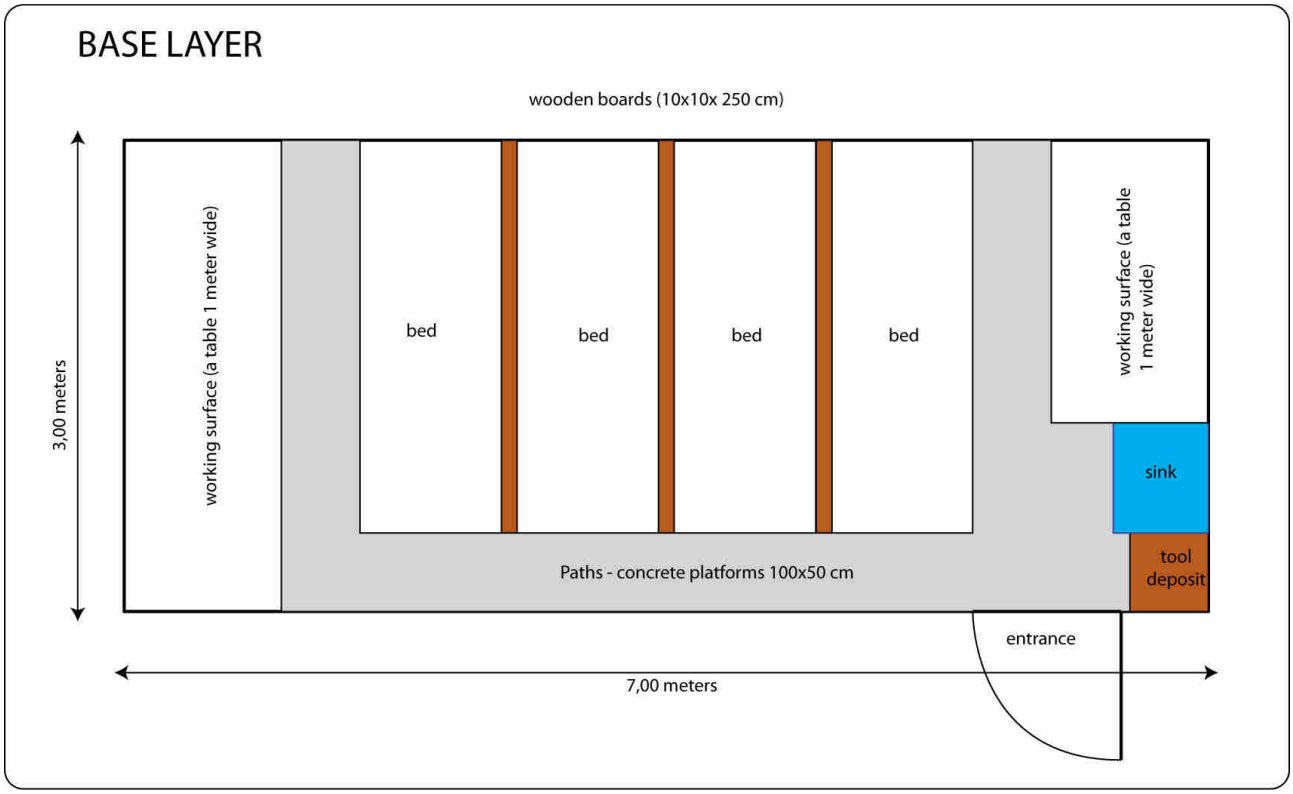
DESIGN FOR A GREENHOUSE



July 2016

Summary

I INTRODUCTION

In my experience as a permaculture designer I have done designs for different homesteads; in these designs there is often the necessity of foreseen a greenhouse. Normally in the design I look for the best place to put the greenhouse and also suggest some integration with existing structures or buildings. Now I decide to create a design for a greenhouse itself to be able to offer a complete solution to the client.

I.1 ETHICS

Earth Care: the greenhouse will produce seedlings using compost. The transplanted plants will contribute to inoculate the microorganisms into the garden beds outside the greenhouse.

People care: the project of a greenhouse is very important for the development of a garden, in particular if the greenhouse will take place in a community project. Community people will work together to assembly the greenhouse finding solution and suggestions, discovering or learning new skills and being happy to realize a common project.

Fair Share: in particular in a community project the time used to realize the structure will be fair shared by the people.

I.2 PERMACULTURE PRINCIPLES:

Observe and interact: this principle has been applied in the investigation phase. The site where to build the greenhouse has been analysed and mapped in order to see the main constraints and also the solution.

Catch and store energy: the greenhouse will catch the rain water and store it in the tanks for later use, it will also catch and store the sun heat both in the structure made of nylon and methacrylate and in the concrete platforms which could be the paths and in the glass wall.

Obtain a yield: the greenhouse will produce a warm environment to grow veggie seedlings and plants, both annuals and perennials.

Apply self-regulation and accept feedback: this principle will be applied with the use of the greenhouse.

Use and value renewable resources and services: the sun used for heating up the structure..

Produce no waste: the greenhouse will not produce waste, the plants waste will be add in the compost, the compost will be used to grow plants. The water used in the sink will be recycled and used to water plants, the sink waste (fine materials, soil, sand, etc..) will be mixed in the soil beds.

Use small and slow solution: the design of the greenhouse is quite smart, and the structure can be built manually with the help of a community.

Use edges and value the marginal: the edges have been used and valorized as for examples: working table places, support for shelves, earth accumulation and tanks support, etc….

I.3 DESIGN TOOLS

For this design I have used the following tools:

- PASTE
- Sectors map
- Zone map
- Input-output analysis
- Flow diagram
- PMI
- 4 questions

III IDENTIFY

WHAT

To identify what I want out of this greenhouse I have decided to use the **P.A.S.T.E. tool**:

PLANTS: The greenhouse I want to design will be essentially for growing vegetable plants in the form of seedlings, starting from seed selected to obtain veggies able to adapt to the climate where I live and therefore to need less care from myself. The second typology of plant I will want to grow in the greenhouse will be perennials. I would like to obtain plants from seeds, and plants from cuttlings sure the greenhouse for this kind of perennials in note mandatory but it will be a more protected and controlled environment and therefore I hope to do it better.

ANIMALS: eventually pollinators.

STRUCTURE:

- working table, need to be wide enough to be easy to work on it, and able to put plastic container to plant seed in it.
- Rain water harvesting system
- Tanks for water storing
- Passive watering system
- Passive sun heat accumulation
- Air circulation system
- Protection from the cold winds
- System for shading
- A sink
- A tool deposit
- A system for hanging sets of wooden or plastic crates for moving seedlings from greenhouse to garden

TOOLS:

- A set of sieves of different dimension
- A set of hooks from the roof for hanging plants in vases

- A set of tools for helping me in preparing the soil for the seedlings

EVENTS:

- Seedling and plants preparation
- Preparation of the soil for the plants
- propagation of trees, shrubs and plants
- Sowing of veggies for having plants direct in the ground
- Sowing of perennials to obtain shrubs and trees
- Transplanting veggies seedlings in vase
- Transplanting of perennials in plastic containers

FOR WHOM

The greenhouse will be designed for me and/or for horticulture or permaculture apprentices. The greenhouse will be a place for working and eventually a place for showing results to interested visitors.

IV INVESTIGATE

SITE

This greenhouse could be constructed almost everywhere. To help me in defining the major characteristic of the site I will use the **Sector Tool**.

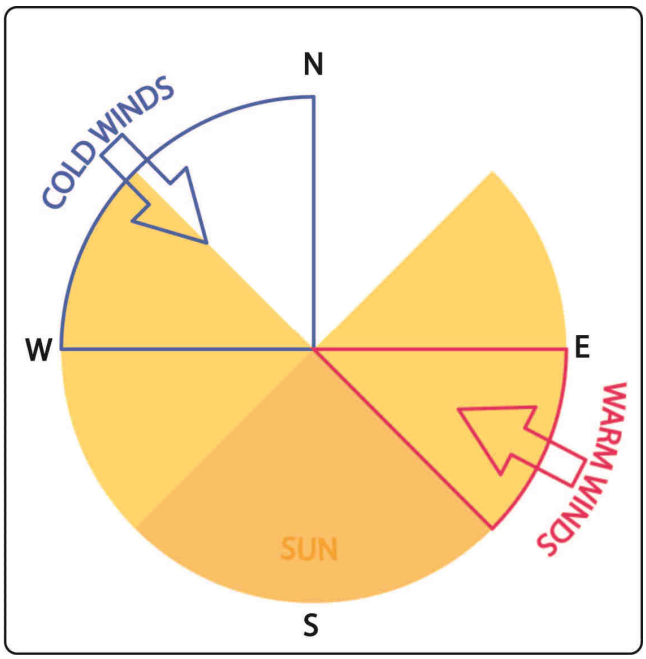


Figure 1: Sectors for the off-grid kitchen. In yellow the area covered by the sun in winter and in summer.

