Permagarden Field Manual

Growing Vegetables and Fruits to Impact Household Nutrition and Economic Strengthening

Lorna Ezekiel and son in semi-arid Dodoma, Tanzania and their Bio-Intensive Permagarden two months after planting.

Peter Jensen
Permagarden Specialist
Addis Ababa, Ethiopia

Feeding the World - One Family at a Time

April 2013

Table of Contents

The Permagarden Vision

Dietary diversity is one of the main objectives of the livelihood and economic strengthening sub-component of the ENGINE project. In order to realize the intended objective, focus on support for vegetable and fruit production and provision of productive livestock are the main activities that receive emphasis under the project. Concomitantly, the livelihood activities of ENGINE are geared towards support for homestead production of vegetables and fruits and provision of productive livestock to the most vulnerable households; while demonstration of agronomic practices and cooking of vegetables at FTCs and schools is intended to reach the wider community to establish productive and efficient backyard gardens.

In order to provide quality technical support for the project implementers and targeted small holder farmers, ENGINE embarked upon an innovative TOT program for its own technical staff and government counterparts in in the area of **Permaculture and Bio-Intensive Home Gardens**. The goal of the program will be to provide to smallholder farmers, and ENGINE targeted most vulnerable households in particular, with an attainable, practical and sustainable method to increase their own household food production and consumption so as to impact household nutrition. Results from across Africa have proven the method's effectiveness to significantly increase household food production and income from smallholdings with a high probability of replication by other organizations and individuals. The method is sustainable as it involves only local materials; fits within accepted gender roles; and strengthens the local environment in an economically viable manner.

Through the adoption of permaculture and bio-intensive home gardens high quality food can now grow, *potentially* year-round, near homes where little to none had grown before. This simple, visual technique is suitable for low literacy populations; requires little to no capital outlay to begin; and has been accomplished solely with local tools, plants and seeds. While the method does require an initial increase in labor for soil preparation, composting and the layout of water retention swales, this applies principally to the first growing season. With proper and timely management, planting and care, weed growth and water loss are reduced by 80%, significantly cutting overall labor requirements while at the same time increasing home food and income potential.

With a Bio-Intensive Permagarden families can begin to feel in control of their own futures. Higher yields of nutrient-dense fruits, vegetables, staple grains and legumes close to home, builds empowered families with reason to be hopeful for tackling malnutrition at household levels. A family–based Permagarden serves as a classroom whereby many lessons can be learned and taught to others, not just in terms of dietary diversity but overall resilience as well.

The long-term vision of permagardening is the creation of empowered and resilient people able to improve the quality of their own lives in a manner of their own choosing. For this vision to be realized we must address the tangible and measurable goals of food and income security. The objective to meet such goals is the Permagarden. They are much more than just "kitchen gardens". Rather, they are a part of a systematic, family-based, livelihood-improvement approach that focus on activities that begin with increasing household food security. With further work, families can graduate to other improvements in farm and non-farm business performance as they gain greater confidence and control. By improving and stabilizing overall economic livelihoods and reducing key vulnerabilities at the household level, families will be able to build economic self respect, reduce aid dependency,

engage in more productive behaviors, and build basic financial and business literacy. All of this is vital for sustaining income generating activities over the long-term. Based solely on locally available resources, these steps become the primary building blocks to more advanced levels of economic development. With this overall strategy in mind, Permagardens provide families with a tangible, visual, adaptable tool to maximize their productive household livelihood assets.

Why call it a "Permagarden": CLOSE = Close.Local.Organic.Sustainable.Easy

This home-based garden system combines many of the basic principles of Permacultural Design and Bio-Intensive Organic Gardening. As this manual 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, soil-based structures: rainwater directing swales and holes (to maximize minimal while minimizing maximum rains); permanent pathways between garden beds to capture and direct water; as well as perennial plantings (known as guilds) within and along the created berms/beds to direct and control the water. In essence, "permaculture" is used around the edges of the garden to control and manage water - and to provide a potential for year round supplemental food production on the berms - while "bio-intensive" refers to the efficient system of deep digging, composting, triangular planting and management of the annual crops in beds within these protective berms. In summary: permaculture protects while bio-intensive produces.

It should be noted that while we use the term permanent garden, this does not mean to imply that the garden is always thriving and producing even during dry periods. Moisture is still essential for continuous plant growth. However, as soil tilth continues to improve (with additions of organic matter) so too does *subsoil moisture retention*. As such you will find that the amount of water required to achieve a good harvest, even during dry periods, will be far less than what is needed in more conventional gardens that dry quickly even after rainfall.

While individual aspects are taken in their turn throughout the manual it should be noted and understood that the permagarden is an evolving, organic system meant to maximize and fit within the potential of any given piece of property; working with, not against, its unique set of challenges and assets such as shade, sun, slope and security. Permagardens are a clear example of the saying: *The whole is greater than the sum of its parts.* All components must work in harmony with the family and the home landscape to build a sustainable future.

Key Steps to Create the Permagarden

(Note: Each step can be done in an hour or less, depending on initial soil quality. It is best to do these actions over several mornings rather than all at once so as to not become overwhelming.)

1. **Garden Location and Resource Assessment.** Take a walk through the home landscape with a family. Together, explore the property and determine the challenges and assets found there. Productive assets are land, water, plants, animals, people and structures. Pose the following questions as you walk: Where does the rainwater move? How can it be

stopped, slowed and allowed to spread effectively? Can the slope be altered? Is terracing required? Is there adequate sun? Where can materials for compost come from and where can the piles be located? What is the quality and depth of the soil? How can it be improved? How are plants currently growing? What is needed to make them thrive? How can animals be better utilized in support of the family? What structural areas can be used or enhanced? The key here is to help people see their landscape with new eyes. To see all the local resources that can be brought to bear at little to no additional cost.

2. **Prepare the Planting Area.** Once a household asset map has been created and a good, small, garden area discovered, clear the soil of weeds and grasses for later composting. Lightly cultivate the entire area -a good starting point is 4mx4m – more space can be added later depending on family acceptance of the idea. Starting small is the best way to ensure full acceptance and adoption. Smooth the surface to allow a garden layout "map" to be drawn.

3. **Create Water Controlling Berms.** Across the "top" of the slope, against the main flow of runoff or roof water, dig a 30 cm deep x 30 cm wide swale (ditch) to stop and redirect the water. Soil should be placed down slope to serve as a perennial planting berm/bed. Dig 50 cm wide and deep holes on either end to catch excess runoff with similar swales aiming slightly downhill with holes at the end of each. Tops of berms should be raked smooth "like a tabletop" to minimize surface erosion. Within the space created by the berms (refer to the cover photo) mark off one meter wide beds with 40 cm pathways in between. You should be able to "see" how the garden will look upon completion.

4. **Plant the Berms.** Before beginning to dig the bio-intensive garden beds that you have marked out, it is important to protect the swales and holes by planting perennial leafy greens and grasses along the top and side berms. Perennial sweet potato vine (Sekuar dinech here in Ethiopia) with its Vitamin A/iron-rich perennial leaves, lemongrass, and aloe vera are good examples of companion plants for the berms. Prior to planting, apply one 20 liter bucket of mature compost or well rotted manure to the 4m long berms. Mix it in and rake it smooth. Pay particular attention to keeping a flat surface.

5. **Double Dig and Plant the Beds.** Start with a "single dig" of the meter wide beds to make the job much easier. Rake it smooth and do the second dig followed by the various soil amendments. See more details later. You are now ready to plant seeds and seedlings.

6. **Plant the "Guilds".** Below and around each water retention hole is an ideal location for a mini permaculture guild. Papaya, aloe, lemongrass, and tenadam work very well together and maximize space and protection and provide food as well.

7. **Make a Plan for or Plant a "Living" Fence.** Fencing is important for security as well as for wind protection. Wind will dry soil very rapidly so it is important to establish this right away. Chickens, goats, etc are also particularly destructive and must be accounted for. Various trees can be truncheoned to create living fence poles which will eventually bear leaves and/or fruit. Tall grasses (vetiver) can be planted between the truncheons.

8. **Visit the Garden Every Day.** Your shadow is the best "thing" to put on your garden to make it grow and flourish. Get those weeds when they are an inch tall; prop the tomato plant back up the moment it falls over; this will ensure a bounty to come.

A completed Permagarden near Gabriel Mbena's home in Morogoro, Tanzania. Note living fence along the lower berm. Beds are laid out on the contour to capture and redirect water coming from the nearby roof and hillside. Runoff water is under control now so there is no erosion and the deeply dug beds readily absorb excess water leaving the soil moist for many days following the rain. This garden took two days to create and will be easy for the family to maintain and enjoy for many years.

For more detail on the above, refer to "Creating the Edible Landscape: Permagarden Lessons for Family Food Security" as well as pages 16-18.

Water Management: Stop – Slow – Sink – Spread - Save

Water is arguably the most limiting factor to successful gardens. And with increasing worries over climate change brought about by global warming, this is becoming more of an issue, especially in places which previously enjoyed "reliable" rainfall patterns. The design of the Permagarden allows for the efficient capture and retention of even the most minimal rainfall while at the same time allowing for the safe and easy removal of the excess. In this way, erosion is minimized and in many instances completely eliminated. Swales, holes and their corresponding berms work to stop and slow the water down which allows it to sink and spread slowly through the soil profile where it is then readily absorbed and saved within the amended soil of the bio-intensive garden bed. This very lesson can be taken from the garden and applied to the broader landscape.

The picture below explains it well. Torrential rain had been falling heavily for 2 hours when this photo was taken. Due to the berms, the water is being moved effectively around the fragile, "single dug", garden beds in the middle. Had the upper most berm *not* been in place to stop the main flow of water down the hillside, the bare soil would not have stood a chance and massive erosion would have been the result. It is advised therefore to create the protective features of the permagarden first and *then* move on to the more involved garden bed work of double digging, amending and intensive planting.

