Permagardens:
Empowerment through Resilience

A Step-by-Step Guide

For the Creation of
Climate-Smart, Nutrition-Focused, Home Gardens

Using the Terra Firma Method

If we prepare for the climate we can stop worrying about the weather.

Climate Smart Allows Daily Nutrition

Adapt x Mitigate x Intensify = Go x Grow x Glow

Purpose

This manual focuses on the particular soil, climatic and social conditions of Africa and Asia but can be used worldwide. The tropical regions are extremely diverse, ranging from hot, humid low lands to hot, dry and cool, moist hilly conditions in the highlands. The Terra Firma Method will guide you through the key foundational aspects of Permagardening: water control, soil fertility and plant health, which are the same around the globe. Specific changes will stem from the availability of certain local materials, drastic differences in soil structure and the timing of operations based on the extreme heat or cold of the local area.

It is intended as a reference guide for those who have participated in a hands-on training. However, by following the steps within this guide, you can create your own 'living classroom', your own "terra firma", in a small space near your own home.

Peter Jensen
Agroecology/Permagarden Specialist

Note: All opinions expressed within this document are my own and do not necessarily reflect the policies nor opinions of the United States Government, USAID or the Peace Corps. The science that is found within this manual, however, is fact and thereby not under dispute.

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Authors note: What is this all about?

The Permagarden is an evidence-based, small-scale, high-yield agroecologically-sound, food production system developed to meet the needs of all families. While initially targeting the highly vulnerable and marginalized rural and peri-urban families they will benefit everyon impacted by the challenges of climate change and chronic disease. Permagardens use only those materials, tools, seeds and plants which are already accessible. Perhaps most importantly, the methods and actions found within this guide follow the Rule of CLOSE, whereby every action or material Close, Local, Organic, Small and Easy. If it fails to meet these distinctions, even just one, our targeted families and individuals will most likely say they can not continue on their own and this method, like other good ideas before it, will quickly loose favorability and will not be sustainable.

These climate-smart, nutrition-focused Permagardens, created within even the harshest environment, provide substantial increases in family nutrition and consumption; environmental resilience and adaptability to climatic change; and finally, maternal income from the sale of excess produce. With these goals met, a Permagarden can help even the most marginalized family reach their overall vision of empowerment and resilience to face whatever challenges they may face in the future. With a positive attitude stemming from these small doable actions, families can begin to look forward to real and lasting nutrition security and environmental resilience even in the face of drastic climatic changes.

If our desire is to end hunger we must feed the soil. By doing so, the plants will feed themselves, the earth, and its many citizens, large and small…including us. You are the one who can make change happen. Start small, slow the water, feed the soil, eat well….teach others.

The Permagarden Vision

Combining the most readily applicable aspects of Permaculture and Bio-Intensive Gardening, a "Permagarden" is a small-scale, high-yield, garden that anyone can create close to home. It uses only locally available materials, tools, seeds and plants, grown on land formerly thought of as 'useless', to provide the family with a diverse supply of fresh, nutrient-dense vegetables, fruits and legumes on a daily basis. Think of it as a Permanent Garden, designed and managed in such a way that, like a house, once built, will continue to provide both protection from the elements and production for the family table for many years to come.

The garden is close to the home and therefore easy to manage even for children and the elderly. The permanent pathways in between the permanent growing beds are easy to walk around allowing easy access to the growing vegetables, fruits and grains. The protective berms, while forcing runoff water to sink, will also hold local medicinal, herbal and edible perennials plants, providing long term ecological benefit.

These actions, when combined in one space, define climate smart gardening. As we cannot change the climate, we must focus our actions on adapting to it, mitigating it where possible, and then intensifying our food production so as to decrease the need for extensive land. These concepts of adaptation, mitigation and intensification are at the very heart of your Climate-Smart Permagarden.

Deeply-dug, carbon-enriched garden beds hold excess rainwater deep within the subsoil.

Intensive triangular spacing creates a healthy microclimate below the closed leaf canopy.

Created slowly, step by step, this garden will continue to provide protection to the productive garden beds in the middle. The soft soil of the garden bed absorbs and holds water from the monsoon and releases that water back up into the root zone throughout the coming dry season for the growing plants. While a permagarden will take more time to create than the typical shallow-tilled, row planted garden, the deeply-dug and closely-planted beds will require much less water yet yield much more food (by as much as 600% more) year to year to year. The resulting sense of control and accomplishment will lead to an overall sense of personal empowerment. And therein lies the vision: empowered families improving the quality of their own lives through nutrition security, environmental control and income.

Think of it this way: Protection x Production x Management = Empowerment. While the first two parts are critical in the first season, without ongoing management it will not succeed into the next. These resilient gardens can be the buffer families need against the ever changing social, economic and climatic conditions of the tropical world they live in.

Defining a Permagarden: Keeping it CLOSE

This home-based garden system combines many of the basic principles of Permaculture and Bio-Intensive Organic Gardening. As this guide will point out, there are various steps to undertake in the creation of this highly productive garden. We have chosen to refer to this as a garden with its implication of smaller size and proximity within the home landscape where more direct control and management can be exercised on a daily basis.

"Permaculture" (a combination of the words permanent and agriculture), as used in this model, gives us permanent protective borders around the garden.

- permanent, soil-based structures such as the rainwater directing berms and holes to maximize minimal rain while minimizing the impact of maximum rains;
- permanent pathways between garden beds to capture and direct water;
- permanent perennials within and along the created berms to deflect animals and wind while enhancing the landscape and providing home for beneficial insects.

"Bio-intensive Gardening" refers to the efficient system of double digging, carbon-rich soil amendments, triangular planting, intercropping and seasonally appropriate crop rotation and pest management of the annual crops in beds within these protective berms.

While this can all sound rather theoretical, we must remember that our purpose here is to be as practical as possible. As we begin to look to the actions needed to create this garden and teach our neighbors, we use just one word to describe ALL of its actions: CLOSE.

C. ***Close*****:** The closer to the home the better for easy management. This is a garden that is right outside the back door which requires attention for a few minutes in the morning and again in the evening. If it is far away results will suffer.

L. ***Local*****:** Everything we use must be from the locally accessible (not just "available") from the local area. If a tool of amendment has to be imported it will be a huge barrier to adoption by others who don't have that item. This applies to tools, plants, seeds, materials.

O. ***Organic*****:** This word has many meanings. First, it means that it is alive and flexible like an organic organism. As such it fits the local landscape in terms of slope, sun and soil. Second, it means that we use nothing synthetic in its creation or management. These materials are not only expensive and imported, then are quite dangerous around the home.

S. ***Small*****:** It is far better to manage a small space very well than a large space half well. As the initial creation phase is labor intensive, one of the biggest mistakes we can make is to make the garden too big. If we start big, that will discourage those with small spaces.

E. ***Easy*****:** Every action is easy to see, do, learn and teach. We use only small, doable actions with locally accessible tools. There will be times when the work is hard, double digging for example, but this is relatively minor in the overall process. We must do all that we can to show just how easy it is to create a new microclimate.

In essence, the Rule of CLOSE is a measure of positive attitude change, the "yes I can" attitude, that can lead to eventual behavior change. While change is hard, it is by definition impossible… if we don't first achieve attitude change.

Terra Firma: The Process that Puts it all Together

The "tropics" is a region of great beauty, potential and opportunity. But it is also a region of the harsh reality of pounding rain and searing drought. This situation is only made worse by unpredictable shifts in weather due to climatic changes caused somewhere else. The people of the tropics did not cause their climate to change; but they are responsible to take responsible actions to adapt to that change. In many ways, the people of the tropics have become the victims of that change and who are currently attempting to practice agriculture the way the industrialized, temperate world has taught them. Regrettably, these methods are woefully *inappropriate methods in response* to climate change. It is our job as gardeners and change agents, be we private citizens or aid workers, to foster a new paradigm of working within the bounds of nature, rather than against them; to adapt and mitigate our landscapes and soils to fit the new reality. And that is where the notion of 'Terra Firma', or Solid Earth, originates.