Where I live the major cold wind are coming from the West and sometimes from the North, while the summer breezes are from the South-East or East sectors. So the greenhouse will have to be protected from the W, N-W and N winds especially in winter, while should guarantee air circulation in summer to be able to work in the greenhouse (in summer the temperature can be over 30 degree for several weeks) during morning or evening time.

To have advantages from the sun exposition it is mandatory to expose the long side of the structure to the sun, this will guarantee to accumulate the majority of the heat and also to have plenty of light for the plants and seedlings.

To decide the structure and the material to be used (in term of insulation for example) let's analyse the climate of the area.

CLIMATE

Precipitations: 546 mm/year has been the average of the period 2000-2010, the hottest decades in the history of civilization. With an hypothetic roof of say 7x3 meters which means 21square meters there could be a rain water harvesting of 21x0,5 = 10,5 cubic meters of water. It is possible to design a system of big tanks to store all this rain water.

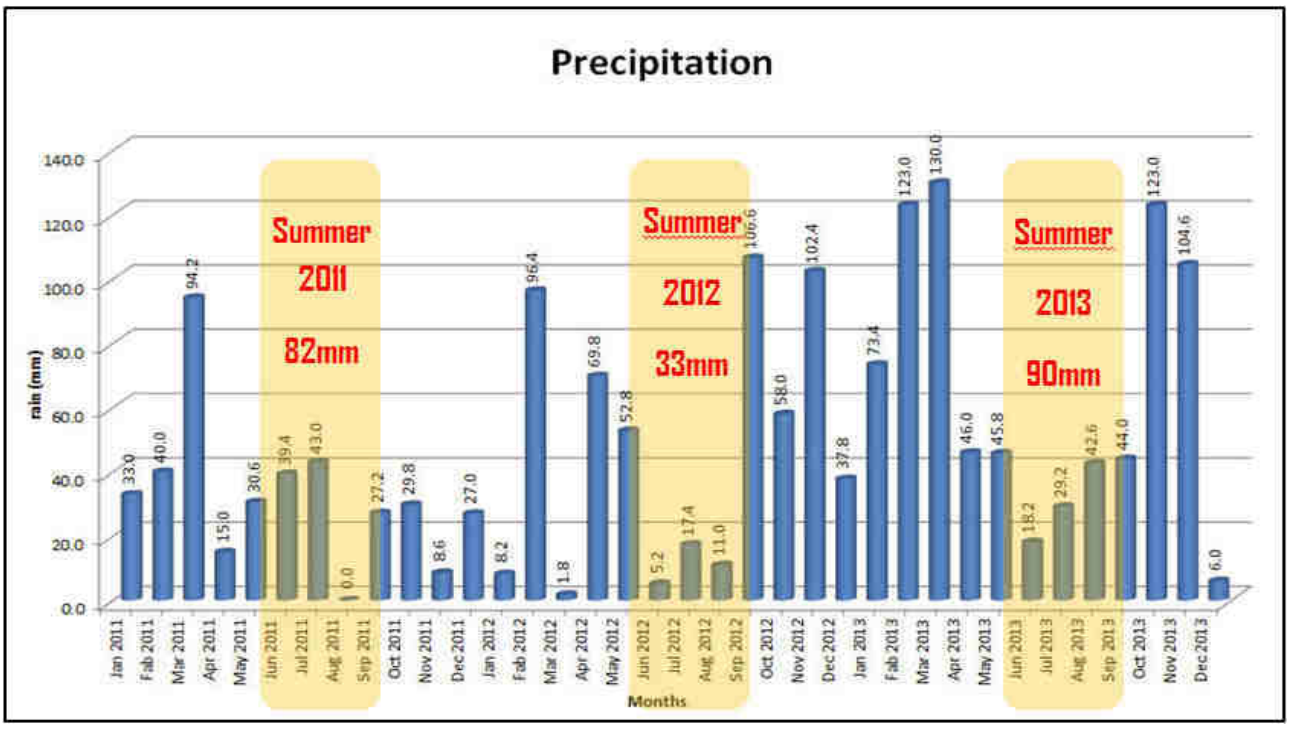


Figure 2: Precipitation (year 2011, 2012 and 2013) with highlighted the small amount of precipitation during the summer time.

Late frost: they could occur between the 16th of March to the second half of April due to cold winds coming from the Balcans. The minimum temperatures are registered at dawn and the duration can be from a few hours (normally 1 or 2 after dawn) to a max of 10 hours in extreme situations. In the greenhouse there won't be the problem of late frost.

Snow: normally between December and March, max 50cm. Late frost in April with an average of 2,8 days of frost in April. This is important to design the strength of the roof. The snow in fact is heavy (150 kilos/cubic meter) and there fore even a small amount of snow can procure serious damages.

Drought: strong from April to May, medium from May to July. With the water stored in the tanks it souldn't be a problem.

Temperatures: Min -5° C, Max 35°C. These are the main issues to be deal with. Not too cold in winter (the four passed winter have been more than one degree wormer then the average of the winter temperatures of the 2000-2010 decade).

NEEDS

- Cheap
- Well designed
- Super organised
- Very practical
- Warm in winter
- Refreshed in summer

ISSUES

Main issues should be:

- To have to possibility to organise a space for growing plants from seeds, both annuals (for the veggie garden) and perennials (trees, shrubs and plants in general). This space (the greenhouse) should : protect annuals and perennials from the cold in winter and let the sun heat pass through the walls and roof.
- The greenhouse have to be protected from the N-W sectors because the cold wind are coming from there
- But in summer the winds will be necessary for air circulation in order to be able to work in it.
- The greenhouse will be constructed using recycled material together with new one.

V EVALUATE

STRUCTURE ANALYSIS

The greenhouse will be rectangular shaped with the long side South facing in order to catch and store the heat of the sun in summer and to be easily protected from cold winds in winter.