A permagarden complete with berms and swales to capture and redirect water to wherever the gardener wishes it to go. Simple ditches and holes can help mitigate the impact of climate change: by minimizing maximum rains and maximizing minimum rains. Without such structures this garden would have simply washed away before it had a chance to get started.

Njombe, TZ. March 2009.

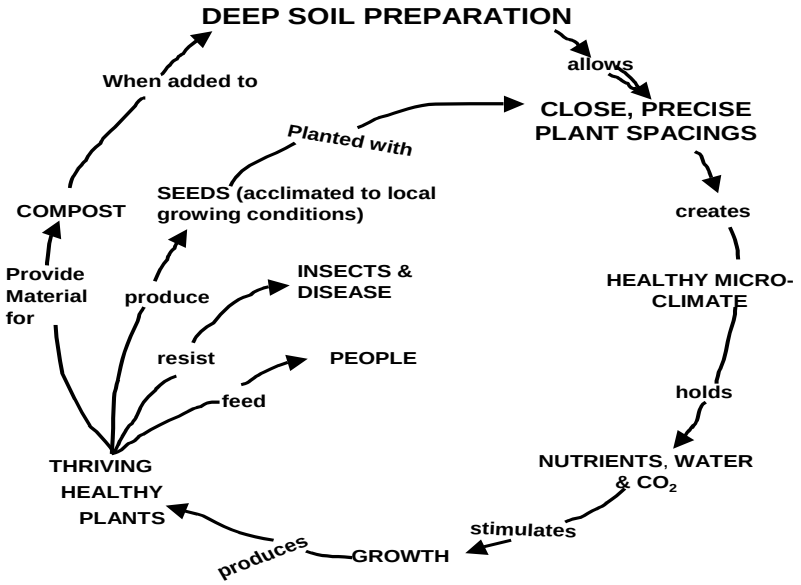
Once the rain stopped, the berm on the left (top of the garden) and the large hole near the old stump remained full of water for 8 hours; the water slowly sinking and working its way through the soil profile. Later, when plants are actively growing in the beds in the middle, the roots will be able to continue to absorb water for many days longer than nearby gardens where no water capture measures had been put in place. With a minimal amount of work (under an hour) and some advanced planning and site assessment the result can be a garden without water stress due to recharged subsoil moisture extending even into the dry season.

The Circle of Sustainability – Why and How "Bio-Intensive" Works.

Bio-intensive gardening fits well within the overall soil fertility management plan for the family garden. The deeply-dug, compost-enriched, garden beds encourage precise plant spacing; a dense leaf canopy which holds valuable nutrients, water and CO2; and creative companion planting to provide a bounty of nutrient-dense, colorful vegetables and staples. In essence, the bio-intensive garden bed is a seasonal "guild", or symbiotic grouping of plants, created to mimic nature. By taking full advantage of the power that nature provides free of charge, families and farmers alike can begin to grow more nutrient-dense crops than they ever thought possible within astonishingly small spaces. This can easily find its way into tiny nooks and niches all around the home in so-called "complementary gardens".

Several years of work and practice has shown that Bio-Intensive garden beds, developed within permanent water controlling berms, can, within a few seasons, provide 3 to 4 times as much food on ½ the land area of conventional home gardens. We are maximizing nature to the benefit of all. Permacultural guilds and water management techniques (swales, berms and holes) work to support the fringes of the property taking advantage of height, space and shade on corners and edges. The bio-intensive garden beds are then developed and managed within the open, sunny spaces. The following section describes in greater detail the "circle of sustainability" (see handout in the appendix) which gives the rationale for the work to come.

BIOINTENSIVE MINI-FARMING
Sustainable Diet Production



CIRCLE OF SUSTAINABILITY

Deep Soil Preparation

The average agricultural field or garden is tilled to the depth of the equipment normally used to work the land. At best this means soils are aerated less than 20 cm, or the length of the average hoe blade. Over time, after successive tillage to the same level, a near impermeable "hoe pan" is created which blocks the movement of air and water through the soil profile which in turn stunts the growth of the roots of plants. If plant roots aren't encouraged to go deep (which they can only do if there is good air-water dynamics in place) then they must be planted farther apart so as not to compete with their neighboring plants. As they must be farther apart, sunlight will easily reach the soil surface causing weed seed germination, evaporative moisture loss, less carbon dioxide retention and generally weaker, under-producing plants overall. We avoid all these losses by digging deeper.

By preparing the soil deeply (see "double digging" on page 16); breaking through and amending that compacted subsoil layer, plant roots will be able to go much deeper. In some cases, over time, as much as 5-6 feet (1.5-1.8 meters) deep! This process allows us to place plants closer together in a smaller space and where we begin to approach those higher yields per unit area. It has been proven that a mere 2% increase in root health (due to greater depth and better air and water retention) will give a corresponding doubling of yield per unit area. It all starts with proper and deeper soil preparation which is followed by additions of locally available amendments such as char, ash, cured compost or well-rotted manures with each new crop being planted.

Close and Precise Plant Spacing

As the garden bed is now well aerated to a depth of at least 40 cm - and has been amended with wood ash, char, aged manure and locally made compost to add to its microbial health, nutrient and moisture holding levels - it can be planted with greater and closer precision. Each vegetable, grain or fruit plant will have a certain root spread and growth habit. It will also have its own unique canopy of leaves and stems. The 'master charts' found in How to Grow More Vegetables *(John Jeavons, Ecology Action, USA)* can serve as a guide here and you are encouraged to study this text in depth. A summary chart of key crops can be found in the appendix of this manual and used as a handout for trainings.

Note: The next time you are walking through the rural areas, take a moment to observe a nearby healthy ecosystem. Do you see plants in rows? Probably not. In fact, does Nature ever plant in rows? Hardly at all. It was this observation that lead to the birth of the modern concept of "Permaculture" in the first place. The stacked forest gardens created by the people living on the slopes of Mt. Kilimanjaro have sustained families for generations and will continue to do so. In this case, people have mimicked nature and families have thrived for centuries as a result. So rather than in rows, a bio-intensive garden is planted in triangles (much like the cells in a honeycomb - a brilliant example of nature's space-saving design) to allow a complete leaf canopy to develop over the bed. Within this natural cover, plants will maximize their space without competition while maximizing use of essential nutrients, moisture and carbon dioxide. In this way, the garden bed looks in many ways like the original layered (stacked) forest gardens from the slopes of Kilimanjaro.

Bed Dimensions – 1 meter wide only

The dimensions of these permanent garden beds and paths is an important detail. While bed *length* is purely up to the individual landscape (though 5 meters is a good and convenient length), it is the *width* which must be watched carefully. Once the bed is fully "texturized " - or double-dug to a 2 foot (60 cm) depth – it is never to be walked on again. Each time you walk on the soil – say when you must weed between the rows of the conventional garden – you are pressing out the air and compacting the soil, seriously jeopardizing root health which, as has been pointed out, is critical if we want to achieve high yields. Therefore, a width of no more than 1 meter is ideal as this makes it possible for the gardener to reach the center of the bed and its plants from either side without ever having to step on the bed itself.

Double digging with local tools allows for closer plant spacing as the roots can grow down rather than merely to the sides. These are permanent beds and permanent paths which also work to capture rain water. Crops are then rotated between beds from season to season to maximize control, break disease and insect cycles and achieve higher yields without a decline in soil fertility or quality. In fact, soil quality will improve over time.

Healthy Microclimate

As the plants grow to maturity, *and after early attention to small weed removal*, the leaves will form a dense, protective canopy. The closed canopy will capture and hold moisture and carbon dioxide while allowing more leaf surface area above for sunlight capture and greater photosynthesis. The carbon dioxide comes up from the rich and diverse microbial life found in the compost you've added prior to planting. Carbon dioxide is of course the first ingredient in the process we know of as photosynthesis whereby carbon and water mix to form sugars and oxygen for plant growth via the chlorophyll found within the structure of healthy leaves and stems. Additional moisture needs are also diminished greatly due to an increase in bed shading and a decline in evaporative water loss. This "micro" climate works to stimulate the growth of thriving, healthy plants which feed people; resist insects and diseases (it is well known that insects and diseases will prey more readily on weak plants); produce seed acclimated to local growing conditions; and, not to be forgotten, provide copious amounts of material for compost so that the process can be continued for long term sustainability.

In subsequent seasons, compost will be reapplied to enrich and replenish the soil. Crops will be rotated from one bed to another so as not to "mine" the soil as well as to break disease and insect cycles. See the Leaf-Fruit-Root rotation discussion later. With careful management of weeds and water, the garden can flourish, potentially throughout the year, or at least to a far greater extent than before. A viable measure of control has been achieved.

Compost

Compost is perhaps the most valuable contribution the gardener can make to improve soil quality, water retention and overall plant vigor; all of which will lead to greater family food security in the long term. Simply put, compost helps us manage "problem" soils: a sandy soil will be able to hold water and nutrients for the plants while a clay soil will release water and nutrients for the plants. While this valuable soil conditioner can hold 6 times its weight in water, its also teeming with hugely beneficial microbial life. In fact, over *6 billion* beneficial microbes can be found in just one tablespoon of mature compost. These microbes generate much needed carbon dioxide which is needed for photosynthesis, but also, when mixed with water in the soil, creates carbonic acid which acts as a catalyst for the release of soil-bound plant nutrients. For example, phosphorus is changed into the plant available form known as phosphate due its interaction with the carbonic acid now found in the soil. Without this acid, phosphate would need to be purchased and applied. And as if all that weren't enough, these microbes are also responsible for a natural increase in growth hormones, plant vitamins and antibiotics. So while the bio-intensive method means more plants per unit area due to soil depth and triangular planting style, it also results in healthier, higher-yielding plants as well. Compost is one of the simplest and most natural things we can add to improve not only the long term health of any problem soil but the very people who depend upon it as well. Further details on compost making and use can be found beginning on page 12.