A major challenge across the developing world, especially in the tropics, has been to create a sustainable linkage between seasonal, agricultural, crop production and the daily, nutritional food needs of the family. On one hand we have smallholder farmers, working hard to produce predominantly cereal crops for the market. And on the other hand, we have the mother, children and the elderly needing food on the table, three or more times every day. Crops are "available" but families lack "access". This 'access gap' between the two can be enormous and socially divisive. The response to this problem, the thing any of us can create to fill this gap, is, quite simply, a home garden. But that garden must be permanently-protective, high-yield, small-scale, easily-managed, and nutrition-focused. By blending locally appropriate agricultural methods of adaptation and intensification with the traditional needs, values and tools found in every home, the permagarden creates this permanently accessible link (Terra Firma) between national-level, seasonal, crop availability and family-required, daily food and nutrition.

What we have been discussing thus far is leading us to a "paradigm shift": Essentially, a move away from "Climate-Dismissive Agriculture" towards "Climate-Smart Agriculture. A move away from seasonal monocropping, towards year-round, agroecological, multicropping.

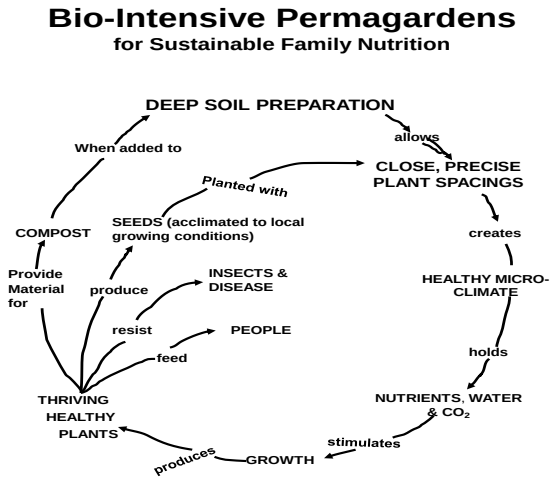
A move away from a "feed the market" approach towards a "feed the family" approach. A move away from "Bigger is Better" towards "Small is Bountiful".

This is, essentially, a movement where all families who so choose to adopt these methods, being able to feed themselves well from a small space, managed well. By coming this far, you are now part of this movement away from systems at odds with nature to a 'whole family ecosystem approach' that works with the natural world, blending environmental, economic and social realities, values and assets with modern science. With this solid framework in mind throughout, we can begin to measure our results. Are we able to move towards communities with well-fed families in control of their own resilient and beautiful home landscapes? Can the Permagarden be the tool that gets us to this vision? How will we know if we achieve this vision? Just as we as change agents are called upon to do, we must help families learn to monitor and evaluate their food security choices so they can make their own informed decisions and chart their own way forward.

Terra Firma literally means Solid Earth. While it is described here as relating to permagardens, take ntcan be applied directly to the garden but other efforts as well. The 'Terra Firma Method' refers to the step-by-step creation of resilient ecosystems and families through home-based, properly monitored and evaluated projects, including gardens.

And that is Terra Firma: the intercultural blending of modern, climate-smart science with traditional values, tools and methods that allows people of all backgrounds and economic standing to create their own environmentally resilient and sustainable future. Their own 'Solid Earth'. By following the principles and techniques laid out in this manual, you will be engaged in the process every step of the way. You are encouraged to teach small groups in such a way that all who start can follow; and all who follow can teach. If our vision is empowered families then our measurable goals must be resilient nutrition and income security. But it is the small measurable tasks that lay ahead which are the stepping stones to sustainable change: **Terra Firma or Solid Earth.**

This diagram shows how the system works. It all starts with increasing soil health and depth through double digging and use of local amendments such as manure, charcoal and wood ash. This deeper, healthier soil allows for closer, more precise plant and seed spacing as the roots of annual vegetables will not have their growth interrupted by compaction, dryness or poor fertility. With closer spacing comes a closed leaf canopy which traps moisture and carbon dioxide while eliminating competitive weeds. With greater moisture and carbon dioxide comes greater levels of photosynthesis and carbonic acid creation (in the soil) which releases more plant nutrients all of which combines to stimulate abundant growth which produces food for the gardener and her family. The thriving plants also produce large amounts of biomass which is later used to generate more compost, further driving the circle from season to season.



CIRCLE OF SUSTAINABILITY

Creating a Permagarden for Home Nutrition

Finding a Good Space

A successful Permagarden Training will involve more hands-on work than theoretical discussion. As such, a suitable garden area will need to be selected. Ideally, as this is a home-based garden, a location should be found immediately adjacent to a small home. This could be any small building that can stand in as a house if indeed a house with land is not available. The area used need not currently be a garden nor need it be high quality soil. In fact, it is better to use the poorest soil around – so long as it is not solid rock. Imagine the feeling of satisfaction at trainings end when participants look back on how they have started a deeply dug garden where no garden had been able to be grown before! Be it a small corner of an existing rice paddy, next to a hillside home, or the back lot of a peri-urban home, the best spot is the one with the most remarkably poor soil you can find. I call this "the badder the better" as it shows just how transformational a permagarden can be to the home landscape.

You will need enough space within which to hold the group; but not so large a space as to appear beyond the scope of a family garden. These are gardens for families of 5, not 25. Remind participants often of that fact! Keep your group size limited so that it will not appear that you must have a large group in order to create a permgarden.

Look for a small piece of land (4m x 4m is a good starting point) near a small classroom or large shade tree so that you can move easily between indoor and outdoor 'classrooms'. Time 'wasted' by walking long distances between the classroom and the garden area can be very discouraging. If, however, you must walk to the garden area, use this to your advantage. Observe and discuss local soil and water conditions, other gardens, trees and fencing, waste materials that could be gathered as soil amendments, green and brown leaves that could be gathered for compost, etc. This can be valuable visual learning time if you manage it in such a way.

Once you have found a good area to create a new garden, dig a small hole to determine the quality and depth (to hardpan) of the soil. If dry, take a handful and add some water to check the clay content. Clay may be difficult to dig but it has the potential to hold nutrients very well. Don't be discouraged by "poor" soil; in fact, recall "the badder the better" perspective. Starting with a stressed site with poor soil will open more eyes in the end, especially following the double digging and amendment portion.

Rwamagana, Rwanda. October, 2016.

An excellent chose for a garden: Sloping, 'bad' soil close to the kitchen!

Note the area beyond the kitchen This really is the 'perfect place' to make the garden. The slope will direct large amounts of rain water to the garden where it will be absorbed by the bers and beds to come. There is ample space for many to follow the see it, do it, and teach it learning method.

Compare this 'before' picture to the 'after' picture on the cover of this guide. It was taken just a few days later and shows all the structural aspects of a Permagarden. Take a closer look at the cover photo. Can you identify the following:

- Water stopping top berm planted with local perennials.
- Permanent hard pathways that will force rain into the bottom of the beds.
- Meter wide garden beds, loosened and amended to 50 cm.
- Water directing side berms planted with sweet potatoes.
- Water holding bottom berm with a seedling nursery growing plants for the next season to come once the beds are harvested.
- Not seen: the cubic meter compost pile in the shade near the house.

Step 1: Community Resource Assessment Walk and Talk

Building local skills and confidence is a critical first step in creating sustainable gardens. It begins in partnership with local families by looking around the community and household to determine what can be of use. Waste materials such as charcoal, wood ash, manure, green and brown organic material, all contribute to the goal of soil health but to simply tell people this fact is not enough. If what is already known within the community can be drawn out via open conversation, local empowerment and ownership will result. Within the household itself there are spaces that could be better utilized, waste areas that could be converted into a bounty of produce with just a little extra work to clear the land, control the water and manage new plants. Our first step is to walk the community landscape and household with family members with the goal of identifying and placing values on waste while mapping suitable garden areas within the family compound. The two principal benefits of this activity are to build awareness of the value of materials normally discarded and to establish trust within the community by focusing on local knowledge, materials, tools, plants and people. The Terra Firma method is 'organic' as it originates from within, not imposed from outside.

