Vertical Farming

Prototype

- Indoor -

This documentation has been created by

Gaia Di Martino,

Svenja Zadow,

Juan Manuel Grados Luyando,

Sebastian Graber.

Contents

Table of Figures

List of tables

DOCUMENTATION

Introduction

The purpose of this document is to document and explain the steps and materials behind making a vertical farming prototype in a DIY style for home application.

The prototype was developed by the team Value Creation of the Laboratory of Production Engineering (LaFT) at the Helmut-Schmidt-University / University of Federal Armed Forces Hamburg for a workshop of the Arab-German Young Academy (AGYA) about Vertical Farming (July 2022). The aim was to create two prototypes (one outdoor version and one indoor version) that can easily be replicated with the help of this documentation.

The journey for both versions started with idea-hunting online: A simple research on the web gave us inspiration for what we wanted to do. The web is full of ideas, so we brought together different styles and adjusted them to our specific conditions. A site inspection was performed to understand some parameters, such as the size limitations of the outdoor prototype[1].

---

[1] Both versions are scalable by reducing or increasing the size. The scalability also influences the size of the used materials: e.g., for a smaller outdoor version, smaller beams should be used.

Indoor version

The indoor version concept is a high-tech, digitally manufactured DIY project. More technical materials, such as acrylic and aluminum profiles, were used.

Materials and costs

Note: Costs may vary according to region, shop, and period; the links may be used as a reference to find the same or a similar item in your country. The prices do not include the costs for plants, seeds, seedlings, and water.

Table 1: Bill of Materials (BOM) for the indoor prototype.

Item	Description	Quantity	Size	Link	Price per Unit	Price	Note
Pump	Landrip DIY Garden Irrigation Kit, Automatic Greenhouse Sprinkler	2	-	Link	53,99 €	107,98 €	
Growing Lights	T5 LED Plant Lamp Full Spectrum Plant Light with Auto Cycle Timer, two strips	2	-	Link	18,99 €	37,98 €	
Acryl	Acrylic plate	18	600 x 600 x 6 mm	Link	26,89 €	484,02 €	
Aluminum T-slotted profiles	Aluminium Profile 20x20 I-Typ slot 5	12	20 x 20 x 1000 mm	Link	6,12 €	73,44 €	
T-nut slot 5 M4	T-nut with spring ball, with guidance I-Type slot 5 [M4]	400	-	Link	21,30 €	85,20 €	
Brackets 20	Bracket 20x20 I-type Slot 5, 10 x bag	9	-	Link	2,84 €	25,56 €	
Screw	DIN 7380, 100 x bag	2	M4 8	Link	10,53 €	21,06 €	
Screw	DIN 7380, 100 x bag	3	M4 10	Link	10,53 €	31,59 €	
Plant Box	Indoor Greenhouse Propagation Box 2 Pieces 38 x 24 x 18 cm	2	38 x 24 x 10 cm	Link	23,90 €	47,80 €	

Table 1 (continued): Bill of Materials (BOM) for the indoor prototype.

Item	Description	Quantity	Size	Link	Price per Unit	Price	Note
Water Canister	JOYBOY 4 PIECE water canister, 10l foldable	1	20,5 x 22 x 21 cm	Link	18,99 €	18,99 €	Any water container that can fit in the cube is ok.
Coconut Fibers	Peat-free growing medium	3	-	Link	3,39 €	10,17 €	
Total							**943,79 €**

Building manual

This section explains the steps followed to design and build the Indoor Version.

Step 1: CAD design

The CAD was essential for the indoor prototype, and great attention was given to debugging and mistakes-proofing.

- Proof of concept: With a technical CAD design, it is possible to see (to a certain extent) if the design is feasible and stable. Some CAD software has integrated features to evaluate the mechanical properties of the project. Therefore, by having a 3D model, it is easier to evaluate the functionality of the idea.

- Clearer understanding of the materials to be purchased: With the CAD design, the dimensions are known. Therefore, less waste in the production is made.

- Reduce the error rate while producing and assembling: With a 3D model as a reference, it is easier to follow the idea. Furthermore, by designing the project, the steps in assembling may be clearer.

- Replicability: CAD file allows people to share their projects and replicate others'[2].

---

[2] This is particularly important when digital techniques (such as 3D printing, laser cutting and CNC milling) are used to produce the parts.

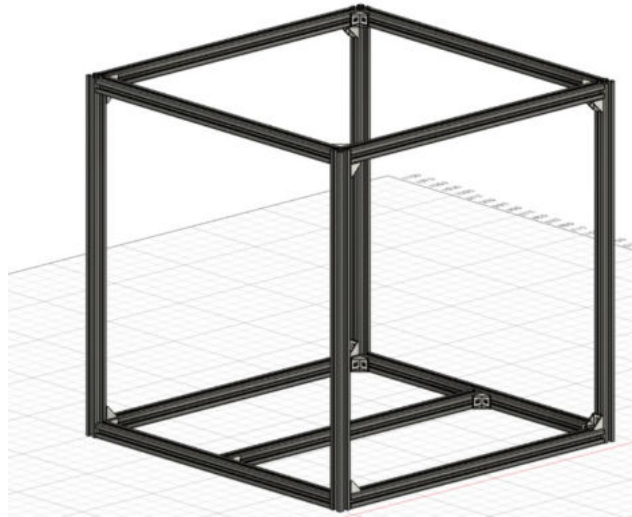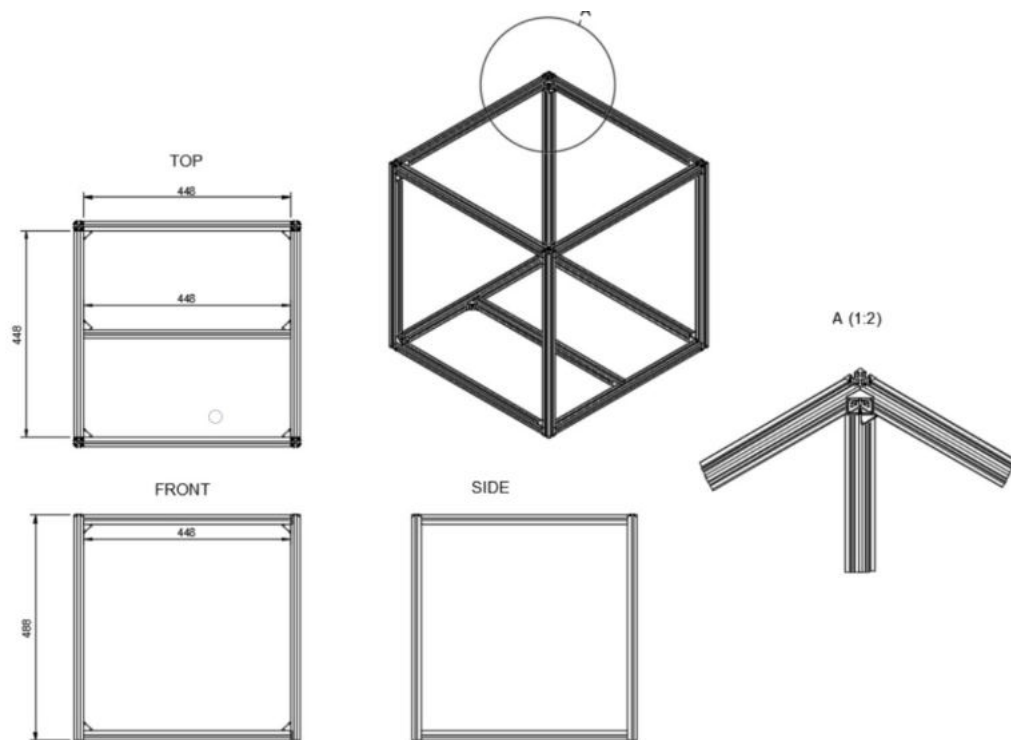**Figure 1: Aluminum profile frame, CAD drawing.**
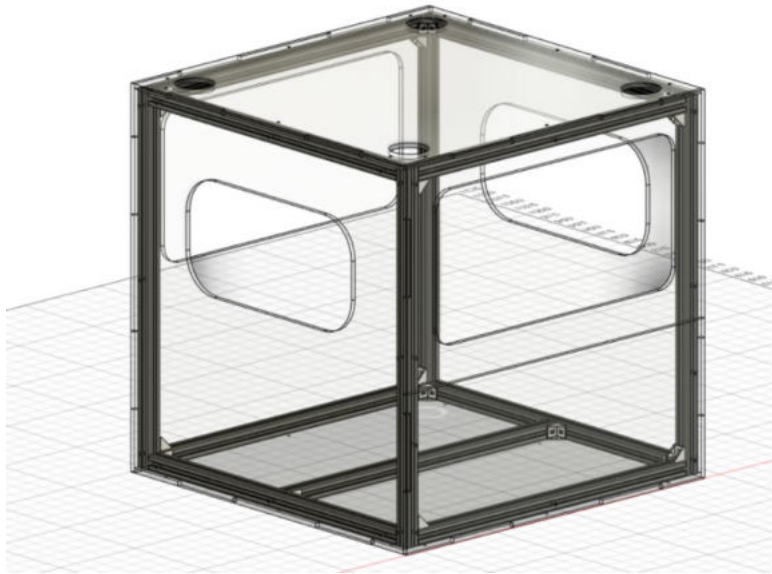