Tools

What is the most appropriate tool to use to improve the agricultural productivity of subsistence farming families? The answer: the tool they already possess. Are special, imported, expensive tools required? Absolutely not! Bio-intensive permagardens work and are being successfully adopted across the region because **only** *locally available* tools and

plants are used in its initial creation. Local hoes, rakes and buckets are all that is required to get started and to be successful. As success builds and as the family decides on the best ways to use its new wealth, they may elect to purchase a better watering can or a new hoe blade or handle to make their work easier and even more effective. But to begin it is not necessary (and in fact it is a mistake) to have brand new hoes and buckets and watering cans. The excellent reference book, How to Grow More Vegetables , details the "double dig" method utilizing "western" spades and digging forks. While the result are in effect the same, these foreign tools only serve as one more barrier to adoption as seen by families here in Ethiopia. Here in the land of the hoe, we need look no further. It is the ideal tool, not only because it is available already, but because it works really well to break up those heavily compacted soils or loose infertile sands so many families and their crops are struggling with.

Nutrition Security "Farming" through Permagardens

It is when all these soil fertility processes and techniques are combined that we begin to see how we have gone beyond mere gardening and are indeed looking at "mini-farming". In many cases this can be accomplished right outside the back door; a very important consideration for family members with significant care giving responsibilities and thus little time to tend distant farmland. Real income can be achieved along with real increases in quality, nutrient-dense, vegetables and staple grains. Land that would have otherwise laid fallow, or which has been so overworked that it has become 'worn out', can now be revitalized and brought back into productive use. Home gardens can once again be rejuvenated and produce real bounty. Bio-intensive methods have been proven to work on some of the least fertile, driest soils and thus can be valuable tools in regions of the world debilitated by perennial drought. If most vulnerable households can grow greater quantities of healthier food closer to their homes where they are needed to assist their loved ones, then they will be that much closer to a meaningful and sustainable improvement in their quality of life and overall sense of accomplishment and empowerment.

As yield levels increase, (often by a factor of 5) so too does the potential for real income generation opportunity. Poverty reduction and better nutrition are often cited as the greatest needs in the fight against malnutrition. With Bio-Intensive techniques, both can be achieved: poverty reduction through income generation AND balanced food and well-being through an improved and varied diet of abundant staple grains and vegetables of vibrant color. *(See pages 29, 31).*

In the promotion of permagardens for family food security we must remember to keep good and varied diet in mind as well. As access to food quantity increases so to will the willingness to expand nutritional choices. And this is what people hope to gain from all this "extra" work of double digging. Better food and more of it too. The Bio-Intensive Permagarden helps people see that they can take control through tangible action. With greater control of the landscape comes greater food, nutrition and income as well as the very real sense of pride in this accomplishment. As worries and stress over food and some economic difficulties become part of the past, a renewed sense of hope for the future begins to take hold. With this feeling of hope comes a greater willingness to become part of the many other solutions to community problems that are being promoted. By keeping actions local and simple people will more fully grasp how these relatively minor changes in agricultural behavior can lead to enormously positive differences for themselves, their families and their communities.

Mr. Gabriel Mbena teaching primary students the permagarden method in Morogoro, Tanzania. This manual is dedicated to Gabriel for all his outreach work.

.

Compost: Benefits - How to Make - How to Use

In brief, compost is a cheap, easy to make, organic material which when added to even the hardest, poorest, or sandiest soil can improve the soil structure, quality and fertility for many years to come. Compost is what makes soil, the crops and the people who eat them more resilient to climatic, economic and societal shocks. It is THE answer to so many problems.

Basically, compost is organic matter (plant and animal residues) which has rotted down by the action of trillions of bacteria, fungi and other organisms over a period of time. Many types of organic matter such as leaves, grass, fruit and vegetable peelings and animal manures can be used to make compost but whatever the initial ingredients, the end product will be a powerful, highly prized soil amendment that will be dark brown, cool to the touch, have a pleasant, earthy aroma that is teeming with vital, soil building, microbial life.

We all know that most crops need a soil rich in fertility. While adding compost to your soil will provide some nutrients, the real benefit of compost comes in the form of greater water and air holding ability. This allows newly planted seeds, seedlings and crops to withstand periods of overly dry or rainy weather. In essence, compost improves the soil's ability to withstand shocks, to become more resilient. As a result, the plants themselves will become more resilient and healthier – just like the people who eat them. That being said, the billions of microbes found in just one handful of finished compost will add certain compounds (carbonic acid and certain growth hormones) to the soil which will cause the existing soil nutrients to be released in a slow and proper manner to the growing crops. Compost will provide these benefits with no additional cost – other than the time spent in the making.

On the other hand, chemical fertilizers are not only extremely expensive, but the cost is repetitious. Plants become dependent. With repetitive use, these chemicals will deplete the naturally-occurring nutrients, beneficial microbes and insects from the soil, creating an unhealthy dependency on these expensive synthetics. And as if that were not enough, plants that are grown with chemical fertilizers tend to be more attractive to pests because they are likely to have more green, sappy, succulent growth.

Compost is one of those essential ingredients for a truly productive, long term, permagarden. It simply takes planning, time and a bit of management but the impact it has is certainly well worth it. The mere act of building a pile now for future use is also a marvelous example of prevention. Planning and preparation now works to prevent problems in the future.

The many advantages to using organic compost include:

- Improved soil structure for easier workability, root penetration, initial and residual water capture and slow release for improved drought resistance.

- Greater resistance to erosion due to decreased soil crusting and compaction.

- Slow and steady release of essential trace and macronutrients. Organic acids in compost dissolve minerals in the soil, making mineral nutrients more available to crops. These acids also increase the permeability of root membranes increasing water and nutrient uptake.

- Microbially-rich compost, when mixed into soil, adds natural anti-biotics which make crops more vigorous and healthier thus increasing their ability to resist disease. It has been proven that pest insects will infest unhealthy crops growing in poor quality soil (ie without compost).

- Less need for chemical pesticides and fertilizers which can potentially be harmful to human health as well as the health and sustainability of our soil.

Materials for Making Compost

There are really only a few materials necessary for the creation of quality compost. The first two materials can be classed simply as "greens" (nitrogen-rich materials) and "browns" (carbon-rich materials). A key point here is that you will need to gather enough materials to make a one square meter pile in one “go”. This may require you to gather the browns after harvest season and save them till the rainy season when the greens are in abundance. The pile will be made up of one-third green and two-thirds brown materials.

The "greens" consist of organic materials that have been recently cut or pulled - weeds, grasses, tree leaves, etc: essentially, those biodegradable materials which are known to be high in nitrogen. Food scraps are considered "green" and can be added throughout the process or in a separate pile made solely for them to be decomposed. Livestock manure is valuable not only as a source of bacteria but as a strong nitrogen source as well which is especially important when working with more woody carbon-rich materials.

The "brown" materials are those that are dry and high in carbon. In many cases, these can be formerly “green” grasses which have already dried, lost their green color and which have

begun to break down already. Grass, once cut and dried, is now considered a brown material as most of the nitrogen (the green) has been lost to the atmosphere. Dried leaves, wood chips, sawdust, straw, are all examples of high carbon "brown" materials and which will make up the majority of the compost pile. No matter the color, the smaller the piece, the faster the decomposition, as bacteria "eat" along the edges.

The third component is good healthy topsoil to add the necessary decomposing microbes. Manure can be used but is not required so long as the soil used is of good quality. The final, and perhaps most critical, element to be added is water. Without adequate moisture, the bacterial population will decline and decomposition will grind to a halt.

Materials that should NOT be added to a compost pile:

- Plants infected by disease or a severe insect attack where eggs could be preserved or where the insects themselves could survive in spite of the compost pile's heat. Most diseases, insects (and weed seeds) will be killed if the pile reaches 160 F but it is best to be on the safe side and avoid these in the first place.

- Plants which are toxic to other plants and microbial life such as hemlock, acacia, juniper, bamboo, gmelina, castor bean and eucalyptus.

- Plants which may be too acidic – like pine needles. (However, special compost piles can be created using acidic materials to lower the pH level in soils that are too basic.)

- Invasive weeds such as wild morning glory, Kuch or Bermuda grass, and/or black jack. These are tough weeds may not break down in the pile.

- Meat or the manure from meat eating animals, like cats and dogs, which may contain pathogens, are toxic to small children and adults alike.

How to Build a Compost Pile *(see also the 2-page handout in the appendix)*

Compost piles are built using a system of layering, followed by a gentle mixing to make a thoroughly homogenous mix. The minimum size for a completed compost pile is 1mx1m. This allows maximum heat and moisture retention while still allowing proper air movement. A pile that is smaller does not provide enough insulation, and the heat generated will escape while a pile that is larger will not allow enough air to flow through which will also cause the decomposition process to slow or stop altogether.

First, a good spot must be chosen for your piles. The ideal spot will be a section of ground, near the garden, but which has plenty of shade. Shade means no sun. No sun means less evaporation. This greater internal moisture means faster,more thorough decomposition. However, if shade is not available, it will be necessary to cover the pile with plastic sheeting, banana leaves, etc so as to keep the sun from drying it out completely. This covering is also good to keep excess moisture off the pile during heavy rainy periods.

Once you have found a good spot, it is necessary to clear the space of leaves, weeds and other debris so you can see clear soil. Next, you will want to loosen the soil to a depth of six to twelve inches or fifteen to thirty centimeters. This provides the pile with a place for water to be absorbed.

The next step is to begin to build your first layer. It is important to understand that the first layer is going to be larger than the rest, and the brown materials used are going to be thicker than the rest to allow air flow through the bottom. You will want to use brown maize stalks, twigs, and/or small branches for the first layer. Again, these materials provide the pile with good drainage. Stack up the brown maize stalks, branches or twigs, until you have a small pile that is roughly six inches or fifteen centimeters high and one meter squared.