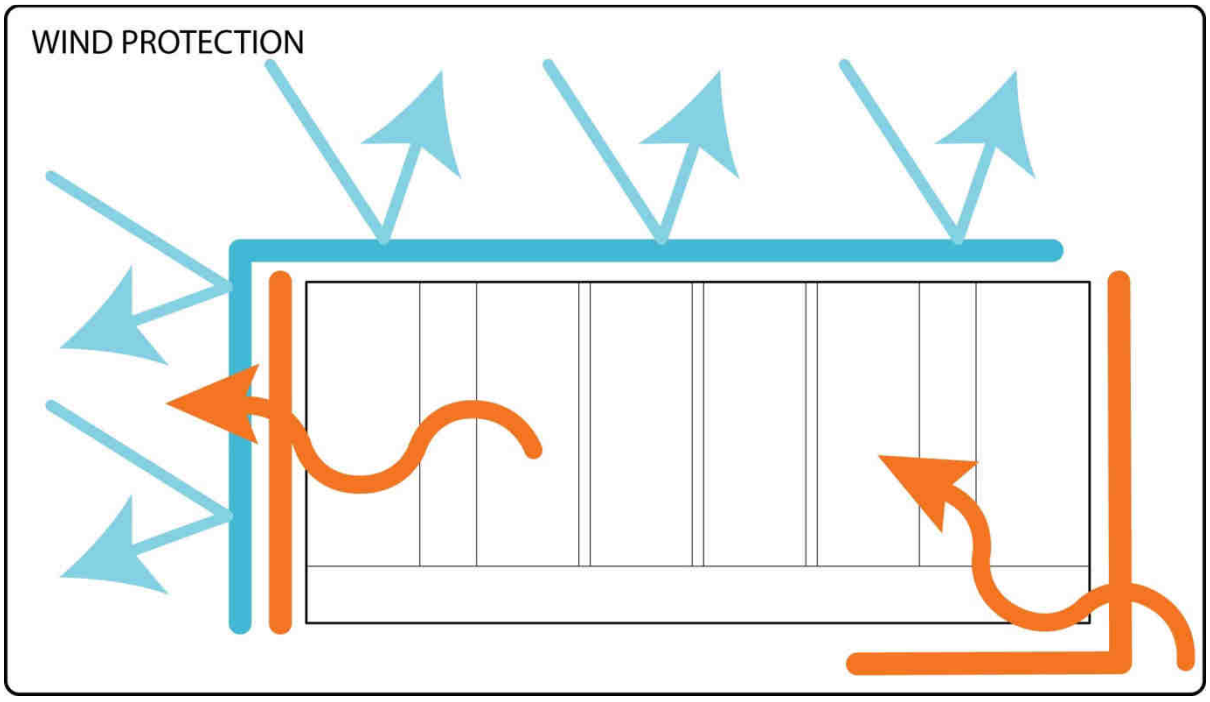


Figure 3: if accepting the rectangular shape, the structure will be protected in the N-W sectors but will need to provide circulation in summer from the S-E sectors.

To better evaluate the inside organization of the structure I will use the **Zone tool**.

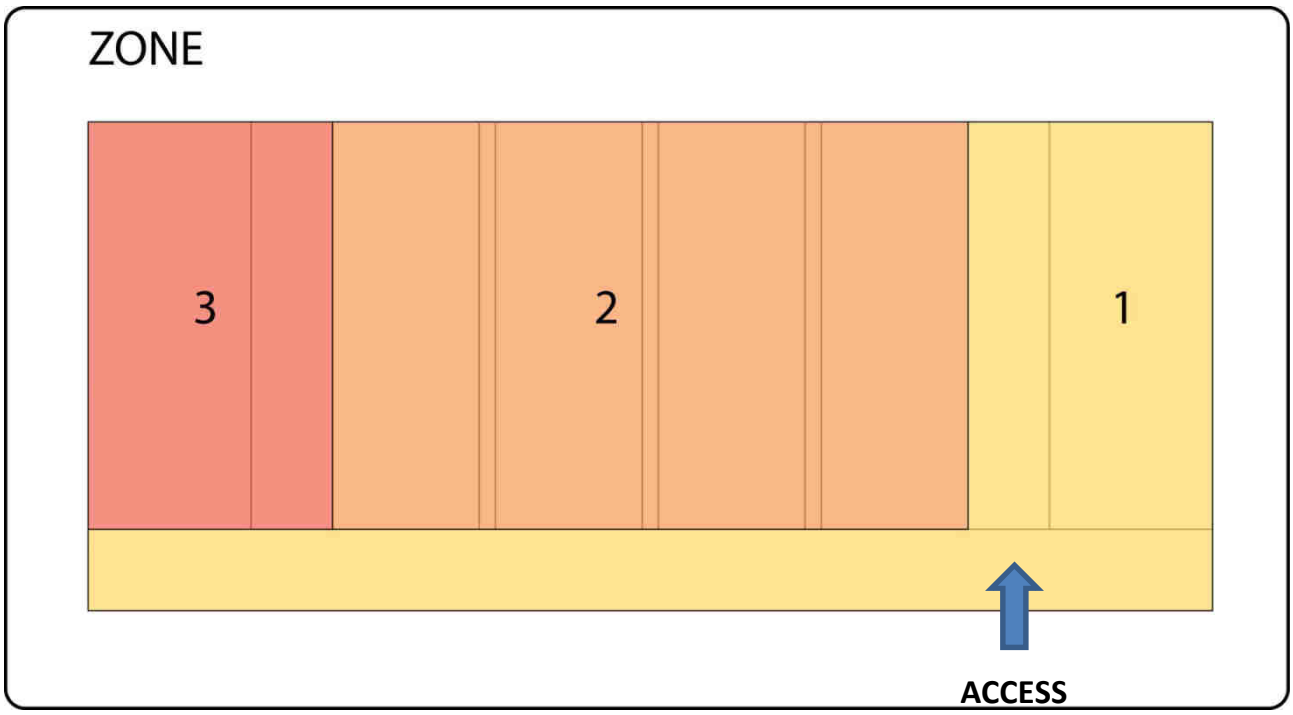


Figure 4: Zone map for the structure.

The rectangular shape allow to distribute the work following a line pattern. From the right to the left the it will be necessary to use more energy (for example if it is necessary to carry heavy loads); but also to spend less time in it. Therefore the right area could be for the annuals while the left could be for the perennials.

Zone 1 will be the zone close to the entrance and therefore will have to house all those activities that require more time or more attention. The zone 2 could host those operation that require less attention and less time, for example once the seedling have been transplanted in small vases these could be the place for let the plants grow. The zone 3 could be the area for the perennials, they need less time for looking at them, and this is the farther area from the entrance.

The zone 1 could house:

- The entrance
- A working table with hard and easy to clean cover
- The tool deposit

- The mass to store the sun heat (for example some concrete platform to use as path, or black tanks full of water)
- A sink
- The water tap
- Some shelves on the wall for storing vases, containers, fertilizers, etc…
- A window or similar

Zone 2 could house:

- Beds for sowing (vegetables)
- Beds for transplanting vegetables
- Beds for seeding perennials
- Beds for transplanting perennials
- Shelves for wooden or plastic crates for moving seedlings or plants from greenhouse to garden
- Beds separators (need to be wide enough to walk on it in order to reach the bottom of the bed and the shelves)

Zone 3 could house:

- A working table with hard and easy to clean cover. The table could also be used for housing plants in vases or containers.
- A walk path
- Some shelves on the wall for storing vases, containers, fertilizers, etc…
- A window or similar

The movements between the three zones are showed in the figure below:

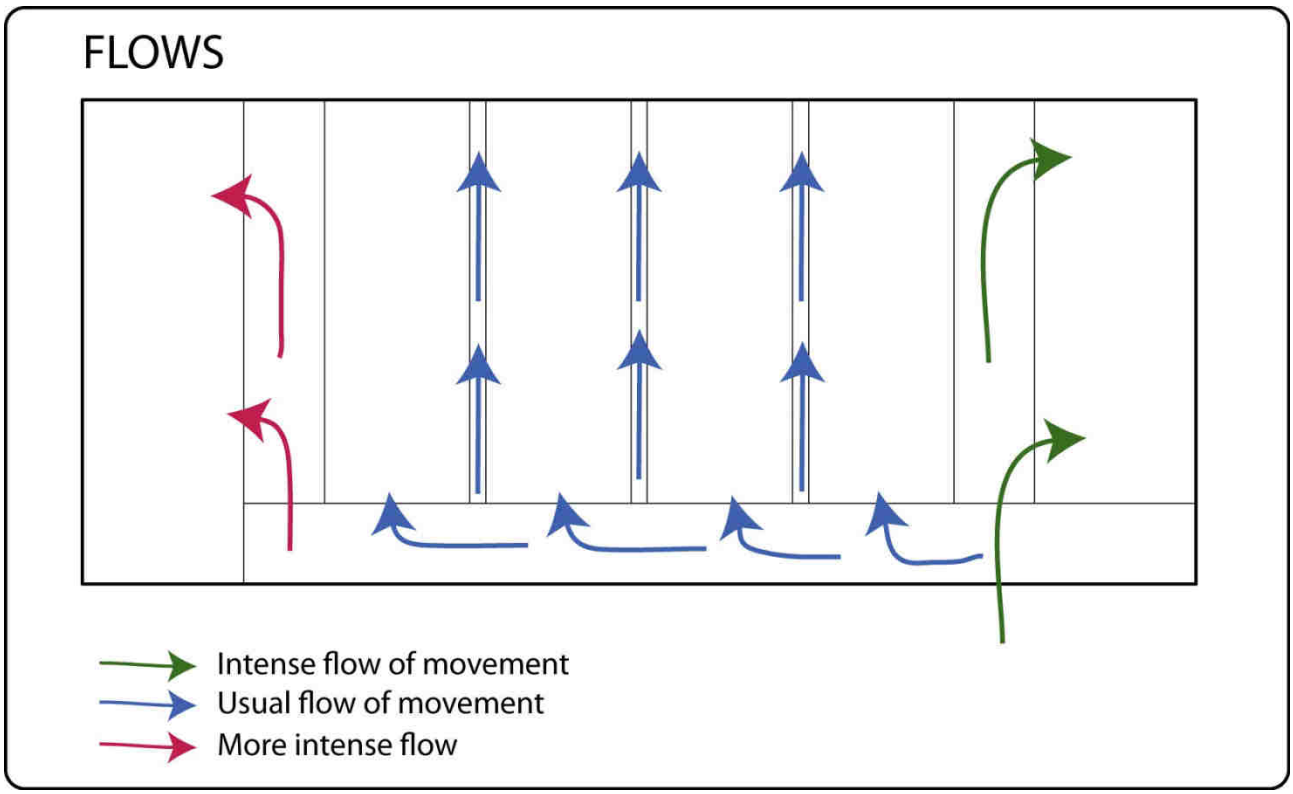


Figure 5: Movements in the structure.