Figure 2: Aluminum profile frame, technical drawing.
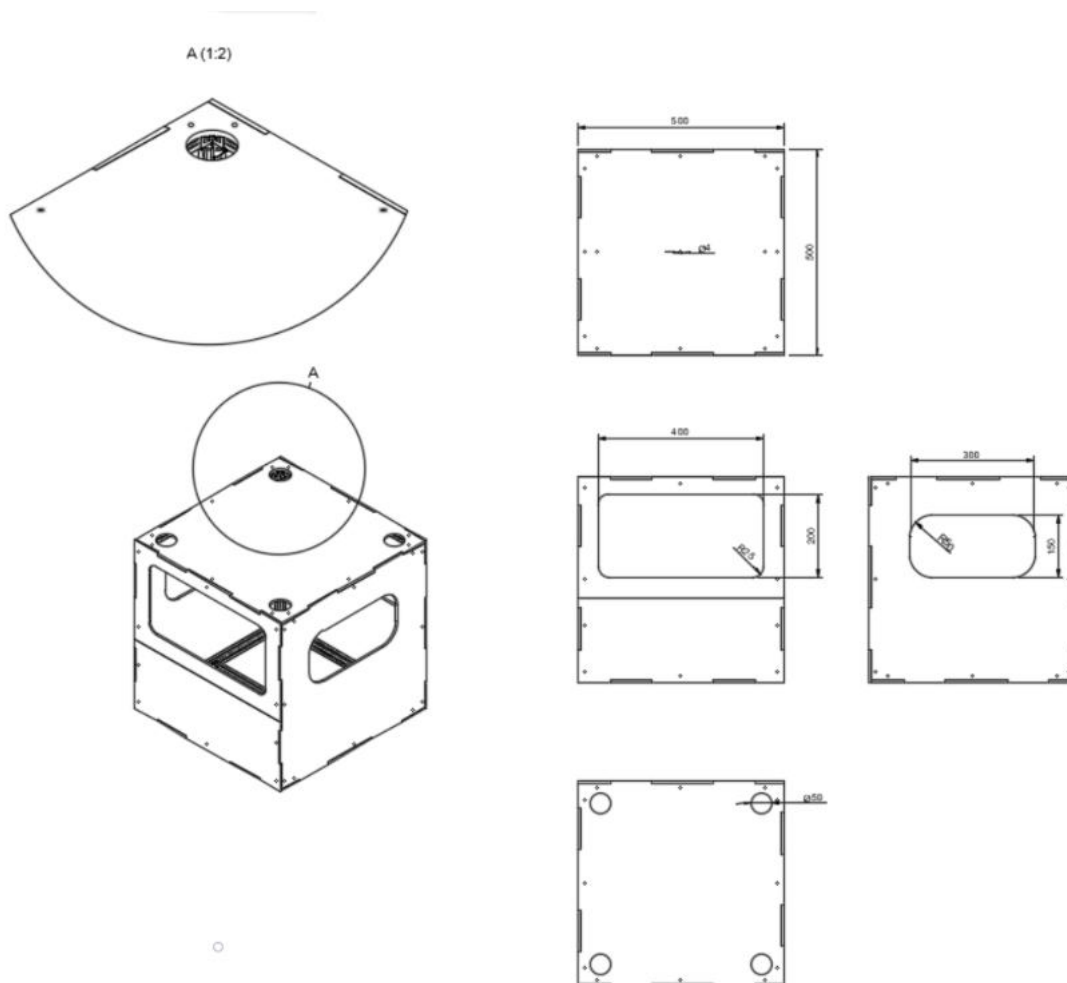
Figure 3: Frame with panels, CAD drawing.

A (1:2)

Figure 4: Frame with panels, technical drawing.

