SUSTAINABLE AGRICULTURE IMPLEMENTATION

Community Outreach Programme
A Step-by-Step Guide of Permaculture Techniques
# Table of Contents

1.0 Permaculture Designs ......................................................... 3
   1.1 Zones .............................................................................. 3
   1.2 Forest Gardening ............................................................... 4

2.0 Organic Fertilizer ................................................................. 5
   2.1 Compost Making ............................................................... 5
   2.2 Liquid Manure ................................................................. 7

3.0 Permaculture Beds ............................................................... 13
   3.1 Raised Beds .................................................................... 13
   3.2 Inverted Bed or Sunken Bed .............................................. 14
   3.3 Key-Hole Bed .................................................................. 16
   3.4 Diamond Bed .................................................................. 18

4.0 Micro Water Harvesting Technique – Conservation Tillage .......... 20
   4.1 Micro Basins .................................................................. 20
   4.2 Planting Pit ..................................................................... 21

5.0 Seedling Transplanting .......................................................... 22

6.0 Seed Saving .......................................................................... 23

Conclusion .................................................................................. 24
1.0 PERMACULTURE DESIGNS

1.1 Zones

Zoning in permaculture design refers to a method of ensuring that elements are correctly placed. Zoning is about correct placement-positioning things in ways that are the most appropriate; Zones are numbered from 0 to 5, and can be thought of as a series of concentric rings moving out from a center point, where human activity and need for attention is most concentrated, to where there is no need for intervention at all.

• **Zone 0:** This is the center of human activity, for example, the house.

• **Zone 1:** Is the zone nearest to the house, the location for those elements in the system that require frequent attention, or that need to be visited often, e.g., vegetable garden or compost bin for kitchen waste.

• **Zone 2:** This area is used for siting perennial plants that require less frequent maintenance, such as occasional weed control or pruning, including currant bushes and orchards. This would also be a good place for beehives or larger scale compost bins.

• **Zone 3:** Is the area where main crops are grown, both for domestic use and for trade purposes. After establishment, care and maintenance required is fairly minimal.

• **Zone 4:** This zone is mainly used for forage and collecting wild food, firewood as well as timber production. An example might be a woodlot.

• **Zone 5:** The wilderness. There is no human intervention in zone 5 apart from the observation of natural eco-systems and cycles. Here is where we learn the most important lessons of the first permaculture principle of working with nature, not against.
1.2 Forest Gardening

Forest gardening is a low-maintenance sustainable plant-based food production and agroforestry system based on woodland ecosystems, incorporating fruit, shrubs, herbs, vines and perennial vegetables which have yields directly useful to humans. Making use of companion planting, these can be intermixed to grow in a succession of layers, to build a woodland habitat. A forest garden is organized in up to seven ‘layers’. Within these, the positioning of species depends on many variables, including their requirements for shelter, light, moisture, good/bad companions, mineral requirements, pollination and pest-protection. The layers consist of:

- **Canopy Trees**: This is an overstore of full-sized fruit, nut, or other useful trees, with spaces between to let plenty of light reach the lower layers.

- **Small trees and large shrubs**: It is a layer of smaller nut and fruit trees. Small trees such as apricot, peach, nectarine, almond, and mulberry can be planted in this layer.

- **Shrubs**: This layer includes flowering, fruiting and wildlife-attracting shrubs. Examples of shrub that can be used in forest gardening are; blueberry, currants, wormwood and hazelnut.

- **Herbaceous perennials**: This is a layer of edible plants that spread horizontally, several of which are herbs and will also contribute to the ground cover layer by self-seeding or spreading. Herbs include vegetables, flowers and cover crops, as well as mulch producers and other soil-building plants.

- **Ground covers**: These are low, ground-hugging plants, preferably varieties that offer food or habitat, plants that snuggle into edges and the spaces between shrubs and herbs. Sample species include strawberries. These plants form living mulch for the forest floor.

- **Climbers and vines**: This layer is for climbing plants that will twine up trunks and branches, filling the unused regions of the all-important third dimension with food and habitat. Climbers can include climbing annuals such as squash, cucumbers, and melons.

- **Rhizosphere/ Roots**: This layer consist of plants grown for their roots and tubers as well as subterranean fungi (groundnuts) that yields through their fruiting bodies and move nutrients between plants through mycorrhizal associations.