PLANS

I need some more information about some system in order to plan it, I will use the **Input/Output tool** for helping me.

INPUT		OUTPUT
Working surface easy to clean and hard Plastic containers, vases, etc.. Soil and compost A place for storing compost and topsoil bags The working surface should be elevated and with a second surface below to	Working table	Seedlings Plants Trees and shrubs Working surface Place for storing things

store useful materials. Non-woven fabrics (NWF) Water A place for storing seeds Sieves Small tools for the sowing, and transplanting operations		
Wooden boards large enough to walk on (say 10 cm) Compost and topsoil Seeds and plants Plastic vases Water access Mulch Manure for speed up germination processes	beds	Trees, shrubs and plants for transplanting Space for storing plants in vases Beds for direct sowing Place for extra heat from manure or compost heating phase.
Concrete platforms (100x50 cm) Sand Wooden boards (10x10 cm and long as necessary)	Paths	Heat accumulation Place for walking A place for put a stove if more heat is necessary A path for circulating hot smoke from an outside stove.
Wooden crates (30x40 or 30x50 cm) Plastic crates (35x52 cm)	Shelf for wooden or plastic crates	Support for crates

Support for the crates (wood or iron)		

With the information gained from the input/output analysis now I have the following hints:

The working tables should be big enough to work easily on it and standing in front it is possible to easily reach the back of the table.

The working table should have a second support surface in order to place and deposit any useful material or tool

The beds could be separated using a wooden board which can be used as a border for the raised bed and a place to stand or walk on to access the beds and the shelf in the back.

The front path could be made of concrete platform, they are quite solid, they are heavy (this meaning they have mass) they can be heated by the sun and release heat during evening time. Concrete is easy to be cleaned as well.

The shelf should be large enough to house the crates and could be fixed directly in the wall.

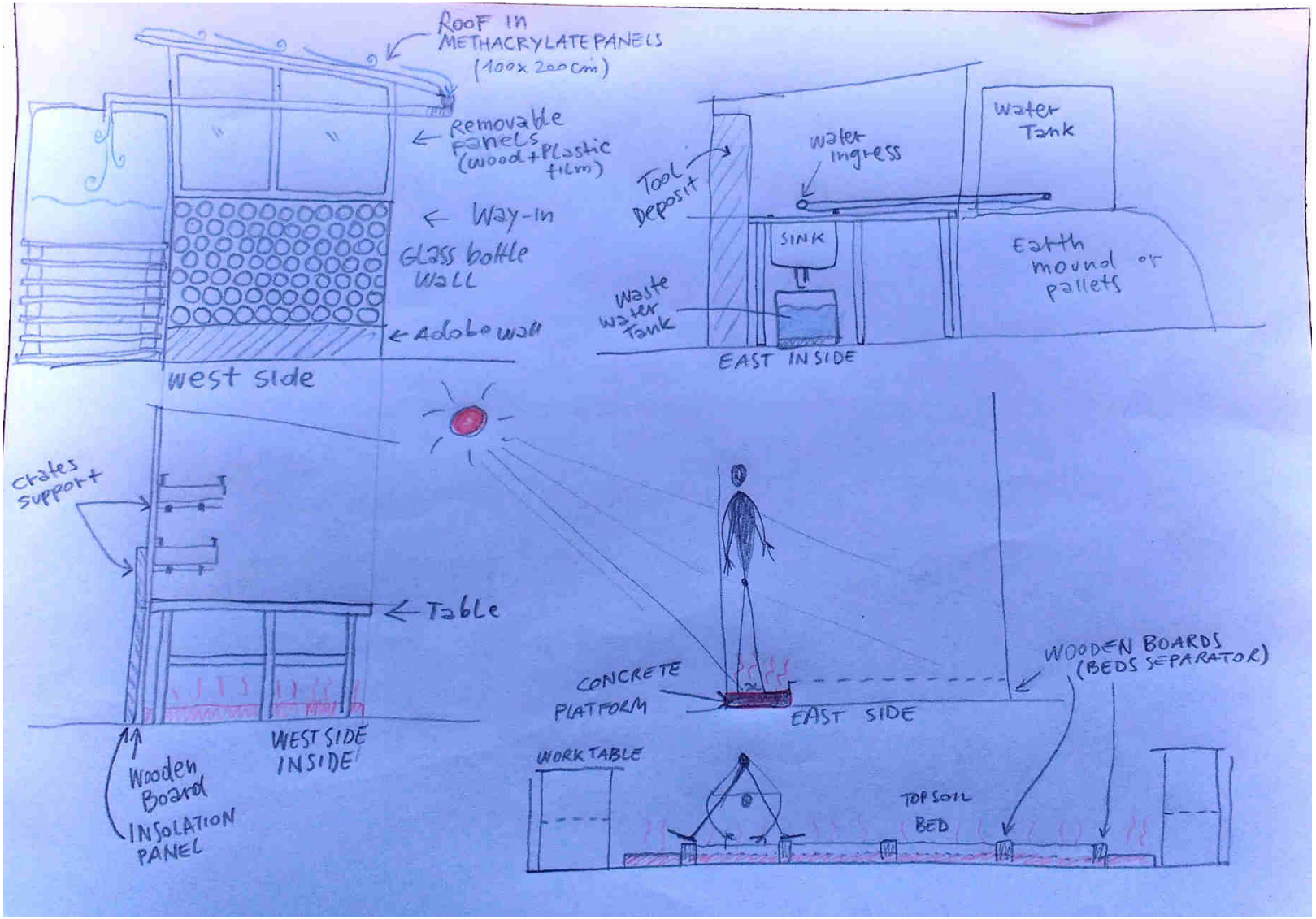


Figure 6: some plans for the greenhouse.

Figure 7: greenhouse structure plans.

NORTH SIDE

KEY ISSUES: wind protection, water storage, insulation, support.

The North side could be made of wooden panel thick enough for fixing the support shelf for crates. The water storing tanks could be positioned against the wall on an earth mound. The earth is a good mass accumulation and a great wind protection. The wooden panel could be separated from the earth with insulation boards. The big water tanks (1000 liters tank) could be positioned on top of the earth mound and could be filled with the rain water. The big tanks are also a good wind protection system and could be used as a support for climbers.

WEST SIDE:

KEY ISSUES: wind protection, air circulation, heat accumulation (the west sun is warmer), support for shelves.

The western and eastern wall can be made of 2 parts: the bottom part could be a glass bottle wall and the top part could be a removable panel made of a wooden frame and a double layer (outside and inside) of nylon film. The glass bottle wall can be made with the clay and sand and with recycled glass bottles, this kind of wall could accumulate heat from the sun and at the same time could protect from the winds (westerly) and let the light come in. The panels are useful because the can be removed in summer to let the air flow, they are transparent and also accumulate the heat inside the greenhouse.

FRONT SIDE

KEY ISSUES: heat accumulation, sun exposition, access.

The front side (exposed to the South) could be made with a wooden frame and with a set of removable panels. Same as for the side windows panels. In the front side will take place also the access door. In front of the panels there could be place for the path made of concrete platforms. The path connect the east to the west side of the greenhouse. The path could be made with 7 concrete platforms (100x50 cm) which could catch and store the heat of the sun and release it during evening time.