Key Messages:

- Nearly every household will have some space to grow plants in a 'complementary' garden that could provide significant nutrient dense food and income for the family.
- Many local resources exist around the home or local landscape that can help sustain productive soil and gardens.
- Long-term planning starts with simple mapping of the homestead and can help avoid further loss of resources.
- Outdoor learning-by-doing is far more effective than lecturing in a classroom. Engaging family members in a powerful new classroom, close to home.

Community members learn more and gain more confidence from self-discovery than from classroom lecture.

What to look for as you draw your community and household asset map:

- Available space: can be less than a few square meters or as large as 25. Look for areas next to buildings or fences that are currently not well used but still offer sunlight at least 4 hours a day.

- Waste materials: wood ash, charcoal, manure are known to have nutrient and organic matter that is useful. Kitchen waste, green and brown leaves and water can be

collected and used in small compost piles. Bones, egg shells, oyster shell are a good source of calcium and phosphates. Ask what is already being used.

- Water sources: this can be future runoff from roofs, hillsides, roads and pathways that can be controlled and redirected, homestead wells or municipal taps nearby.

- Dangers to be controlled: livestock, birds, children are all sources of useful materials or labor but also need to be controlled by fencing or other means.

- People within the household: who is going to be the principal manager of this new space? Ownership of the means and profits must be understood from the beginning, as especially important consideration if the garden is in public space.

- Plants and Seeds: Many of the most important vegetables to promote are the ones which people already eat, just not enough of. Ask neighbors, friends, the family itself what seeds or plants they have or are willing to share. Perennial herbs such as lemongrass, aloe, rosemary, rue, are all possible to be divided and replanted.

- Tools: contrary to popular belief, the only tools you need to create a vibrant garden are hoes and buckets. Survey the household and neighborhood for additional tools that could be useful such as rakes, watering cans, grain sacks and shovels.

By asking open-ended questions, those that require explanation rather than simply yes or no, people begin to see landscape challenges and assets with new eyes. This process allows participants to look critically at what they want, what they have and what they need to do to get there. This *appreciative inquiry* process builds awareness of what is around us and how we can bring all of it together in a permagarden where we will realize that we can change our circumstances through planning and careful work. This is how we begin to "take control" and build personal empowerment which is so essential to successful development.

Based on these assessments and conversations, gather useful materials, tools and plants, and bring them to the garden area. Remove any debris, rocks or weeds. Now we can begin to determine how best to create a fully protective and productive permagarden in terms of soil and water management, as well as areas for making compost and biochar where appropriate.

Guiding Questions:

- How can rainwater be captured from the roof or nearby hillsides?
- Where does the rainwater move once it hits the soil?
- How can it be stopped and allowed to sink and spread within a new garden?
- How can the slope be altered? Why would this be a good idea?
- How much sunlight is needed? DeIs there adequate sun in this area?
- How can wind be a factor in limiting plant health? What can we do to mitigate this?
- Where can materials for compost (green and brown leaves, water, manure) come from and where can the piles be located?
- What is the current soil quality in terms of structure and texture?
- What techniques do you already use to improve the structure of the soil?
- What materials could be used that are available here to improve the soil?

Step 2: Prepare the Planting Area

The resource walk has revealed possible garden spaces and resources. A suitable garden space has been found to include the following in terms of sun, soil, slope and security:

- Sunlight: at least 4 hours a day in the tropics
- A slight slope is ideal, but not required
- Water is easily accessible
- It can be protected from extreme winds, livestock, people
- Soil is present (ie, the area is not solid rock) for improvement

A good starting point is 4m x 4m. The key message is to start small. More space can be added later depending on family acceptance and desire. A large starting space can become too labor intensive too quickly and become very discouraging. Starting small will ensure the best possibility for further expansion within the community.

This is a relatively simple first step. It allows us to properly plan for protection and production aspects of the garden to come.

- Clear the area of rocks, weeds and other debris.
- Lightly cultivate the entire area to remove weed and grass roots that are just below the surface. These removed weeds can be used later in the composting process once the roots have completely dried out, an especially important point with the perennial grasses. Lightly cultivating the entire area to a depth of just 5 centimeters. Not only will we remove potential hazardous waste materials, stones and weeds but this will also allow the easy smoothing of the entire surface so as to "draw" a garden plan that will lead to a fully protective and productive garden with the swales and beds to come.

Mark out the entire area then remove any debris or rocks. Grasses and weeds should be removed below the root mass and discarded for later use. Lightly cultivate the area to just 5 cm.

Tae Mauk Village, Myanmar.

March, 2014.

Step 3: Garden Layout for Water Management

The objective of this step is to create a garden map that includes swales berms and holes for protection as well as meter-wide garden beds for production. Refer to the appendix for a sample garden plan. The focal point of this step is to determine where runoff water enters the garden and where it will naturally want to go as it passes through the garden. Tremendous amounts of rainfall will fall on this garden space. We want to control it during the heavy rain so that we can access it via soil capillary action during the ensuing dry periods.

Proper water management follows five main pathways: stop, slow, sink, spread and save. By forcing the excess water to stop and slowly sink, moisture will be held as it spreads deeply within the improved soil structure of the double dug garden beds. As dry weather returns, capillary action within the improved soil will draw this moisture back up from the saved excess into the root zone of dry season vegetables.

This plan will be the initial diagram of what we want the overall garden to look like: an upper water controlling berm (which includes a swale or ditch with holes at either end); the defining side berms; 2 or 3 meter-wide beds with narrow permanent paths in between; and, space for fencing to block both wind and animals and to serve as climbing support for certain climbing perennials. The hard (never dug) pathways between the beds will work to help to direct water into the well aerated and amended garden beds.

Creating the Garden Plan

Visualize water flow by ask these simple questions: Where will the water come from? Where will it first enter the cleared garden area? Where do we want the water to go?

The answer to that last question is critical. We want gardeners to answer "Exactly where we WANT it to go!" The key message being that the gardener is in control and can make decisions that make the most sense for her garden and surrounding landscape. Consider all water runoff sources, roofs, paths and roads that can be taken advantage of during heavy rain events. Our overall goal is to increase the amount of water entering the garden so that we can absorb and store as much as possible for the coming dry season or dry periods within the rain season to ensure continual growth.