The second layer consists of three inches or about eight centimeters of fresh green material. This should be piled directly on top of the first layer, covering it completely.

The third layer is that of old compost, good quality topsoil or medium quality soil mixed with manure. A few handfuls is enough as this is your source of decomposing bacteria.

Gently mix these 3 layers so that all ingredients are in contact. Add some water- enough so that the pile remains damp, but not soaked. You want the pile to feel like a wrung out sponge. This will energize the bacteria which will begin to generate significant heat within 36 hours. That heat is the sign of decay that you are looking for.

Continue this layering/mixing/watering process until your pile is one meter high. Cover the pile with a 2 inches or 5 centimeters layer of soil to retain the heat and moisture and allow to sit for 2-3 weeks.

A quick check of the interior moisture and temperature level can be done periodically if a long stick is placed in the center of the pile from the beginning. The temperature should rise quickly, so much so that the stick cannot be held for more than a second. If that is the case, then most of the disease pathogens and weed seeds have been killed. After about a week, if the stick can be held for more than 5 seconds, and is still moist to the touch, that indicates the compost is in an active decomposition phase. If however, the stick is dry and cool soon after making, then you must add water, air and perhaps more green materials to get the decomposition process moving forward.

After the initial two week settling in period, mix the pile once per week, adding moisture as needed. You will know if there is enough moisture if, when squeezed, two or three drops of water fall from your fist. If not, add water to keep the bacteria working and thriving. By the end of two months you will be left with compost that is cool to the touch, has a rich, earthy aroma and which looks like loose, dark soil. What you won't see are the trillions of beneficial microbes ready to go to work to improve your garden soil, but trust me, they are in there!

One finished pile should provide 12-15 20-liter buckets of finished compost. That will be enough to amend 3, 4-meter-long, bio-intensive garden beds. Simply place one bucket of finished compost per one square meter of garden bed. Spread it out evenly over the entire surface and lightly till it into the top 10 centimeters. This should be done prior to each new crop you plant.

Soil Amendments: Wood Ash, Charcoal and Biochar

Wood ash has long been recognized as a good source of pH balance and plant nutrients (calcium, potassium, magnesium, phosphate) but what about the char? Charcoal fines, the

tiny pieces left at the bottom of the bag or on the ground at the selling and/or making point, do indeed make a very useful soil amendment. Charcoal holds and filters water; serves as home for millions of microbes; and lasts forever (or at least for 1500 years as determined by research in Amazonia). And as if that were not enough, it is carbon negative, meaning it will actively absorb excess atmospheric carbon dioxide, hold it (sequester) in the soil and slowly release minute amounts of carbonic acid which will work as a catalyst to increase soil fertility naturally over time. Woody crop residues such as maize stalks, which are very difficult to compost and therefore routinely burned, can also be charred in much the same way (and in much less time)as wood. This is what is known as "biochar". While it may not work well as a fuel, it will have huge impacts upon soil quality as listed above. Simply collect and add one large bucket of charcoal bits and dust per 5 meters of garden bed and mix in to the top 10cm of the surface.

Double Digging: The key step to Permagarden Success

With an active composting system in place (with multiple piles at varying stages of decay and use) you can easily maintain a complete permagarden. But what if you don't have compost ready? No worries. Relax. The compost, while indeed critical for longer term sustainability, is not *essential* for initial creation of the bio-intensive permagarden. Using well-rotted manures will also help soils hold moisture and create the healthy carbon dioxide rich microclimate just as well as compost will in the future. However, there is a "danger" with relying on manure. First, it is not always readily available (as compost can be later on) and second, it can inject a huge amount of weed seeds into your garden soil as it has not gone through the intense heat cycle of a well made compost pile. But DO NOT let an initial lack of compost keep you from getting started. Just keep after the weeds while they are very small and all will be well.

A properly constructed garden bed will allow plants to gather and absorb all the water and nutrients they need to grow more strongly. A 4-meter long garden bed can be completely "double dug" and amended by one person in just less than two hours. This may seem like a lot of extra work at first but when **5-fold** yield increases are the result, the work seems minimal in the extreme. It should also be noted that in most cases, double digging need only be done once, or perhaps twice in the truly hard-packed soils. The goal is to achieve a deep soil profile with good air and water flow. Once created, in subsequent years you will need only to amend the surface with compost, mix, smooth and plant.

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

- Remove weeds and grasses within the entire garden area, but in particular the space where you are about to dig the garden bed. These old plants can be used in your compost piles, especially if they have not already gone to seed.

- Along the contour of the land – so as to maximize water capture in the permanent pathway created between garden beds - mark off a space that is 1 meter wide and 4-5 meters long. Simply stand with your legs a comfortable width apart to mark off your space. This width allows access from either side of the bed without ever having to step onto the top surface of the bed either now in digging or later when it comes to weeding, watering or harvesting.

- Straddling the bed and moving forward with your hoe, loosen the topsoil as deep as you can until you hit either a color change (subsoil) or the compacted layer within this space. At first, you will need to pull out the first 20cm wide "trench" of soil along the width of the bed leaving it outside the bed for now. While still straddling, move forward, pulling the loosened topsoil back into the space you just opened up. If the soil is very dry, add a few cups of water over the compacted subsoil letting it soak in before moving forward. This will help considerably in the second phase of the digging. When you reach the end you will be left with an open trench down to the compacted layer along the width of the bed.

- Rake the soil smooth but leave the final trench open. This is what is known as the "single dig" and can be done the day before the "double digging" begins. It is best to dig this first section either after the soil has been softened by the first rain or by judicious and directed hand watering as mentioned above.

- Gather your soil amendments (rotted manure, charcoal) in buckets and have them at the ready. Standing to the side of the open trench, remove a small section of the hard subsoil closest to your feet. Remove it temporarily to the path between your feet. Continue to loosen the exposed subsoil at the bottom of the trench moving it back as you go into the mini open space you just created. Go as deep as you can. Really break it up. Move to the other side of the bed to ensure that the entire trench has been evenly loosened.

- To the loosened subsoil, add 3 large handfuls of manure and the same amount of charcoal pieces and mix it in.

- Straddling the bed as before, but now facing and moving in the opposite direction, pull the next 20cm trench over the subsoil trench you just amended so that you expose the next trench of compacted subsoil. Think of this as more like cleaning than digging as the digging has been done already. Stand to the side on the path as before and loosen and amend the compacted layer as done previously. Repeat this entire process all the way to the end of the bed. Pause every meter to pull the loosened topsoil along with you so as to save you this step later on.

- When you come to the last trench, simply add the soil you set aside from that first trench in the beginning. Rake the entire bed smooth, shaping it so it looks like a comfortable bed. Which is exactly the imagery we are going for.

- The digging is now complete but the amending has only just begun. Add one bucket of old manure or finished compost per meter of garden bed. Smooth it evenly along the entire surface. Next, add 1 bucket of charcoal dust and 1/2 bucket of wood ash per 4 meters of garden bed (adding nutrients such as Ca, Mg and P as well as raising the pH of acidic soils). With hoe or hands, mix all these amendments into the top 10-15cm of the bed.

- Rake the bed smooth again to prepare for planting. As the bed is on the contour of the land as well as flat on the surface, any water that hits the surface will be absorbed and not run off. If available, apply 2, 15-liter watering cans of water gently to the surface to settle the amendments, moisten the seed/seedling zone and to check for possible

erosion points. Fix any sections where the water runs off. Later in the afternoon you can be ready to plant your seeds and seedlings.

Use local tools to loosen compacted topsoil in one meter wide beds. Water applied to the hard, dry subsoil will help soften the soil for easy "double digging" the following day.

Subsoil is loosened and amended with charcoal dust, manure, and small amounts of wood ash. The next trench of topsoil will be pulled over the top of these amendments creating a deep soil profile.

Dealing with Problem Soils – Heavy Clay or Loose Sand

The basic method of double digging as described above applies to all soil types with a few notable exceptions. *Sandy soils* will often have a layer of darker organic matter which has been trapped in the subsoil below a heavy top layer of what appears to be pure sand. It is best to first remove this top layer (it can be used in brick construction) to allow easier access to the "richer" soil below. Loosen, dig and amend as described. Aged manure or compost applied to the lower layer especially will help to enhance soil water holding ability. *Dry, compacted subsoil* found in clayey soils can be loosened by applying a small amount of water over the exposed subsoil trench (see picture above) and allowing it to soak down and soften the subsoil over night. The double dig can proceed with relative ease the next morning. *Heavy clay topsoil* can be extremely sticky when wet so should be allowed to dry slightly before attempting the double dig. Ample use of char, ash and compost or aged manure is critical to loosen these dense soils which will continue to improve with each growing season.

Seed Spacing

You have taken great care in making a deep, nutrient-rich bed. Now you must take care when choosing quality seeds to plant. Make sure they are large with smooth outer skins.

As a measuring tool, take a stick from your garden and measure the length of your forearm. About 35cm will be the proper spacing between maize seeds. Maize and beans can be planted on the same bed because they grow well together as they have different rooting and growth patterns along with different nutrient and sunlight needs.

Next, choose another small stick and measure the spread of your fingers; thumb to pinkie. This will be the proper seed spacing for bush beans. As each plant grows, its leaves will come to cover the bed yet not compete with each other.

Next, place the long maize spacing stick along the end of the bed. Make marks for the seeds at either end. Place the stick on an angle toward the middle of the bed. Seeds will always be one stick's length apart. Continue down the length of the bed. Notice how the spacing is at an angle. If your bed is a meter wide you will be able to make a 3-2-3 hole pattern along the length of the bed. Once the initial pattern is established the sticks can be discarded.