EAST SIDE

KEY ISSUES: heat accumulation, air circulation, sink, tool deposit.

The East side could be made with fixed and removable panels (same as for the west windows panels). The working table could be long 200 cm and house also a sink for hands and materials washing. The water for the sink could come from the tanks.

ROOF

KEY ISSUES: protection, heat accumulation, support, water harvesting system.

The roof should be made of transparent panels and methacrylate panels could be a good solution. The panels should be placed on top of a wooden boards frame strong enough to support also a roof covered with snow. A roof of 21 square meters could accumulate more than 10 cubic meters of mater. On the North side there could be place for at least 7 or 8 big tanks.

PRIORITIES

The priorities are:

1. The construction of the structure.
2. The paths
3. Beds
4. Working tables

VI POSSIBLE OPTIONS

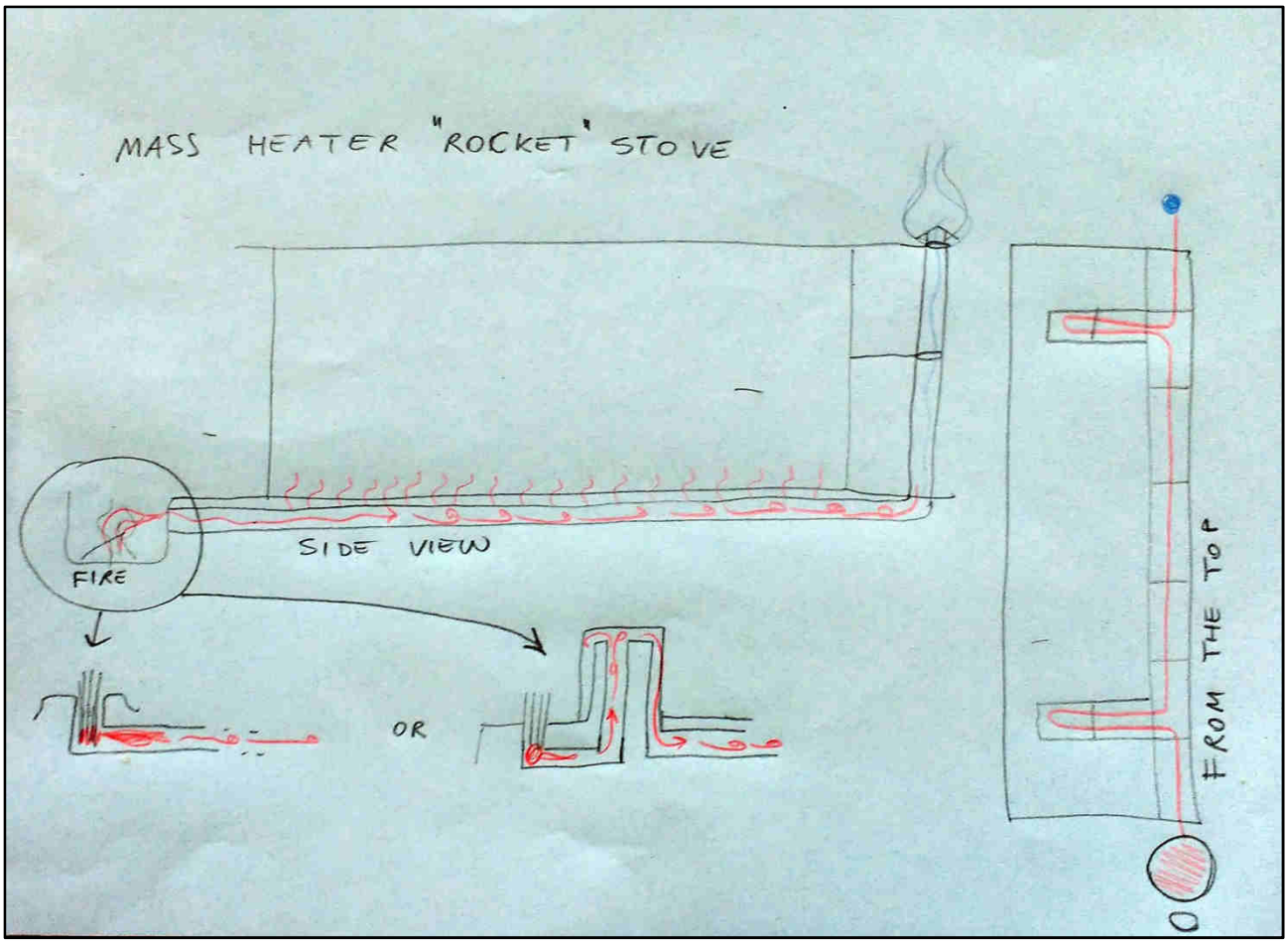
FUNCTIONS, SYSTEM AND ELEMENTS

To analyse possible options I will use the Functions, Systems and Elements tools. The main issues to analyse are:

- Heat accumulation system
- Roof material
- Structure material

FUNCTIONS	SYSTEMS	ELEMENTS
Heat accumulation	Glass bottle wall	Clay Sand Glass bottles Wooden boards Working tools
	Path	11 concrete platforms Sand Working tools
	Wooden and nylon panels	Wooden boards Nylon film Nails Working tools
	Rocket mass heater stove	Iron or steel tubes Connectors Cement

		Recycled bricks
Structure materials	Nylon panels	Wooden frame Nylon films Nails
	Methacrylate panels	Methacrylate panels Silicone glue



A rocket or non-rocket mass heater system could be a possible solution for extra heating the greenhouse. The fire could be placed outside to avoid problems (flames, smokes, etc..) and also not to occupy precious space. The hot smoke can pass below the paths and flows outside in a chimney. This solution could bring extra heat in particularly cold days. The rocket could be placed in an additional room (for example a bath room) to be used for different aims or also outside.

Some possible options for the roof could be the glass. Let's use a **PMI** to identify issues:

	PLUS	MINUSES	INTERESTING
GLASS	Very good in heat accumulation Strong Easy to clean Very transparent	Fragile Difficult to manage Need stronger supports Expensive	
METHACRYLATE	Easy to manage Strong enough Easy to clean	Not cheap	Can be recycled for other uses
NYLON	Cheap Easy to manage	Not strong enough to support snow layer Degrades in short time	Can be recycled for other uses

From this analysis it is clear that the glass are the best material but they are too expensive and very difficult to manage.

The Nylon solution are the cheaper but not strong enough in case of snow. This solution are not very good for managing rain water and could form area of water accumulation.

The methacrylate solution seems to be the best one, even if the methacrylate panels are not cheap at all and they are difficult to find recycled.

For the side materials (the walls) the nylon seems to be a good solution in particular if the west side is joined with a glass bottle wall.

A different solution could be to buy a tunnel greenhouse:

	PLUS	MINUSES	INTERESTING
DIY	Fix almost all the issues highlighted in the analysis (water harvesting, passive water system, water storage and passive heat accumulation system)	Need time and skills to build Need help Need to find materials Could be expensive	Can be built with recycled materials Create a community working group Skills harvesting
TUNNEL	Very cheap Easy to build	No water harvesting No passive watering system No inside space optimization	Can be easily moved Can be found recycled from farmers