Determine Primary and Secondary Slopes

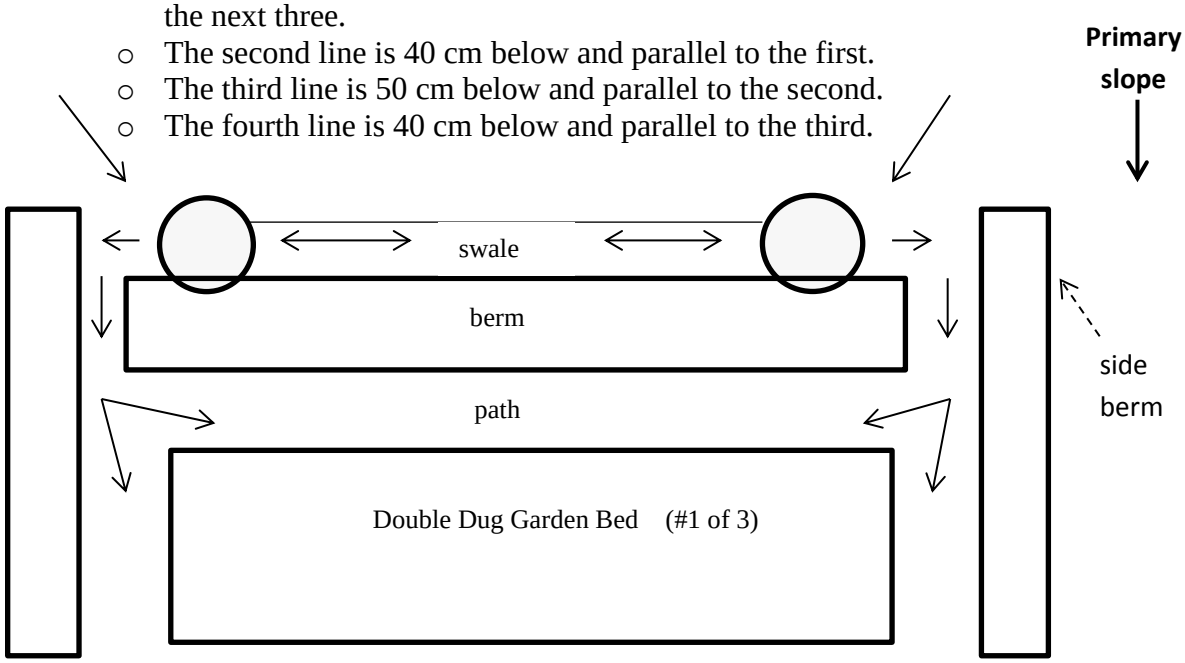
- Stepping back from the cleared garden area, look for the most obvious slope from top to bottom. This is the Primary Slope.
- Standing at the bottom of the garden area, looking up the primary slope, determine the right-to-left 'tilt' of the garden area. This is the Secondary Slope.
- We want to encourage water to slowly move along the secondary slopes so that the water has time to sink into the soil.

Draw the Garden Plan

(See the Appendix for a complete Plan)

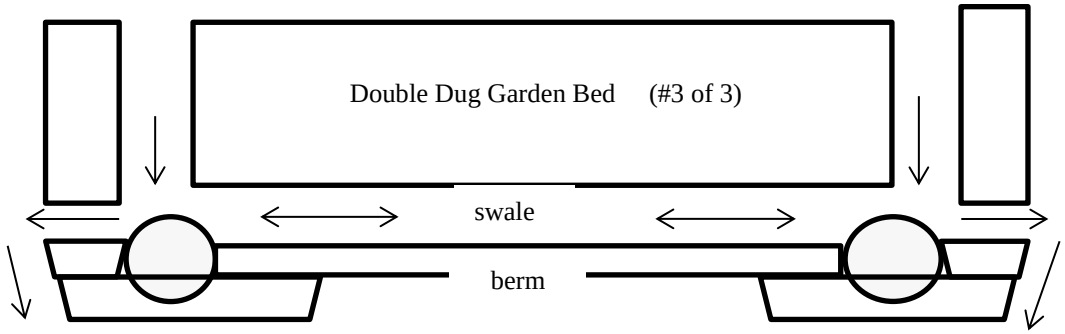
- The stopping berm will be placed at the top of the garden so that it will block the main flow of water coming down the primary slope and then gently guide the water slowly along the secondary slope.

- Using a stick, draw 4 long lines only the top slope of the garden.
    - The first line is <u>perpendicular to the primary slope</u> and forms the baseline for the next three.
    - The second line is 40 cm below and parallel to the first.
    - The third line is 50 cm below and parallel to the second.
    - The fourth line is 40 cm below and parallel to the third.



(note: arrows indicate surface water movement)

- At either end, just above the second line, draw 2, 50cm circles. These will be the receiving holes (saturation basins) that capture and slow the bulk of the water coming into the garden.
- Envision these holes filling with water during a rain event. Where do we want the water to go? Right. Exactly where we tell it to go. As the water slowly spills out of the hole, we want to direct it along the side of the garden so that it does not flow into the garden beds in the middle.
- Draw an outline of the swale that will carry this water down the primary slope eventually into another hole that will be part of the lower stopping berm. Draw a parallel line 50 cm towards the outside of the garden. This is the side berm.
- Below the first bed, repeat the steps above creating the outline of as many one meter wide beds as the space allows.
- Complete a drawing of the lower "holding" swale, complete with 50 cm wide berm and holes at either end. *Note the holes within the berm, to keep the swale/path intact.*



Step back to survey your garden drawing. Does it "Minimize the Maximum <u>and</u> Maximize the Minimum"? Make minor corrections as the group decides. This will serve as your guide as you begin to create the swales and paths and dig the berms and beds.

Step 4: Creating Protective Swales and Berms

"Six S": Stop, Slow, Sink, Spread, Save, Shade

It is now time to create the protective berms, swales and holes based on the map. Before you start, walk through the drawing so that all can describe the six water management pathways: stop, slow, sink, spread, save and shade and how each structure will assist.

Create the Top Berm, Swale and Saturation Holes

- Pull 5 cm of loosened soil from the top line down to the 2nd line.
- Pull 5 cm of loosened soil from the bottom line up to the 3rd line.
- This should make a low mound of soil with a path on either side: the upper path is the swale, the middle mound is the berm and the lower path is the path around what will become the first meter wide garden bed.
- Remove the soil from the circle representing the hole to a depth of 10 cm only. Place removed soil below the hole and along the berm. Once the berm soil has been amended, this hole will be deepened to 40-50 cm.
- Using your hands or the hoe handle, shape the soil so that the top of the berm is flat.

- As you complete this process you will have four complete swales, berms and holes.

Side Swales and Berms:

- Following the pattern drawn previously, loosen the soil within the side berms.
- Drag the soil from the marked drainage path (swale) onto the berm.
- As above, smooth the surface of the berm like a tabletop.
- At the bottom of each side swale, create two more holes as above.

Lower Swale and Berm:

- Remove soil from each of the lower holes, placing soil below the hole for added strength as well as along the lower berm, copying the upper berm and swale.
- Loosen the soil of the lower berm and smooth it as was done for the upper berm.
- The final exit hole, at the lower end of the secondary slope, will need a small drainage ditch leading out of the garden so as to prevent garden flooding.

Amending the Berm Soil

The primary function of the berm is to control runoff water. However, by amending the soil within the berm, much in the same way as for the garden beds in the step to follow, the secondary function becomes possible: the planting of medicinal, nutritious or culturally important, protective perennials. This process is the same for all the permagarden berms: top, bottom and side.

- Straddling the smoothed berm, using the local tool, loosen the soil down to the compacted subsoil, along the entire length of the berm.
- Go back to the beginning and remove a 50 cm wide portion of this soil and place it on a grain sack for later use.

- Standing on the path or to the side, facing the exposed subsoil, loosen this subsoil as deep as possible (a further 30 cm is sufficient) leaving the soil in place once loosened.
- Amend the subsoil with 2 handfuls each of charcoal and/or small sticks and manure. Mix well.
- Again straddling the berm, moving along the secondary slope, pull the next 50 cm of loosened berm topsoil over what you just amended, exposing the next portion of compact subsoil.
- Loosen and amend this new area of subsoil with the carbon and manure, continuing the process down the entire length of the berm. Note that this is a simplified double digging exercise.
- When you finish amending the subsoil, including the berm that surrounds the hole, use the initially removed topsoil to cover this final section of amended subsoil.
- Rake the entire surface smooth and flat. The berm should be 10-15 cm higher than the paths on either side.
- Amend each meter length of the berm with ½ bucket manure, ¼ bucket charcoal, and several handfuls of wood ash. Mix all amendments into the top 10 cm of the berm.
- Make sure the berm is flat so as to prevent surface erosion during watering.
- Gently water the berm with one 20-liter watering can or bucket. Allow to fully soak.
- The berm is now ready to plant with useful perennials and annuals.

Planting the Berms

During the community resource walk, locally perennials were discovered. These perennials can be divided and replanted. It is important to use only locally accessible and appropriate perennials but a few examples are aloe, lemongrass, rue, birdseye chillies, rosemary, papaya, and even sweet potato for its nutrient-rich leaves.