Now make larger planting holes at each of the marks that you just made. Each hole, for maize in this case, will hold two seeds placed on either side of the planting hole. It is important to plant only two seeds in each hole. Do not cover the maize holes yet as it helps to guide placement of companion crops. Use the smaller stick to mark where to plant the beans. They can be planted along the sides of the bed in between the maize seeds.

Place a single bean in each of the holes. You will be using fewer seeds, but each plant will become much stronger this way and you will get more food in the end.
Finally, cover each seed with soil and make the bed smooth and ready to receive the rain. A smooth, flat bed will not erode during heavy rains. It will absorb more of the rainwater.

After the maize seeds germinate and grow for about two weeks, select the strongest of the two. The one you remove is not tossed away but it should be eaten by something: goat, rabbit, or bacteria in the compost pile. At the same time, lightly cultivate the soil around each plant to remove small weeds before they remove important nutrients or water.

Permanent pathways not only capture and direct water but they also allow easy access for weeding the garden beds from either side. Removing weeds at this stage is fast and simple. Compost added to the soil also aids in seed germination and emerging plant vigor as the soil remains moist longer. After two weeks, only one maize plant is allowed to remain in each space so that it can achieve its maximum potential.

Starting Seedlings

Most of the commonly planted staple food crops found in both field and garden (maize, wheat, sorghum, beans, pumpkins, amaranth, potatoes and sweet potatoes) are directly sown in the soil. In fact, they must be direct seeded as they will not transplant well once they have germinated and their root systems have developed. Vegetable plants, on the other hand, 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. The exception to this rule are the root vegetables such as carrots and beets as they also do not transplant well. 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.

By starting seeds in good soft soil in a nursery bed, or in small plastic bags, the gardener is once again asserting control - control over moisture, sunlight and seed quality. Upon development of sturdy stems and leaves, vegetables such as tomato, pepper, cabbage and kale, can be outplanted into prepared garden beds at their rightful and proper spacing (see chart on page 23). As they have been treated to a steadily increasing amount of sun, moisture and quality soil they will continue to flourish with limited delay. Care should be taken so as not to damage either stem nor root at transplanting. Growth will be continuous as a result.

Seed Starting Steps

1. Prepare soft, light soil (compost mixed with topsoil and sand is a good mix) in a small section of a garden bed. Crush any large clumps of soil or compost to make a fine seed bed. Moisten the surface, allowing water to soak down at least 3 inches or about 8 centimeters.

1a. You may choose to put seeds directly into small plastic bags (filled with the soil mix) which will have the advantage of being moveable depending on sunlight needs. This will also make it easier at transplanting time when you need only remove the bag rather than dig up the small section of garden bed as in step 5.

2. Sow your seeds 2cm deep and close together at offset (triangular) spacing according to the Seed Spacing Chart at the end of this manual. 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.

4. Cover this small area (less than a square meter) with a simple thatch structure to keep intense sun and heavy rain off the fragile seedlings. As the seedlings develop (within 7-10 days), gradually increase the amount of sunlight they receive so that by the time they are fully developed (in about 6 weeks) they will be prepared for transplanting into the harsher world of the larger garden bed.

5. Once 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. Simply loosen the soil on all sides of the seedling bed so that tender plants can be easily removed one cluster at a time. Before outplanting, remove a few lower leaves to allow the roots to develop quicker.

6. Roots and stems of tomato, pepper and eggplant can be planted deeply, up to the first set of true leaves. Roots will develop from that part of the stem which has been buried in soil and a much stronger, healthier and productive plant will be the result.

Crop Rotation: Leaf – Fruit – Root- Legume

Crop rotation is arguably one of the most important organic cultural practices you can employ to both enhance soil fertility and limit garden pests and diseases. Planting the same crop (including from the same family) from season to season will cause nutrients to decline and pest and disease cycles to flourish. The permagarden beds make crop rotation simple – don't change the location of the beds; rather, change what is planted in each from season to season.

Different crops have different primary fertility needs. Take note that before planting any new crop, additional compost is needed to maintain micronutrient, organic matter and beneficial microbe levels. An excellent cycle to use and educate others to maintain between your double dug garden beds would be leaf, fruit, root, legume.

Leafy crops (spinach, amaranth, sorghum, maize) enjoy lots of nitrogen so should be planted "first" in newly manured and fertilized garden beds. The following season, plant a fruit crop (tomato, eggplant, pepper) which like some nitrogen but need more phosphorus for proper flower development. Actually, too much nitrogen and your tomatoes will be "all plant, no fruit" and could develop various imbalances causing blossom end rot or make them susceptible to fungal diseases. Next comes a root crop (carrots , turnip, beets) as they require even less nitrogen but need more potassium for proper root development Finally, follow it all by planting a legume (peas, beans) which will use few nutrients while adding nitrogen back into the soil through the process of atmospheric nitrogen fixation.

By following a good crop rotation plan, we are also breaking the pest and disease cycles which will mean healthier, stronger plants and little to no need for costly and "dangerous" pesticides.

Training of Trainers (the ripple effect)

When even the smallest stone is dropped in calm water the ripples go far and wide. Each of those ripples will go on to create even more and before we know it, the once calm water is a "perfect storm" of activity, learning, growth and empowerment. Perhaps that sounds too optimistic? Don't ever think that a few people working together can't change the world - in fact, that is the only way it ever has. Change will come and it can last if it starts with small and doable actions. You can be that small stone that creates ripple after ripple after ripple.

Families or small groups can plan and create a complete Permagarden in a short amount of time. It is important that this method be seen as doable. The best way for this to be done is to teach it with an action-oriented training. This method will appear to require a large amount of energy to start and that may be a barrier to acceptance. If you find that to be the case, then do each step of the permagarden over the course of several mornings when the family has the time available. Using only local tools, seeds and plants is critical but the method must be seen as worth the "extra" effort by family members. Start small – create one water swale with a double dug garden bed below it. Then simply let the family decide if they want to make it bigger. It has often been said that the hardest thing we can do is to make something look easy. Proper planning, materials gathering, soil preparation and choosing to do the heavy digging work during the early or later part of the day will go a long way towards overcoming resistance to what has already been proven to be a highly successful method of family food production. Finally, train your groups and individuals with a return visit in mind.

Key Permagarden Training Themes:

- Small Changes - Big Differences (Small Doable Actions for Behavior Change)
- The 3-legged stool of sustainability: the methods must be seen as environmentally sound, economically viable and socially acceptable.
- Water Control and Management with swales, holes and berms
- Use of Only Locally Available Resources – tools, seeds, plants, amendments

- Perennial Food Production and Environmental Enhancement near the Home
- Simple Compost for Water Retention and Soil and Plant Health
- Double Digging to Increase Plant Health, Density and Water Holding
- Plant and Seed Spacing to maximize yield from a small space
- Bed Management and Sequential Planting (Crop Rotation)

Available Training Resources:

1. Permagarden Outreach and Extension Manual: The Dialogue Approach. This manual guides you through a series of small group discussions and actions which focus on various household assets which can be enhanced to create sustainable, edible, home landscapes; including a full permagarden.

2. Creating the Edible Landscape: Permagarden Lesson Plans. A field manual which outlines objectives, materials and time requirements for each critical step in the creation of a small, family-based, permagarden.

3. Gardens for Better Living (25 minute DVD). This recently produced video (2008) gives an inspirational view of subsistence farming families using permagardens to gain a sense of:

- Control (environment, soil and water, more food from a small space)
- Accomplishment (sense of pride and well-being from greater food security)
- Hope (for a better future and a "reason" to adopt other sustainable behaviors)

Conclusion

Permagardens have been shown to be excellent tools to have in our soil fertility and food security toolbox as we look to build the resilience of the local environment and the people living within it. Effectively and economically rebuilding depleted soils, human and plant immune systems, will strengthen not only the people but their landscapes and watersheds for future generations to enjoy and enhance.

It is important to remember however that the garden is still merely a tool. And, like any tool, if it remains in the toolbox, no matter how useful initially, it is not doing anyone much good. As this particular "tool" is used, people will slowly gain confidence with it, manage it, even change it as it suits them. The family permagarden serves as a classroom for the family to learn small scale techniques that, if they so choose, can be extended to the broader landscape and farm field. Once people accept these gardens as a socially viable way to sustainably enhance their food and economic security, their overall sense of empowerment and subsequent resilience to local and global shocks will put them on the path to improving the quality of their own lives. The work put in now will continue to yield benefit to those who choose to accept it. And, perhaps most importantly, the efforts will be sustainable as it has come about in a manner of their own choosing.

