roll” Online Store
Transistor - bipolar NPN	2	TIP120 with H(rf) ~ 1000	Water pump switching	0.98 €	“Electrofun” Online Store
Resistor - high valued	5	2.2 kOhm	Transistor Base isolation	0.25 €	“Electrofun” Online Store
Resistor - low valued	5	1 kOhm	RGB LED anode isolation	0.25 €	“Bot'n'Roll” Online Store
Diodes	2	1N4001 rectifying diode	Prevention of Immersible pump backward voltage spikes	0.20 €	“Bot'n'Roll” Online Store
Cable	1	Rigid core, 25 m roll	Connections	2.90 €	“Bot'n'Roll” Online Store
Power source	1	12 V - 1 A unit	Supplying energy to the device from the standard household mains	6.00 €	“Bot'n'Roll” Online Store
Power source adapter connector	1	-	Connecting the Power source to the device without the necessity of damaging the source's cable	1.00 €	“Bot'n'Roll” Online Store
Project Box	1	Medium-sized box with 12 output sections	Organisation of electronic components and limiting contact with stray moisture	2.75 €	“Electrofun” Online Store
Shiping					
Botnroll	-	-	Free delivery over 50.00€	0 €	-
Leroy Merlin	-	-	Free pick up at the store	0 €	-
Electrofun	-	-	Free pick up at the store	0 €	-
TOTAL				**89.11 €**	

7.6 Functionalities

The user of the product is able to grow different plants sought-after, due to controlling everything with an Android application the product is very user-friendly. Just insert the water, nutrition, plug it into the circuit and after that choose the plant from the Android application and enjoy. Thanks to the sensors and application you get notifications when product needs attention. This way, you will be able to cater your plants and give them the attention they need when they need it. The notifications may include:

- Water supply is getting low
- Plant is ready to be harvested
- etc…

7.7 Tests and Results

7.8 Conclusion

Provide here the conclusions of this chapter and introduce the next chapter.

8 Conclusions

8.1 Discussion

Provide here what was achieved (related with the initial objectives) and what is missing (related with the initial objectives) of the project.

8.2 Future Development

Provide here your recommendations for future work.

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