VII CONCEPT DESIGN

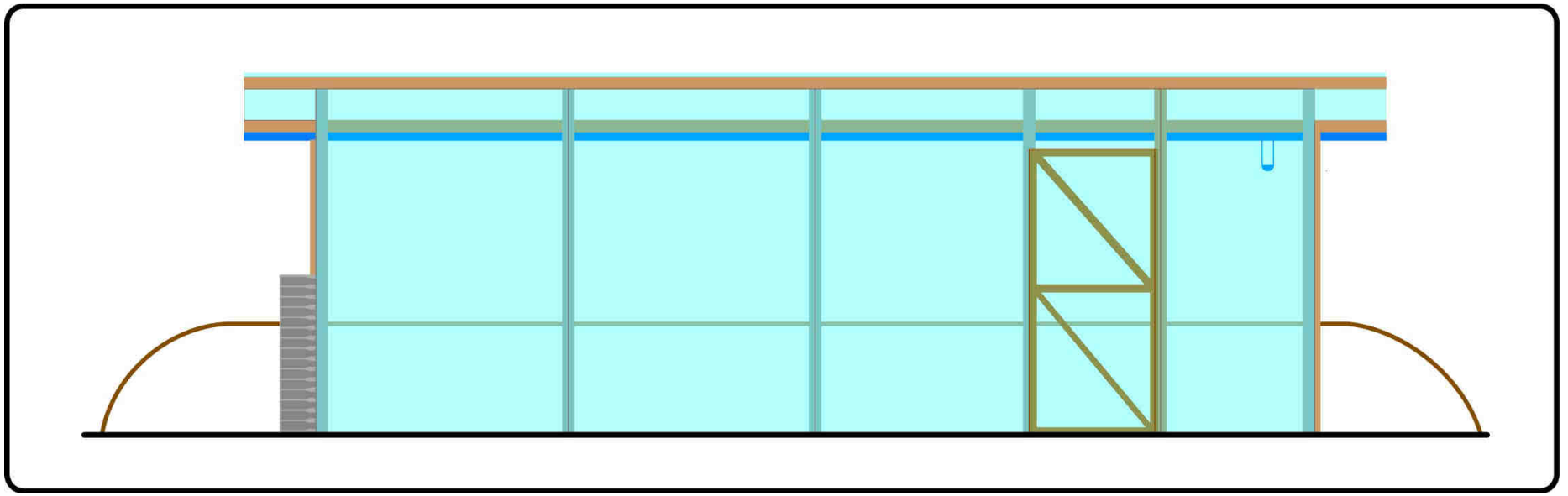


Figure 8: Master Plan.

Material for the structure:

6 – 8 concrete supports poles (recycled from the vineyard)

10 wooden boards (3,50x15x3)

2 threaded bars1 meter long and 20 bolts and 20 washers

16 wooden axes (5x5x400 cm)

14 methacrylate panels (100x200x0,5 cm)

VIII IMPLEMENTATION

STRUCTURE SCHEDULE

1- Identify the available materials and tools
2- Plant the concrete support
3- Build the glass bottle wall
4- Build the wooden frames for the roof
5- Build the wooden support for the side walls
6- Fix the wooden board for the North side wall.
7- Add insulation layer in the North side wall
8- Accumulate the earth in order to create the mound necessary to support the water tanks
9- Add the water tanks
10- Set up connections for the water tanks
11- Fix the methacrylate panels on the roof
12- Set up the tubes and connections for rain water harvesting and storing
13- Prepare the nylon panels
14- Fix the nylon panels
15- Prepare the door and fix it
16- Add the concrete platforms in the paths
17- Add the wooden boards to delineate the beds
18- Fill the beds with good topsoil and compost

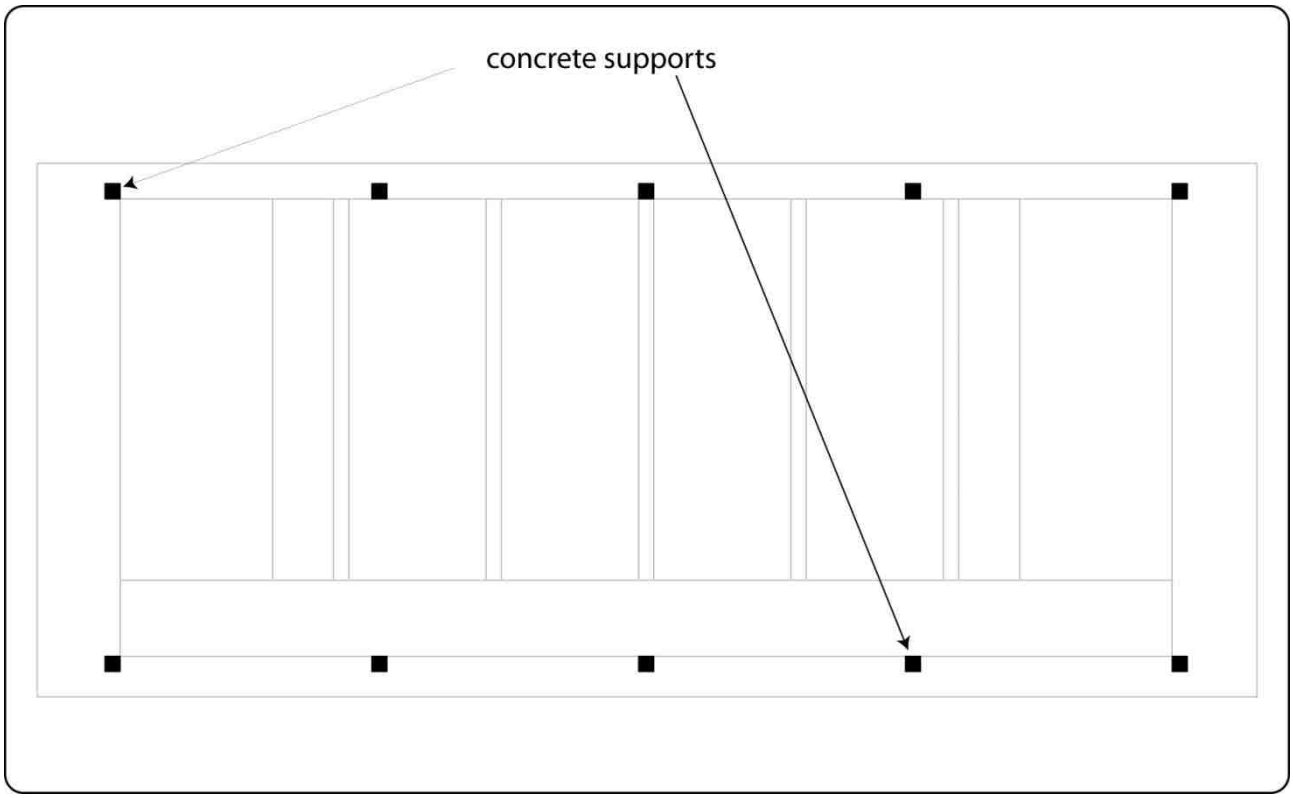


Figure 9: first phase is to plant the concrete support. It is necessary to dig a hole to house the support, than it's necessary to plant it vertical and check for verticality with levels.