*Photo 1 - 2: Depicting forest gardening, Masansa demo plot, Masansa, Mkushi (February, 2018)*
2.0 ORGANIC FERTILIZER

2.1 Compost Making

Compost manure is rotten plant and animal waste. Composting produces an organic fertilizer high in plant nutrients which improves soil physical characteristics, reduces organic waste on the farm and eliminates pathogens. The following are steps in making compost.

• Gather Composting material: Gather all the composting material needed. Compost material includes dry leaves, fresh leaves, dry twigs and tree branches and crop residues. Avoid meat and dairy products.

• Choose Compost Shape and size: There are many shapes that can be used to make the compost pile. There are square, rectangle or circle. Each type of shape has its own advantages and disadvantages but all types of shapes can be used for composting. When making a compost "pile", size determines how the system will be managed. Pile size and shape also influence composting rates and temperatures.

• Select a Location for Your Compost: Choose a site that is level and well drained, that is easily accessible year round. Place the pile over bare soil rather than concrete or paving

Photo 3 - 4: Youths collecting materials for compost, Kafunda demo plot, Serenje (November 2018)

Photo 5: Compost shape
to ensure that worms and other beneficial organisms can make their way into the pile. It's a good idea to remove any grass or plants and turn the soil to a depth of about 6 - 9 inches.

- **Pile materials:** Make layers of compost materials in a ratio 6:3:1 of dry materials, fresh materials and soil. When piling, start with the dry twigs and branches cut into small pieces for easy decomposition. Build the compost pile by beginning with a bottom layer of bigger sized materials such as maize stalks of about 15cm long. Add another layer of dry vegetation, hedge cuttings or grass of about 15cm. Sprinkle top soil and add water to moisten the whole layer.

- **Enclosing the Compost:** Enclosing the compost pile saves space and prevents litter. The enclosure should provide an entry large enough to permit the pile to be turned.

- **Maintaining the compost:** Turning and mixing the pile provides the oxygen necessary for decomposition and compensate for excess moisture. When the compost texture is uniform, and turning the pile no longer results in a temperature rise, the compost should be complete.
• **Finished compost**: Finished compost is dark brown, crumbly and has an earthly odor. Depending upon seasonal temperatures, well tendered pile, generally yields finished compost in 2 weeks to 4 months. Unattended pile may take longer than a year to decompose.

### 2.2 Liquid Manure

Nowadays, the use of poisonous chemicals to control pests and diseases on crops is very common. These chemicals don’t only kill pests, they harm us as well. To protect us and the environment from this harm, we can use locally available herbs for pest control instead. Liquid Manure is made from local herbs and it can work as a pest control as well as provide nutrients to the plants. Liquid manure has the following benefits;

- uses local resources
- saves cost
- protects beneficial insects
- uses local knowledge
- protects the environment
- helps us to be self-reliant
- improves the soil
- Saves our health by reducing use of harmful chemicals.

Materials needed to make liquid manure include various plant leaves (leaves without oil), fresh cow dung, Jute sack/onion sack, drum (200ltr), mortar and pestle and measuring container/bucket/pot. The procedure of making liquid manure is as follows;

- Collect as many plant leaves as you need.
- Cut the leaves into small pieces or grind the leaves with mortar and pestle.
- Put the leaves in the measuring container and fill it up until it’s full.

*Picture 11-12: 11 - different plant leaves, 12 - youths cutting leaves in small pieces*
• Put the leaves on the sack and lay them.

• Take fresh cow dung and break up with hands
• With the same measuring container, measure 1 full container of fresh cow dung.
Youth measuring fresh cow dung using the same measuring container

- Put the cow dung on the sack where the leaves are.
- Mix grinded leaves and fresh cow dung together

Picture 17-18: Youth measuring fresh cow dung using the same measuring container

Picture 19-20: 19 - Youth putting cow dung on a sack where leaves are. 20 - Youth mixing leaves with cow dung
Picture 21-22: 21 - leaves and cow dung being mixed 22 - well mixed leaves and cow dung

- Put in an empty sack with a 1Kg stone or brick o help it sink
- Tie it in a ball

Picture 23-24: Youth tying the mixture into a ball

- Fill the drum with 20 buckets (measuring container) of water
Picture 25: a 200 lt Drum filled with 20 buckets of water

- Put the ball in the drum filled with water.

Picture 26-27: Youth putting the ball a drum filled with water

- Stir clockwise and anti-clockwise for 21 days.
- After 21 days, filter with sieve and the manure is ready for use. Use the manure within four weeks.
How to use liquid manure

Liquid manure can be applied to plants by using one tea cup per plant per week.

