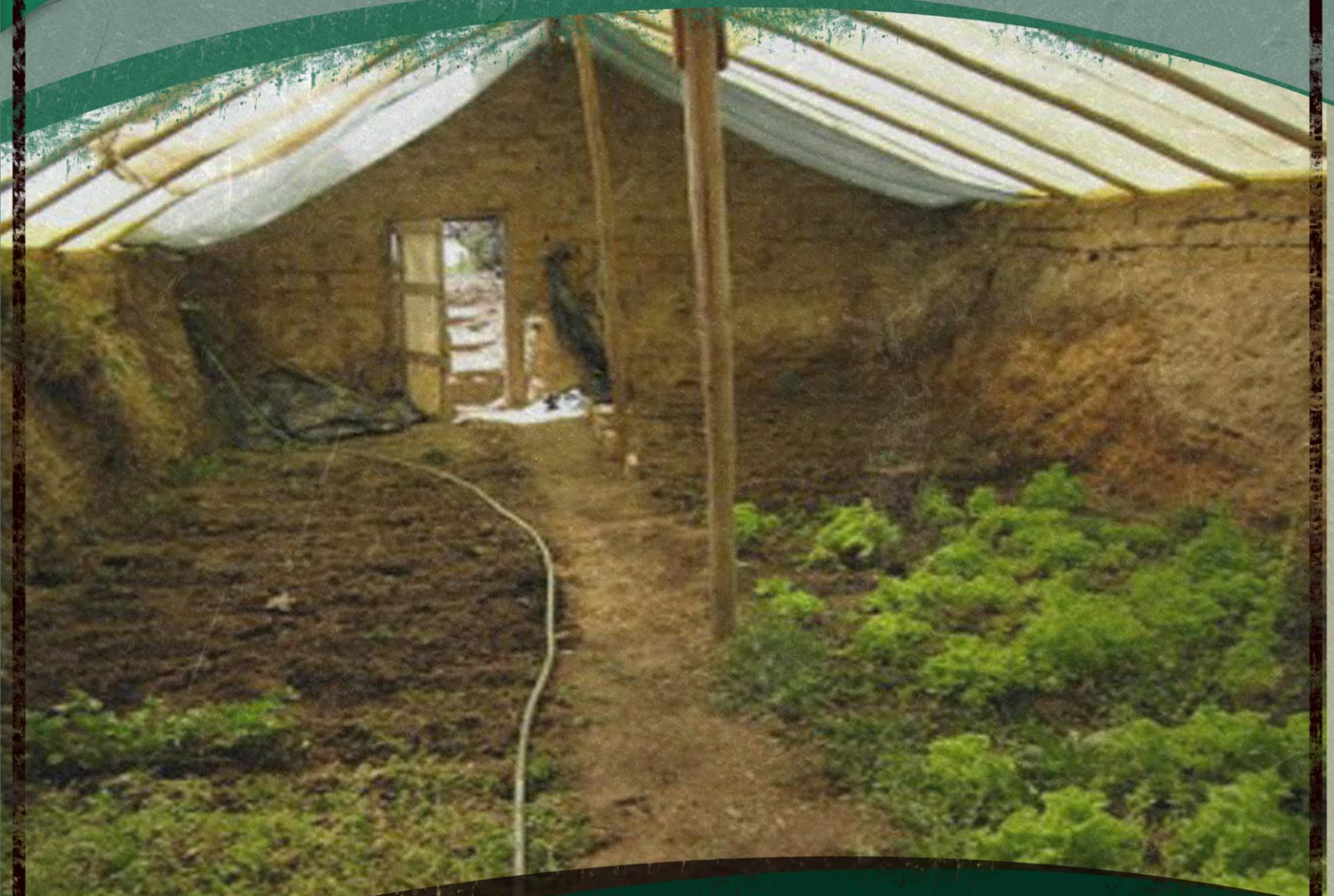
An Underground Year-Round Greenhouse in Your Backyard



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Introduction

Nowadays people are becoming interested in growing their own food to guarantee fresh, safe, and healthy food. Most people enjoy garden-fresh food, but the problem is created in areas where winter is too cold so that crops can't be grown. But people are not willing to sit down and suck their thumbs. They are researching, and they have already created the method to solve the problem. The best solution to the problem is to use a greenhouse.

A greenhouse is a house that is constructed with glass or special PVC that is used to grow crops in the winter where crops can't be grown in too much cold. At the present time, one of the most used special types of greenhouse is the underground greenhouse. It is also named as "Walipini," which means "the place of warmth."

Chapter 1:
Mechanism of Greenhouse and Underground Greenhouse

Sunlight is the all in all in the greenhouse. Normally, sunlight has a lower wavelength, and that's why glass and PVC permit its entry. When the sunlight enters into the greenhouse by penetrating the glass or PVC, it increases the soil warmth in the greenhouse. Then the soil starts reflecting the heat, but the reflected heat energy has a higher wavelength. The glass or PVC doesn't permit the higher wavelength to penetrate. So the heat energy can't go outside and makes the environment warm in the greenhouse.

Underground greenhouse:

The mechanism of an underground greenhouse is the same as the regular greenhouse. An interesting mechanism of soil is that it remains cooler in the summer and warmer in the winter. An underground greenhouse is generally constructed three to five feet underground the soil, so the mechanism of soil is also used in the underground greenhouse, which makes this type of greenhouse more advanced.

Its mechanism is discussed below with details.

Sunlight is the main source of energy used by the Walipini and enters from the plastic-covered roof. The underground structure absorbs the energy of the

sunlight and also reflects some. The absorbed energy is used to heat the ground portion as well as be stored. As reflected energy can't go outside, it remains in the Walipini and makes the Walipini air warmer. Generally, plastic sheet is used as the roof of the underground greenhouse instead of glass because plastic sheet facilitates the plant growth properly.