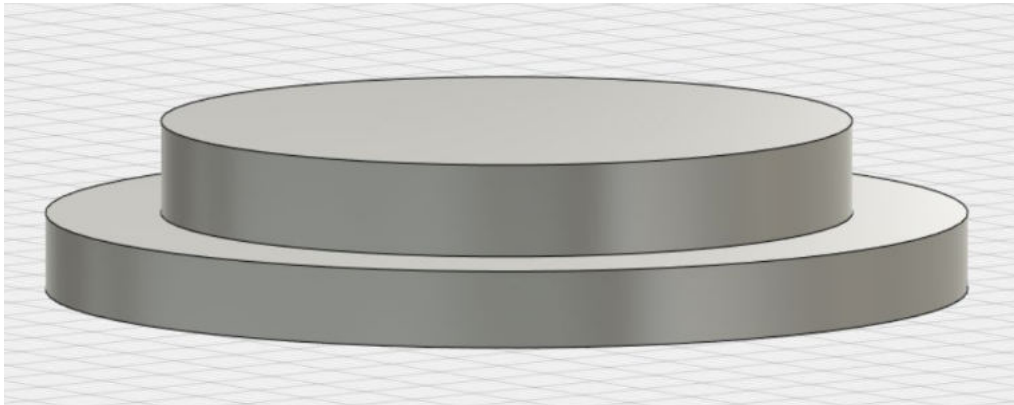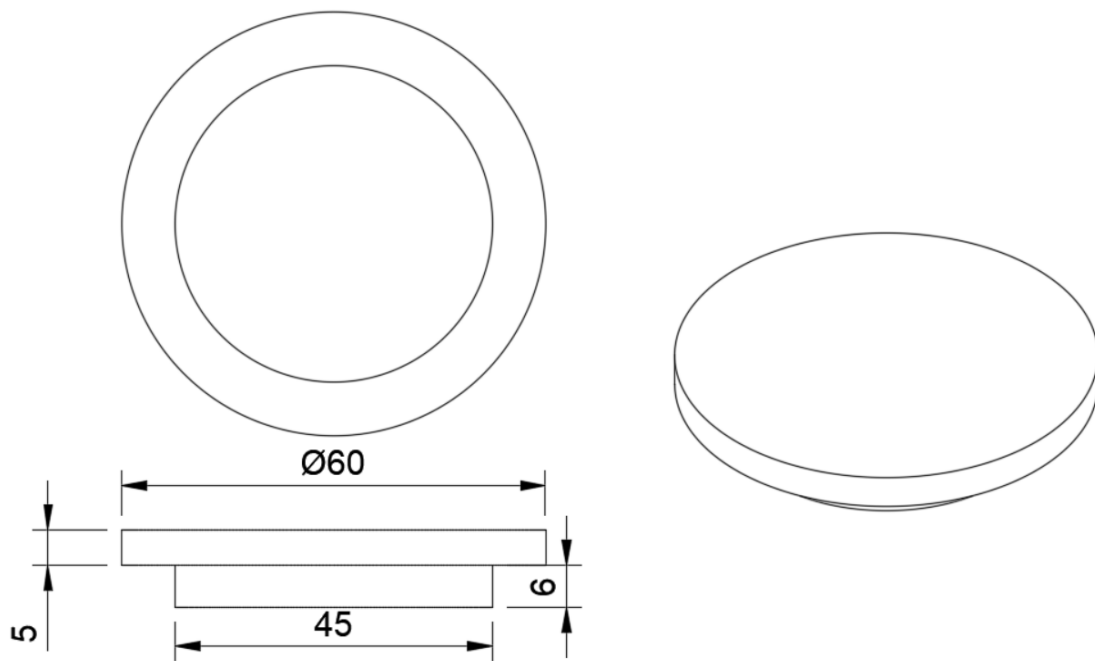**Figure 5: Foot, CAD drawing.**
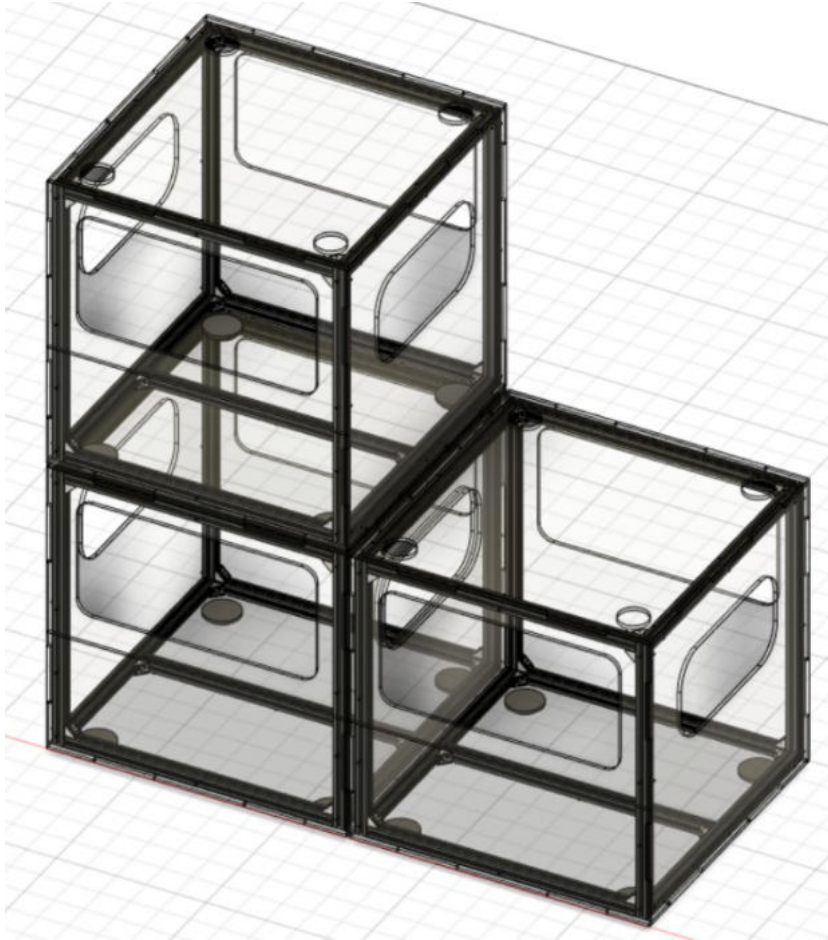

Figure 6: Foot technical drawing.
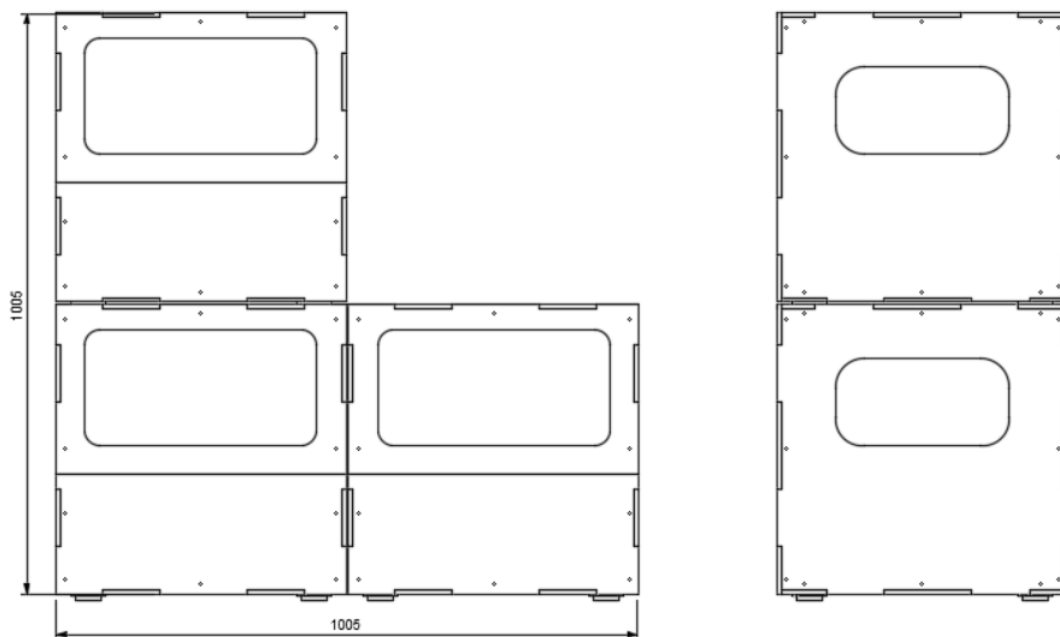
Figure 7: Three cubes, CAD drawing.

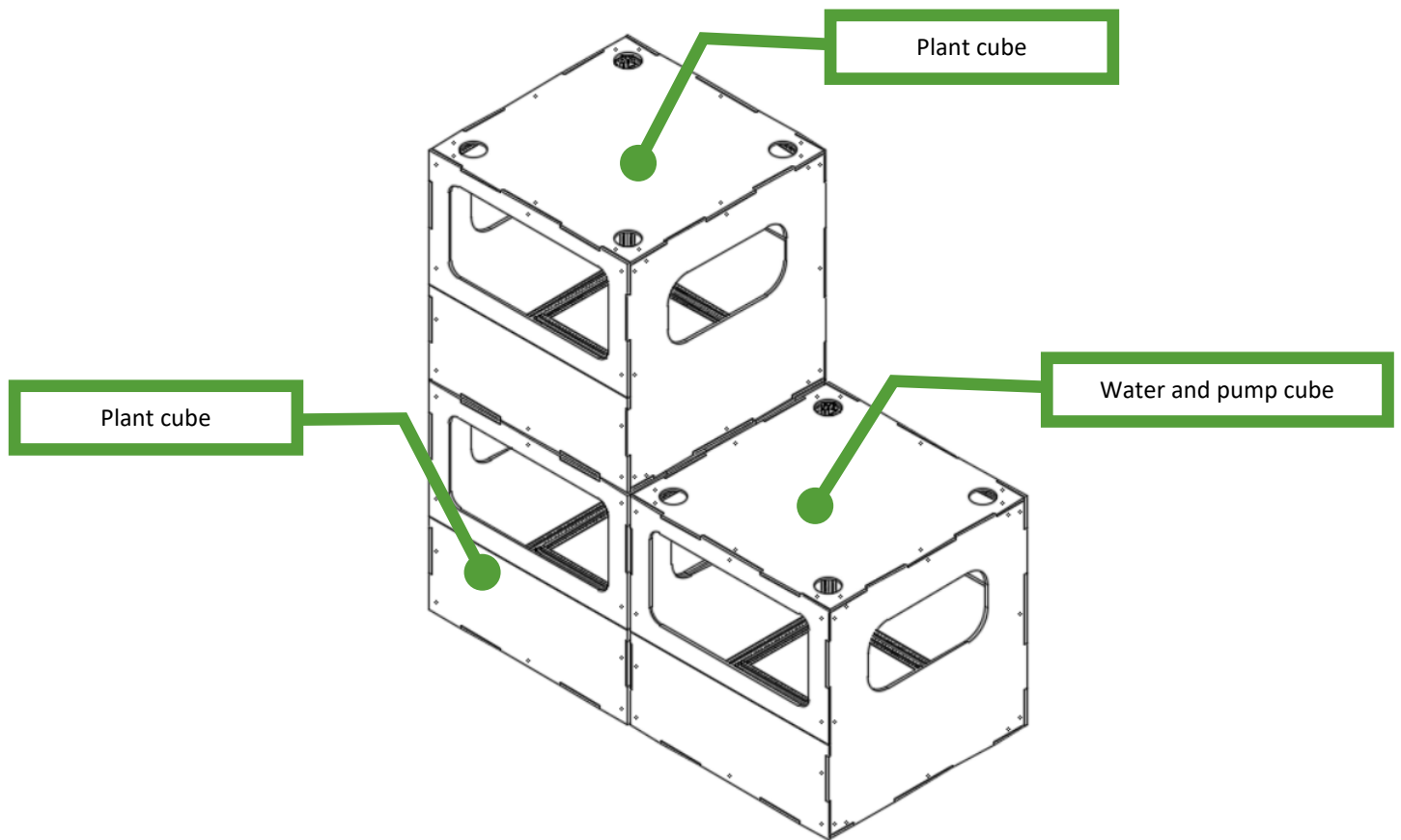**Figure 8: Three cubes, technical drawing.**