- **Liquid manure on young plants:** Newly made liquid manure is very strong so it needs diluting with more water.

- **Liquid manure on older plants:** When they are bigger and more mature, plants can stand stronger liquid manure. Insects are often stronger as well. Liquid manure helps to repel these insects. Plants can take in nutrients from liquid manures through their leaves. On the soil, liquid manure also acts as irrigation.

- **Spraying liquid manure:** Mix in a suitable container or watering can 1 part water with 1 part liquid manure and spray the liquid manure. Spray whenever pests are present, or before they are expected to arrive. The objective is to repel, not to kill. The pests may come again, so liquid manure needs to be re-applied from time to time. Pests are repelled because of the various smells and tastes. And the plants get some food as well as water.
3.0 PERMACULTURE BEDS

3.1 Raised beds

A Raised Garden Bed is an elevated garden bed that sits higher than the surrounding soil or the ground that it sits on. The optimum size of a raised bed is 4 feet wide or less. They can be made to any length though it is more efficient to keep them reasonably short to save having to walk long distances around them constantly. The steps used can be followed to make raised ridges. Raised ridges need to be slightly higher than raised beds.

• **Site Selection**: Select a suitable location to construct a no-dig garden bed. Ideally it should be on a fairly level surface, and it should receive 5 hours or more of sunlight each day.

• **Bed Orientation**: Orientate the beds east to west to optimize sun exposure. However slope and working with beds on contour may indeed change all of that as each site is unique especially as it pertains to topography, aspect, and access to water.

• **Land Preparation**: Dig the pathways down and use this displaced earth in the raised bed itself. From there, you only need to dig down the pathways about six inches. Raised garden beds are open on the bottom which enables plant roots to access soil nutrients below ground level. When first setting up a raised bed, double-dig the soil which underlies the raised bed (9 inches) to get an appropriate height for the bed, loosen the earth where the bed will be and never step on the bed.

• **Addition of Amendments**: Once the ground plot has been dug and cleared of rocks, add manure to top up the beds and improve the soil fertility. Once the bed is filled with manure and raked level, it is ready to plant in or sow seed.

• **Maintenance**: Raised beds require very little maintenance. Each planting season, it’s a good idea to top dress with fresh compost and manure, or, if your bed only holds plants for part of the year, go ahead and dig the compost or manure into the top several inches of soil. Mulching the top of the soil will help retain moisture and keep weeds down. Moisture retention is important, because raised beds tend to drain faster than conventional beds.
3.2 Inverted Bed or Sunken Bed

Sunken beds act as if they were a valley instead of a mountain (raised bed). When working with sunken beds, the valley space accumulates organic material and does not allow it to wash away as it does with raised beds. This accumulation of organic matter reduces water consumption and boosts soil fertility, which cascades into more disease and pest resilient plants. It also brings the height of the bed quickly back up to almost a level ground surface after just a short period of intensive mulching. When irrigating the water doesn’t shed quickly from the sunken bed making this precious resource even more efficient. This is very important in drylands areas and beyond as water becomes an increasingly scarce resource. To create sunken beds, simply invert the process for raised beds. Their layout according to aspect, contour, and proximity to water resources is part of the design process. Size wise, they do often follow similar dimensions as a raised bed in terms of width four feet. The following steps can be used to make sunken beds.

* Mark out where you want to site your sunken bed. The size of your bed will be 4 feet wide and 10 feet long.

**Photo 31: Youths levelling raised bed**

- Remove the top soil 4 inches worth. Store it aside where it will not be trampled on to resume later.
- From there, dig down 4 feet down. With the subsoil at the bottom of the sunken beds bring that up to the pathway areas and begin to raise them.

**Picture 32-33: 32 - Youths marking out where to put the sunken bed. 33 - Youths digging out top soil**
• Continue digging the sunken bed to loosen the soil and remove all the roots from the soil. Once this is done, put back the top soil. This will mean there is some microbial life intact and some organic matter already accumulated.

• Add as much manure or compost as possible to fill the bed to 1 foot and water thoroughly. The bed is ready to be planted and always remember to mulch.
3.3 Key- Hole Bed

Key-hole bed is circular raised bed gardens. Planting in a circle is much more efficient than planting in straight rows, allowing you to fit a greater number of plants into the space and thus, increase your yield. Keyhole beds can either be stand-alone structures or combined into a series, with keyhole access points branching from a central path. Key-hole bed can be created by following these steps:

- Mark out a circle where you want to site your keyhole bed. The size of your bed will depend on a number of factors. The available space for cultivation, your mobility and reach, the materials you have available, and the number of species of plant you wish to grow will all play a part in deciding how large to make your bed. Prepare the space by cropping existing vegetation as close as possible, but leave the top soil alone.