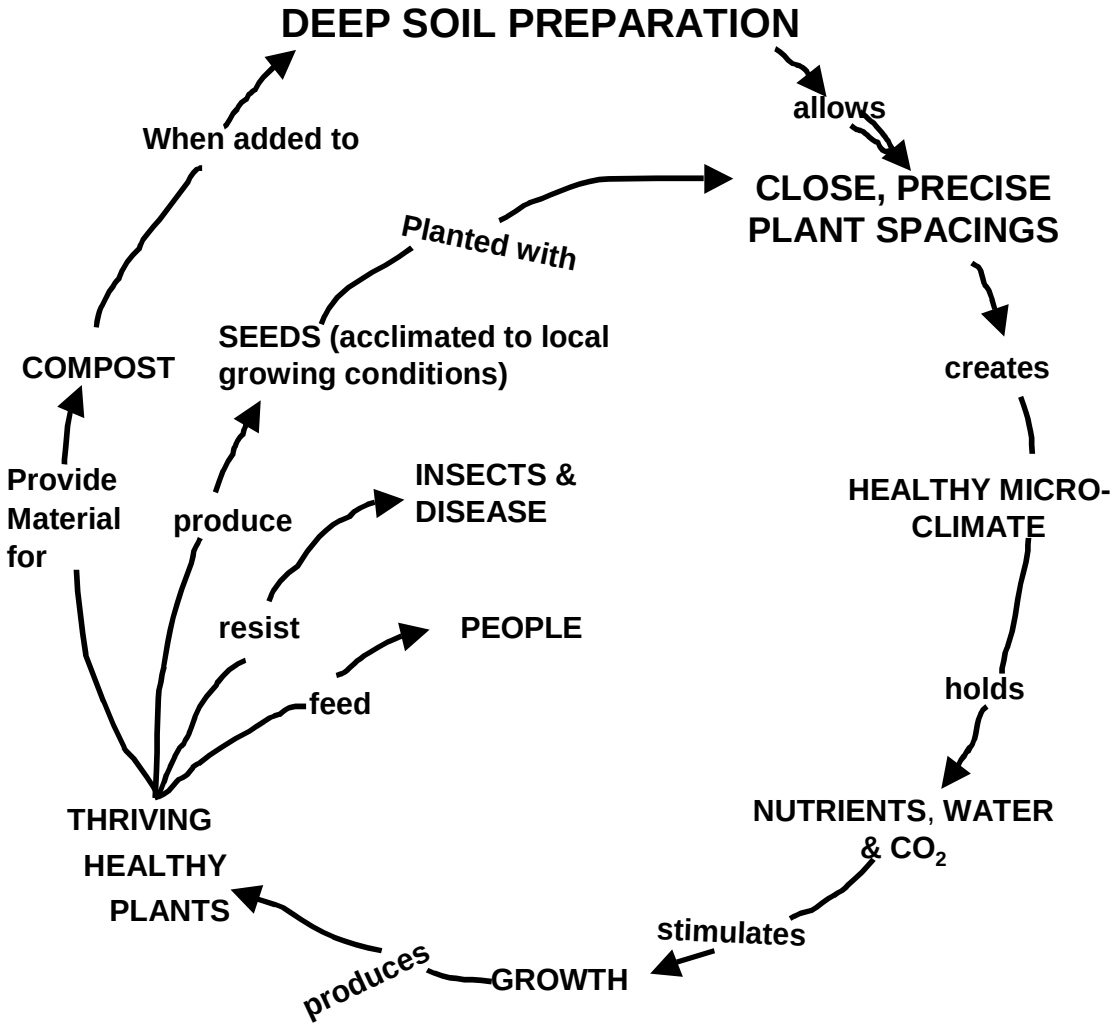
The cycle of better living – healthy people growing healthy food from healthy soil and water – can truly lead to the creation of sustainable communities able to tackle any number of development challenges. Without family food security in place there can be little further development. We all need to eat. With a functioning permagarden, and farm field using

elements of Permaculture and Bio-Intensive Gardening, families can grow big, eat well, and stay home to tend to their many other needs.

Control – Accomplishment – Hope…By using these small, doable actions which give immediate visible results, real change and real empowerment can occur…and the vision of hope for tackling malnutrition can be achieved.

BIOINTENSIVE MINI-FARMING

Sustainable Diet Production



CIRCLE OF SUSTAINABILITY

Bio-Intensive Plant and Seed Spacing

Double dug beds should be one meter wide only with the seeds spaced hexagonally to maximize efficient use of 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 leaf canopy. The more carbon dioxide and moisture which is captured the better. Also, as little sunlight will reach the soil surface with the closed canopy, there will little weeding, significantly reduced water needs, and overall healthier plants which will yield more food on less land than you ever thought possible!

[For more information: How to Grow More Vegetables. John Jeavons. Ecology Action.]

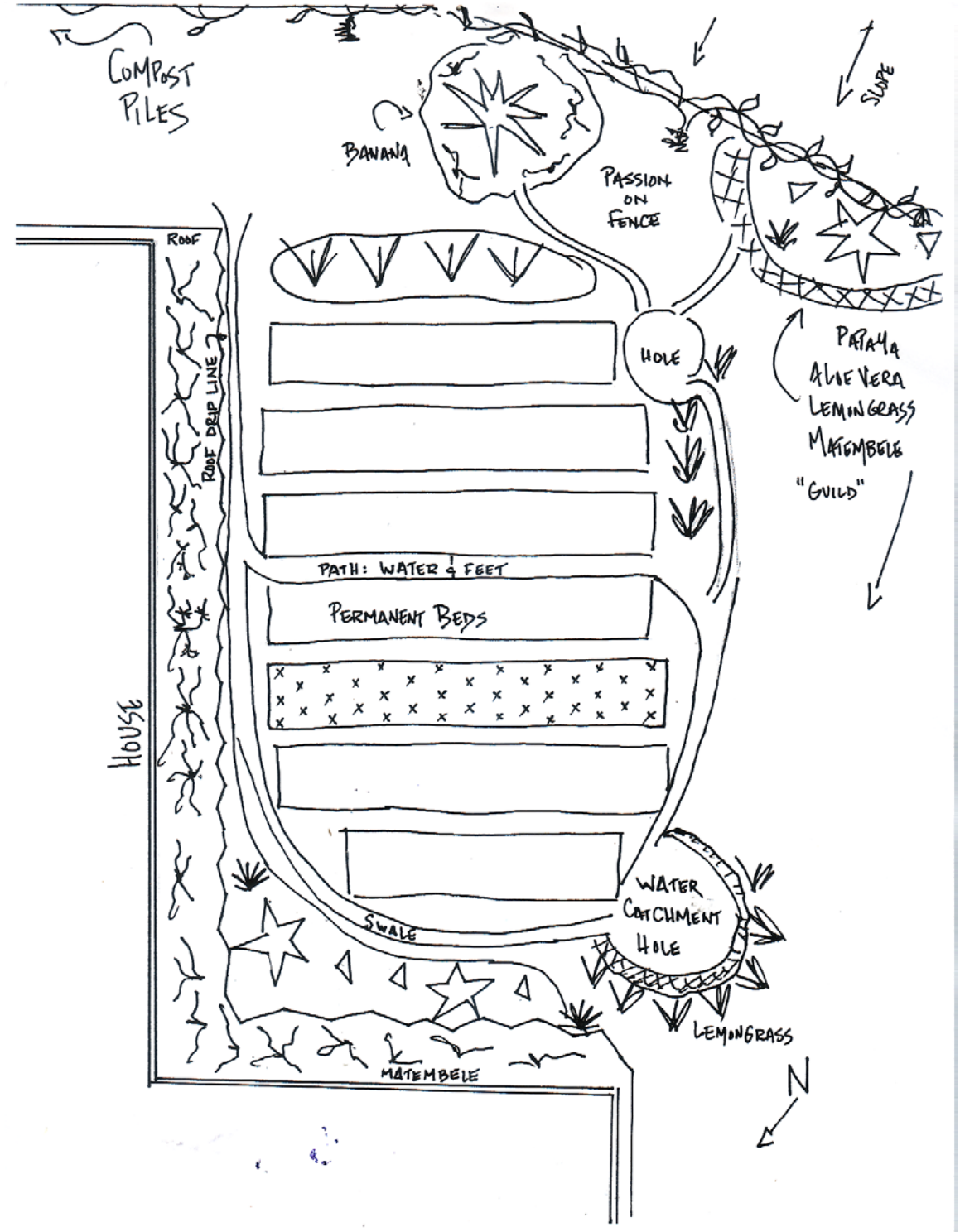
Seed Spacing (in centimeters) for Direct Seeded Crops:

Crop	Spacing in Garden Bed
Maize	35 (plant 2 but remove 1 at 2 weeks)
Wheat	5
Beans (dry/green) and cowpea (khunde)	15
Chickpea (garbanzo bean)	15
Radish	5
Carrot	Broadcast lightly, thin to 5 cm
Onion (may need to start plants)	6
Millet	15
Amaranth (mchicha)	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	8	35 (stake up with poles)
Brocolli	6	30
Cabbage	5	30
Chinese Cabbage	5	20
Eggplant	5	35
Pepper (hot or not)	5	25
Cucumber	4	25 (train to grow up trellis)
Leaf Lettuce	BC then thin to 6	15
Basil	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 drastically reduces water needs and ensures better growth upon transplanting into the production bed.



The Bio-Intensive Home Garden
at the home of Gabriel Peter Mbena
Morogoro, Tanzania

Compost – The Key to Soil Health

The many functions of compost in soil make it perhaps the most important ingredient that we can add to garden soil so as to achieve sustainable yields of highly nutritious vegetables, grains, legumes and fruits. It is easy to make but does require advanced planning and time.

1. **Improved Structure** – compost breaks up heavy clay clods and binds together sandy soil. Proper aeration allows a sandy soil to hold water and a clay soil to drain water and promotes proper root growth and health.

2. **Moisture Retention** – compost holds 6 times its own weight in water. A soil with good organic matter content soaks up rain like a sponge and regulates the supply to the plants. A soil stripped of organic matter resists water penetration, leading to crusting, erosion and flooding.

3. **Aeration** – plants can obtain 96% of the nutrients they need from the *air, sun and water*. A loose, healthy soil assists in the diffusion of air and moisture into the soil and in the exchange of nutrients. Carbon dioxide released by organic matter decomposition diffuses out of the soil and is absorbed by the canopy of leaves above in the raised bed microclimate created by closely spaced plants.

4. **Fertilization** – compost contains some N, P, K Mg, and S but it is especially important for trace elements such as molybdenum, zinc, and iodide.

5. **Nutrient Release** – related to the above, organic acids (carbonic and fulvic) from decomposing organic matter dissolve soil minerals and make them available to plants. As organic matter continues to break down it slowly releases key nutrients for plant uptake and to ensure a healthy soil microbe population.

6. **Nitrogen Storage** – Nitrogen, one of the most important of plant nutrients, is also the most volatile. If added to soils low in organic matter, this N is quickly converted to gas and lost to the air. Organic compounds bond to the nitrogen and allow it to be released slowly and steadily as the plant needs it, stopping its loss to leaching and volatilization.