7

Figure 9: Functions of the three cubes, technical drawing.

Step 2: Purchasing the materials

Materials were purchased from different sellers, considering the price, quality, and shipping times. For a detailed view, refer to the Bill of Materials (BOM).

Step 3: Building

The building involved different techniques:

- Laser cutting
- 3D printing
- Analog fabrication (as opposed to digital fabrication)

a.   Preparing the aluminum profiles

The t-slotted aluminum profiles were purchased with a length of 2 m. Therefore, cutting them to the right lengths with a bend saw was necessary.
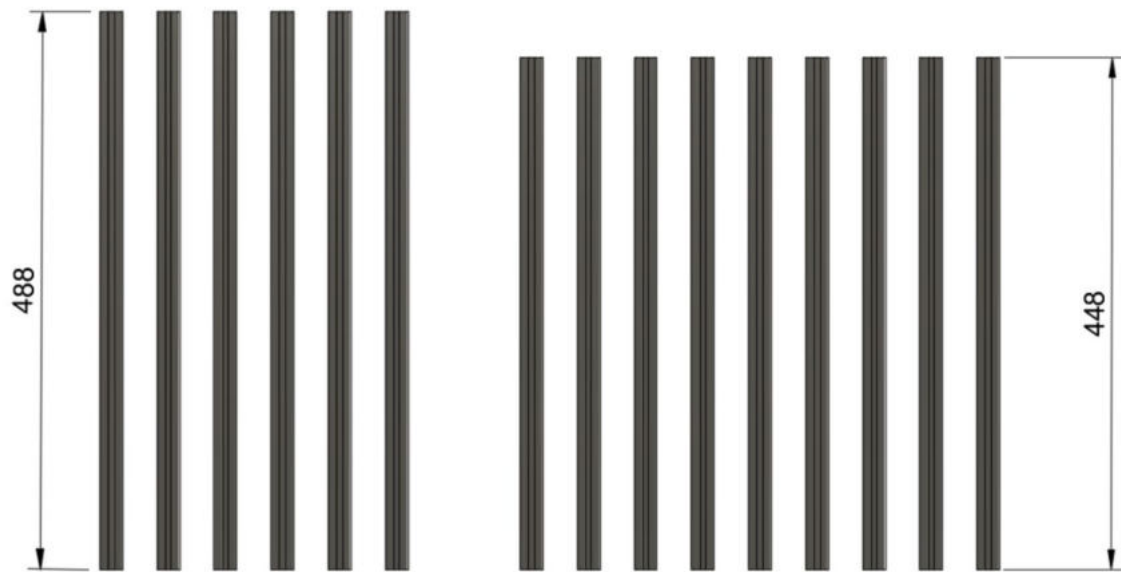
Figure 10: Guideline for sawing the T-slotted aluminum profiles.

Figure 11: Sawing the T-slotted aluminum profiles.

b.   *Laser cutting the panels*

For the panels, acrylic sheets of 600 x 600 mm, and 6 mm thickness were used.

DXF files were prepared from the CAD design[3].

<p align="center">Figure 12: Sketches used to save the DXF files.</p>

---

[3] The process varies depending on the CAD software. Please, use the DXF files provided or follow tutorials online in the case of scaling.

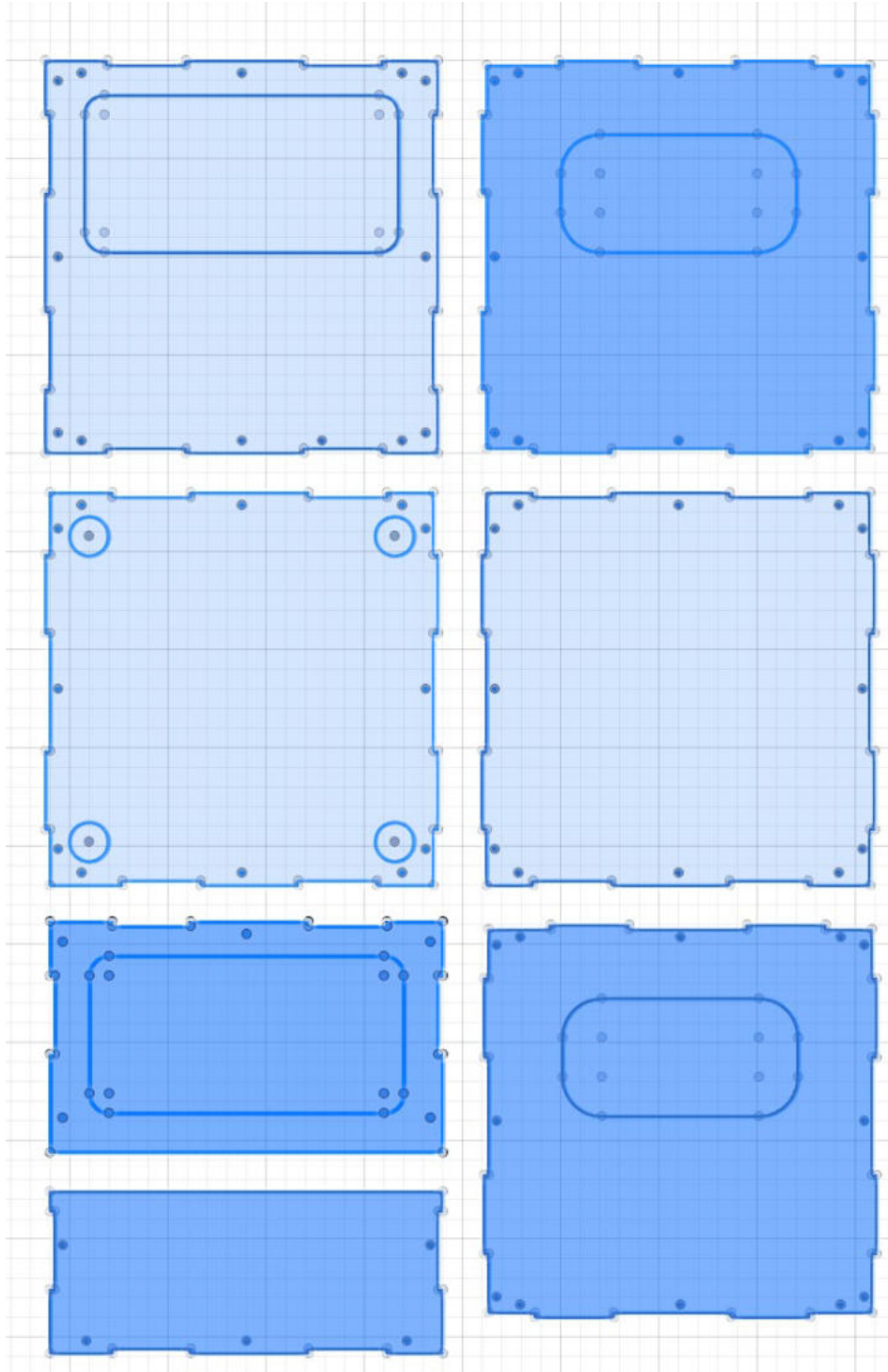Visicut[4] was used to produce the g-code.