*Photo 38: Youths making a center compost provider.*
Draw a 1½ foot diameter circle around the stake to mark the central core. Leave the stake and rope in place as a guide for your walls. Then draw in the edges of the cut-out wedge, connecting the inner and outer circles.

• Mark out the keyhole access path. This is where you will stand to reach the bed and also where you will site the central composting pile. If using the 6-foot diameter circle, mark a center circle of around a foot across, and then mark a path – either straight or in a wedge shape depending on your mobility needs, to the edge of the main circle.

• Create the center compost provider. This is a place where brown and green composting material is placed, providing the keyhole bed with a constant supply of nutrients and moisture.

• Fill in the keyhole bed series with layers of compostable material. At the top add soil to cover the compostable material and some compost. The heat generated by this layering of material will serve to break it down and turn it into rich soil.

• Plant your keyhole bed. The species you choose will depend upon your personal taste and the climate conditions on your site.

• Harvest your crops when they ripen, and return any residue of crops that result from their use to the center compost pile. This will ensure a sustainable keyhole garden bed that is energy efficient and productive.
3.4 Diamond Bed

Diamond bed is one form of raised bed with a diamond shape. Diamond beds require digging a pit and filling it all up with compostable material and are mainly constructed at the boundaries of the garden. Diamond bed can be constructed by these steps;

* Draw a diamond shape on the ground each side being 1m long. The sides of the bed can be shorter or longer than 1m depending on your requirement and mobility needs.

* Dig out the soil forming a pit depth of 1m. The top soil (9inches) which is usually black should be placed on one side of the pit and the subsoil on the other.

* Fill up the pit with compostable materials such as dry twigs, tree branches and leaves. Always start with the twigs cut into smaller pieces.

* Cover the pit with the soil that was dug out. Start by covering it with the top soil then the subsoil. The top soil contains all the nutrients plants require and the entire microorganism that help in decomposition of materials. Always remember to retain the diamond shape of the bed.

* Plant the diamond bed. Fruit trees like oranges and lemons can be planted on diamond beds. Cucurbits like watermelons, cucumbers and pumpkins also grow well on diamond beds.

Photo 41: Youths drawing and making a diamond bed.

Picture 42-43: Youths digging out the top soil.
Photo 44: Diamond bed filled with twigs.

Photo 45: Diamond bed.
4.0 MICRO WATER HARVESTING TECHNIQUE - CONSERVATION TILLAGE

4.1 Micro Basins

Micro basins are a common technique used in agriculture to collect surface run-off, increase water infiltration and prevent soil erosion. Their principle is simple: small pools are surrounded by soil ridges on all sides to collect the rainwater and surface run-off. This allows storing rainwater and using it for small-scale tree and bush planting, enabling increased growth of plants if there is a moisture deficit. Each basin consists of a catchment area and an infiltration pit, which serves as the cultivated area. The construction of micro basins is done by following six steps:

• First step is clearing the catchment area of weeds. Shaping can then be carried out with hand tools or plows. The catchment area is smoothed with hand rakes.

• Detecting and marking the contour line on the land, for example by understanding the slope of the land. The slope is divided into plots by small earth ridges 4-8 inches high and 8-14 inches wide. The ridges can be constructed by hand or with small plough.

• The infiltration pits are then marked and dug out in each catchment.

*Photo 46-47: 46 - Youths making contour lines on the catchment area. 47 - Contour lines in a basin.*
• The basins need to be cleared of all vegetation. However, grass growing on the low soil ridges can protect the walls from erosion.

4.2 Planting Pit

Planting pits are used as a precipitation harvesting method to prevent water runoff and thereby increase infiltration and reduce erosion. Basically, holes are dug 3m apart from each other with a depth of 50cm in order to prevent water runoff. Planting pits are most suitable on soil with low permeability, such as silt and clay. Planting pits are the simplest form of in situ rainwater harvesting for optimizing crop production. The soil removed from the piled in a half moon shape along the lowest edge of the pit. Planting on the top of the ridges can be beneficial and increase crop production.
5.0 SEEDLING TRANSPLANTING

Seedlings are the easiest and most common way of starting a Vegetable garden. Seedlings are basically the germinated stage of a seed, taking out one of the harder steps in getting into gardening. The following are the steps to follow when transplanting seedlings.