An underground greenhouse is generally constructed three to five feet underground. But what's the benefit of this? Actually, the benefit is the usefulness of the soil temperature. For the example, if the temperature of the soil is 10°F, then the temperature of the soil four feet deep will likely be 50° to 60°F. Now imagine that the temperature of any greenhouse should be something like 100°F. If you use an underground greenhouse, then the greenhouse will get about 60°F from the ground. So it needs an outside temperature of only 40°F to provide 100°F of heat that will be produced by sunlight and other sources, while the normal greenhouse needs to produce the total 100°F from the sunlight and other small sources.

The roof of the underground greenhouse is made of a dual-layer sheet. The place between these two sheets is full of dead air which ensures insulation. This is approximately 3" to 4" thick to facilitate insulation. Moreover, the use

of soil in constructing the wall of the underground greenhouse should be increased because the soil acts as an insulator in this case. It's normal that the temperature falls at an alarming rate at night. That's why the sheet or glazing should be covered with insulation board, which is filled with foam, straw, grass, etc. This will help to insulate it.

You may have heard about the flywheel effect. If you haven't, then let me clarify. Earth such as stone, water, soil, etc., absorbs heat when it comes into contact with solar energy or sunlight. This is called the flywheel effect. The greater the mass, the greater the absorbing tendency. Mass is not the all in all in this effect. The color also plays an important role while absorbing heat energy. For an example, a deep color such as gray, ash, or black absorbs more heat, while a light color such as white or pink absorbs less heat as they reflect the energy at a higher rate.

The use of a full water tank in an underground greenhouse is essential. Water can absorb huge amounts of heat, and that's why water is used in the cooling system of the engine of vehicles. The water in the tank absorbs heat from the sunlight and stores the heat. When the temperature falls, especially at night, the water supplies its stored heat. This water helps to keep the Walipini environment warmer.

Chapter 2:
Site Selection for an Underground Greenhouse

There are some basics that you have to consider before starting the construction. For example, if you think that you can make the Walipini anywhere besides your home, then you are absolutely wrong. Site selection is one of the most important topics to think about before constructing an underground greenhouse.

What to consider when selecting a site:

1. First of all, you have to select a place that can get sunlight all day. That means you have to ensure that the place won't get any shade during the daytime because the Walipini needs sunlight all day long as sunlight is the only source of energy for it.
2. Water penetration demands great consideration at the time of site selection. Sometimes it can be seen that water penetration occurs through the wall or the floor of the Walipini, but it's undoubtedly destructive as it hampers plant growth. It mainly depends on the soil type surrounding the Walipini. If the soil has a lower permeability, it is good to construct the Walipini in there, but if the soil has a higher permeability rate, then you should use plastic sheeting. Clay soil is the best for underground greenhouse construction, so you should test the soil before constructing the Walipini. Moreover, you have to be careful about the drainage system. So you have to dig a good drainage ditch around the Walipini.
3. Compare the area with the water level. The area should be placed five feet above the water level to facilitate the drainage system.

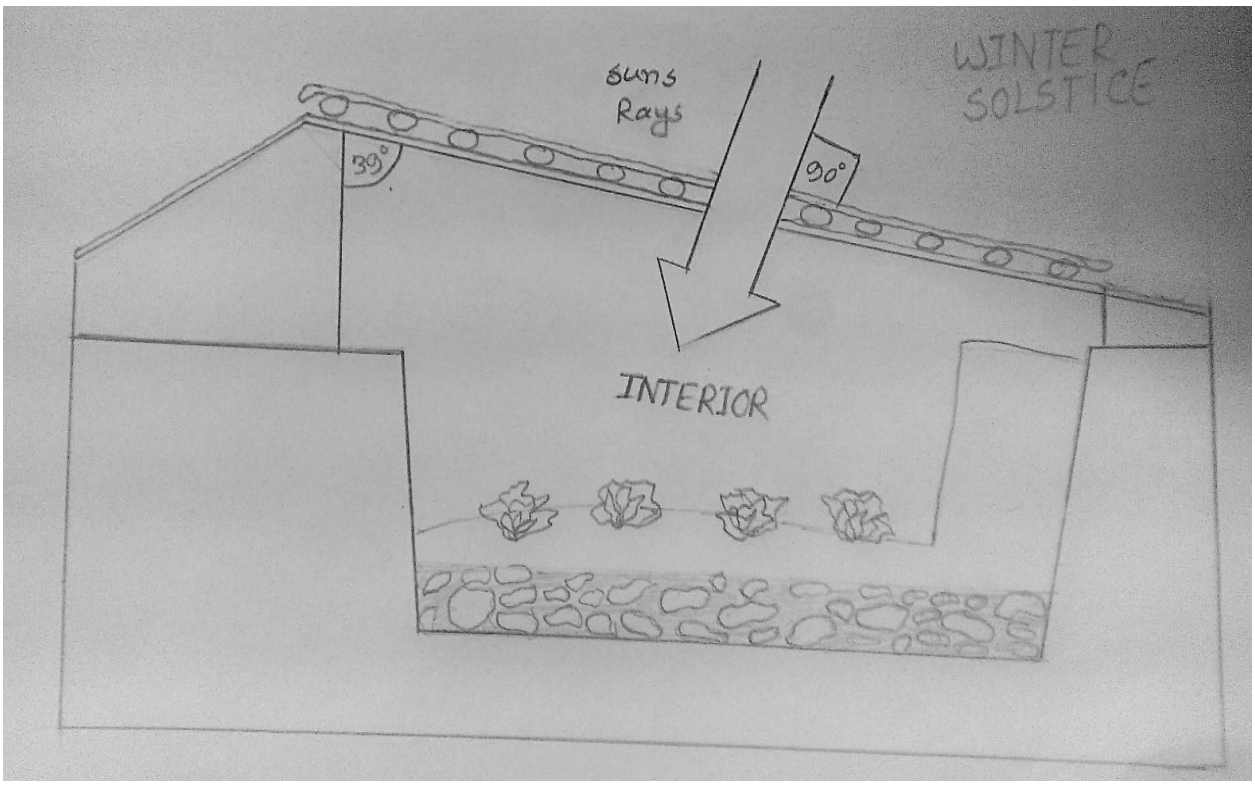
Placement of the underground greenhouse:

The placement of the Walipini should be in such way that it can ensure maximum sunlight penetration in the winter season and minimum sunlight penetration in the summer. In the summer, the environment normally remains warmer. So the Walipini doesn't need extra warmth in the summer. That's why the Walipini needs minimum sunlight during the summer. Because plants need a reasonable temperature for better growth, the Walipini needs maximum sunlight penetration in the winter.