Figure 13: Visicut interface.

Laser Duo was used to laser cut the panels. For Laser Duo, the settings used were[5]:

- Power: 80
- Speed: 2,5

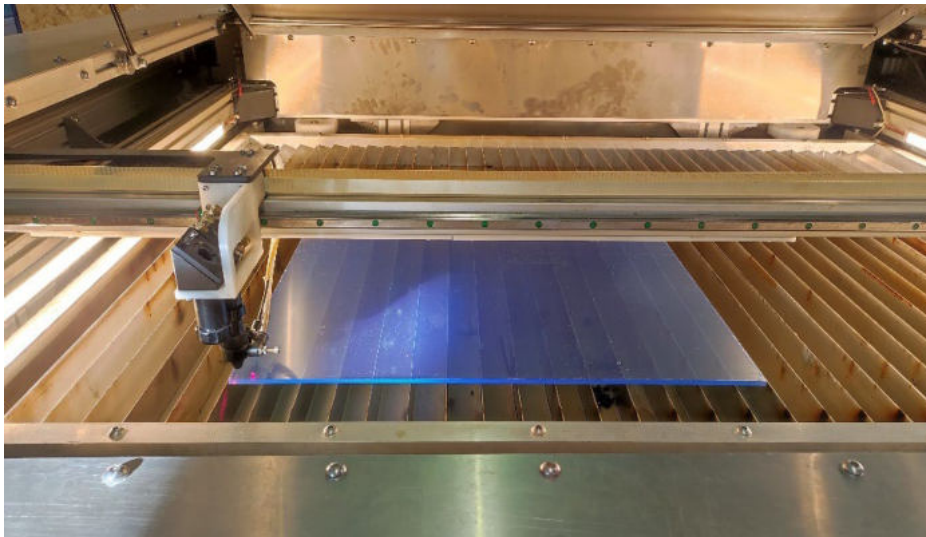**Figure 14: Preparing the laser cutter.**

---

[4] Visicut is an open source g-code generator for laser cutters. It is free to download here: https://visicut.org/.
[5] Please, note that the settings vary depending on the laser cutter. It is suggested to run some tests with the material before cutting the design.
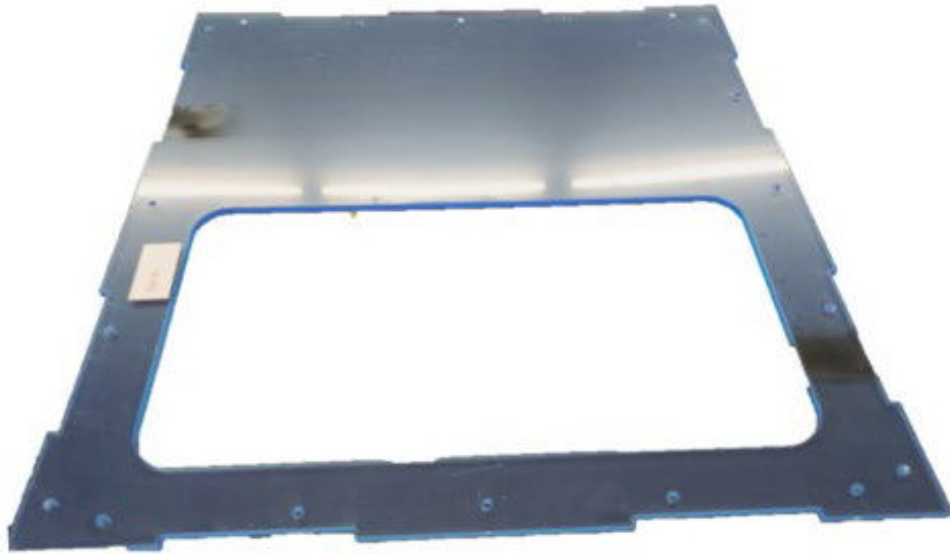
Figure 15: A laser cut panel.

c. *Mounting the frame*

The cubebs were prepared by fastening the t-slotted aluminum profiles. For one cube, the following materials were used:

- 4 x aluminum profiles 488 mm
- 9 x aluminum profiles 448 mm
- 36 x T-nut slot 5 M4
- 36 x screws DIN 7380 M4 8
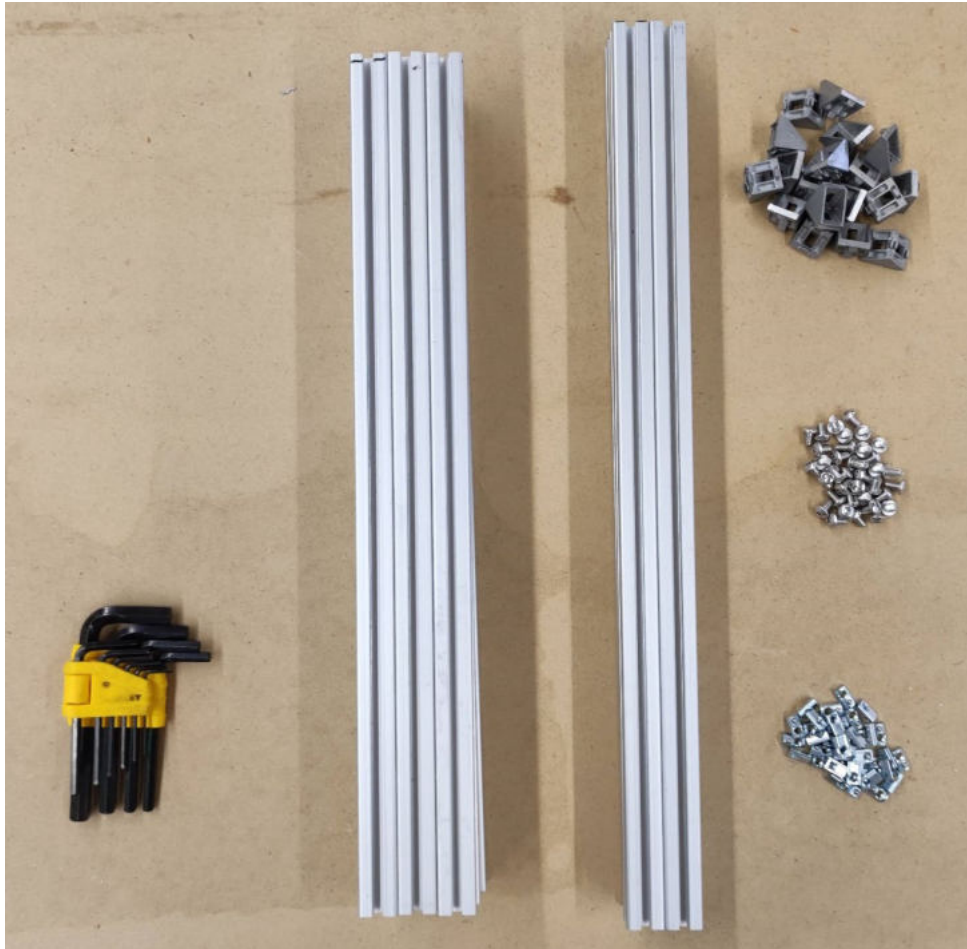
Figure 16: Parts used for the frame of one cube.