1. Seedlings should be hardened-off, well-fed and watered before transplanting.
2. Prepare a weed-free surface. Loosen and aerate garden soil by tilling or hoeing.
3. Dig a hole large enough for seedling.
4. Carefully remove seedling from its container or nursery bed. Try not to disturb the roots.
5. Set seedling in whole level with soil surface. The exception is tomato seedlings, which can be transplanted a bit deeper.
6. Feed seedling to kick start growth. Transplant each seedling with a hefty handful of compost.
7. Surround seedling with displaced soil.
8. Water seedling thoroughly.
9. Mulch seedling to maintain soil moisture and regulate temperature.
10. Keep area weed-free

*Photo 51: Transplanting carrots.*
6.0 SEED SAVING

Seed saving is the practice of saving seeds or other reproductive material from vegetables, grain, herbs, and flowers for use from year to year. This is the traditional way farms and gardens were maintained centuries ago. Seed saving has been known to preserve genetic diversity, which is why the practice is often used to preserve plants that are on the verge of extinction. Following are the four basic steps in saving seed.

• **Choose seeds to be saved:** When saving vegetable seeds, it is important to choose open-pollinated varieties. Open-pollinated varieties set seeds whose plants resemble the parent plants.

• **Plants can be roughly divided into three types of pollinators:** self-pollinated, wind pollinated and insect pollinated.
  - Plants that self-pollinate, like tomatoes, peppers, beans, lettuce and peas are the easiest to save seed from because they rarely cross-pollinate. Self-pollinating seeds that are biennial crops, such as carrots are harder to save since they need two seasons to set their seeds.
  - Crops that are wind or insect-pollinated, including cucumbers, melons, corn, pumpkins, gourds, and squash, will readily cross-pollinate. If you want to save viable seeds from these plants, you can only grow one variety during any given season.

• **Collect the Seeds:** Take seeds from the healthiest-looking plants. You can also select for a particular desirable trait. For example, if you want to develop a more heat tolerant mustard variety, collect seeds from plants that were last to bolt. Allow the seed to reach full maturity before collecting. Mature seeds usually have a hard seed coat or a darkened color. When the seed is fully ripe, pick and dry the seed as soon as possible. Seeds contained in a pod or husk should be left to dry on the plant. Each pod can generally be harvested individually as it dries, but if heavy rains or freezing weather threaten, harvest as many as possible. The entire plant can even be removed from the field and hung inside to complete the maturation process.

• **Clean Seeds:** Saving seeds requires careful planning. Seed cleaning methods can be divided into wet processing and dry processing.
  - Wet processed seeds are embedded in the damp flesh of fruits such as tomatoes, cucumbers, and melons. To clean wet processed seeds, begin by cutting open fruits and scraping seeds out. The seeds, pulp and juice from the fruits may need to go through a fermentation process. During the fermentation process, microorganisms such as bacteria and yeast destroy many of the seed-borne diseases that can affect the next generation of plants. Next, wash the seeds by placing them in a large bowl or bucket. Add water, and stir the mixture vigorously. Viable seeds tend to be denser and will sink to the bottom, while poor quality seeds are more likely to float. Add more water and repeat the process until only clean seeds remain. Pour the seeds into a strainer and washed under running water. Finally, dry the cleaned seeds by spreading as thinly as possible on a flat, dry surface such as a glass or ceramic dish,
cookie sheet, window screen, or a piece of plywood. Stir the seeds several times during the day.

- To clean dry processed seeds, begin by separating seeds from husk, flower head, or pod. Seeds that are in pods, may need to be smashed. Once the seeds have been released from the pods or husks, you can separate them from the pods by using hand. Once the larger pods are removed, lighter chaff can be separated by winnowing.

**Storing Seeds**: Proper seed storage ensures a high percentage of germination at planting time. Keep in mind that damage begins to occur whenever the temperature of seeds rises above 35°C. Placing seeds on window screens is best of all as they allow for excellent air circulation.

**CONCLUSION**

Permaculture works with nature instead of against it, creating ecosystems that can be sustained. Ideally, these systems are thoughtfully laid out not only to sustain themselves but their caregivers. A permaculture design and integrated farm is so much more than an organic farm. It shows us that the system just doesn’t stop at the produce itself, but started long before and ends long after all crops have been harvested.