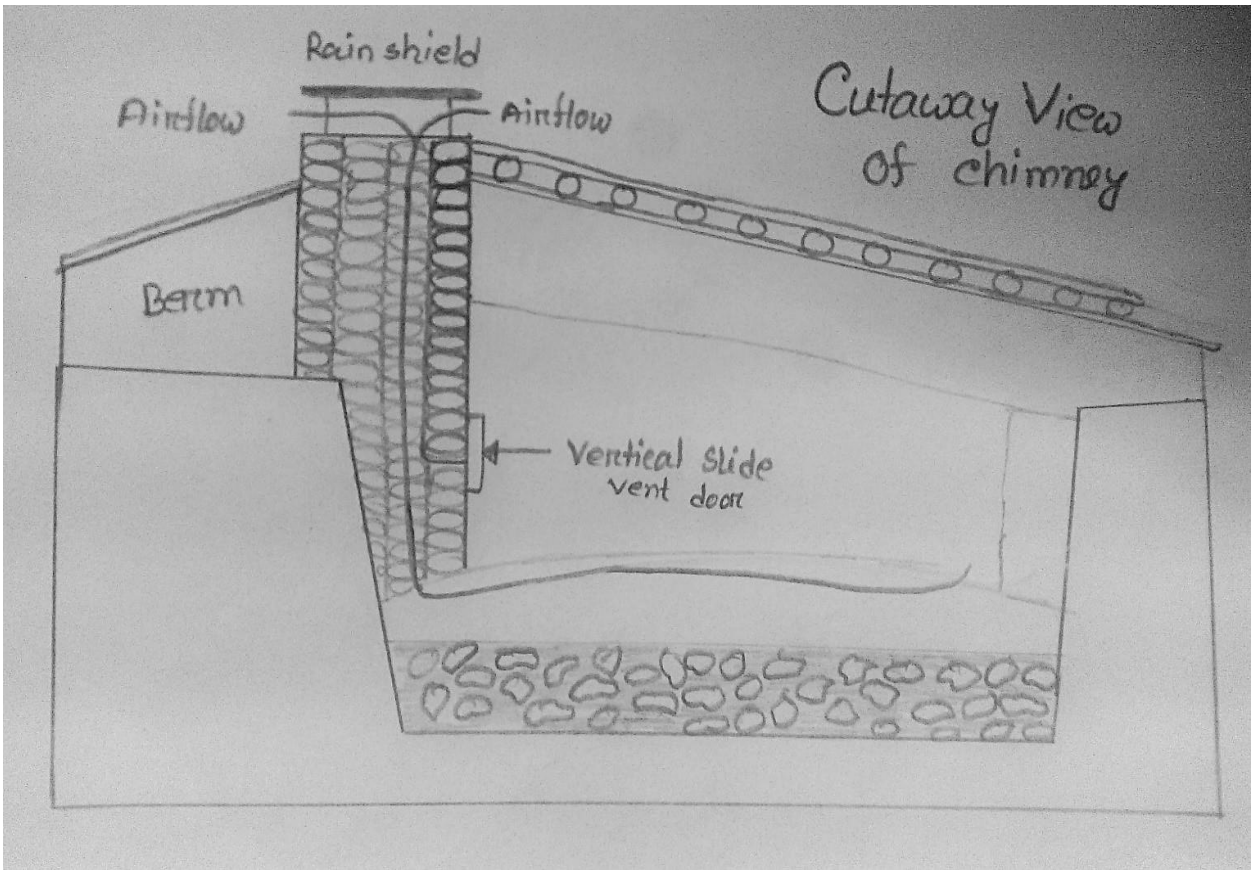
The angle of the Walipini and the angle of the roof is also very important. The Walipini should be constructed at a north-south angle, so the front or back side of the Walipini should remain either in the north or in the south because the sun rises in the east and sets in the west. This way the Walipini will get sunlight all day long.

The question normally arises concerning what's the problem with the east-west angle. The problem is actually shade half of the time and light during the other half of the day. In this system, the Walipini will get sunlight for half of the day either on the front side or back side.

Roof angle is also a vital matter. The roof should be angled in such a way that the sunlight can be perpendicular with the roof angle in the winter to penetrate with the maximum amount of sunlight. Again, the sunlight should penetrate the roof with a minimum 105° angle in the summer to maximize reflection so too much heat through sunlight can be avoided.



The roof should be extended in the north to the southern hemisphere or in the south in the northern hemisphere because the sun is slanted in the south in the northern hemisphere and slanted in the north in the southern hemisphere in the winter. The best time to get maximum heat from sunlight is 10 a.m. to 3 p.m.



Design of underground greenhouse:

You can select any design according to your choice. The cost and the number of your family members can both affect your Walipini design choice. The main objective of constructing a Walipini is to get fresh vegetables all year round. A Walipini of 94 square feet of growing space is recommended per person to get a year-round vegetable supply. The minimum size of a Walipini may be 8 feet x 12 feet. Another important thing to consider when choosing a design is cost.

The larger the Walipini, the higher the cost. So you should consider your purpose as well as the members of your family.

As an example, a Walipini of 10 ft. X 45 ft. is enough to supply year-round vegetables for four family members. About 16% of this space will be accommodated by the construction of the wall, inner road, etc. So 16% of 450 sq. ft. = 72 sq. ft. The remaining space for growing is 450 sq. ft. – 72 sq. ft. = 378 sq. ft. Divide it by four (for a family of four).