Figure 17: Assembled frame.

d.   *Mounting the panels*

The panels were mounted using (for one cube):

- 41 x T-nut slot 5 M4
- 41 x screws DIN 7380 M4 10

Figure 18: Number of screws for each panel.
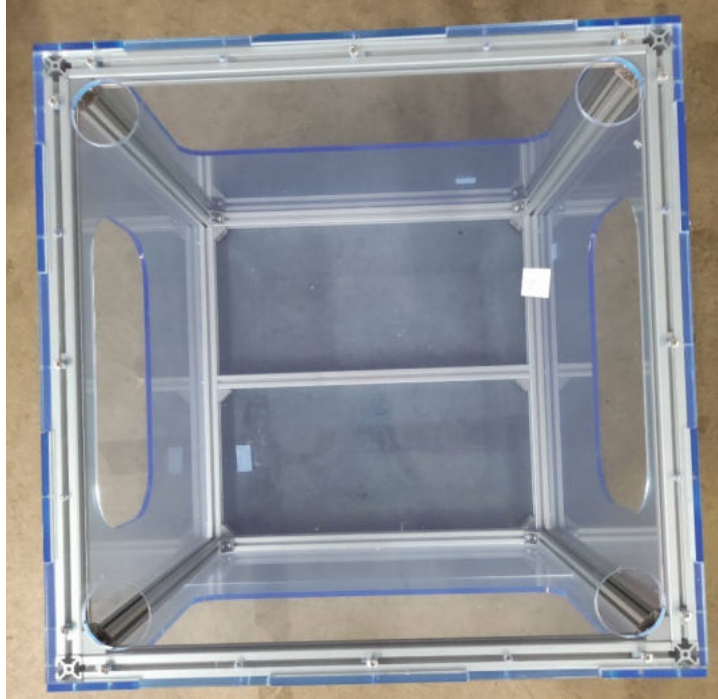
Figure 19: Fastened panels.

e.   *Printing and gluing the feet*

After being 3D printed, the feet were glued to the bottom of the cubes using extra strong glue.
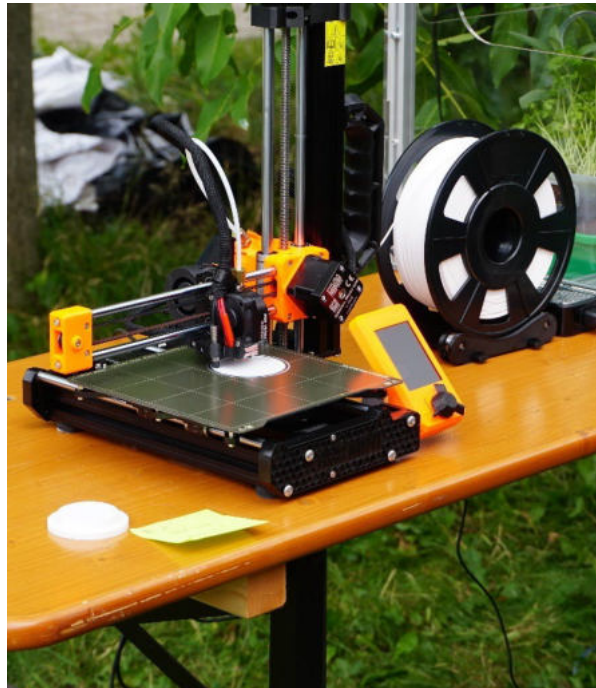
Figure 20: 3D printing the feet.

Figure 21: Feet attached to the base of the cube.

f.   *Placing the growing lights*

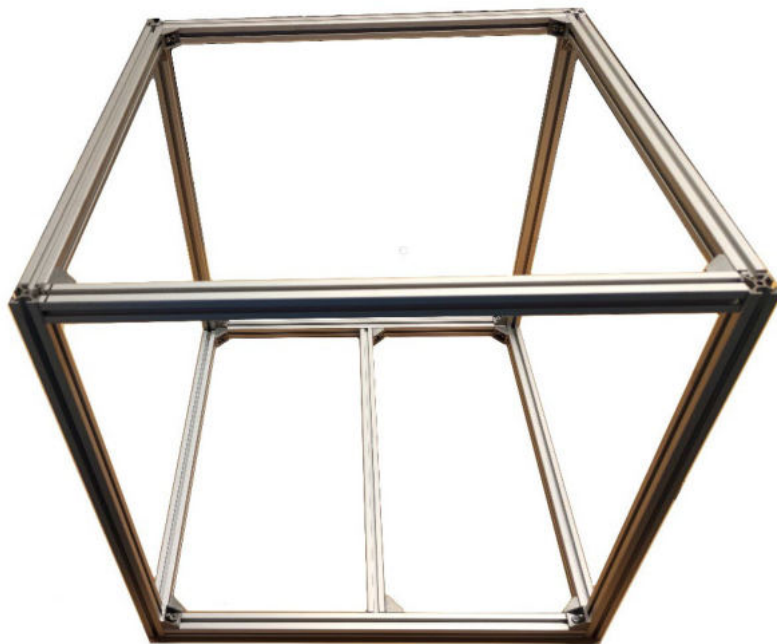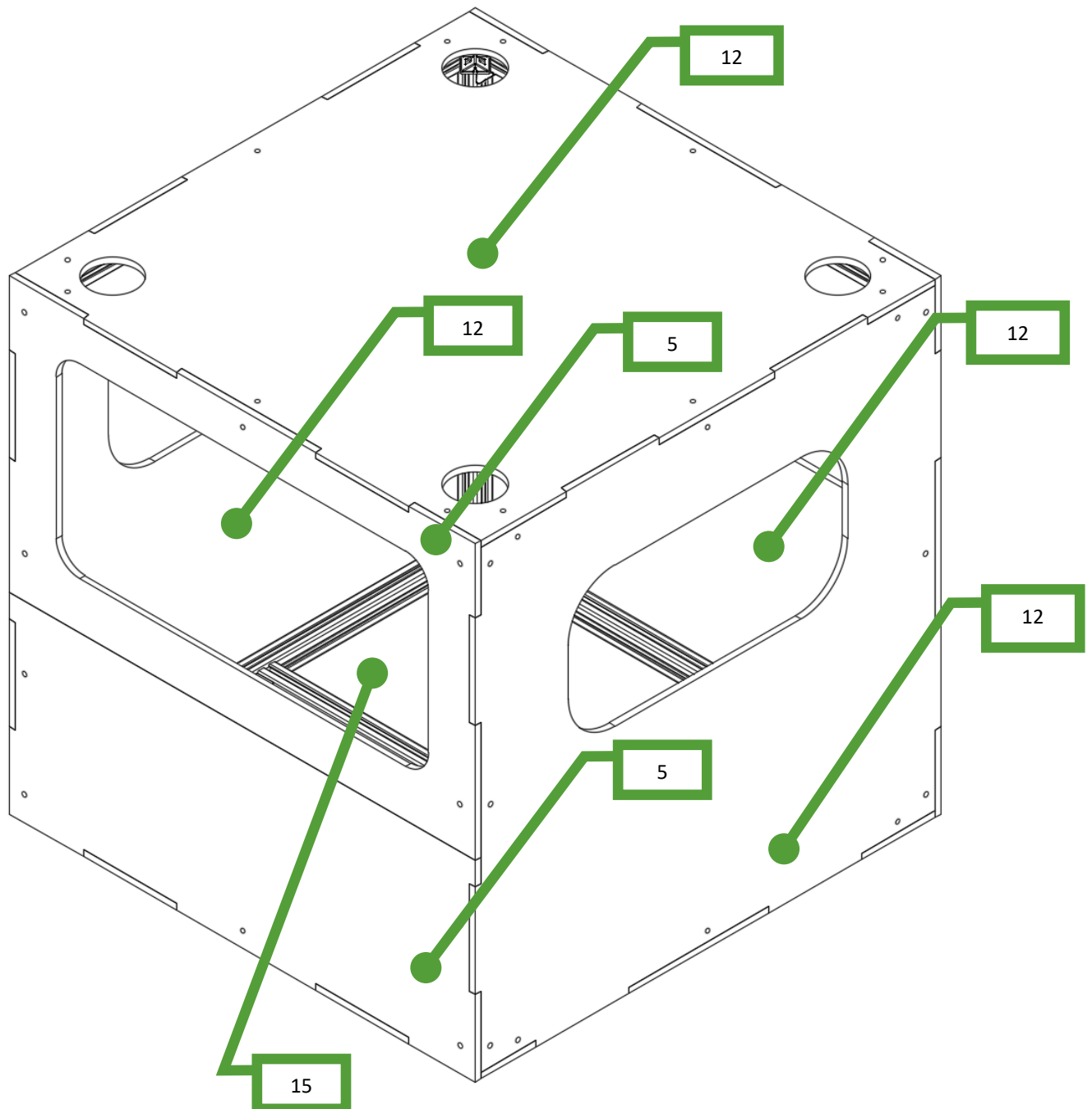Growth lights were attached to the top panel using the tape provided with the lights. One cube contains two strips.