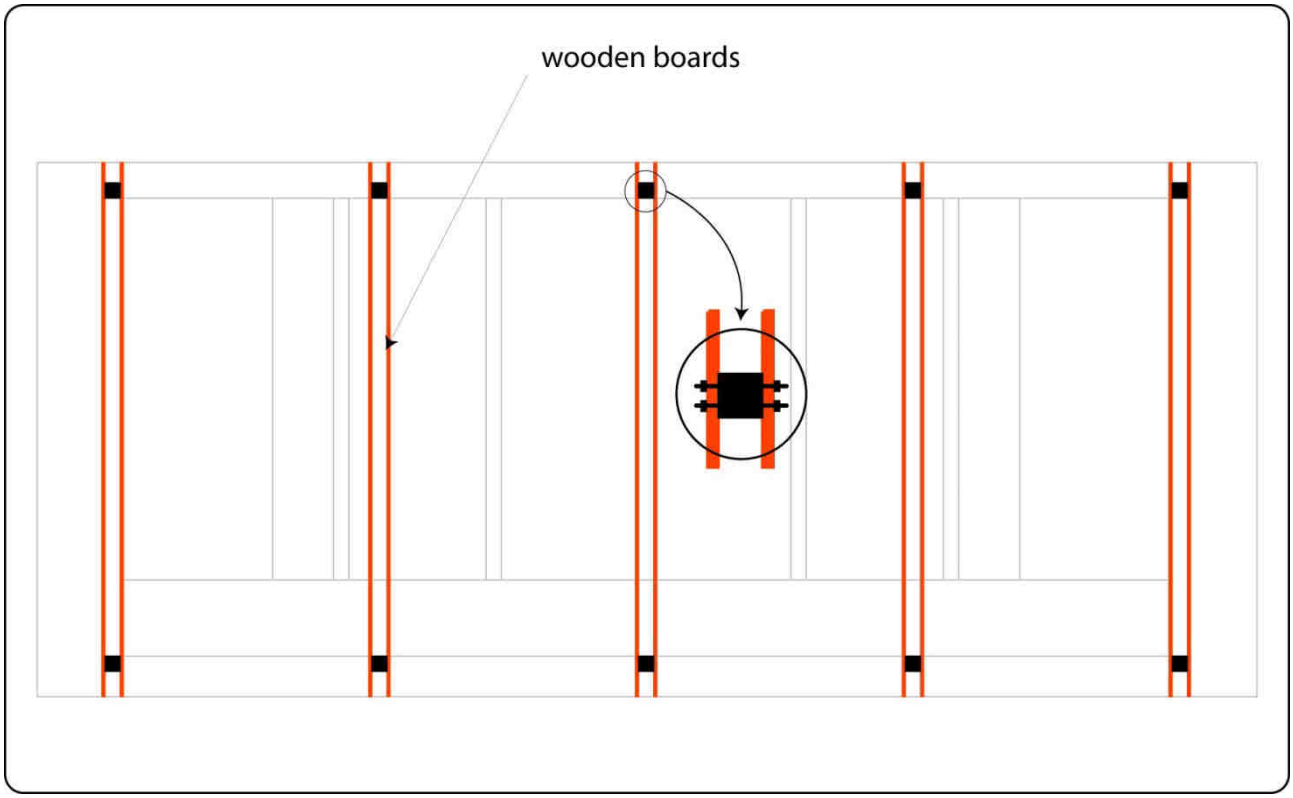


Figure 10: Second step is to fix the traverse wooden boards with threaded bars and bolts (see detail in the picture) at the concrete support.

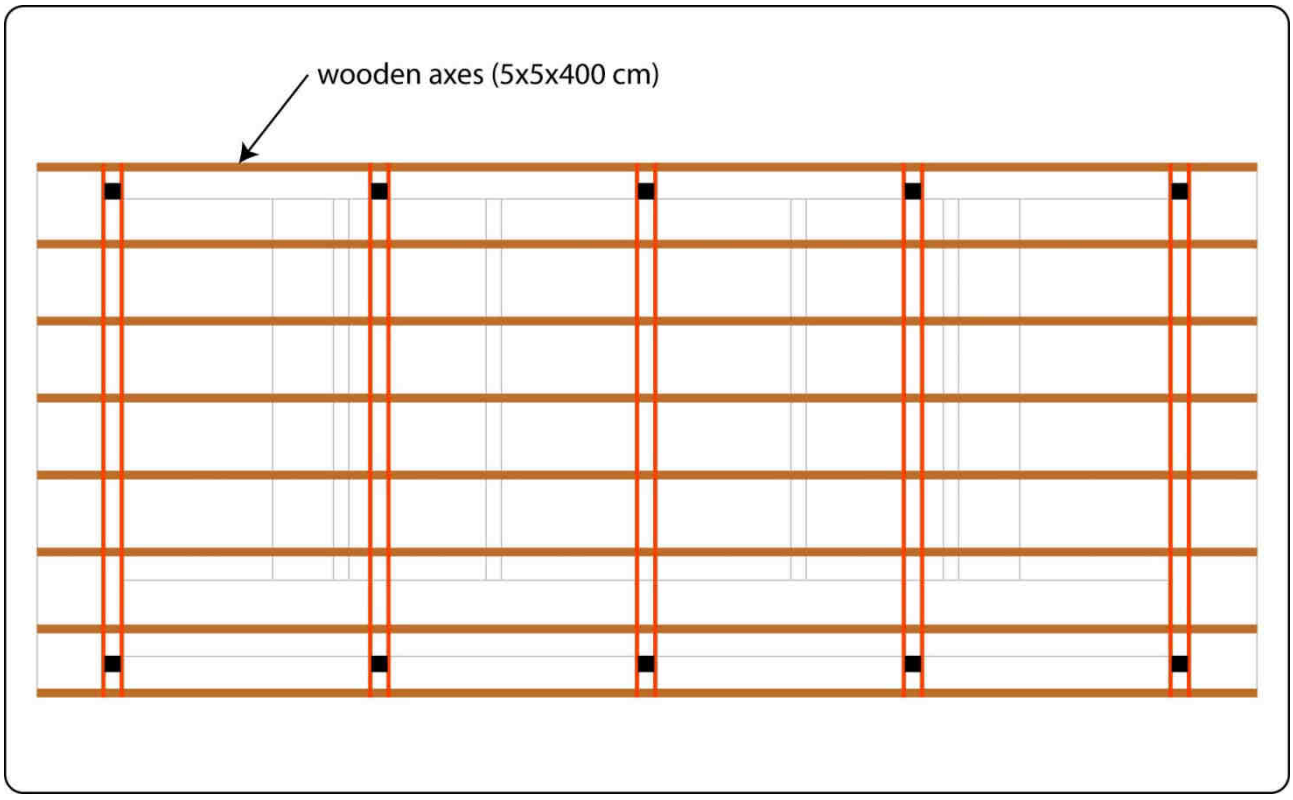


Figure 11: Step three is to fix the long wooden axes on top of the traverse. This is the frame for the methacrylate panels.

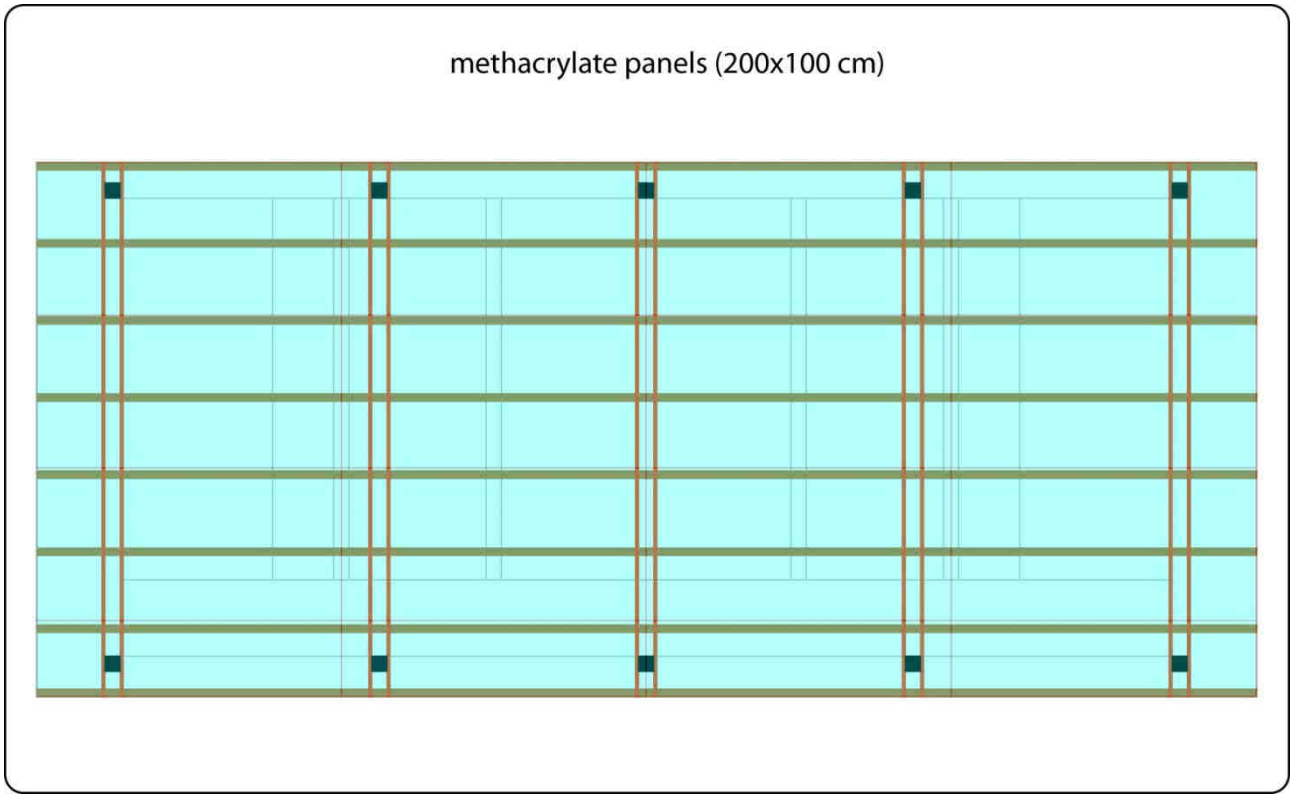


Figure 12: final step is to add the methacrylate panels on to of the long axes. To fix the panels can be used a silicone glue.

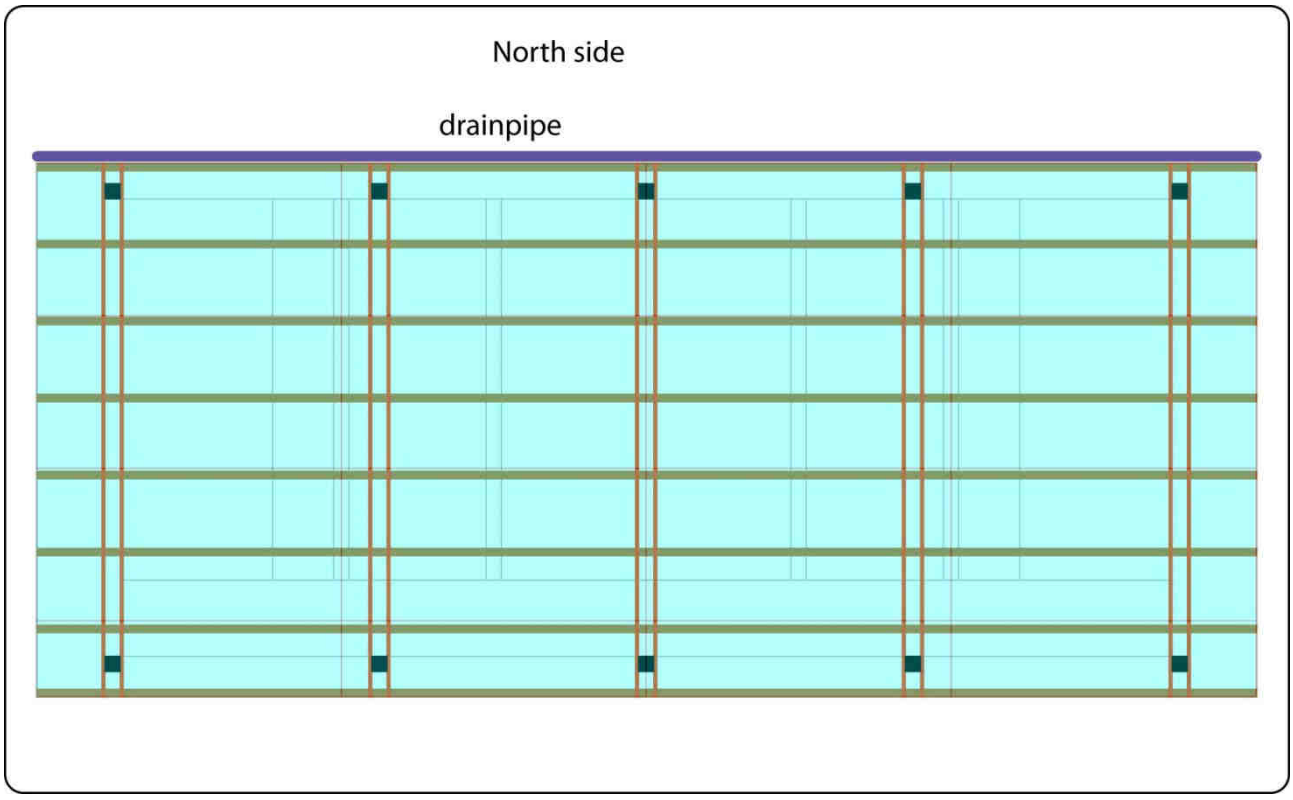


Figure 13: At this point can be added also the drainpipe to collect the rain water and bring it into the water tanks.

COSTS

MAIN STRUCTURE (275,00 €)

- 6 – 8 concrete supports poles → recycled from the vineyard
- 10 wooden boards (3,50x15x3) → 30,00 €
- 16 wooden axes (5x5x400 cm) → 70,00 €
- 14 methacrylate panels (100x200x0,5 cm) → 170,00 €
- 2 threaded bars1 meter long and 20 bolts and 20 washers → 5,00 €

NYLON PANELS (90,00 €)

- 14 Wooden axes (5x5x400 cm) → 60,00 €
- Nylon films (more or less 60 square meters) →30,00 €

IX EVALUATION

During this design I have tried to use more design tools in order to get ideas and solutions for the design itself. I have decided to use the **I.I.E.P.C.I.O.R.R.** even if this is not yet realized, but I think I will implement it very soon in a very interesting community project we are developing in Bagnacavallo (RA). At that time I will be able to go ahead with the design and add any suggestions and critiques from the community people that will help me in the implementation of the greenhouse. Off course the most interesting phase will be the Observation phase. What will work and what will not or the impacts of the greenhouse in the overall project. At this phase will follow reflections and review, and we will start again with identification of problems or solutions and so on.

Since that moment I will add my evaluation of the deign process:

The framework has proved useful for the development of the design, because it gave me easy steps to follow. Also the small question within every steps help in knowing what to do and how to keep going. The observation phase has not been implemented but has been substituted with the evaluation on the tools used and on the reflection on the whole process. I will try to use this framework for a client design because it is well organised and offers points of contact with the client during the design phase.

Normally, in the past designs I have used the **P.A.S.T.E.** tool to record the existing elements of a project, in this design I have used to visualize what elements could be part of the system. Having a list of elements help me and an hypothetic client or builder what is needed to build the main structure, and also if it's possible to find recycled material or to adapt an existing structure.

The **SECTOR** tool has been used to identify the possible constraints and to find the right solution for them. It is the case for the winds, knowing that the major wind events are coming from a sector has helped me in finding solution both in positioning the greenhouse and in determining the best available material to build the protection.

I have created a simplify map with a scheme of the greenhouse and I highlighted the side that need protection from the wind using simple colored lines. This helped me in easily print an image in my mind for further thinking. While evaluating the process I decided to make a tweak at the image to have a stronger connection with the protection event. Therefore I use the blue for the N and NW side (where the cold wind came) and the red for the sector that need air circulation. I also added some arrows which help in understanding the ongoing events even more.

I have used the **ZONE** map to find out how to set up the elements inside the greenhouse. By analyzing the printed map it came out very clear that there is a gradient from the right to the left that can be used for managing the future events (use of annuals or perennials connected to the time needed in the management).

The **FLOW** maps together with the sector map helped me in deciding the typology of paths, for example a good and solid pavement towards the South could be good for a continuous flow of people and material (using a wheelbarrow as well) and also for accumulating the heat of the sun. The division of the beds facing North instead could be done with wooden boards because they can be both paths and container edges.

The **INPUT/OUTPUT** analysis has been used to clarify needs of the elements of the greenhouse allow me to visualize the necessary materials for every system but also to understand what any system is needed for and what else could be done with it. Connection also came out from this analysis. For example to use the bed in front of the door to add manure (to bring manure into the greenhouse I need a wheelbarrow and it is easier to leave the manure in the bed in the front of the access than turn around to reach the others.

X REFLECTION

WHAT IS GOING WELL?

This design is still not implemented but I can say that it help me in achieving more skills in designing, in fact I have produced a lot of maps and scheme which helped me a lot in visualize things better. The power of the map is to put together different information and data and represent them in the easier way. I can say that I have now more skills in representing information using maps.

In some cases I have used the analysis tools from a different point of view, this helped me in having more knowledge and more confidence with the tools and more design skills.

WHAT HAS BEEN CHALLENGING?

The evaluation phase is always my weak point, but I think I am getting better than before and that I will to be able to put thinking into words even better in the future designs.

WHAT ARE YOUR LONG-TERM VISION AND GOALS?

Create a workshop to build the greenhouse in the HumuSapiens site with the people of the Association.

Use the achieved skills in a PDC course.

Use the greenhouse to really grow plants from seeds and improve my skills in germinating seeds and make seedlings.

Integrate the principles more inside the design.

WHAT IS YOUR NEXT ACHIEVABLE STEP?

Integrate much more the evaluation phase in my design skill and be able to use more evaluation tools within designs and courses.