With gathered perennials at your side, you are now ready to plant your perennials in guilds around the holes and in the berms. A guild is perhaps best described as a team; where each plant plays complementary roles. For example, a medium height Rosemary can be planted next to a bunch grass such as lemongrass which are in turn protected by creeping ground covers below and a tall papaya above. This companion planting concept will lead to further discussion of crop rotation and intercropping during the planting of the production beds.

Preparing the top berm for double digging
(Burkina Faso, May 2016)

Amending the topsoil of all the protective berms
(Nepal, April 2016)

Step 5: Create Bio-Intensive Garden Beds

- Double Dig Garden Beds
- Amend with Local Materials

Bio-intensive refers to both the manner of deep digging as well as the manner of offset triangular spacing to be outlined in the following step. Just as in the berm soil above, breaking through the lower compaction found in most cultivated soils will improve the overall structure (air and water holding capacity) of the soil which allows annual crops to flourish.

It is good to do a quick review of the key reasons for the double dig.

- To allow annual crop roots to go deep quickly so as to reach air, water and nutrients.
- To allow closer plant spacing so that the leaf canopy closes, capturing CO^2, holding moisture and eliminating weed growth. (triangle spacing)
- To create a healthy microclimate below the leaf canopy helping the plant grow to its fullest possible potential while being resistant to pests, diseases and drought.

A properly constructed garden bed will allow plants to gather and absorb all the water and nutrients they need to grow. A 4-meter long garden bed can be completely "double dug" and amended by two people, moving slowly and steadily, in about two hours. The goal is to create a deep soil profile with good air and water dynamics. Once the double digging process has reached 50 cm, in subsequent years one need only amend the surface with compost, blend, smooth and plant. The double digging work is finished so long as you do not allow people or animals to walk within the beds and continue to practice crop rotation and regular compost adding.

To complete the fully texturized double dug bed, follow these simple steps:

- Straddling the defined bed and moving in one direction, chop into the surface down about 5 cm. This is merely a cleaning/organizing process that allows us to remove stones and perennial grass roots and to make sure the shape is correct and even.

- Straddling the bed once again, but moving in the opposite direction, loosen the topsoil down to the compacted lower soil. Pull out the first 40cm wide "trench" of this topsoil, placing it temporarily on a sack at the end of the bed. Moving forward, straddling the bed, continue to loosen to the hardpan and pull the loosened topsoil back into the space you just opened. If the soil is very dry, add a few cups of water over the compacted subsoil letting it soak in before moving forward.

- When you reach the end you will be left with an open trench down to the compacted layer along the width of the bed. This has been what we call the "single dig".
- Rake the soil smooth, leaving that final trench open.
- Gather your soil amendments (manure, char, sticks, other local carbon materials).
- Standing to the side of the open trench, loosen the hard subsoil. Go as deep as you can. This is the double dig.
- To the loosened subsoil, blend in 3 large handfuls each of manure and carbon waste.
- Pull the next 40cm of loosened topsoil (from the single dig) over the newly amended subsoil, exposing the next trench of compacted subsoil.
- Loosen, amend and repeat to the end of the bed.
- Into the last trench, return the soil that was first removed during the single dig. Rake the entire bed smooth so as to redefine the new bed for all to see.
- Now amend the topsoil. Per square meter, add 1/2 bucket of dry manure t, 1/4 bucket of charcoal dust, 1/8 bucket of wood ash, and (if available) a handful of egg shell.
- With your hands, blend all ingredients uniformly over the bed before incorporating all with the top 20cm of topsoil.
- Rake the bed flat and add 10 liters of water/m^2 gently over the entire bed. This helps to settle the soil for planting. As you apply the water, check for possible erosion points and fix any sections where the water runs off into the pathways.
- After an hour has passed, thoroughly crush, blend and smooth the surface to receive seed, seedlings or other plants.

- **This bed is now amended to a depth of 40-50cm and will be slightly elevated.**

  Proper management will mean never having to deeply dig this bed again!

Any soil can be improved by double digging and proper amending. This photo shows the first three steps:

1. Loosen topsoil
2. Pull back to expose hard subsoil
3. Aerate subsoil another 20 cmbefore amending with carbon rich materials

Make note that the root zone has just expanded by over 400% . This will greatly increase root health and overall plant yield and resilience.

Step 6: Bio-Intensive Plant and Seed Spacing

- Crop Rotation Planning
- Benefits of Triangular Spacing

The deep digging allows us to place our plants using close, precise triangular spacing. By planting in triangles we maximize plant density, plant health, and overall yield per square meter. The soon to close leaf canopy will maximize sun to leaf and shade to soil increasing photosynthesis and decreasing moisture loss from evaporation. As a result, 30% more plants can fit within a given space and each plant has the potential to be 2-3 times as productive. Overall yield increases while resource needs decrease. It's a pretty good idea. But it can only be done if the beds have been properly dug and amended as described in Step 5.

Triangular spacing with tomatoes: two weeks and 6 weeks after planting. Note the use of mulch and drip bottles placed around the seedlings during the first month in the garden bed.

The Benefits of Bio-Intensive Spacing: (see seeding chart in Appendix).

- Increases Plant Density (deeper roots allow close space, able to grow more/unit area)
- Increases Plant/Root Health (moisture and CO2 capture)
- Decreases Weed Pressure (canopy shading of bare soil)
- Decreases Hand Water Requirement (canopy shading of bare soil)

Crop Rotation Planning and Planting

To review, the crop rotation pattern we use, balances soil and plant fertility between crop families while also breaking pest and disease life cycles. Crop rotation is one of the most important plant health and pest control practices in home gardens and crop fields alike. Each bed, or portions of beds, can hold successive plantings following the Leaf – Fruit – Root – Legume rotation plan. For example, over the course of 18 months depending on the rain/dry season, a bed will be planted with Kale, then Tomato, then Carrot, and finally Fava Bean.

Marking and Planting the Bed

Following the seed and plant spacing chart (pg 42), and using a meter stick along one end of the bed, mark seed holes along the end of the bed 15, 20, or 35 cm apart depending on the crop being planted. Place small sticks in each hole. Move the meter stick that same distance

down the bed but shifted half that distance to the left or right. We are making equilateral triangles and marking holes with sticks down the length of the bed, as this shows:

Companion Planting

Planting varying species has several advantages to the gardener. It increases the diversity of plants grown per unit area and will be healthy for all concerned so long as plants with compatible growing seasons and root habit (one long, the other short) are chosen. This method of joint planting also confuses pests who far prefer to attack monocultures

There are several good combinations of plants that grow well side by side and work well to help each other flourish. This is not an exhaustive list. Use local seeds and ideas as much as possible

- Tomatoes with Carrots
- Tomatoes with Basil
- Maize with Cowpea
- Maize with Beans and Pumpkins

From a crop rotation perspective, the heavier feeder is considered the lead plant. For example, maize as a heavy feeder is the key rotating crop as compared to beans a heavy giver. When planting companions, expand the recommended plant spacing by a few centimeters to continue to avoid root competition

Relay Intercropping

Planting varying species in the same area but at slightly different times is a good way to maximize productive space. This is combining fast growers with slower growers such as tomatoes, which take a few weeks to expand into their entire growing area and radish, a fast grower which can be harvested just as the canopy begins to close. Beans can be planted for just 6 weeks for the express purpose of invigorating the soil for an incoming heavy nitrogen feeder such as kale, spinach, cabbage or maize. The beans are essentially starting the relay race and have the principal job of nourishing the soil (through atmospheric Nitrogen-fixation which completes its task in under 8 weeks) rather than provide any edible beans or leaves for the gardener. It is essentially sacrificed to provide both nitrogen and organic matter from the decaying leaf and root material that is sliced out of the garden and incorporated into a compost pile nearby. This may seem like a harsh activity. But it helps the next crop immensely rather than simply leaving the soil empty and lifeless for 8 weeks. It is exactly this type of activity which is inspired by the protective and productive permagarden.