Figure 22: Explanation of the options for the LED growth lights for the indoor prototype
(Source: https://www.amazon.de/-/en/Spectrum-Dimmable-Levels-Hydroponics-
Succulent/dp/B0957X5RW1/ref=sr_1_5?keywords=wachstumsleuchte%2Bled%2Bstreifen&qid=1654179579&sprefix=growing%2Blight%2
Bled%2B%2Caps%2C92&sr=8-5&th=1).

SCIENTIFIC & PERFECT SPECTRUM

Red LEDs
Efficient for photosynthesis

Blue LEDs
Promotes chlorophyll synthesis

Full Spectrum LEDs
Provides efficient sunlight for plants

Box contents:

1 x LED two-head growth light strip, 1 x charging head, 1 x instructions, 1 x 3 metre double-sided tap and cable ties

Intelligent Controller

- 10 Dimmable Levels
  10%-100% adjustable brightness levels
- 3 Switch Lighting Modes
  Different spectrum modes
- Auto Timer Setting;
  3H/9H/12H auto cycle timing
- Power Button;
  Turn on/off

High Quality
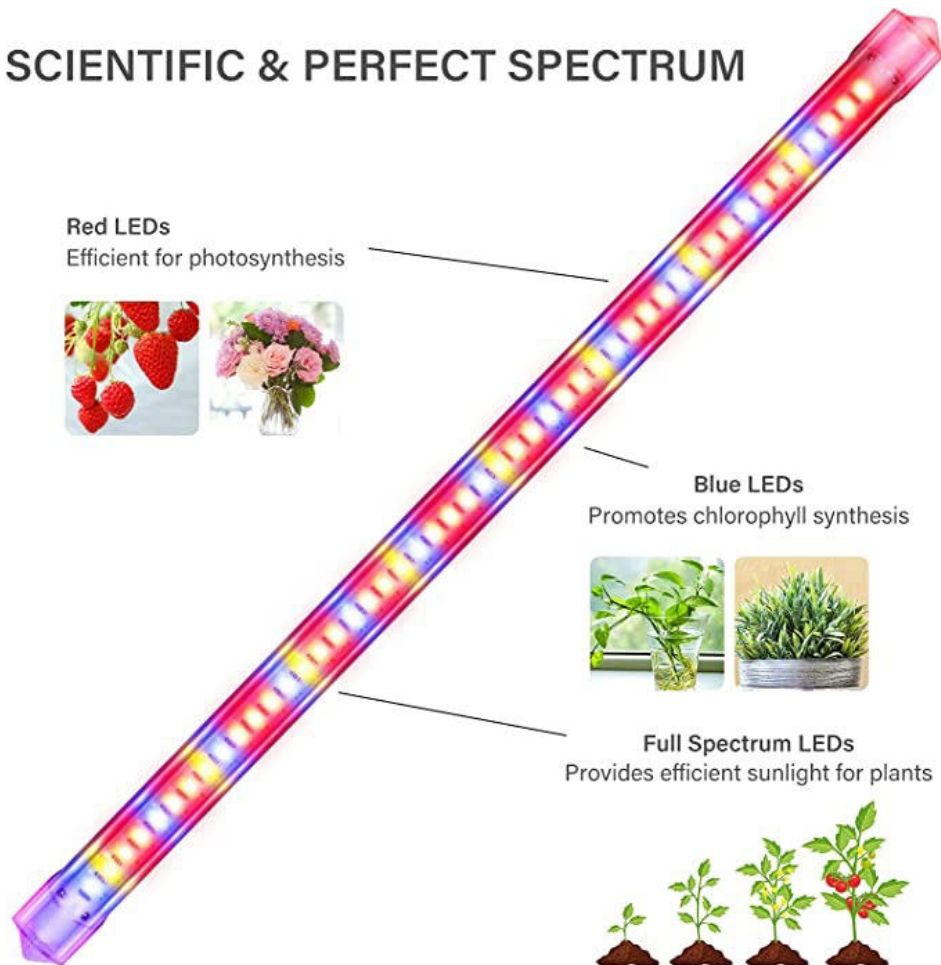High Efficiency LED chips

(5000 hours lifetime)

Before   **After**

Timer setting function

3 timing modes: 3/9/12H. This timing function is a 24-hour cycle timing. If you want the plant lighting to be switched on for 3 hours daily from 7 to 10 o'clock. You only need to turn it on at 7 am in the morning and set it for 3 hours. With continuous power supply, the cycle works and is invalid after switching off.

High quality LED chips

Each strip with 48 highly efficient LED chips has a lifespan of 5000 hours. You can use the plant lights many times for your plants. It is easy and safe to use.

Multi-Purpose Plant Grow Light Lamp

Accelerate the ripening of fruits, promote plant growth and colouring of succulents, improve flower quality and extend flowering time. Suitable for different plant lighting requirements.

Figure 23: Description of the LED growth lights for the indoor prototype
(Source: https://www.amazon.de/-/en/Spectrum-Dimmable-Levels-Hydroponics-Succulent/dp/B0957X5RW1/ref=sr_1_5?keywords=wachstumsleuchte%2Bled%2Bstreifen&qid=1654179579&sprefix=growing%2Blight%2Bled%2B%2Caps%2C92&sr=8-5&th=1).

- Full spectrum LED plant lamp: 2-strip LED plant light (each 16.1 inches) contains 96 LED chips with excellent heat dissipation, which provide perfect full spectrum light for indoor plants. As for LED power consumption, this plant grows with less watts. It is a perfect investment if you grow small plants.
- 3 spectrum modes and 10 brightness levels: the grow lamp with 3 spectrum modes. Different spectral modes are suitable for the light needs of different plants. 10 adjustable brightness levels to meet the lighting requirements of each plant in different growth stages.
- Auto cycle timing: the LED growth light timing function has 3H/9H/12H. And it is 24H cycle timing. It can be turned on and off automatically every day according to your settings. When the display is turned off, the timing function is off. It is very useful and practical when you are busy or travelling.
- Easy installation: the grow light bar comes with 3 metres of double-sided adhesive tape and cable ties that are suitable for different devices and surfaces and stick perfectly to the shelves. You can easily adjust it to your interior.
- Wide application: perfect for indoor plant shelves or cabinets, widely used for germination, seedlings, seed start, potted plants, succulents, catcus. Especially if the plant needs extra light in rain, cloudy or dark indoor conditions.

Widely used full spectrum LED grow lamps for indoor plants

Red light x 56 chips: Contribute to photosynthesis, germination, flowering and results.

Blue light x 24 chips: Help plants with chlorophyll synthesis absorb more energy for better germination.

Yellow light x 16 chips: Provide sun-like light for plants, let plants grow like in nature.

These plant lights are ideal for your plant tents, plant shelves, seedling cultivation, succulents, hydroponic rooms, greenhouses, etc.

Wide range of uses:

For hydroponics and seedlings, for plant rack and gardening, for succulents, indoor plants, for greenhouses

The length of the grow light strip is 16.1 inches. Large cover for your plants that need enough light to grow. Simply place your plants in the middle of the two light strips to get even light from both sides.

Note:

- Recommended height for plants: 0.5-1 metre (19-39 inches) and 12-16 hours a day can completely replace the sun.

Figure 24: Instructions for the growing light
(Source: https://www.amazon.de/-/en/Spectrum-Dimmable-Levels-Hydroponics-Succulent/dp/B0957X5RW1/ref=sr_1_5?keywords=wachstumsleuchte%2Bled%2Bstreifen&qid=1654179579&sprefix=growing%2Blight%2Bled%2B%2Caps%2C92&sr=8-5&th=1).
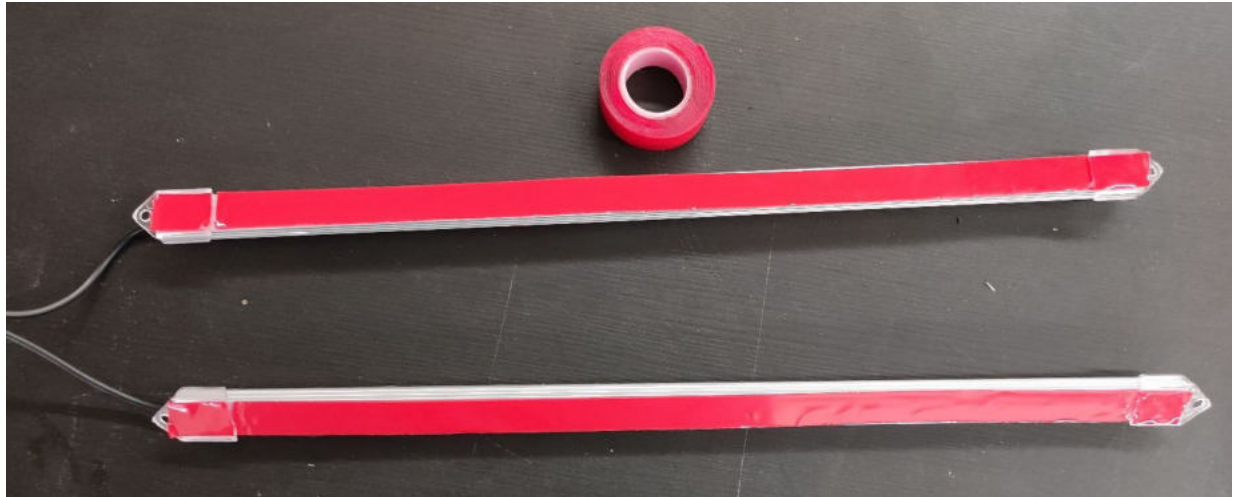
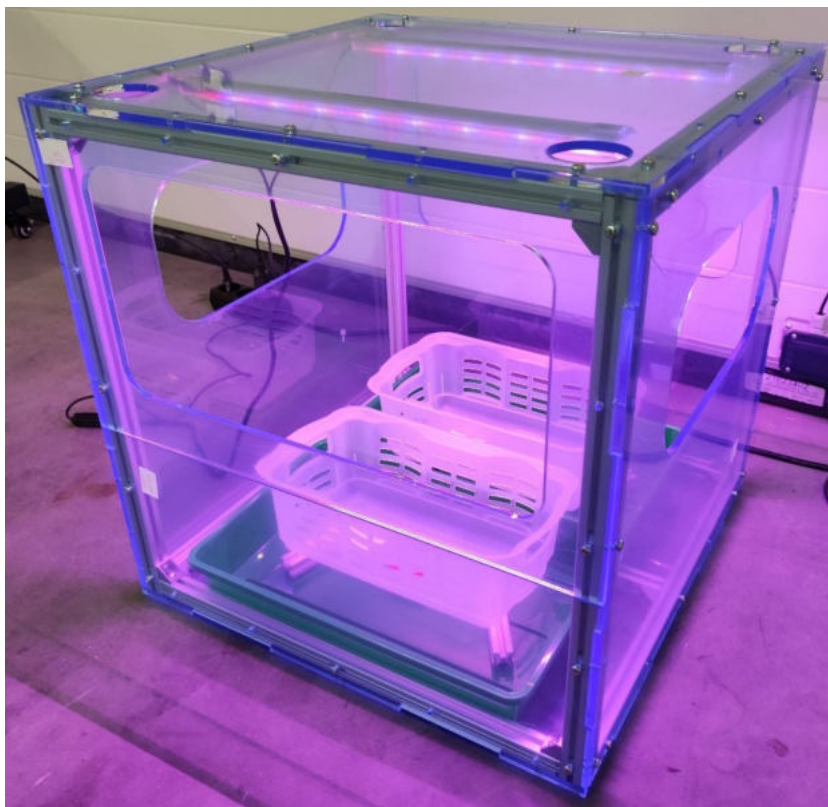**Figure 25: Preparation of the LED growth lights.**

Figure 26: Testing the growing lights.

g.   Watering system

A 5 L container was used to store the water. To the water was added liquid fertilizer.

A programmable pump was used to ensure watering.

Step 4: Planting

The pots were filled with coconut fibers, and each was placed into a saucer (to collect drainage water). The reason for this setup is the decision to use the "nutrient film technique"[6].

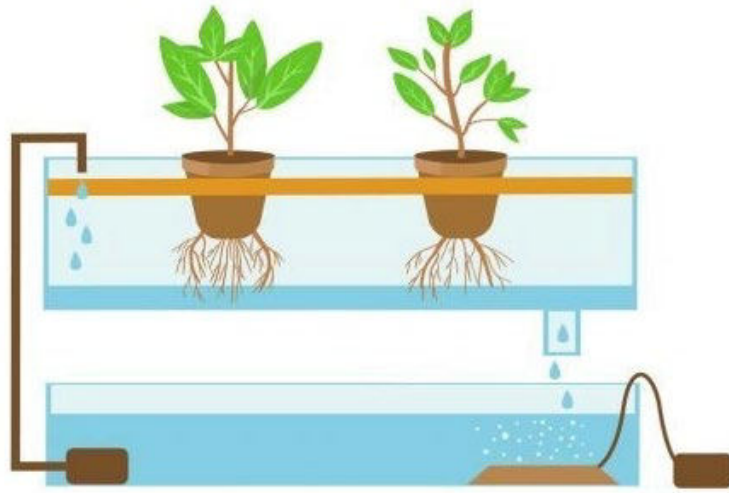**Figure 28: Schematics of the used technique**
(Source: https://naturezedge.com/how-to-start-a-hydroponic-vegetable-garden).

The seedlings were planted in the coconut fibers. The pipes were brought to the pots.

Figure 29: Transplanted lettuce.

---

[6] More information: https://naturezedge.com/how-to-start-a-hydroponic-vegetable-garden

Figure 30: Setup of the indoor prototype for the workshop.

Figure 31: Indoor setup with active lights.

USEFUL LINKS

https://www.fabcity.hamburg/agriculture/

https://www.gut-karlshoehe.de/

https://agya.info/

https://visicut.org/

https://naturezedge.com/how-to-start-a-hydroponic-vegetable-garden

ACKNOWLEDGEMENTS

We would like to thank the photographer, Tarik Ziyad (https://www.instagram.com/tarik_ziyad_pro/), who on behalf of the Fab City Hamburg association, took wonderful pictures used also for this document.