Now, 378 sq. ft./4 is equal to 94.5 sq. ft. The minimum requirement of the growing space for a single person is 94 sq. ft.

Direct calculation:

45 ft. X 10 ft. = 450 sq. ft.

450 sq. ft. X 16% = 72 sq. ft.

450 sq. ft. – 72 sq. ft. = 378 sq. ft.

378 sq. ft./4 = 94.5 sq. ft.

Another calculation for Walipini size suitable for six family members is given here. A Walipini of 12 ft. X 56 ft. is suitable for a proper supply of the required vegetables for six family members. As the construction site accommodates about 16% of its space, 16% of 672 sq. ft. will be 107.52 sq. ft. = 108 sq. ft. So the inner free space for cultivation is left as 672 – 108 sq. ft. = 564 sq. ft. Now divide the free growing space with the number of family members. As the family members equals six, the calculation will be 564/6 equals 94 sq. ft.

Direct calculation:

56 ft. X 12 ft. = 672 sq. ft.

672 sq. ft. X 16% = 107.52 sq. ft. = 108 sq. ft.

672 sq. Ft. – 108 sq. ft. = 564 sq. ft.

564 sq. ft./6 = 94 sq. ft.

I'll explain another calculation to make this concept completely clear. A calculation of a Walipini suitable for eight family members is explained here, where 13 ft. x 69 ft. is a very good size for cultivating year-round vegetables for eight family members. About 16% of the space will be accommodated by constructional purpose. So 16% of 897 sq. ft. will be 143.52 sq. ft. = 144 sq. ft. The free space will be 897 sq. ft. – 144 sq. ft. equals 753 sq. Ft. Now divide it by the number of family members. Here the family members is eight, so the equation will be 753/8 = 94.125 sq. ft. = 94 ft.

Direct calculation:

69 ft. x 13 ft. = 897 sq. ft.

897 sq. ft. X 16% = 143.52 sq. ft. = 144 sq. ft.

897 sq. ft. – 144 sq. ft. = 753 sq. ft.

753 sq. ft./8 = 94.125 sq. ft. = 94 sq. ft.

You have to also be aware of the construction cost of a Walipini. The Walipini should be chosen and designed so that the cost becomes minimal. Here are some ways to minimize the costs.

1. Firstly, labor costs can be huge, but you can minimize the labor costs by doing it yourself. You can also ask your family members, neighbors, and close friends to help. If you can't get help from them, then you can hire a single laborer to work with you or assist you.
2. You will have a large amount of soil after digging. You can use that soil as a planting medium in the underground greenhouse as the soil is also valuable and you shouldn't waste it.
3. The rest of the dug up soil can be used in the earthen wall construction.
4. On the top, you should use plastic sheeting instead of a corrugated fiberglass panel or glass because the plastic sheet is relatively cheap and the penetration of the sunlight is more accurate.

5. The foundation and the footing are traditionally created with concrete, but it's not really necessary. You could skip this to minimize the cost.
6. While digging, you will get some stones. You can use them in the base construction as well as drainage construction work.
7. You can utilize some used materials where possible. Suppose you have a used door in your store room. You can use that in this construction. You can also use larger oil drums, pots, a water tank, and even internal wooden parts.

Drainage:

At the beginning, the destructive effect of water coming into the Walipini was discussed. Undoubtedly, a proper drainage system can prevent the entry of water. Not only the outer water but also the inner high moisture condition is harmful to the plants. Only a proper drainage system can solve this problem. Normally two types of drainage systems are used in the Walipini. The presence of both of the two systems is mandatory. Let's have a look.

1. Inner drainage:

The well-constructed interior drainage system is very important for a standard Walipini. Moisture is really necessary for the plants, but high moisture is harmful as it causes diseases. Fungal and bacterial attacks increase as well. About 1.5 ft. to 2 ft. from the Walipini ground is where you dig for interior drainage. This space is filled with stones, gravel, and about eight to ten inches of soil. The largest stone or gravel is placed at the bottom, and then smaller stones are placed on top of it. The eight to ten inches of soil is placed on top. All of the materials are placed loosely. It is built in such a way that the user can open the cover of the system when necessary.

2. Outer drainage:

Water is the life for both plants and animals. But water is not always a friend; it can also be a foe depending on the situation. Outer water is a foe for the plants of an underground greenhouse. To prevent the entry of the outer water, an exterior drainage system must be constructed surrounding the Walipini. It

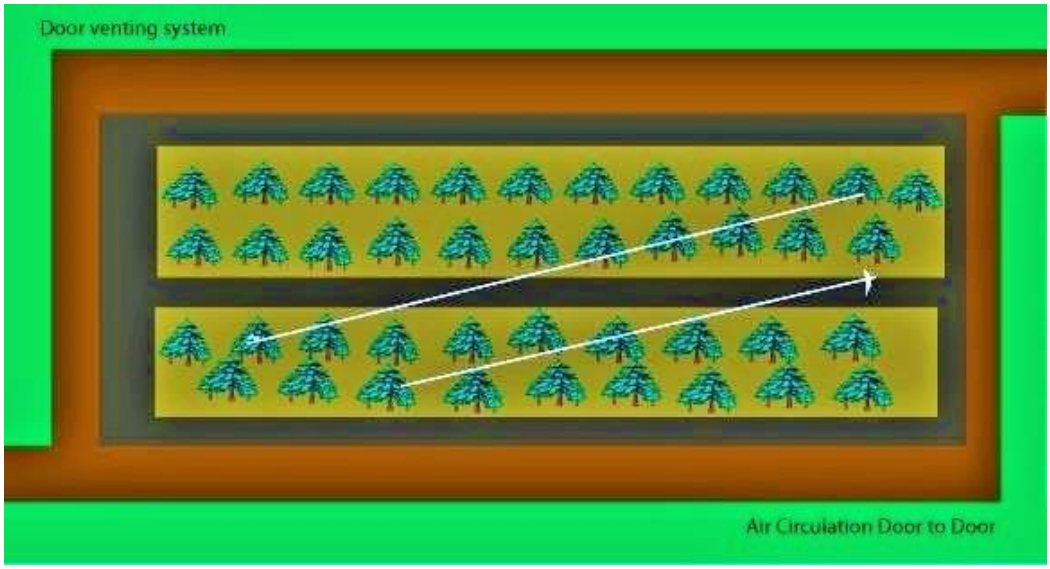
should be constructed two to three feet away from the Walipini wall on all sides. If it is constructed accurately, the outer water won't be able to come in contact with the Walipini wall. Another problem is the inclined water of the roof. When it falls on the ground near the Walipini wall, it may come in contact with the wall. That's why the ground of the Walipini construction should be a little high in comparison to the surrounding ground so that the dropped water can be inclined to the drainage ditch and move away (although the rain water of the roof is removed by another system).