7. **Soil Acidity and Toxin Buffer** – plants have specific tolerances in terms of soil acidity and toxins. Organic matter allows plants to have a broader range of tolerances to these elements common in the world's poorest soils.

8. **Germination and Early Seedling Growth –** once seeds are placed in the growing bed or seedling flat the soil is watered thoroughly so as to allow the seed coat to soften and crack open to allow for proper seedling growth. Compost in the soil will act like a sponge absorbing the water and keeping it moist around the seed for a much longer time which will increase the speed of germination and the likelihood of the young seedling growing through periods of dry weather that would otherwise destroy the tender stems, roots and leaves.

Home and Garden Compost

Simple Steps to Building a Healthy Soil

Why Make Compost: Compost has many benefits to the soil and the plants that we grow. It is also very easy to make and requires only a small amount of labor and materials.

- 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 (fertilizer) 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 bacteria and fungi 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. In both types, we make a pile 1m x 1m x 1m which is both easy to turn and manage. Materials needed for making compost:

- Brown leaves, straw, plant stems. These things contain a lot of Carbon.
- Green grass clippings 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.

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 such as dry leaves. Hold them till you have enough green grass materials to make a compost pile. Large brown leaves should be chopped into small pieces so they will break down quicker.
3. Gather green grass clippings or other green materials. You will need less than half as much green as brown materials. A compost pile will contain 1/3 green and 2/3 brown materials.
4. Begin to layer and mix the brown and green materials. Start with a 6 inches or 15 centimeters layer of brown.
5. Add a 2 inches or 5 centimeters layer of green.
6. Add 5 large handfuls of top soil or finished compost. Mix all this together by hand.
7. Add water to thoroughly moisten the materials.
8. Repeat steps 4 through 7 until the pile is 1m x 1m x 1m. Cover with 1 inch or 2.54 centimeters of topsoil or 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.
10. Turn/flip the entire pile to a space just next to itself. Mix well and add water.
11. Make a new pile where the old one was.
12. WAIT TWO WEEKS. After one week, add more water over the top as needed.
13. Turn/flip both piles to the spaces nearby. Mix well and add water as needed.
14. WAIT TWO WEEKS. When the inside of the pile is brown, crumbly and cool to the touch the compost is ready to be used in the garden.

Kitchen Waste Compost: Use a 20 liter Jerry can with the bottom cut off and turned upside down. Poke a hole in the cap to allow liquid to drain out. The cut off 'bottom' can be used as the lid. Elevate the barrel and place a basin below to catch the 'tea'.

In the bottom, add a 4cm layer of old manure or compost and a 2cm layer of dry grass.

Prepare a box of dry brown leaves or wood chips and leave nearby. This will be used every time you add vegetable and fruit waste from the kitchen and will help to absorb odors.

- Every night, add a small bucket of saved vegetable waste from the kitchen *(no oil, meat*), cover with 2 cm of the dry brown materials that has been set aside.
- Clean the kitchen bucket with ½ liter water and add this to the Jerry can and cover.
- The following morning, collect the 'tea' in the basin below the barrel. Mix with 3 parts water before using to irrigate your garden vegetables.
- Continue in this manner until the jerry can is full. This may take over a month depending on how much vegetable "waste" you generate.
- When can #1 is full, slide it over and start again with can #2. Continue to add ½ liter of water to can #1 to keep it moist and to collect the fertile 'tea' from the bottom.
- When can #2 is full (after another month) empty can #1 and use the cool compost in the garden. Slide Can #2 over and continue to make tea. Can #1 can begin again.

A cubic meter compost pile will give 15 buckets of finished compost after 2-3 months of twice a month mixing.

Evening additions of kitchen waste, brown leaves and water will give morning 'compost tea' which can be used to irrigate garden

Summary of Nutrients

Nutrient	Description	Foods
Proteins	"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	"mud" 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	"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	"Firewood" of our house Fuel for our body from calories	Plants—Grains, starchy roots, fruits, legumes Milk
Fats	"Paraffin" 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 not a nutrient, it works like the "Broom" of our house. Fiber removes wastes with water. Fiber is only in plant foods—vegetables, fruits, legumes, seeds, roots, & whole grains*		

Source: Permaculture Nutrition Manual. 2003. Kristof Nordin.

Permaculture Guild

A "guild" in Permaculture is a system of efficiently grouped plants so that each may grow to its fullest potential. When planting a guild there are several things to keep in mind:

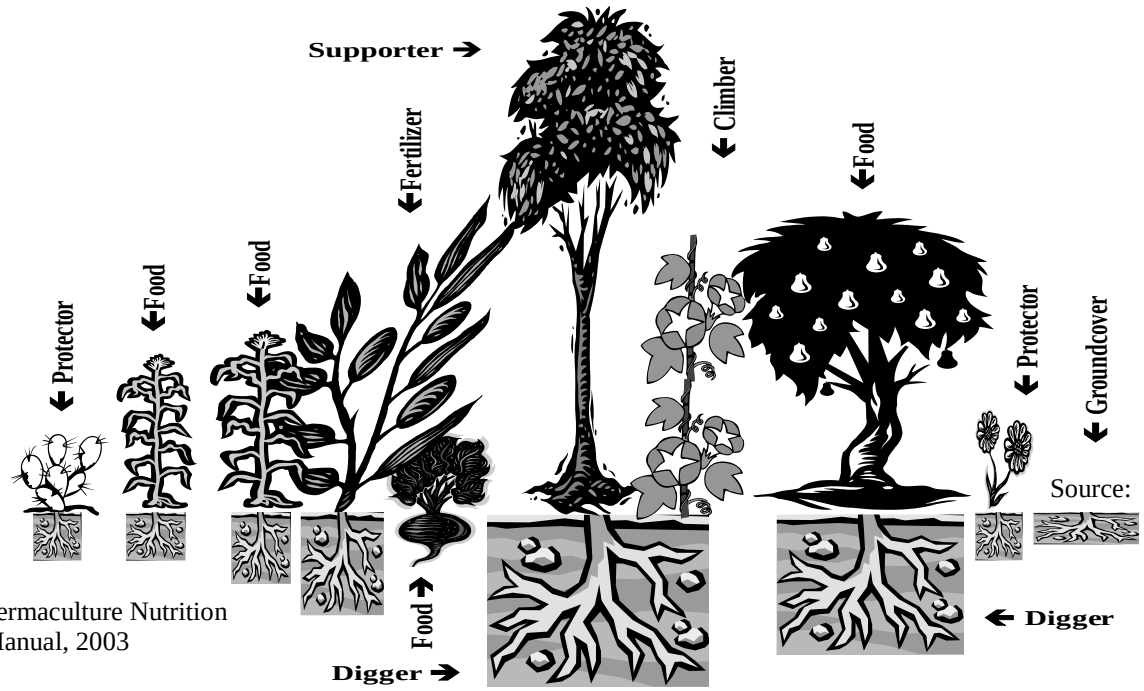
Nature plants in steps: Large plants depend upon the smaller plants around them.

Nature always plants a variety: Observe the large diversity of plant life that occurs in an undisturbed forest, each plant has a specific purpose.

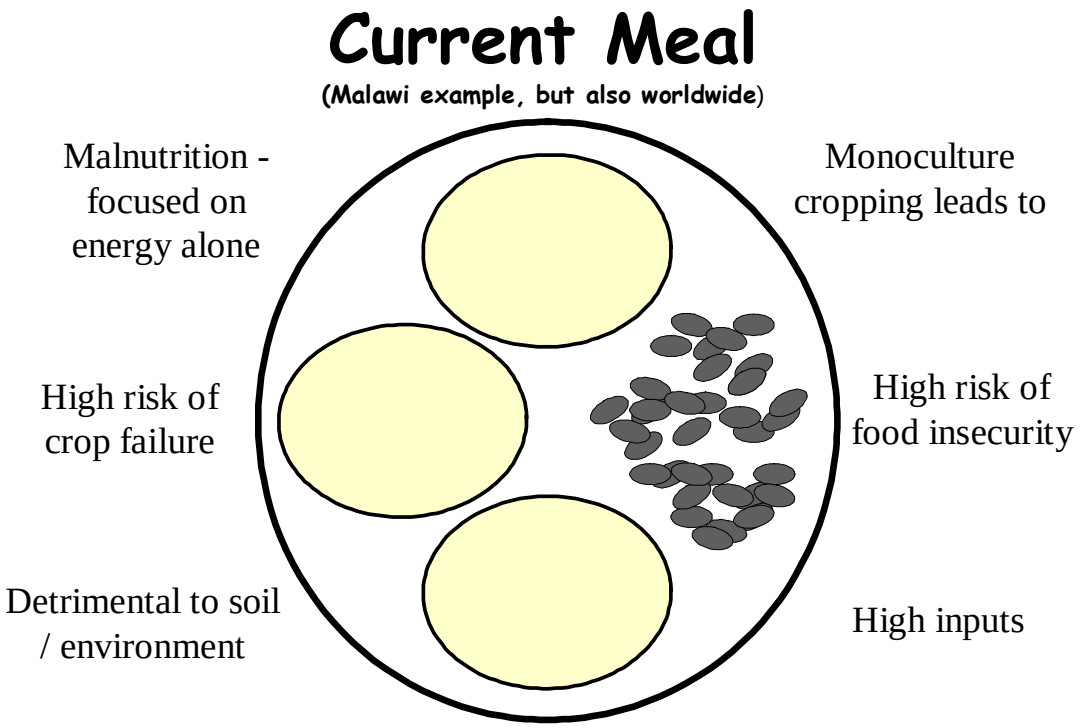
Nature "stacks" plants in both time and space: A natural forest is comprised of many layers of plants that grow and die according to the season and which extend from high above the earth to deep below it.