Step 7: Garden Management

- Mulch
- Drip Bottles
- Pest Control
- Crop Rotation

Once planted, the garden will require ongoing care and management to minimize the negative impacts of weeds, insects and diseases; to repair minor damage from wind or rain when it happens; and to harvest vegetables at peak growth so as to maximize yield per square meter.

Mulch

This is one of the more important steps in vegetable production. Whether planting seeds or seedlings, continuously adequate soil moisture is essential to foster rapid seed germination and a reduction in transplant shot. Any dry material can be used that has no viable seed heads: straw, bark chips, grass without seeds and dry brown leaves.

Drip Bottles

Watering seeds and seedlings is critical. For freshly planted, mulched beds, once a day is sufficient. As seedlings grow into mature plants they will have greater water and nutrient needs even as the leaf canopy closes blocking sunlight from hitting the soil. A simple technique using locally available water bottles allows the garden manager to apply water exactly where it is needed, to the roots. Most vegetables can be harmed by overhead watering which wets the leaves unnecessarily. Vegetables want wet roots but dry leaves making them difficult to grow during the rainy season. The 'drip bottle' is the answer.

- Poke three small holes into the bottom of a 1 liter used water bottle.
- Fill with water or the diluted compost tea. Place the cap on firmly.
- Liquid will only come out of the bottom as the cap is opened.
- Bury the bottle so that the cap is still above ground and the bottom is at the lower roots, 5 cm from the main stem. Open the cap slightly, allowing liquid to slowly drip.
- Keep bottles in the ground, refill each morning as necessary.
- Place up to 8 bottles per square meter of garden bed.

Pest Control

Prevention is the first order of business. All of the work that went into the creation of controlled water and deep healthy soil will produce vigorous plants that are resilient to pest and disease attack. But there could still be a need for work beyond these cultural techniques. As described earlier, there are four levels of pest control, each with varying tasks:

- Cultural: Swales, Double Digging, Amendments, Plant Spacing of Healthy Seedlings
- Physical: Pruning away the dead, diseased and damaged limbs, traps, hand picking, and netting
- Biological: Companion Planting, perennial borders housing beneficial insects, botanical mixtures.
- Chemical: biological and synthetic insecticides, fungicides and herbicides often beyond what we need

Compost tea and botanical mixes prevent damage from insects and disease fungus.

Physical protection with thorny branches keeps chickens away. If insects arrive, a simple piece of mosquito netting serves as a physical barrier that still allows in light and moisture.

Crop Rotation

One of the best ways to maintain a healthy garden from year to year is to develop a crop rotation plan that follows the **Leaf – Fruit – Root – Legume** pattern. This works to balance nutrient needs between crops while breaking disease and insect life cycles never letting them become established. This is indeed how "a gram of prevention is worth a kilo of cure."

Appendices:

A deeply dug and amended garden bed such as this allows closer plant spacing as the roots can grow deep to capture moisture and nutrients. The plant leaves form a canopy over the bed which traps moisture and carbon dioxide while reducing weed growth. This leads to a great increase in yield per square meter and allows the home gardener to harvest a large amount of food from a very small space.

Appendix 1: The Essential Nutrition Actions

Peace Corps aligns its approach to nutrition with a framework known as the Essential Nutrition Actions (ENA). The ENA framework combines best practices with contemporary evidence to highlight interventions demonstrated to have the greatest potential for optimal nutrition outcomes. The framework embraces the 1,000 days—a critical window from pregnancy through a child's second birthday—and uses a life cycle approach focused on prevention.

ESSENTIAL NUTRITION ACTIONS

(1) Nutrition for adolescents and women during pregnancy and lactation
(2) Exclusive Breastfeeding during the first six months of life
(3) Complementary feeding starting at six months, with continued breastfeeding to two years of age and beyond
(4) Nutritional care of sick or malnourished children
(5) Prevention of vitamin A deficiency in women and children
(6) Prevention and control of anemia in women and children
(7) Consumption of iodized salt by all household members

Nutrition for adolescents and women during pregnancy and lactation:
Adolescent girls and pregnant/lactating women have increased nutritional needs. When planning a permagarden to target these groups be sure to select micronutrient-rich (colorful) foods that might include amaranth, various types of beans, peanuts, orange-fleshed sweet potato, pumpkin, moringa, okra, papaya, spinach, tomato etc.

Complementary feeding starting at six months (with continued breastfeeding):
At six months of age breast milk no longer fulfills a child's energy and nutrient requirements. Breastfeeding should continue while supplemented with age-appropriate, energy-rich, nutrient-dense foods to support optimal development. When targeting households with small children, select crops for the permagarden that make ideal complementary foods including orange/yellow vegetables and fruits such as carrots, orange-fleshed sweet potato, pumpkin, mango, papaya; dark green leafy vegetables like kale or chard, as well as important fat and protein sources such as avocado, beans, eggs, peanuts, peas or lentils.

Prevention of vitamin A deficiency in women and children:
Women and children—particularly 6 months to 2 years old—are especially vulnerable to vitamin A deficiency. During permagarden planning, be sure to select vitamin-A rich foods. Consider supporting animal husbandry in conjunction with the garden, as animal-source foods including fish, eggs, chicken, liver, meat and milk are prime sources of vitamin A. You might also choose to grow vitamin-A rich fruits and vegetables including papaya, mango, orange-fleshed sweet potato, pumpkin, other orange/yellow fruits and vegetables (with the exception of citrus fruits which can be included, but are not sources of Vitamin A), dark green leafy vegetables etc.

Prevention and control of anemia in women and children:
Women and children are also vulnerable to developing anemia, often the result of advanced iron deficiency. Selection and promotion of iron-rich foods can mitigate the risk of anemia. Support animal husbandry practices as animal-source foods such as fish, eggs, chicken, liver and meat provide the most bioavailable form of iron. Iron-rich plant foods however, despite containing a less bioavailable form of iron, can be combined with vitamin C-rich foods to increase absorption. In garden planning, select iron-rich plant foods like legumes (peas, beans, lentils etc.) and dark green leafy vegetables.

Adapted from "Essential Nutrition Actions and Essential Hygiene Actions: A Reference Handbook for Peace Corps Volunteers and Community Members" USAID, SPRING, 2014.

Appendix 2: Home and Garden Compost

Simple Steps to Building a Healthy Soil Amendment

Why Make Compost:

- It helps the soil hold more water – both from rain and from hand watering so that plants get as much water as they need to grow throughout the growing season.
- It holds beneficial nutrients in small stable amounts that build up over time.
- It helps soil release its own natural fertility because of many natural acids.
- It holds huge numbers of beneficial microbes which help keep diseases away.

Making Compost: There are two types of compost: one for leaves and grass and other garden materials; and another for managing and using vegetable and fruit waste from the kitchen.

Materials needed for making compost:

- Brown leaves, straw, plant stems. These contain a lot of Carbon.
- Green grass, market vegetable waste or leaves. These contain a lot of Nitrogen.
- Old, finished compost or good garden top soil which has a lot of bacteria.
- Water. Bacteria need moist conditions to live and do their work for us.
- Air. Proper mixing allows the process to continue steadily.

Follow these simple steps

Garden Waste Compost:

1. Select a large space in the shade. Bacteria need water so too much sun will dry out the compost pile and slow down the decomposition process.
2. Gather brown materials. 4 large sacks. Crush them into small pieces. Large brown leaves should be chopped into small pieces so they will break down quicker.
3. Gather green materials. You will need 1 part green for every 3 parts brown.
4. Dig a shallow 1mx1m hole just 10 cm deep to hold excess water.
5. Add a 10cm layer of brown materials.
6. Add a 3cm layer of green and 4-5 large handfuls of healthy garden soil, manure or old compost from previous piles.
7. Blend these layers together by hand adding 5 liters of water as you mix.
8. Repeat steps 5 through 7 until the pile is 1m x 1m x 1m. Cover with a sheet of plastic to help hold the moisture in the pile. (After 2 days the pile will become very hot – this means the bacteria are working to break down the materials.)
9. WAIT TWO WEEKS. But after one week, add more water over the top to keep moist. Gather more brown materials for the next pile.
10. Mix/flip the entire pile to a space just next to itself. Add 20 liters of water.
11. Make a new pile where the old one was.
12. WAIT TWO WEEKS. Repeat steps 9-11.
13. Turn/flip both piles to the spaces nearby. Mix well and add water as needed.
14. WAIT TWO WEEKS. When the pile is brown, crumbly and cool to the touch the compost is ready to be used in the garden.

Appendix 3: Permatainers: The Two-Tier Tire-Tower

Container gardens offer opportunities for those who do not have the space for a full garden to still grow food near their homes. Large buckets, wicker baskets, old oil jugs and tires are all good examples of useful containers. For any container garden to be successful it must have a deep soil profile and loose fertile soil heavily amended with charcoal and compost. The tire tower described below displays all elements of the permagarden: assessment, protection, production and management. Remember to recirculate the water after it collects in the pan.

1. Gather compost, mineral soil, charcoal and wood ash.
2. Find two tires of equal dimensions.
3. Elevate the tires with bricks and boards to allow a drip pan to fit below.

Remove three side walls then stack tires on a platform with a sack with hole in bottom.

Fill lower tire with charcoal/soil mix and the upper tire with soil/compost mix.

Amend top with ash, char, coffee grounds and place drip pan below for easy recycling.

Appendix 4 : Bio-Intensive Plant and Seed Spacing

Double-dug beds should be one meter wide only with the seeds spaced in triangles to maximize space. Proper bed width and planting technique will give the gardener easy access from either side yet be wide enough to allow for the development of a healthy microclimate under the growing leaves.

Seed Spacing (in centimeters) for Direct Seeded Crops:

Crop	Spacing in Garden Bed (cm)
Maize	35 (plant 2 but remove 1 at 2 weeks)
Wheat	5
Beans (dry/green) and cowpea	15
Chickpea (garbanzo bean)	15
Radish	5
Carrot	Broadcast lightly, thin to 5 cm
Onion (use root portion from previous)	6
Millet	15
Amaranth	Broadcast lightly, thin to 4 cm
Groundnut	14
Pumpkin	100 (allow to spread within bed)
Zuchini	30 (can plant hill with 2 per hill)
Garlic (cloves)	8
Irish Potato (sprouted tubers)	18
Sweet Potato (stem cuttings)	18

Seed Spacing (in centimeters, in trays) for Transplanted Seedlings:

Crop	Spacing in Seed Tray/Bed	Spacing in Garden Bed
Tomato	5	35 (stake up with poles)
Brocolli	5	30
Cabbage	5	30
Kale	5	20
Eggplant	5	35
Pepper (hot or not)	5	25
Cucumber	5	25 (train to grow up trellis)
Leaf Lettuce	BC then thin to 6	15
Spinach	BC then thin to 6	12
Swiss Chard	5	15
Onion	5	8

Seed starting in small portions of garden beds or in separate flats reduces water need and ensures better growth upon transplanting into the production bed.

Appendix 5: Permagarden Teaching Check List

Reasons for Promoting Permagardens:

Food Security at the Family Level	(Availability)
Income Generation Opportunity	(Access)
Nutrition Supplementation to Family Diet	(Utilization)
Family Resilience and Empowerment	(Control Accomplishment Hope)
Climate Change Response	(max/min rainfall management)
PLHIV Care and Prevention	(Behavior Change Communication)
Environmental Mgt Education	(expansion to the farm field)

Why do we call it a Permagarden?

Permaculture (Permanent Agriculture)	=	Permanent Protection
Bio-Intensive Annual Garden	=	Year Round Production
Protection x Production x Management	=	Empowerment and Resilience

Key Training Messages:

- Small and Close to the Home (can expand once skills develop)
- Everything is Local (Plants, Seeds, Tools, Amendments)
- No or little start- up cost (reusing what is being wasted)
- Simple Behavior Change serves as analogy for other prevention education
- Family Food, Nutrition and Income "Security" OPPORTUNITY (no guarantee)
- Climate Change Response and Adaptation leads to Resilience and Empowerment
- Small Changes = Big Differences
- Start Small, Grow Big, Stay Home, Eat Well
- All activities/materials must be Close, Local, Organic, Small and Easy

Local Waste Products for Soil Improvement

Wood Ash	(Minerals and pH balancing – Ca, Mg, P, K)
Charcoal dust	(carbon sequestration, air/water holding, microbe housing)
Livestock Manure	(Minerals – N, P, K; water holding, better tilth)
Green/brown leaves	(compost materials, green manure, nitrogen, tilth)
Egg Shell, crushed	(calcium)
Coffee Grounds	(Organic, slow release Nitrogen)

Local Perennial plants/shrubs useful in the Permagarden:

Papaya	(food, shade, medicine, income, gift)
Aloe Vera	(medicine, income, immune system support, gift)
Lemongrass	(palliative tea, income, gift)
Rosemary	(herbal remedy, bush)
Banana	(food, income)
Passion	(grow on fencing, food, income)

Local Multipurpose Trees/Shrubs and there uses/benefits

Neem	(GManure, Medicine, Insecticide, Soap, Firewood, Shade
Leucaena	(GM, Fodder, Fencing, Medicine, Firewood)
Moringa	(GM, Food, Medicine, Water Purification, Fencing)
Glyricidia	(GM, Fencing, Shade, Firewood)
Lantana	(Nutrient accumulator, hedges, insecticide)

Compost Making

Browns (carbon), Greens (nitrogen), Water, Soil/Manure (bacteria), Air and Time
Make in the shade to prevent excessive moisture loss; cover with plastic
One cubic meter, mix 2x/month, finished when brown/crumbly and cool

Water Management Pathways and Structures

STOP	Swale
SLOW	Berm
SINK	Hole
SPREAD	

SAVE (deep below the Bio-Intensive Garden Beds)
SHADE (under the leafe canopy of the Bio-Intensive Garden Beds)

Measuring Roof Runoff: (mm Annual Rainfall) x (square meter of roof) = Liters of water

Why plant Bio-Intensive triangles (double digging and amending first to increase soil health and structure)

Increase Plant Density (deeper roots allow close space, able to grow more/unit area)
Increase Plant/Root Health (moisture and CO2 capture)
Decrease in Weed Pressure (canopy shading of bare soil)
Decrease in HandWater Requirement (canopy shading of bare soil)

Basic Nutrition Food Groups:

Go Foods	(Carbohydrates – grains, tubers, fruits/vegetables)
Grow Foods	(Proteins – legumes, peanuts, animal products)
Glow Foods	(Vitamins/Minerals – DGLV, colored fruit and veg, meats)

Crop Rotation Cycle - Reasons and Plant Families

Break Plant Disease Cycles
Break Pest Insect Life Cycles
Balance Soil Fertility additions and losses

Leaf	(Higher Nitrogen need)	maize, millet, sorghum, DGLV
Fruit	(Less N, More P for fruit)	tomato, pepper, eggplant
Root	(little N, More K, some P)	carrot, potato, beet,
Legume	(returns N to soil)	beans, cowpea, peanut

Common Sense Pest Control: Cultural, Physical, Biological, Chemical

Behavior Change Formula: SDA w/IMVR = AC ==BC (Small Doable Actions with Immediate Measurable Visible Results = Attitude Change ===Behavior Change

Appendix 6: Summary of Nutrients: Go x Grow x Glow

Nutrient	Description	Foods
Proteins "Grow"	"Bricks" of our house Protein builds all parts of the body from Amino Acids There are 8 Essential Amino Acids that must come from our diet, plus another for infants	Plants—Dark leafy greens, whole grains, legumes, nuts, seeds Animal Foods
Minerals "Glow"	"mortar" of our house, they connect parts of our body 2 common minerals: Calcium—Strong teeth & bones. Iron—carries oxygen in our blood. Other 12 minerals: Chloride, Copper, Phosphorus, Potassium, Iodine, Magnesium, Sodium, Chromium, Cobalt, Fluorine, Manganese, Zinc	Small amounts found in many foods—Eat a variety from all food groups! Plants—Dark leafy greens, legumes, colored vegetables Animal Foods
Vitamins "Glow"	"Watchdog" of our house Fights disease, healthy eyes & skin, communication At least 13 known that our bodies need. Fat Soluble: A, D, E & K. Water Soluble B (8 types) & C.	Plants—Fruits, yellow and orange Vegetables, Whole grains, Legumes, Seeds (All vitamins) Some animal foods (A & B)
Carbohydrate "Go"	"Firewood" of our house Fuel for our body from calories	Plants—Grains, starchy roots, fruits, legumes Milk
Fats "Go"	"candles" of our house Reserve energy, carries fat-soluble vitamins, brain & cell walls, warmth 3 Essential Fatty Acids	Plants—Seeds, nuts, soybean, margarine, whole grains Milk, animal fat, butter, eggs
Water	Removes wastes with fiber Carries nutrients, controls temperature	Water, fruits, vegetables, milk

***Fiber** -- Is technically not a nutrient. But it works like the "Broom" of our house and is therefore essential to good cleanliness. Fiber removes wastes with water. Fiber is only in plant foods—vegetables, fruits, legumes, seeds, roots, & whole grains.*

Appendix 7: Starting Seedlings

To ensure quality growth while limiting water need, most vegetable plants, with the exception of legume and root crops, must be planted out into the garden beds as fully developed young plants so that they have the best chance for survival and productive life. Much less water will be required to develop these plants and you will be assured that when the time comes, you are planting only the healthiest plants into your fully texturized, double-dug, garden beds.

Seed Starting Steps

Prepare soft, light soil (compost mixed with topsoil and sand is a good mix) in a small section of a garden bed or directly into small boxes as in the photos below. Moisten the surface, allowing water to soak down at least 5cm.

Sow your seeds 1-2cm deep and close together at offset (triangular) spacing according to the Seed Spacing Chart. Cover and firm the soil lightly and gently water the entire surface. Water should be reapplied before the soil dries out – this is where the compost is helpful as it helps to retain moisture around the developing seedling.

Cover this small area in the gardeb with a simple thatch structure to keep intense sun and heavy rain off the fragile seedlings. If using the box method, simply move them in and out of the sunlight. As the seedlings emerge (within 1-2 weeks), gradually increase the amount of sunlight they receive so that by the time they are 4 weeks old they will be strong enough for transplanting into individual boxes and then at 7-8 weeks, ready to be planted into the garden bed itself.

When seedlings have stems nearly as thick as a pencil and at least three sets of true leaves, they are ready to be planted deeply and at their proper spacing. Before planting, remove a few of the lower leaves to allow the roots to recover from 'transplant shock' and develop quicker.

Appendix 8: The Progressive Productive Behavior Checklist

Measuring Permagarden Progress towards Perfection

Family Name _____ Village/Town/Kebele _____

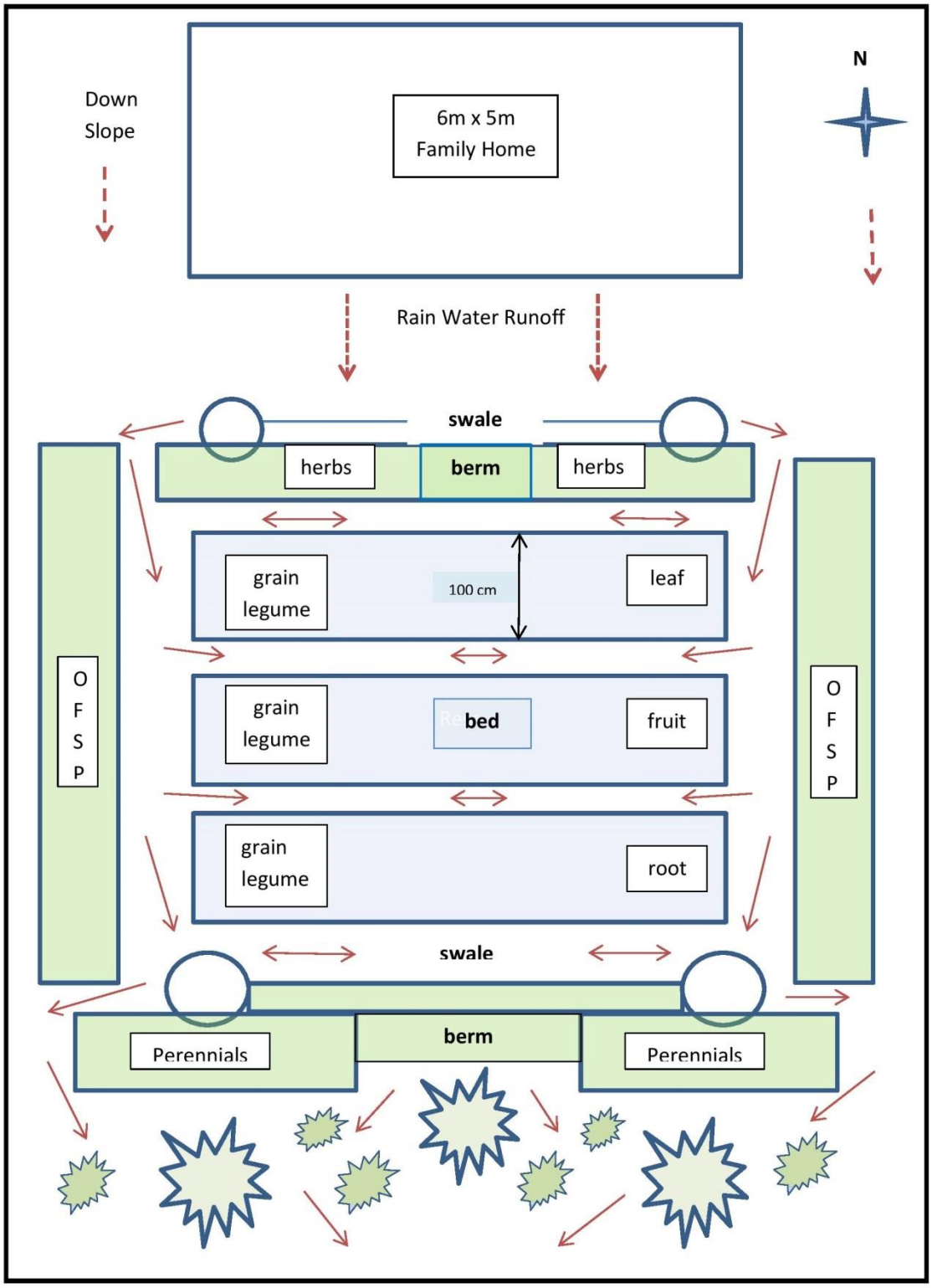
Date (s) of Garden Visit _____ _____ _____ _____ _____

Action/Behavior	Date First Observed	Comments
Gathering charcoal, ash, egg shell, manure, etc (specify)		
Stockpiling Carbon Materials for later use (compost or mulch)		
Created Berms (w perennials?)		
Have made a Garden Plan outlining berms, paths and beds		
Made Single Dug Beds		
Made Double Dug Beds amending with local waste materials		
Use Triangle Spacing		
Use Companion Planting or Relay Intercropping		
Apply Mulch		
Use Crop Rotation Plan for next planting season		
Making Compost		
Using Compost		
Making 'Tea' from saved kitchen vegetable waste		
Have Taught Others		
Other:		
Other:		

Name of Person Reporting _____

Appendix 9: The Garden Map

The Permagarden Layout: Planning for Resilience



Notes