Ventilation:

Ventilation is used in buildings to promote good health. Similarly, to ensure healthy plants, an underground greenhouse needs a ventilation system. It aids in maintaining the inner temperature as well as humidity. How much ventilation is needed depends on the environment. If the temperature of the surrounding environment is relatively high, then it needs high venting to avoid overheating. Sometimes the air becomes humid, and high venting is also necessary at that time. Again, when the temperature becomes too low, ventilation should be minimal at that time. There are several ventilation systems that are used in the underground greenhouse. Which system is best for your Walipini will be determined by the environment of your Walipini.

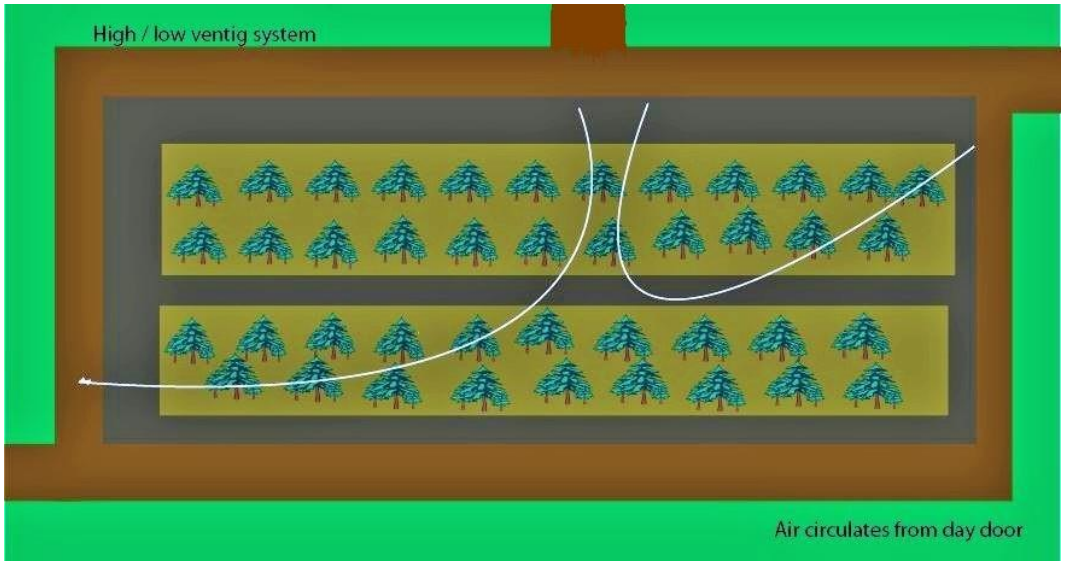
Ventilation system #1:

This is the simplest ventilation system. In this system, two doors are used as a venting operator to regulate the ventilation. The doors are located opposite of each other. The inner air can pass moderately through the doors. Labor cost is truly minimum in this system, and it doesn't require additional ventilation materials. However, it can't provide enough ventilation when high ventilation is required, especially in the summer.



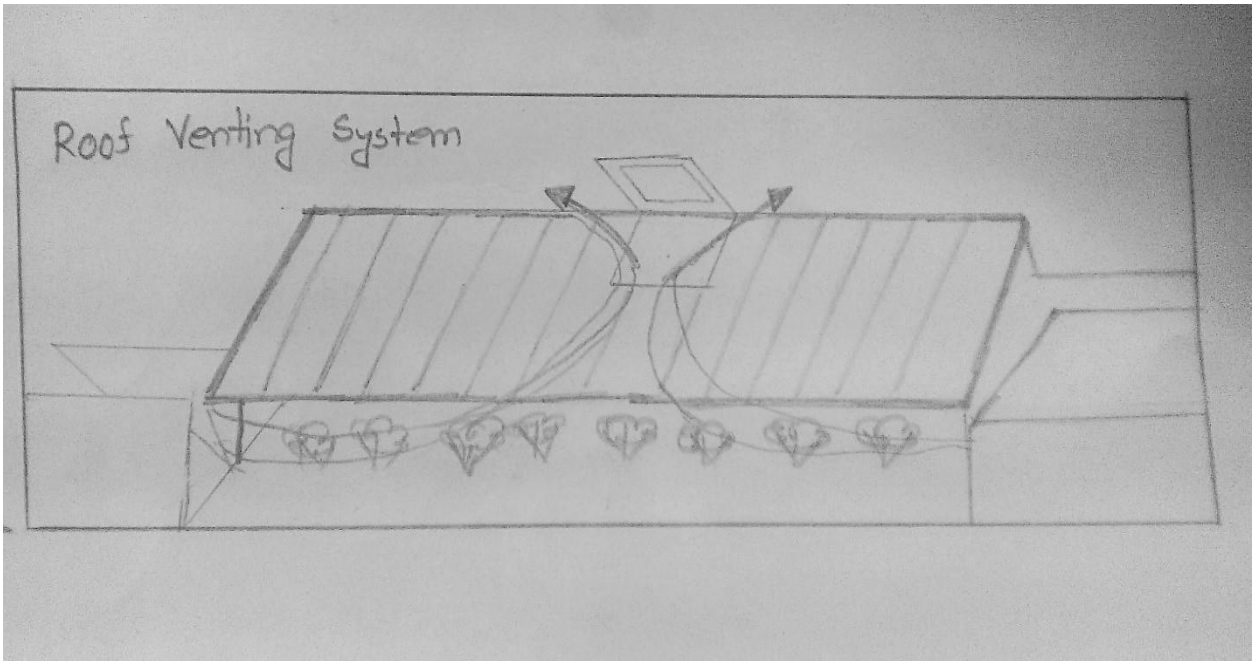
Ventilation system #2:

This is as same as the first one, but it has an additional door on the rear wall. It ensures proper ventilation when necessary. It also requires less labor costs, although more than the first system. It doesn't require additional materials, and that's why it's relatively cheap. But the problem arises with the rear wall in this system. Most of the heat is collected and stored in the back wall of the Walipini. As a central door is constructed on the back wall, the heat storage mass becomes lower. Other than that, this is really a good ventilation system.



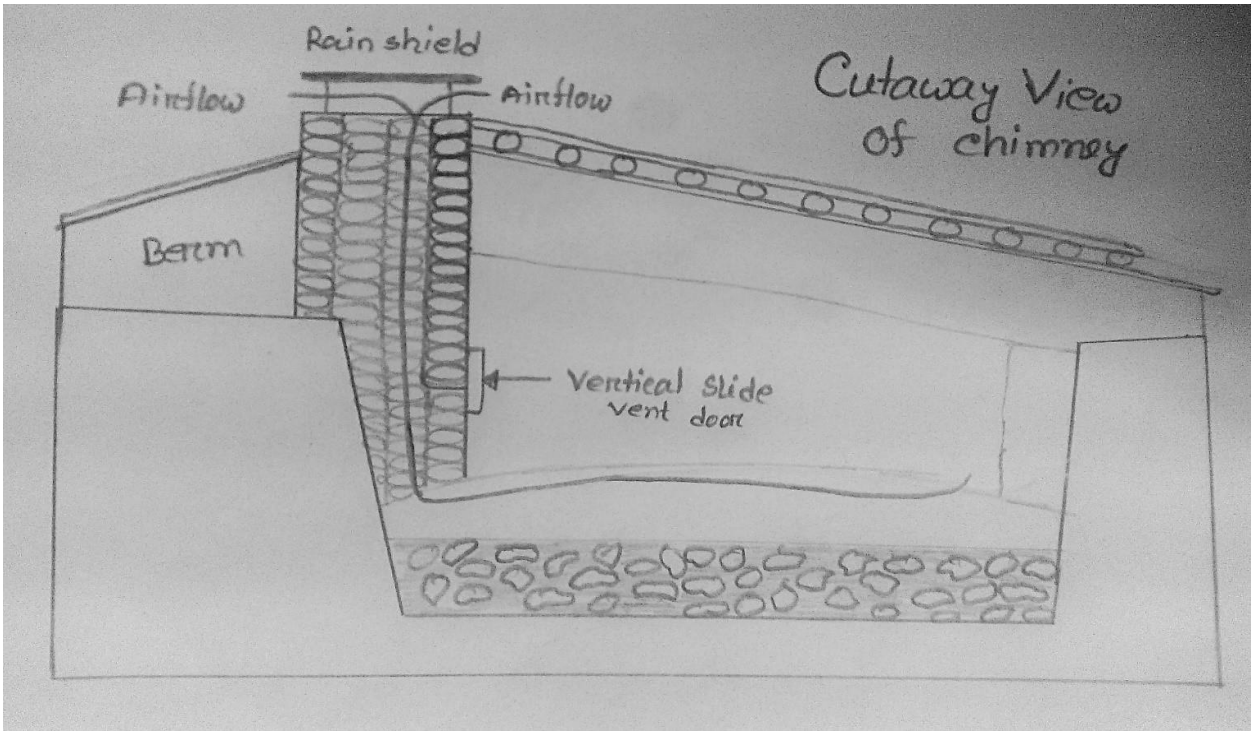
Ventilation system #3:

This is also similar to the first system. It has two doors, which are situated opposite to each other. But unlike the second system, it does not have the third door at the rear wall. Rather, the third door is present at the center of the roof. That's why there is no possibility to lose heat storage mass. It also ensures the highest amount of air exchange when needed. But the roof door should be constructed with special care so that it does not create a problem. If it's not constructed properly, it may permit rain water to leak, even when it is closed. Moreover, it can permit unwanted heated air or too much cold air. Just two hinges and some boards are used to construct the roof vent, and a 4 ft. x 4 ft. size is considered standard for the roof vent.



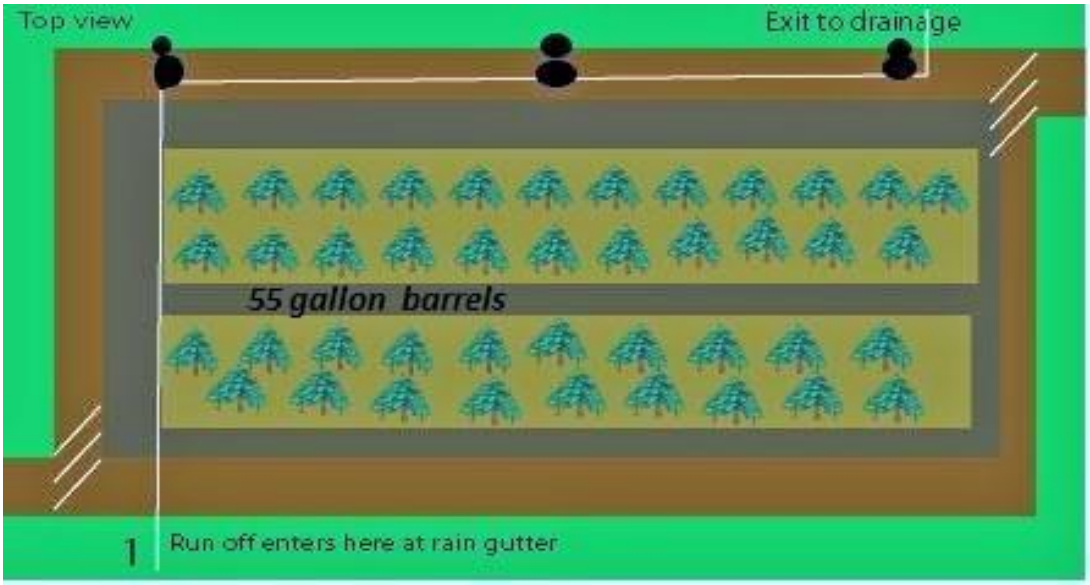
Ventilation system #4:

This system is more or less similar to the previous system. The addition of a chimney is the single difference between them. The chimney is joined with the roof vent, and it is adjacent to the rear wall. It regulates the airflow better than any other system, but it demands more labor and more construction materials. That's why it's relatively expensive. A rain shield is used at the top to prevent the entry of rainwater.



Collecting and storing of rain water from the roof:

PVC or a galvanized metal rain gutter is set on the roof to collect rain water. The gutter is connected with the water barrel through a pipe. This rain water enters into the water barrel through the pipe, which is used for irrigation. It is also used to store heat from penetrated sunlight. An overflow pipe connects all the water in the barrel at the top, and the last water barrel is connected with the drainage ditch to get rid of overflow inside the underground greenhouse. Using a T valve on the gutter is recommended to avoid the entry of excess rain water during rainy days. The amount of water entry depends on the diameter of the pipe as well as the size of the gutter. When you use a larger gutter with a pipe with a greater diameter, it will regulate the entry of rain water at a higher rate.


Top view
Exit to drainage
55 gallon barrels
1
Run off enters here at rain gutter

Chapter 3: Walipini Construction

Required materials:

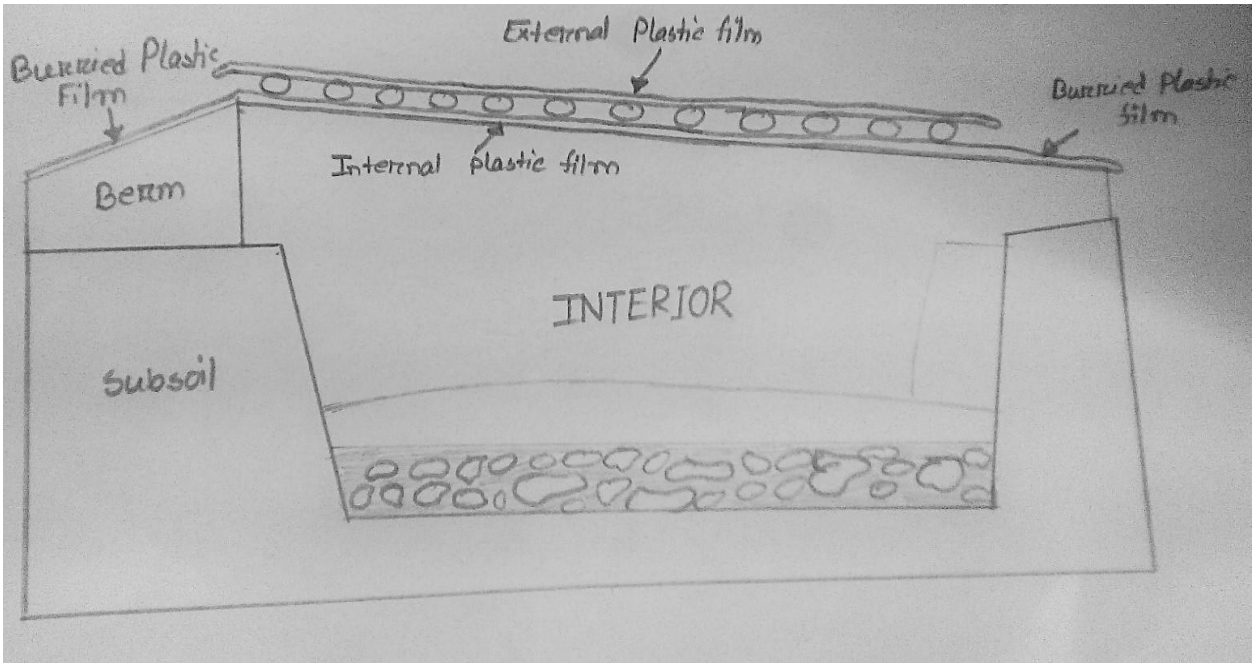
1. Hinged door (wooden door is recommended)
2. Door lintel
3. Door frames
4. Roof frame or roof lintel
5. PVC pipe
6. Agro-film
7. Soil (clay soil, mixture of silt and clay soil)
8. Large to medium gravel and stones
9. Plastic sheeting for drainage
10. T valve and gutter to use on the roof
11. Drain gutter
12. Overflow pipe
13. Wood stripis
14. Plastic sheet to use on the roof
15. Adobe mud (mixture of clay, sand, and straw)
16. Digging materials, etc.

Digging and ground construction:

First of all, you have to determine the design of your Walipini. Measure the width and length in the selected area, and start digging from each of the measured poles. Don't waste the dug up soil because there are other uses for the soil. This soil will have to be used as the cultivable land of the Walipini.

The ground of a Walipini is normally made of soil. You can also use rough tiles or bricks, but that will just increase your costs. So a dirt floor is the best and is the most commonly used all over the world.

The cultivable surface should be loose to facilitate the interior drainage. The soil has to be dug in such a way that the interior drainage system construction becomes easy. The larger stones and gravel should be placed at the lower base. Medium-sized stones and gravel should be placed over the larger ones. The top soil should be placed over these stones of the interior drainage system. This top soil should be a minimum of eight inches.



The soil of the Walipini should be fertile enough to get good crop production. You can use organic manure at a controlled rate. You shouldn't use inorganic fertilizer at the beginning stages. You should also be careful about the pH of the Walipini soil. The best pH range or optimum pH range for crop cultivation is 6.5 to 7.5, where 7 is the best.

Wall:

The importance of the wall of a Walipini can't be described in words. It makes the difference between a greenhouse and an underground greenhouse. The wall has to be laid out from the edge of the digging. You can use adobe mud for plastering the wall. You can use bricks at the middle of the mud layer. The bricks must be first-class bricks. The mass of the brick can also store the heat energy. You have to consider these factors when choosing your bricks:

1. Try to make a crack with your nail in the brick surface. If it cracks, avoid it.
2. Strike the brick with another brick or hammer. If it sounds clearly and doesn't break, then it's undoubtedly a good brick.

3. Take two bricks, and make a T-shaped structure. Then select such a moderately hard surface. Drop the T-shaped bricks from about six feet up. If the bricks break down, then they should be avoided.

You need good mud for the Walipini wall. The soil should be clay soil, and the mud should have a 10% moisture content. Next, the adobe mud (a mixture of clay, sand, and straw) should be ready. The adobe mud is normally used as a very thick layer of the brick skeleton for the Walipini wall, which makes the Walipini wall more heatproof. The four walls also have to be constructed in such a way that the roof can be constructed over it at a 39° to 41° angle.

Roof of the Walipini:

Recheck and make sure that the angle of the roof is approximately 39º to 40º so it will be perpendicular to the sun's rays on the winter solstice. Next place the twenty 4" x 16' long poles on 4' centers spanning the roof beginning at one end of the growing area which will place the 18th pole at the other end of the growing area. Poles 19 and 20 are placed at the ends 4' from poles 1 and 18 so that there is minimum 1' overhang over the two doors on the ends of the building.

Little overhang on the front and back walls is needed, if plastic sheeting is used to protect the immediate area from erosion and water penetration. Before pinning the poles into the tops of the back and front walls, place a sheet of plastic running the full length of the interior of the building, including the overhangs, at both the top and bottom so that this interior glazing will be staked down with the end of each pole. Drill a hole in each pole and stake it into the rammed earth with rebar, a wooden stake or dowel. Fill the wall in between each pole with adobe mud the width of the wall following the angle of the poles. This will seal the area between each of the poles to prevent outside air from coming in and inside heated air venting to the outside. Now cover the entire exterior of the roof with the plastic sheeting overlapping each joint at least 6" to minimize air leakage and securing each overlap with wood stripping and nails at one of the poles. Nail stripping the full length of each pole to secure the plastic and to prevent wind damage. Place a single course of adobes all the way around the perimeter of the roof with the exception of the bottom

side where the water runs off into the gutter system. This will secure the boarder of the plastic to the walls. On the lower wall the plastic must run down to the gutter system unobstructed so the water freely follows this course. Now go inside the Walipini and finish lining the underside of the poles/roof with the plastic securing it with nailed stripping as well. Make sure to seal the overlaps to prevent heated air and moisture in the growing area from entering the dead 4" insulation air space. Now check all areas where the poles and plastic join the roof for open spaces that will leak air and fill them with adobe mud from the inside and the outside. Next return to the outside and install the rain gutter at the lower end of the roof so that it will catch all of the run off from the glazing. Make sure that the gutter is lower at the end where the distributions of the water will take place. At the gutter exit install a T-pipe so that water can be directed to the nearest surface drain ditch and/or inside to the barrel water storage/heating/overflow system.

Run a pipe from the T valve inside above the door and over to the first barrel in the corner. Then run additional pipe for overflow from the first to the last barrel and then an exit pipe from the last barrel through the back wall of the Walipini over to the nearest surface drainage ditch. The roofing system is now completed.

Door:

The door of an underground greenhouse is very important. The door should be installed in such a way that the air can't be exchanged between the inside and the outside environment of the Walipini. Because of this, a metal door should be avoided since one of the most important characteristics of the metal is its conductivity and a metal door can conduct and exchange heat. So a wooden door is recommended for Walipini construction. You should consider the following things when choosing the wood:

1. The timber should be uniformly shaped and mature. Mature timber is generally grey or black in color.
2. The timber should sound clear when striking with a hammer. The clear sound shows the high density of the wood.

3. The crown of the timber should be sound and vigorous. It must not be cracked.

The wooden door should be well burnished, and a water-protecting polish should cover the whole door so that the door can't come in contact with water, which would be harmful to the wood and reduce its lifetime. Because of the water and high moisture, this precaution should be maintained.

You must be very careful when installing the door. There must not be any gap between the door frame and the wall. If any gap remains, it should be covered with the mixture of clay, sand, and straw so the heat cannot escape the greenhouse. Similarly, there shouldn't have any gap between the door and the doorframe because of the same reason.

Chapter 4: Completion and Use

Construction of the Walipini is completed. Before starting cultivation in your newly constructed Walipini, you have to do two simple things. First of all, you have to recheck for any leakage. If any leakage is found, use the adobe mud again as instructed. When you are sure that the Walipini is free from all leaks, you should test its temperature. If the temperature can reach about 60°F in the winter, the Walipini is ready for use.

You can use the Walipini to cultivate several types of vegetables. You just need to pay attention to the length of day. If the day is relatively short, then you have to grow short-day plants, which means you should cultivate winter-based crops. If the day is relatively long, then you will have to cultivate summer-based crops.

At this stage, normally some questions begin to arise: Are all the crops that are grown in the Walipini the same as the normal field-cultivated crops? Is there any difference in the taste? Any difference in the size and quality?

The answer is "yes" to all the question. There is a difference between the Walipini-grown crops and field-grown crops. The Walipini-grown crops are three times better than the field-grown crops. Here's why:

1. Diseases and pests are rare in the Walipini, and that's why your crops remain free from pesticides.
2. Attacks by insects are minimal in the Walipini, and that's why you don't need to apply insecticides. Your crops remain free from harmful chemicals.
3. Weeds seldom grow in the Walipini.
4. You can use hybrid varieties and give individual care to each of the crops.