The following is a list of seven different functions that a Permaculture guild tries to include:

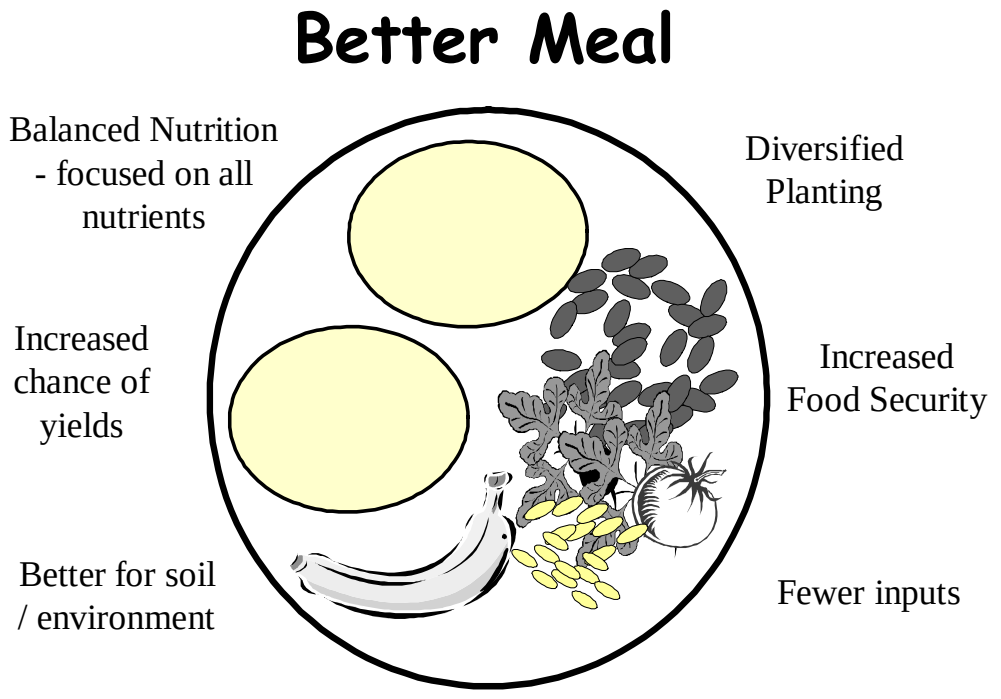
1. Food	Staples, legumes, fruits, vegetables, and fats
2. Food for the soil	Legumes and organic matter that provide nutrients to the soil
3. Climbers	Important for making the most of vertical space
4. Supporters	Plants that provide support to climbers
5. Miners or diggers	Deep roots or tubers that open the soil and bring up nutrients from deep
6. Groundcovers	Protects soil, provides shade, holds moisture, and suppresses weeds
7. Protectors	Protection for others in the system (Repellents, attractors, live fencing, etc.)



Source: Permaculture Nutrition Manual, 2003



Source: Permaculture Nutrition Manual, 2003. Kristof and Stacia Nordin.



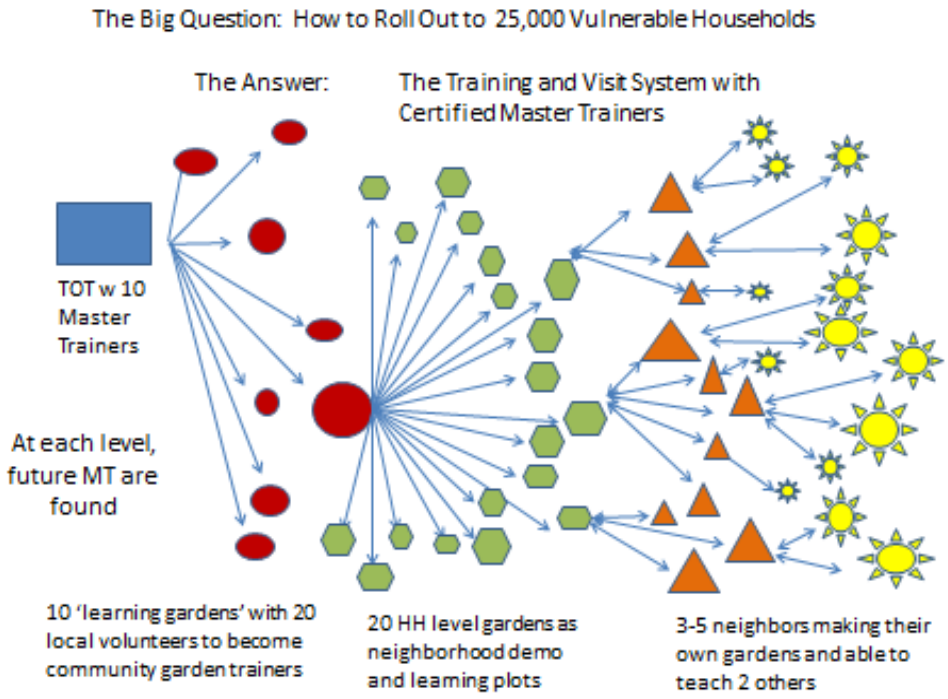
The Training and Visit System

One Master Gardener TOT creates 20 Master Garden Trainers **OUTPUT**

Each Master Garden Trainer teaches 10 community based volunteers **OUTCOME**

Each community based volunteer teaches 5 vulnerable households how to grow nutritious home gardens from year to year **IMPACT**

Each vulnerable household has the skills to grow and teach their neighbors through an established local "Neighborhood Network" **SUSTAINABILITY**



Train at each level so that the next level has the knowledge, skills and attitudes necessary to continue to learn and teach on their own. This requires not only proper hands-on training at local gardens, but well-planned and carried out visits within a month of the initial training. This builds the confidence and the neighborliness necessary to carry on for many years to come.

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 = Abundant Production
CLOSE = Close . Local . Organic . Sustainable . Easy

Key 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

Local Waste Products for Soil Improvement

Wood Ash	(Minerals and pH balancing – Ca, Mg, P, K)
Charcoal dust	(carbon sequestration, water holding, microbe housing)
Livestock Manure	(Minerals – N, P, K; water holding, better tilth)
Green/brown leaves	(compost materials, green manure, nitrogen, tilth)

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)
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	

Shade (in the Bio-Intensive Garden Beds)
Save (in the Bio-Intensive Garden Beds)

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

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.

Zeer Pot Refrigerator

Clay pots are unglazed, kiln dried once so that moisture can move through the porous clay.

Vegetables placed inside the inner pot will keep for up to two weeks when they would otherwise spoil within 2 days. This system works best in a dry climate where evaporation will be high causing cooling of the inner pot.

Steps:

1. Find two large unglazed clay pots. One must be larger than the other.
2. Plug any holes in the smaller pot.
3. Line the larger pot with wet sand so that it sticks to the sides.
4. Place the smaller pot within and fill the rest of the way up with wet sand.
5. Water must be added every day to keep the sand moist. As the water evaporates it cools the inner pot and anything inside.
6. Place a damp towel over the entire unit to keep the cold air within.

Productive Behavior Checklist

Region	Woreda	Kebele	Village	Household name
Name of Project staff visiting	**1.**	**2.**		**3.**
Date of visit				

Household Production Behavior	Tick if Observed
1. Household production dialogue Participation	
Active participation in regular household production dialogues within savings, health or other self-help groups.	
Active participation in household production dialogues with different neighbor and peer networks.	
2. Nutrition	
Basic understanding that a balanced and diversified diet of protein, vitamins and carbohydrates is important for a families' nutritional security.	
Presence of a household nutrition garden with at least three different nutrient-dense, multi-colored vegetables (orange, yellow and dark-green).	
3. Land	
Effective utilization of a variety of different household assets, materials and resources in household's agriculture and gardening, including water, animals, manures, fruit, timber, fuel wood, fodder, compost, etc.	
Presence of a household garden with cash and food specific crops.	
Presence of double dug garden beds.	
Effective making and utilization of compost (to condition and fertilize soil) made with green material, dry brown material, manure and water.	
Effective mulching of plants (to hold moisture and provide nutrients), with Dried or fresh leaves, dried grass, banana leaves, rice straw, coconut	
Effective utilization of a variety of soil amendments, including wood ash from cooking area, charred crop residues/remains such as rice husks, dry grasses or crop waste (rice straw), fresh or dry animal manure, green leaves from leaucaena, glyricidia, or neem	

trees, etc.	
4. Water	
Effective utilization of waste water (from bathing, cooking, and hand washing, etc.) for garden irrigation.	
Presence and effective utilization of a variety of different water storage and catchment devises, including roof gutters, water pots, etc.	
Presence and effective utilization of simple, permanent, water-holding berm and swale. Is berm planted with local perennials?	
5. Plants	
Effective utilization of vertical space to grow different varieties of climbing plants (such as passion fruit, cucumber, yard-long bean).	
Effective growing of a diverse variety of crops:	
Improve Soil Fertility: beans, climbing and bush	
Improve drought Tolerance: orange sweet potato, chilli pepper	
Use limited soil area: passion fruit, , cucumber, climbing bean	
Attract beneficial insects: flowering plants and shrubs	
Build nutrient density: colors: green, yellow, orange, red	
Increase marketability: based on market survey of local needs	
Effective utilization of triangular spacing in garden beds.	
Effective utilization of staggered plant timing techniques.	
Effective utilization of homemade, organic, liquid plant fertilizer.	
Effective utilization of botanical pest control techniques.	
Effective utilization of physical pest control techniques.	
Effective utilization of cultural pest control techniques.	
Effective knowledge and utilization of basic Leaf-Fruit-Root-Legume crop rotation plan.	
Effective utilization of simple post-harvest handling techniques.	

General Observations and Comments

Signature of Project Staff Conducting Site Visit	

Notes and Contacts: