Okumura Farm: Self-Resiliency Recommendations

Self-Resiliency Consultancy by

Permaville Consultancy Group

in partnership with WWOOF, Thailand and Okumura Farm

30 April 2014

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Foreword

This document is the result of a two day visit to the site of, Okumura Farm. We were invited by our friend and Permaculture professional, Howard Story, to conduct permaculture design for the future site. The site is a small steeply sloped land. Although much of it is in a mildly degraded state with exposed clay due to burning, erosion and leaching of the soils, it has great potential.

We would like to thank everyone who made this possible. Our friend Howard for introducing us to this sustainable project, Yuki and Jon for their vision and desire for sustainability, variety and quality of life they strives to achieve and the wisdom to see that Permaculture is the best way to achieve these goals, sustainably. Last, but not least we would like to thank the entire community for being so hospitable and open.

In this project, Permaculture Design is being used to increase food production, enhance variety and restore landscape on the Okumura Farm site. The strategies, philosophy and ethics that Permaculture uses align well with these goals and values. We believe that adopting a Permaculture Design is going to be very easy and straightforward.

Although, as is inherent in all land-based design, what we set forward in the following pages will have to be changed as circumstances and needs dictate, that said, we believe this document will supply you with a solid start to a more self-reliant future. Please make any changes with the same passion, enthusiasm and thoroughness we have used in these recommendations.

Sustainability Recommendations for Okumura Farm

The following is a list of recommended action steps for Okumura Farm, to help the systems run effectively, efficiently, and sustainably in the future, while incorporating Permaculture principles. These recommendations come after a **two day visit from Permaville Education and Consulting Services** as well as conversations with the founder and community.

This report has been laid-out, first with an overview of Permaculture, its ethics and principles. It then moves into a generalized list of observations and recommendations. More detailed technical information regarding the implementation of these recommendations will be provided later in the report.

This is a basic document. It is focused on what Okumura Farm expressed as desires and priorities. It is unreasonable to expect to find all your answers here. Although we have introduced many ideas here, it will be necessary to do additional research for sections with less detail.

Please take this document as recommendations, only. You may choose to implement, ignore or alter anything in this document to fit your needs and/or desire.

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Permaculture

Permaculture is a **systematic design science** developed by Bill Mollison and David Holmgren. It aims at assisting people to become more self-reliant, through the design and development of productive and sustainable gardens and farms. It is the conscious design and maintenance of cultivated ecosystems which have the diversity, stability and resilience of natural ecosystems. Through harmonious integration of landscape, people and food production; it provides shelter, energy, food and other needs sustainably. It is a philosophy and approach to land use which works with natural rhythms and patterns, rather than against. The permaculturist aims at plugging energy leaks through the application of permaculture principles and strategies while leaving the earth richer than he found it.

In Permaculture, **three ethics and twelve design principles** are used to guide us through the design process and to remind us of the importance of holistic and conscious design.

Ethics

1. Earth Care - The Earth is a living, breathing entity. Without ongoing care and nurturing there will be consequences too big to ignore.
2. People Care - If people's needs are met in compassionate and simple ways, the environment surrounding them will prosper.
3. Future Care - We are provided with times of abundance that must be used to create a better world for the next generation.

Design Principles

1. Observe and interact - By careful observation and thoughtful interaction, we look at nature for inspiration in our designs.
2. Catch and store energy - By developing systems that collect resources and store them long-term, we create resilience and true wealth.
3. Obtain a yield - Ensure that you are getting useful rewards as part of the work you are doing.
4. Apply self-regulation and accept feedback -
5. Use and value renewable resources and services - Make the best use of nature's abundance to reduce our consumptive behavior and dependence on non-renewable resources.
6. Produce no waste – Closing loops on site and value every resource, nothing goes to waste.
7. Design from patterns to details - By zooming out, we observe patterns in nature and society. These patterns form the backbone of our design. Why reinvent the wheel, if nature has been fine-tuning her systems for billions of years.
8. Integrate rather than segregate - By studying relationship between elements, permaculture aims to design integrated solutions to problems.
9. Use small and slow solutions - Small and slow as an alternative to big is better. By working locally and growing slowly, we are able to work more efficiently, naturally and sustainably.
10. Use and value diversity - Diversity reduces vulnerability to a variety of threats and takes advantage of the unique nature of the environment in which it resides. Diversity equals stability.
11. Use edges and value the marginal - The interface between things is where the most interesting events take place. These are often the most valuable, diverse and productive elements in the system.
12. Creatively use and respond to change - We can have a positive impact on inevitable change by carefully observing, and then intervening at the right time

Observation and Survey

It looks as though there has been extensive burning on the property, leaving the soil victim to erosion and direct sunlight. The property is above a valley running, approximately, south to north. Much of the surrounding area is community forest and national preserve.

Geography

- Altitude Samoeng = 2,266 m
- Climate = Tropical

Climate

Okumura Farm is located near Samoeng, Thailand approximately 30 Km West of Samoeng with an altitude of 2,266 m. It experiences a tropical climate; with an **Average rainfall of southern Thailand is about 2,400 mm**, with the rainy season being between July and October with very heavy, short rains. It has a mild and dry season from November to February and it's warm season spans from March to June. Average temperatures range **from 25 °C - 40 °C**, and receiving no frost, with the historic **record low being 5 °C.**

Plant species

Due to the poor compacted soils, most natural occurring plants observed on Okumura Farm are **hardy pioneer species**. Much of the south end of the property is exposed slope with sparse, but mature trees and an abundance of pioneer shrubs. Lush green vegetation grows all around. **Jackfruit, Large Mango, Bamboo, Banana** and **Tamarind** are all present near the property and seem to be very healthy. Various edible roots and shrubs were observed plentiful in surrounding villages. Located around the local are some marsh areas that have **cattails, taro** and a few other marsh species. Any available species should be generously transferred to your pond.

Soil

Most of the sloped land has some degraded topsoil. Much of the area has been stripped of precious topsoil due to burning and erosion. The farm needs to rapidly combat soil compaction and erosion and deal with the lack of topsoil in order to create a sustainable habitat for humans, animals and plants.

The first step towards breaking the soil compaction and bringing more fertility to site is through the growth of a **green manure**, turned back into the soil. To do this, we recommend a combination of nitrogen fixing ground covers and **deep rooted dynamic accumulators** anywhere there is bare compacted soil. In addition to that, **guilds** should be planted around the fruit trees to stop the need of digging and create self-maintaining and fertilizing systems. Finally, we suggest **planting nitrogen fixing trees and shrubs** to replace the need of external fertilizers. Additionally, these plants can be used to replace elephant or cattle manure in the compost piles.

It is recommended for the heavy use of **mulch** in the exposed areas, where planting is taking place. This will reduce the need to water by up to 50% and reduce the need of digging around the desired species to weed. This will prevent the soil from continually drying out.

By incorporating composting strategies and techniques, such as **rapid thermophilic composting** to be used in the vegetable garden and **long term composting** for the fruit orchard, you will rapidly build topsoil and improve the overall health of your ecosystem. A realistic strategy is provided. In addition the supplemental **application of liquid fertilizers** provide readily accessible nutrients and promote microbial soil life.

Food

Although there is currently a little managed food growth on site, the presents of large, healthy and mature fruit trees and edible perennial greens shows that much more food growth is possible. The farm needs to focus on growing more nutritious and diverse foods. By diversifying the yield and expanding the diet of the community, it will positively benefit the health of the community members as well as the entire eco-system.

By appropriate seasonal planting and the use of **perennials**, adapted to a seasonally dry climate, Okumura Farm can produce a much wider variety of food. In addition to that, **water conservation strategies** such as **drip irrigation** and **terracing** are important to minimize human input and allow a production of year round food.

It is recommended using **high quality compost** (produced on site) and **liquid fertilizers** (produced on site) to provide all of the long term nutritional needs of the garden and food forest.

Applying organic gardening techniques will solve many agricultural problems that may face Okumura Farm. We suggest the use of **crop rotation, aggressive soil building techniques, companion planting** and the use of **tree guilds** to ensure a healthy and food production. These techniques will also help with the planning and maintenance of your garden. To stop the use of pesticides, we advise **integrated pest management** in combination with the use of **homemade organic sprays** when necessary.

Water

We observed that the kitchen **grey water** may be difficult to use efficiently, but it could be drained back into the land for the benefit of plants and trees. At the very least, planting should be done wherever water is "dumped". Most other water waste, such as shower and basic hygiene, may be drained into small, bio-diverse ponds or to irrigate the gardens directly; thus help you to grow food all year round with little human maintenance.

A series of **terraces** is recommended to capture rainwater on the slope of your fruit orchard and vegetable garden. These terraces will capture all available rainwater during the rainy season and help to raise your water table.

Catching and storing rainwater for the purpose of drinking or watering is also a recommended technique.

By applying water conservation strategies, you can use the available water in the dry season more efficiently. We also recommend **drip irrigation** and **hugulkultur**.

Sanitation

The treatment of human waste is a concern for any sustainable living community. The application of raw human excrements is illegal under international law, a health hazard and dangerous for the natural environment. The use of raw night soil or improper disposal of human waste will scare foreign visitors away as well as prevent Okumura Farm from using all its waste resources to their maximum benefit. This document recommends multiple safe and beneficial solutions.

A **biogas toilet** would "cure" the human waste, making it safe to compost or apply directly to trees, while producing cooking and/or heating gas. Since the existing toilet is relatively close to the kitchen and can be easily converted, this would be an ideal solution. For a simpler, cheaper option, we advise the use of **human compost toilets**. Although it is cheaper, it does not produce as many benefits, but it will also allow for the safe use of human waste in compost or directly to trees.

Animals

The benefits of increasing and attracting biodiversity on the property will yield startling benefits to humans and the eco-system. Okumura Farm should focus on attracting and maintaining the wellbeing of wild species as well as introducing more domestic animals, such as chickens. This will provide healthy, thriving eco-system as well as organic eggs, meat and fertilizer for the community members.

Chickens can be put to use and perform symbiotic functions that benefit both chickens and humans. Chickens can be difficult to control. Incorporating a "chicken tractor" or bamboo cage into your vegetable gardens will serve multiple functions. It allows you to control and limit the chickens' access within the garden. Additionally, it will reduce human intervention in the garden by minimizing the need for weeding, digging and watering.

Appropriate technology

The objective is to reduce the impact on the environment and improve health and standard of living through the application of appropriate technology.

After observation of the solar-electric system, we feel this is a good way to receive power. Although, the use of compact florescent bulbs robs the system of power, it is recommended to convert to more modern, efficient and longer lasting LED, when appropriate. It is also recommended to implement some type of solar hot water heater to the shower system. This will increase the over-all quality of life.

It is recommended to implement the use of a rocket stove for cooking, whenever possible. They are extremely simple to make and are far more efficient, cleaner and healthier cooking.

Goals of the project

Mission statement

"To grow virtually all food needs on site while significantly increasing food diversity by applying permaculture design principles to mimic natural systems in order to create low-maintenance, high yielding perennial polycultures."

Key Functions of the design

1. Greater Food Production and Variety
2. Building Soil
3. Sanitation
4. Animal Maintanance

System Design

The design laid out has been created keeping in mind the context, parameters, and limiting factors of Okumura Farm. The design as proposed is only a starting point, how it will eventually be implemented will only be seen in the years to come. Our hope is that the information and guidance below, helps to plant seeds of inspiration and turn this land from a semi-degraded, less productive, state into pure abundance and variety.

Self-Resiliency Recommendations

Part One – Gardening and Food

Edible Landscaping and Perennial Plants

In order to minimize labor, incorporate long living species in agricultural systems to eliminate repeat planting and maximize output. By **incorporating perennial plants** into your landscaping, as well as agriculture, you will receive many **benefits**.

- Provide **food all year long**
- Live for multiple years
- Are **drought resistant** (need less water) because they have deep root system
- Diversify your diet (perennials have different levels of nutrients than annual plants)
- Healthier, due to their deeper root system, they are able to mine nutrients and minerals from the subsoil
- Can be used as support species for your annual vegetables
- **Stop soil erosion** with deep root system
- Hold soil nutrients and stop leaching into groundwater
- Prevent weeds and the need for herbicides
- **Require very little maintenance from humans**

*****Perennial plants are one of the most important applications of Permaculture and should be planted as many places as possible with as many species as possible.** ****

Edible Landscaping of perennials

By planting perennial grasses and plants with deep root systems, they will require little maintenance, inhibit erosion, be drought resistant and look beautiful. Defining walkways and paths using any number of perennial plants such **as New Zealand spinach** or a wonderful spice like **cuban oregano**, and filling less traffic areas with **sweet-leaf, chicken spinach or sweet potato** (its leaf is also edible), lastly, replacing traditional potted plants with edible plants, like **Okinawan spinach**, *(Gynura bicolor, hongfeng cai*) or **Perennial cilantro** *(Eryngium foetidum).* By creatively implementing these strategies will allow you to fill every square meter of your property with aesthetically pleasing food, while supplying absolute abundance.

Examples of perennial plants

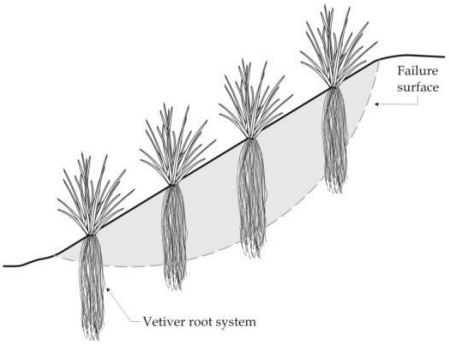
- Garlic chives (*Allium tuberosum*)
- Asparagus (*Asparagus officinalis*)
- Chinese arrowhead (*Sagittaria sinensis*)
- Malabar spinach (*Basella alba*)
- Sweet potato (*Ipomoea batatas*)
- Cuban oregano (*Plectranthus amboinicus*)
- New Zealand spinach (*Tetragonia tetragonioides*)
- Cassava (*Manihot esculenta*)

Example of edible landscaping - Purple Okinawa spinach, Cuban oregano, sissoo spinach, true oregano, marjoram, sage, thyme, lovage(a perennial celery substitute), Vietnamese coriander, lemon verbena, spearmint, apple mint, chocolate mint, orange mint, perennial cilantro, nasturtium, comfrey, aloe vera, yarrow, garlic chives, bunching onions, basil, cranberry hibiscus, feverfew, ti, coleus and several other ornamentals.

For a wider variety of species see **Appendix 2** and ***ask locals*** about what they have growing, visit local nurseries and botanical gardens as well as Mae Jo University in Mae Joe, Chiang Mai district. It is a public university in Thailand with the primary teaching subjects related to agricultural science. There are also an abundance of organic and sustainable projects throughout Thailand, like the ***Panya Project*****, Pun** ***Pun*** and the ***Mindful farm*** *(*very near Okumura Farm). These organizations are great resources for local, organic seeds and cuttings

Contour plantings of perennials

By planting perennial grasses and plants with deep root systems on contour, erosion on the steep slopes will be strongly reduced. Examples of plants that are very suitable for reducing soil erosion on steep slopes are vetiver, lemon or citronella grass.



For a **complete list of perennial plants** suitable to your climate please see **Appendix 2**

Companion Planting

The aim is the planting of different crops in proximity so they assist each other in nutrient uptake, pest control, pollination, and other factors necessary to **increase crop productivity**. This will make the orchard and vegetable garden **more resilient and strong**.

It is important to move towards a more diverse polyculture of plants in all areas of Okumura Farm, where every plant fulfills multiple functions and contributes towards the wellbeing of the ecosystem. These plants are often dynamic accumulators, nitrogen fixers or aromatic herbs and they store nutrients in their leaf matter and roots. **See appendix 1 for a companion planting guide**.

Integrated Pest Management

Confuse potential pests using Permaculture techniques. Plants may be planted at the end of each garden bed or in between rows. Highly scented herbs and foliage will helps to repel pests.

Examples of different species suited for insect repellency:

- Marigolds
  Excrete substances in roots which companion plants pick up via the soil, helps to repel pests
- Nasturtium
  Deters aphids and squash bugs

-Companion to radish, cabbage, and curcubits

Allium family	*Lamiacea family*
- onion	- mint
- garlic	- basil
- chives	- rosemary

Gardens

Contour Gardens

Design

Contour gardens have been designed in or near living areas. These will be raised annual garden beds and may be placed on contour. The placement of garden beds on contour has many advantages:

- Paths act as small swales
- Paths act as slow release nutrient composting areas (organic matter from garden thrown in path)
- Contour placement stops erosion in beds
- Reduces surface runoff of water

Raised beds should be designed due to degraded, compacted and high clay content soil.

Raised beds allow:

- Increased growing space and microclimates (vertical edge of beds)
- No soil compaction as beds and paths clearly defined
- Ideal soil structure can be created, with the addition of compost and other organic matter.
- Increased drainage over natural clay soils

These two techniques have been combined to create the highest yielding, lowest maintenance system possible, given the available resources and specific site conditions.

Implementation

If garden areas are not flat, **contour lines** should be found to create overall “shape of garden”. Beds should be 1.5 m wide, to allow easy reach and harvest of all parts of garden from either side.

The garden beds themselves can be created through double digging or mulch layering techniques mixed with large amounts of compost. Double digging alone will not be enough as the soil has very high clay content and has very low levels of organic material. Bacterial dominated compost, such as generated from thermophilic composting, should be used.

Double digging involves removing the top soil layer, exposing the subsoil or hardpan beneath, breaking it up, adding organic matter, and replacing the topsoil that was initially removed. Double digging allows roots to reach deeper into the earth, where better-draining subsoil makes it less likely they’ll become water-logged or oxygen-deprived. Deeper roots mean plants don’t have to be watered as often. And more plants can grow in the same area because they don’t have to rely on the topsoil alone for moisture and nutrients.

How to make

1. Begin at one end of the bed and dig a spade-head depth (approx. 12" deep or 30cm) trench across the bed's width, placing the excavated dirt off to the side (or in a wheelbarrow)
2. Work a garden fork into the floor of the trench, and loosen the soil by tilling this layer too. Continue until the soil at the bottom of the trench is loosened.
3. Dig a second, similar-size trench directly next to the first. Place the excavated soil into the first trench you dug. Mix soil with equal amount compost to create raised portion.
4. Loosen the soil at the bottom of this second trench with the garden fork as well.
5. Dig a third trench next to the second trench. Backfill the second one + mix compost, loosen the bottom of the third trench, and continue this process until you have tilled the whole bed.
6. Fill the LAST trench with the soil excavated from the first. (The soil in the wheelbarrow)

Sheet Mulching or Lasagna Garden

Sheet mulching is highly recommended for its ease and organic benefit. Sheet mulching is a no-dig gardening technique that attempts to mimic natural forests' processes. When deployed properly and in combination with other permaculture principles, it can generate healthy, productive, and low maintenance ecosystems.

How to make

1. Flatten desired area by trimming down existing plant species such as grasses.
2. The soil is moisturized to facilitate the activity of decomposers.
3. The soil is then covered with a thin layer of slowly decomposing material (known as the weed barrier), **typically cardboard**. This suppresses the weeds by blocking sunlight, adds nutrients to the soil as weed matter quickly decays beneath the barrier.
4. A layer of Manure may be added.
4. A layer (around 10 cm thick) of weed-free soil, rich in nutrients is added.
5. A layer (at most 15 cm thick) of weed-free, woody and leafy matter is added, often straw, in an attempt to mimic the forest floor. The soil is now ready to receive the desirable plant seeds.

These are just "suggested" layers and materials. Do not concern yourself too much with the order or amounts. If you put it on the ground, it will decompose

Nursery

A nursery is a controlled environment that allows you to monitor growth and health of young plants. This controlled environment gives you the advantage to plant in a continuous cycle and extending your growing season. A shaded location with good water access is ideal. In Okumura Farms case, using the space under the main house may be ideal.

Potting Soil

Just as creating a healthy soil environment is crucial for your ecosystem plants, providing a suitable soil for your potted plants is a key factor to success. Most gardeners do fine with bagged container mixes available at the nursery, but these one-size-fits-all options might not be the best options, especially if you are growing plants with specific soil needs.

Making your own container soil might sound like a lot of unnecessary work, but it can improve your plants' performance. And because these mixes have the optimal amount of nutrients and proper drainage, they reduce the amount of time you spend feeding and caring for your containers.

The recipe below is for starting seeds, it is also the base for other homemade potting soil that can be used in raising vegetable seeds and seedlings.

A seed starting mixtures is very basic and only need to contain;

1 part coconut coir fiber

- 1 part compost or vermiculite
- Water to moisten

Seed Saving

Hybrid varieties do not always breed true to type. The seed from last season's mammoth tomatoes may only produce scraggly plants bearing tiny red buttons the following season. To avoid this problem, always start with standard (or heirloom) vegetable varieties, or stick with hybrids that you know will breed true.
Second, if you plant two or more standard varieties of corn (squash, tomatoes or any flowering vegetables) you're likely to have crosspollination by wind and/or insects. This results in an uncertainty of your seed quality.

These particular steps are describing a “wet” or fermenting process, but the “dry” process is similar. It is also recommended that Okumuri Farm consult local residence for tips and advice on how they save their particular seeds, or propagate a particular plant. No other technical resource may be as helpful.

Step #1: Choose Seeds

Save seeds from “open pollinated” (OP) or heirloom plants. These varieties are true to their type from their own seed, which means the next season’s plants maintain the same characteristics as they previous one. Hybrid plants, on the other hand, are bred from two parents of different varieties. Because of that, it’s questionable whether or not they produce seeds that keep their characteristics from season to season. **Select your tastiest and healthiest heirloom from which to save seeds.**

Step #2: Extract Seeds

- With a spoon or your finger, scoop out seeds. Place them in a bowl, cup or jar. Reserve the remaining tomato to eat fresh or use to make salsa.
- Add enough water to the seeds and pulp. Stir the mixture to loosen the pulp from the seeds.
- Cover the container with cheesecloth. If using a jar, punch holes in the lid or don’t screw it on too tightly. Air circulation helps fermentation. Fermentation causes air to expand. A tightly-fitted lid on seeds could make the container explode during fermentation.
- Label the container with the name of the variety. Don’t trust your memory!
- Set the container in a warm, protected area, such as on top of the refrigerator or dehumidifier. The ideal temperature for fermenting seeds is 70º-80º F. Try to avoid drafty areas. If your house is cool, or you can’t find a warm area, seeds will still ferment but the process may take a day or two longer.

Step #3: Ferment Seeds

The key to this step is careful observation. Watch closely to note when fermentation begins.

- Each day, remove the covering from the container. Stir the seed liquid. Replace the cover. Set the container back in its warm area. Repeat for 2-7 days (on average 4-5 days), depending on the temperature of your house and the area in which seeds are placed to ferment.
- As the mixture ferments, it will turn darker and emit odor. Look for three additional signs of fermentation:
    1. seeds separate and sink to the bottom of the cup as you stir

2. A white, foamy mold will form on the top. The mold is harmless to the seeds. In cooler temperatures, mold may not form.
3. bubbles start to rise to the top of the container

Fermentation helps dissolve the gel casings around the seeds.

- Remove seeds from the liquid as soon as fermentation begins. If you allow seeds to stay in the liquid as it ferments, they may begin to sprout. Warm, wet conditions in the jar are perfect for sprouting seeds – a development you want to avoid when saving seeds.

Step #4: Rinse Seeds

There are three purposes to rinsing: you want to stop the fermentation process, separate the pulp from the seeds, and separate the good seed from the bad. Take these steps to properly rinse tomato seeds.

- Remove foamy mold from top of container.
- Rinse seeds. Add water to fill the container. Stir the mixture several times and then wait about 10 seconds. Good seeds will sink to the bottom of the container; bad seeds will float to the top. Pour off the liquid and bad seeds.
- Repeat the rinsing process as many times as you need until all pulp, mold, and debris is rinsed from the seeds, all remaining seeds have settled to the bottom of the cup, the water is clear, and no seeds float to the top of the cup. It's important to continue to rinse the seeds in the container in order to separate out bad seeds as they float to the top.
- When seeds are thoroughly rinsed and sorted in the container, pour them into a thin-gauged wire mesh sieve to wick out remaining water.

Step #5: Dry Seeds

After rinsing, monitor seeds carefully to make sure they dry thoroughly before you store them.

- Stir and dry: spread rinsed seeds in a single layer on a paper plate, glass dish, mesh screen placed over a plate, parchment paper, waxed paper, or coffee filter to prevent sticking. Avoid drying seeds on ceramic, metal, or plastic, which don't breathe and don't allow water to wick away from seeds. Label each tomato variety.
  You can also save seeds on paper towel to save time and produce your own seed tape.
- Set seeds in a warm area to dry, away from direct sunlight. The top of a refrigerator works well.
- Shake plate or stir seeds daily to prevent clumping and allow even drying. Spread seeds in a single layer after stirring. When seeds are exposed to air, they dry quicker.
- Seeds will dry in 1-2 weeks.
- Seeds have difficulty drying in high humidity and high temperatures. If exposed to those conditions during the drying process, wet seeds may sprout.
- Do not heat seeds as they dry. Never place them in an oven.

Step #6: Store Seeds

- Store dry seeds in either paper envelopes or zipped plastic bags.
- Make sure seeds are 100% dry before storing them, especially if using plastic bags. Otherwise, extra moisture will be locked into plastic bags and spread to all seeds, allowing mildew and rot to spread and ruin the whole batch.

- Add silica gel packets to saved seed bags as an additional moisture deterrent and to increase shelf life.
- Label seeds with variety and date.
- Store seeds in a cool, dry place. Many gardeners store tomato seeds in the refrigerator or freezer.

Soil Building

Due to the semi-degraded state much of the land is in, a combination of multiple permaculture strategies and techniques will be necessary to build soil at Okumuri Farm. Building soil has to be an absolute priority during the implementation of the design. When compared to burning unwanted material or simply mixing raw manure into soil, composting is far superior.

Burning kills many beneficial soil organisms, adds stress to your system and leads to air pollution and many health related problems as well as fire hazards. Moreover just adding manure to your soil is an inferior technique for building the healthiest soil. Composting makes the soil rich and fertile which can be used to grow healthier and more productive plants.

Techniques

Composting

In a compost pile, **microbial life transforms organic material and waste products into soluble plant nutrients**. By making high quality compost, it is possible to recycle nutrients, add life to the soil and increase the soil fertility. It is highly recommended to combine multiple different ways of composting, thereby meeting different needs. (i.e. long term compost pile, thermophilic fast compost pile, compost toilet, earthworms,..)
Although there are many different techniques of composting, they all require 4 components.

- Carbon: for energy
- Nitrogen: for microorganism reproduction
- Water: for habitat
- Oxygen: for respiration (some composting requires the lack of oxygen)

Thermophilic 'HOT' compost pile

One of the fastest ways of composting, this method harnesses the power of microbial bacterial to break down the organic material. The most famous example of a thermophilic compost is the **Berkley 18 day compost**. This method should be used when compost is required quickly. Thermophilic compost is best used for annual plants, such as in the vegetable garden or around flowers.

The advantages are:

- Rapid decomposition
- Kills the pathogens and weed seeds in the compost pile (pile must reach 65 degrees Celsius for 72 straight hours)
- High quality compost

How to make a 18 day Berkley Compost
The following steps describe in detail how to make a 18 day compost on site:

- Build pile by alternating layers of:
    - Carbon / Nitrogen
    - Layers should be around 10 cm thick

- Pile size should be no less than 1 cubic meter (i.e. 1 m x 1 m x 1 m) and no bigger than 3 cubic meters
- Total components should be:
    - 55% Carbon
    - 45 % Nitrogen
    - All components should be smaller than 2 cm thick (thinner than a finger)

- The smaller your materials the quicker your pile will break down
    - If using food scraps put in the middle (to stop smell)
    - Inoculate with a handful of finished compost or forest soil

Optional : add supplements

- Dynamic accumulators
    - Comfrey, Nasturtium, Dandelion, ..
- Effective Microorganisms (EM) solution
- Rock dust (from nearby rock quarry)
- Egg shells

- **Flip the pile to keep aerated (oxygen)**

- Day 4 – 6 – 8 – 10 – 12 – 14 – 16 – 18
- When flipping check water content -> Squeeze test (should get 1 drop of water on palm)
- When flipping check temperature -> first few days(day 2-6) should heat up to between 50 degrees Celsius and 65 degrees, then slowing cooling down over next two weeks. Days 6-16 should be around 40 degrees.

- Compost is finished when:
    - Pile cools down to room temperature
    - It smells like forest
    - Individual ingredients can no longer be recognized

Long term 'STATIC' compost pile

Where thermophilic composting relies primarily on bacterial activity, static composting uses both bacteria and fungi to break down organic material. This composting method uses time to kill pathogens as opposed to heat, and provides good fungal dominated compost to be used around perennial plants (fruit trees, ornamental trees). The building process is the same as for a thermophilic compost, except that it is not flipped. Larger materials can also be used within this system as they have a longer time to break down (including large tree branches). Long term compost piles should be a minimum of 1 cubic meter and no larger than 3 cubic meters. **Many piles can be constructed throughout the Okumura Farm property to provide continuous compost close to where they are needed.**

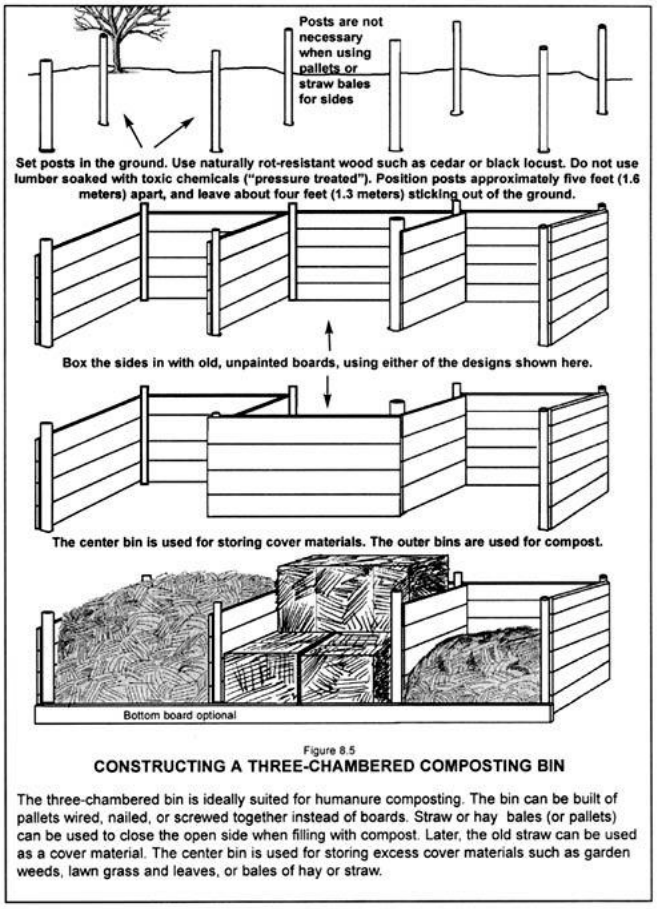


Figure 8.5
CONSTRUCTING A THREE-CHAMBERED COMPOSTING BIN
The three-chambered bin is ideally suited for humanure composting. The bin can be built of pallets wired, nailed, or screwed together instead of boards. Straw or hay bales (or pallets) can be used to close the open side when filling with compost. Later, the old straw can be used as a cover material. The center bin is used for storing excess cover materials such as garden weeds, lawn grass and leaves, or bales of hay or straw.

Troubleshooting Compost Problems

Symptom	Problem	Solution
Pile is wet and smells like a mixture of rancid butter, vinegar, and rotten eggs	Not enough air	Turn pile
	Or too much nitrogen	Mix in straw, sawdust, or wood chips
	Or too wet	Turn pile and add straw, sawdust, or wood chips; provide drainage
Pile does not heat up	Pile is too small	Make pile larger or provide insulation
	Or pile is too dry	Add water while turning the pile
Pile is damp and sweet smelling but will not heat up	Not enough nitrogen	Mix in grass clippings, food scraps, or other sources of nitrogen
Pile is attracting animals	Meat and other animal products have been included	Keep meat and other animal products out of the pile; enclose pile in 1/4-inch hardware cloth
	Or food scraps are not well covered	Cover all food with brown materials such as leaves, woodchips, or finished compost

Okumura Farm might also opt to use this composting method to process human manure into high quality compost. For more information see “Humanure Handbook”, by Joseph Jenkins.

Mulching

To improve soil structure, health, and water retention through the application of mulch is imperative. Mulch is the application of organic material on top of the soil.

The benefits of mulching are:
- Temperature regulation
- Moderate moisture content
- Suppression of weeds
- Improve soil aeration
- Improve soil structure
- Habitat creation
- Slow release nutrients to the topsoil
- To enhance the visual appeal of the soil

Because mulch breaks down, the continual application of it is necessary. Mulch should be reapplied in the vegetable garden as soon as bare soil starts to poke through, or every time a garden bed is replanted. In the orchard and around ornamental plantings mulch should be applied 1 month before the onset of the rainy season, and reapplied 1 month before the end of the rainy season. Mulch should generally be applied 5 – 10 cm thick. If mulch is applied too thickly it will continue to suppress weeds, but can lead to some fungal disease and inhibit the soil from properly breathing.

Site specific resources

This is a list of internal and external resources; many of these have already been observed or will be produced on site in the future. There is probably many more, so this list should definitely be kept up to date. As the seasons change, many mulch materials change with availability.

Current internal resources
- Leaf litter from trees
- Weeds without seed heads
-Tree pruning's
    The small green branches are not used for cooking
- Residue from vegetable garden
    Materials not suitable for composting or chicken feed, for example corn cobs
- Banana
    Trunk can be used as mulch in dry season due to its high water content (up to 95% water)
    Leaves can be used to suppress weeds

Potential internal resources
- Native pioneer species (for example leguminous trees, Leucenae)
- Permanent living mulch in the orchard system
    Covers the soil
    Low maintenance (does not break down and does not need to be reapplied)
    Can fix nitrogen
    Esthetically pleasing
    Possible species: Chinese milk vetch, clover, pinto peanut, sweet potato, strawberry

Potential external resources
- Rice straw / wheat straw
- Rice husks
- Elephant dung

Green Manures

Green manures are plants that are sown specifically to improve fertility. They are not harvested for food, and are either turned into the soil while they are flowing and before they set seed, or allowed to compost on the soil floor. Green manures are typically legume plants that fix nitrogen into the soil.

Green manures should be allowed to biodegrade on top of the soil in the food forest and natively reforested area in year one. Green manures have to be turned into the soil if there any agricultural fields Okumura Farm will be turning.

Growing green manures will:
-**Improve soil fertility** - legumes harvest nitrogen from the air through a symbiotic relationship with soil bacteria
-**Keep soil fertile** - mop up plant foods on empty land, so they are not washed out by the rain
-**Protect soil structure** - a cover crop protects the soil from damage by heavy rain
-**Keep down weeds** - smother seedlings and compete for light and plant foods
-**Help control pests** - provide safe cover for beetles, frogs and other predators
-**Stimulate soil biological activity** - microbes and other soil organisms rapidly colonize green manure foliage dug into the soil. Increased biological activity makes for a more productive soil.
-**Loosen the soil** - deep rooting green manures can help to loosen and aerate the soil deep into the ground
-**Protect soil life** - living mulch protects creatures in the soil from the extremes of weather

Recommended green manures
We recommend a mixture of **Sunhemp** (*Crotalaria juncea)* and **Cowpea** (*Vigna unguiculata)* broadcast as a cover crop in year one and two. Cowpea acts as the initial biomass, growing quickly during the rainy season, but dying back once the rainy season comes to a close. Sunhemp acts as the dry season cover crop creating 5 – 10 ton/ha of organic material in a single year. Sunhemp should be

broadcast generously. Cowpea should be broadcast generously, also. Cowpea seed is soft so germination is usually rapid if moisture and temperature are adequate. Estimates of fixed nitrogen from cowpea often range from about 50 to 100 kg/ha. These plants create the initial biomass needed to jumpstart the land from a degraded state to an abundant diverse ecosystem. They should be allowed to grow full term, not harvested, and allowed to return to the soil in place.

Bio Fertilizers
An at least quarterly application of liquid bio-fertilizer to the soil helps to boost the micro-organism diversity and numbers to give the entire system a jump start on their processes, as well as gives the entire ecology a health boost. The most important time to apply bio-fertilizer is at the beginning of the rainy season, but doing it at least once every three months would be very helpful (you cannot do it too often).

The benefits of making your own fertilizers include:
- low cost and low tech
- recycling an otherwise waste product
- providing nutrients in an easily accessed form (great for fast growing, leafy green vegetables).

Actively Aerated Compost Tea
Compost tea is an aerated solution that is teeming with billions of beneficial microorganisms that can be applied directly to the leaf surface of a plant as a foliar spray or used as a soil drench to improve root systems. Compost (full of beneficial microorganisms) is put into water and then nutrients or foods are added to allow the bacteria and fungi to multiply rapidly. Air is sent through the water to keep the water oxygenated. This puts the "good" biology where the plant needs it to protect itself. It keeps the plant healthier and helps it to fight off potential diseases. By using compost tea to replace chemical-based fertilizers, pesticides, and fungicides, you can garden safer and be more protective of the environment.

Advantages of compost tea
-Increases plant growth
-Provides nutrients to plants and soil
-Provides beneficial organisms
-Helps to suppress diseases
-Replaces toxic garden chemicals

How to make
1. Fill 120 L drum with clean non chlorinated water
2. Add 2 kg well-decomposed compost (compost should be pathogen free)
3. Add 2 cups of molasses
4. Bubble using fish bubbler for 18-24 hours
5. Spray within 4 hours of bubbler finished onto leaves and soil. Spray using backpack sprayer not previously used for pesticides or herbicides.

Complete bio-fertilizer mix
Bio-fertilizer uses an anaerobic fermentation process to secure vital minerals in bio-available form. In these bio-available forms, minerals are less susceptible to leaching and more available to plant roots than minerals just scattered on the ground. Bio-fertilizers are particularly important to help replace these highly mobile nutrients. A detailed soil test will help you determine what minerals might be in short supply and thus what ingredients are essential to add. Regardless the recipe, below is beneficial for all tropical soils.

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Ingredients:

- 20 sacs of soil
- 20 sacs of fresh manure (cow, horse, donkey, goat, sheep, or else)
- 20 sacs of chopped straw (no more than 5 cm)
- 1 sac of charcoal (small 2-3 cm pieces)
- 1 sac of wood ashes (no charcoal)
- 1 sac of rock dust
- 15 l of molasses
- 1 kg yeast
- 300 l water
- One 200 l plastic container
- 6 buckets (20 l bucket)

How to Make Compost Tea

Part 1

- Mix molasses in 20 lts of water
- Add yeast, dissolving it perfectly in the water (use your hands...mixing does not dissolve it)
- Once you have the molasses and yeast well dissolved in water, pour it into the 200 l drum and fill up with water (so you get a nice 200 lts batch of water+molasses+yeast)

Part 2

- Spread one sac of straw on the floor (making a 2 m diameter mat)
- Spread one sac of manure on top of it (making a 2 m diameter mat)
- Spread one kg of charcoal + one kg rock dust + one kg ashes
- Wet the above cake using 15 l water from your 200 l drum

From then on, repeat the operation in order to build up a "cake" made of layers as described above. Water content should be 50 %. To test water content, take handful and squeeze. One or two drops of water should be left on the palm of your hand.

Part 3

- Never add any more water
- Day 1-3: Flip the pile in the morning and evening, making sure all layers are mixed together (similar to process of a flipping thermophilic compost pile)
- Day 3-12: Flip daily
- After 12 days pile should be dry and cold...ready to be used!

This is very raw compost and should only be used to top dress around plants, or scattered around land to act as a bio-inoculant.

Weed tea

This "liquid gold" contains all the nutrients those weeds were taking/ and accumulating from your land; so you can return them to the soil by applying the tea. Many weeds are dynamic accumulators and thus have a higher percentage of nutrients than the soil they were growing in. The liquid can also
be added to compost heaps and used just about anywhere.

How to make weed tea

1. Fill burlap bag with weeds from vegetable garden and fruit orchard
2. Add bag to 120 L drum of non-chlorinated water
3. Add a stone to the bags so they do not float (bag should be completely submerged)

4. Let this soak for 4-6 weeks (until weeds have mostly decomposed)
5. Remove burlap bag and let water drain back into drum
6. Dilute this 10:1 (parts of water to weed tea)

Vermiculture

Vermiculture is the process of using worms to decompose organic food waste, turning the waste into a nutrient-rich material capable of supplying necessary nutrients to help sustain plant growth. This method is simple, effective, convenient, and noiseless. It saves water, energy, landfills, and helps rebuild the soil. The worms ability to convert organic waste into nutrient-rich material reduces the need for synthetic fertilizers.

The worms most often used, *Eisenia fetida* (Red Wigglers), are about 4 inches long, mainly red along the body with a yellow tail. These worms have a healthy appetite and reproduce quickly. They are capable of eating more than half their own weight in food every day.

Prepare the bedding for your worms. The bedding is the natural habitat of the worm that you're trying to replicate in your compost bin. Fill your bin with thin strips of unbleached corrugated cardboard or shredded newspaper, straw, dry grass, or some similar material. This provides a source of fiber to the worms and keeps the bin well-ventilated. Sprinkle a handful of dirt on top, and thoroughly moisten. Allow to soak in for at least a day before adding worms.
Feed your worms digestible amounts regularly - Worms need a steady diet of food scraps in order to stay healthy and produce compost. Feed your worms at least once a week. Worms eat fruit and vegetable scraps; bread and other grains; tea leaves; coffee grounds; and egg shells. Worms eat basically what humans eat, except they are much less picky!

- Over time, the bedding will be turned into nutrient-rich compost material by the worms.
- Avoid putting pine, redwood, bay or eucalyptus leaves into your bedding. Most brown leaves are acceptable in vermicompost, but eucalyptus leaves in particular act as an insecticide and will kill off your worms.

Maintain your bin - Keeping your bin elevated off the ground, using bricks, cinder blocks, or whatever is convenient will help speed composting and keep your worms happy. Worms are capable of escaping almost anything, but if you keep your worms fed and properly damp, they should not try to escape.

- Bedding to have the dampness of a wrung-out sponge.
- Add more cardboard, shredded newspaper, hay, or other fibrous material once a month, or as needed.

Harvest the compost once it's ready. After 3-6 months, you should have a fair amount of worm compost stored up in your bin. You might not be able to save every worm when harvesting the compost. That's okay; by and large, your worms have multiplied, and there should be plenty to continue composting.

- Move any large un-composted vegetable matter to one side. Wait a while giving the worms time to burrow into the center of the mound. Eventually you will end up with a pile of compost next to a pile of worms. After harvesting, use the compost.

Food Forest

A Food Forest is a permaculture term referring to **a perennial polyculture of multipurpose plants** designed with the aim of producing food, fodder, fuel, fertilizer, fiber, and medicinal plants. Forests are the climax expression of natural systems and once covered almost the whole earth. Today, forest covers only 29.3 % of the earth's land mass but holds 60-90% of the entire world's terrestrial (land-living) biodiversity. Food Forests seek to replicate the biodiversity and life sustaining systems inherent to natural systems while still producing goods for human consumption. Food forests differ from orchards, in that they are **complete functional systems** that at establishment **need no maintenance.** A food forest may not necessarily have all seven layers of a natural forest, but it does have multiple layers, and even more importantly, it is **a virtually self-sustaining living ecosystem.** In terms of *form*, the very thing that differentiates it from a two dimensional field of lettuce or any other monoculture is that it is **a three dimensional structure.**
In terms of *function*, being a **living ecosystem** gives it properties and attributes that are not present in agricultural systems and many gardens.

Design/Implementation

The intended food forest slopes down south-east with available water increasing towards the bottom. The tallest canopy species should be placed to the north with trees in descending height towards the south. Additionally trees with highest water needs are located to the south and the most drought tolerant species located at the top of the ridge.

All support species have medium to low water needs so that they do not compete for water with the larger fruit trees during the dry season. It is easiest for humans if the food forest is planted on a grid system with appropriate spacing between canopy species. This spacing is chosen to allow light filtration to the lower levels of the forest to encourage undergrowth species in the shrub, herbaceous and ground cover levels. The shrub and herbaceous levels will act as support species for the canopy fruit trees by creating organic material through leaf litter, deterring pests, attracting pollinators, and accumulating key nutrients. These nutrients will be cycled through the system as the shrubs drop their leaves and/or are chopped and dropped. These support species are necessary due to the degraded conditions of the soil and to encourage diverse biological life. All species should be chosen and located within the forest based upon light, water and soil needs.

We recommend sowing a **ground cover of perennial peanut** (*Arachis pintoi*) depending on seed quality and price, it should be broadcasted as generously as possible. Perennial peanut will act as a living mulch fixing nitrogen from the atmosphere, creating biomass, shading the soil, moderating soil temperature and creating a beneficial environment for the microorganisms of the soil food web. While broadcasting the ground cover seed, a mixture of **sunhemp** (*Crotalaria juncea)* and **Cowpea** (*Vigna unguiculata)* should also be broadcast as a cover crop. Sunhemp and Cowpea should be **broadcast generously.** Cowpea seed is soft so germination is usually rapid if moisture and temperature are adequate. Estimates of fixed nitrogen from cowpea often range from about 50 to in 100 kg/ha.

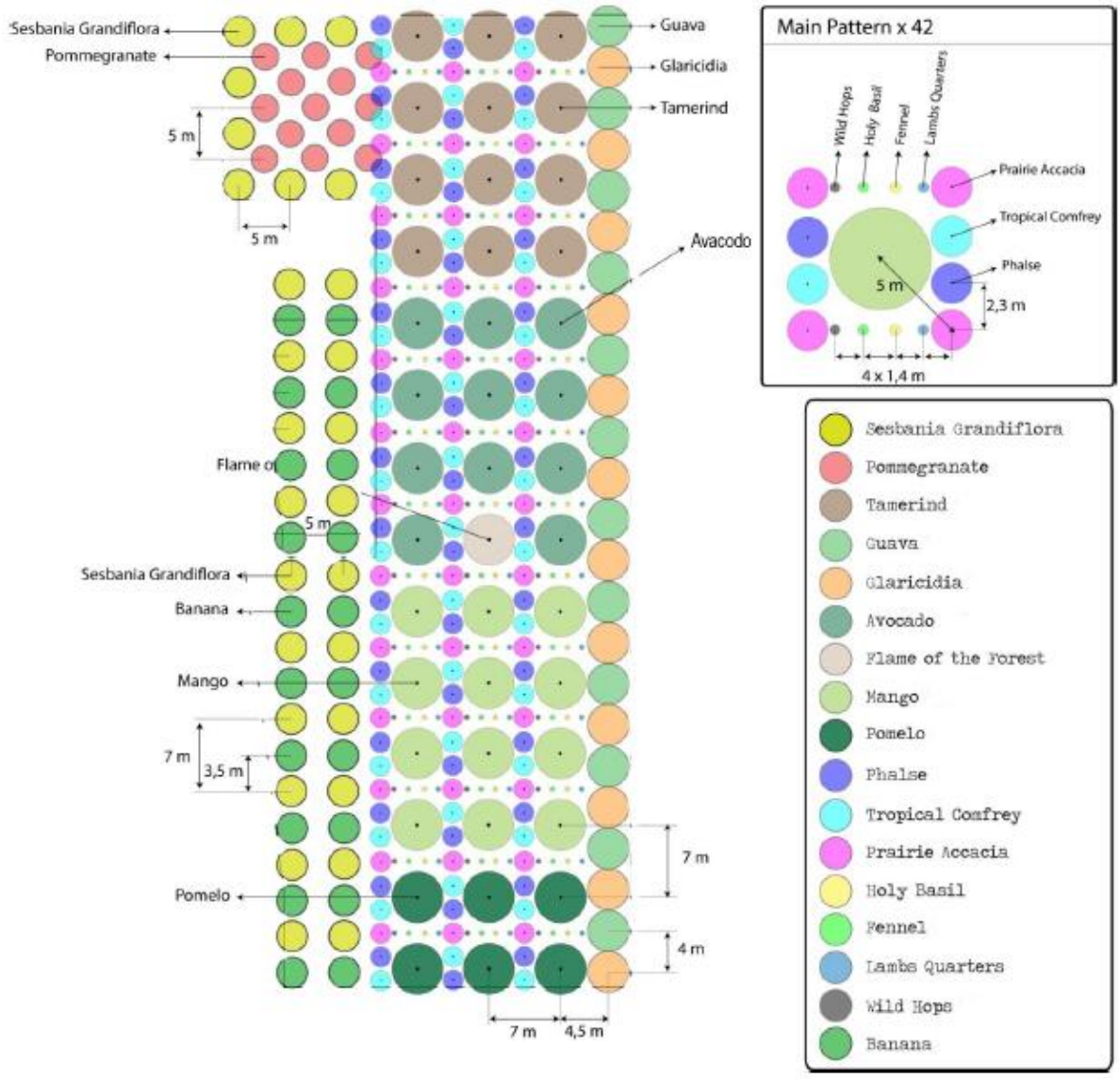
These plants will create the initial biomass needed to jumpstart the land from a degraded state to an abundant diverse ecosystem. They should be allowed to grow full term, not harvested, and allowed to return to the soil in place. Anywhere there are existing trees (not bamboo) within the newly designed area should, within reasonable attempts, be worked around. They can be used as trellises for a vertical climbing layer**.**

Passionfruit (*Passifloraedulis)* **Winter gourd** (*Benincasa hispida)* or **Vannilla** seeds should be planted 15 cm from the trunk of the tree and allowed to climb up canopy. This creates a secondary

yield from the previously existing trees without hurting the tree. When soil fertility has been built and the soil is less compacted **Turmeric** (*Curcuma longa) and* **Ginger** *(Zingiber officinale)* should be planted within the tree rows. As both crops are a root yield they will not compete with previously planted crops and require low levels of sun light, so can be planted underneath the tree canopies. This will diversify the yield and add stability to the system

Example Design 1

How a Food Forest at Okumura Farm might be designed on the south side, with the recommended list of species.



Species

Canopy

- Tamarind (*Tamarindus indica*)
- Avocado (*Persea americana*)
- Mango (*Mangifera indica*)
- Pomelo (*Citrus maxima*)
- Guava (*Psidium guajava*)

Herbaceous

- Holy Basil (*Ocimum tenuiflorum*)
- Fennel (*Foeniculum vulgare*)
- Lambsquarter (*Chenopodium album*)
- Wild Hops (*Flemingia macrophylla*)

Groundcover

- Pomegranate (*Punica granatum*)
- Banana (*Musa sp.)*
- Madre de cacoa (*Gliricidia sepium*)
  or another Legume
- Flame of the Forest (*Butea frondosa*)

Shrub

- Prairie Acacia (*Acacia angustissima)*
- Phalsa (*Grewia asiatica*),
- Tropical Comfrey (*Tithonia diversifolia)*
- Perennial Peanut (*Arachis Pintoi*)

Initial Cover Crop

- Sunhemp (*Crotalaria juncea)*
- Cowpea (*Vigna unguiculata*)

Management needs

Forest Gardens inherently need more maintenance in the first years of establishment than they do at climax. In the first dry season after planting, the fruit trees should be watered deeply once every month. The Pomelo trees need to have a **shade covering** to protect them during the first dry season; all other species are ok with full sun. All fruit trees have to be **pruned** as needed to create an open vase shape allowing adequate sun and wind penetration. Improper pruning will result in decreased fruit production and unhealthy trees.

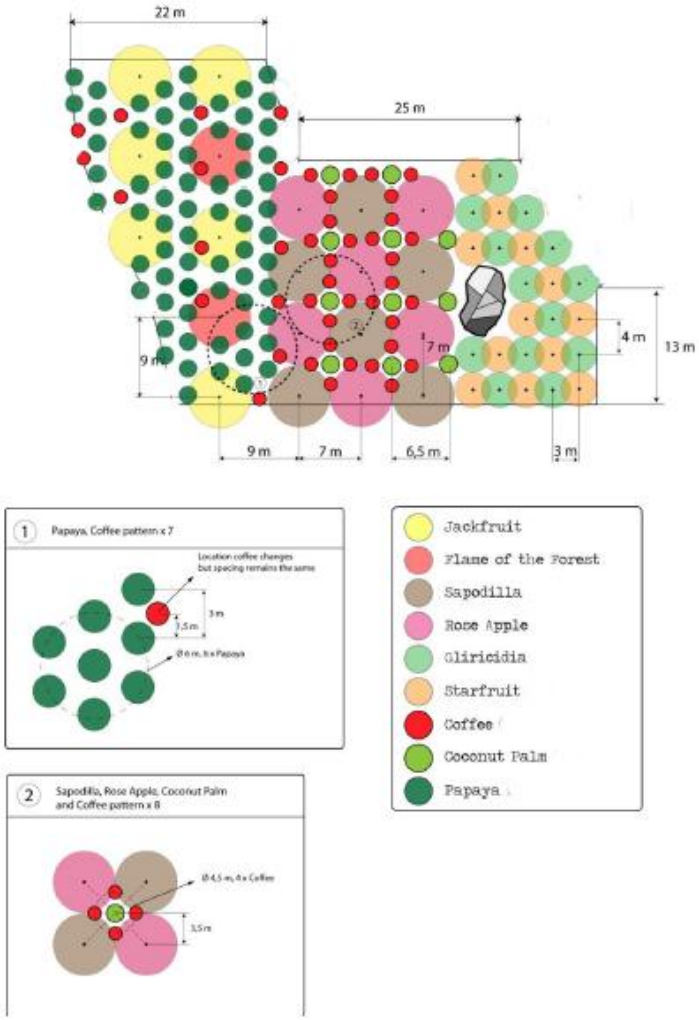
Ongoing maintenance of the food forest will be in the form of **chopping and dropping** the Prairie Acacia (*Acacia angustissima)* and **mulching** with the organic material around the fruit trees. This should be done at the start of the rainy season and once every month during the rainy season (when precipitation exceeds evaporation). Prairie Acacia should be allowed to grow un-coppiced during the dry season to provide shade for the young fruit trees.

Prairie Acacia (*Acacia angustissima)*, Phalsa (*Grewia asiatica*), and Tropical Comfrey (*Tithonia diversifolia)* are all fodder crops that can be harvested year round and eaten by cows as high quality fodder.

Chop and drop mulching

In the orchard system and perennial landscaping, it is important that we plant a large percentage of nitrogen fixing, leguminous shrubs and trees. These plants are placed as support species for the others, and used to fix nitrogen in the soil through a process that is called chop and drop. Just as the rainy season sets in, and at least once more a month during the rainy season, these support plants should be chopped back and their woody matter applied as mulch around our more important plants (the fruit trees, etc). This chop and drop action works in a number of ways to benefit the system. During the dry time of year, these fast growing shrubs and trees provide much needed shade for the system. When the rainy season comes, they are cut back. This pruning process sees a roughly equivalent amount of matter from the root structure also drop off, giving a flush of nitrogen to the soil. All the woody matter on the surface then becomes nitrogen rich mulch which also gives nitrogen, suppresses weeds, holds moisture, creates habitat, and performs a number of other functions for the receiving tree and the general ecology of the area. These legumes then sprout again, setting up their shade and ready to give again the following year. The legumes can also be used as a source of nitrogen in a compost pile. This reduces the need of buying (expensive) nitrogen rich materials, like elephant or cow manure.

Example Design 2 How a Food Forest at BTEH might be designed on the north of the site, with the recommended list of species.



Species

Emergent
- Coconut palm (*Cocos nucifera*)

Canopy
- Jackfruit (*Artocarpus heterophyllus*)
- Sapodilla (*Manilkara zapota*)
- Rose Apple (*Syzygium samarangense*)
- Starfruit (*Averrhoa carambola*)
- Madre de cacoa (*Gliricidia sepium*)
- Flame of the Forest (*Butea frondosa*)

Shrub
- Coffee (*Coffea arabica*)
- Papaya (*Carica papaya*)

Herbaceous
- Sesbania *(Sesbania rostrata)*

Groundcover
- Perennial Peanut (*Arachis pintoi*)
- Dwarf morning glory (Evolvus alsinoides)

Initial Cover Crop
- Sunhemp (*Crotalaria juncea)*
- Cowpea (*Vigna unguiculata***)**

Management Needs

This system has been designed to mimic the natural pattern found in nature and minimizes human intervention. With canopy sized, deciduous legumes placed throughout the system, mulch will not need to be imported or even spread around.

The Madre de Cacao can be harvested as fodder to stop competition for light with the Starfruit during the dry season and can be chopped and dropped during the rainy season to create mulch for Starfruit.

In the first dry season after planting, fruit trees should be **watered deeply once every month**.

Guilds

Orchard guild for a fruit tree

The members of the guild support the fruit tree in numerous ways that eliminate the use of fertilizer, pesticides and fungicides:

- Luring beneficial insects for pollination
- Building soil health and fertility
- Reducing root competition
- Conserving water
- Promoting fungal health
- Diversifying the yield of food
- Creating beneficial habitat

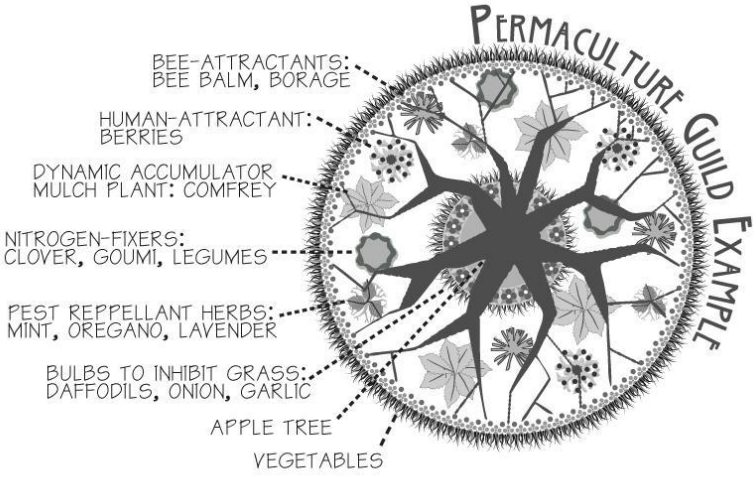
The result is **a healthier fruit tree and a more varied ecology**. Moreover, this guild helps to replace human intervention, shifting the work from human to natural; minimizing input while maximizing output while letting nature do the work for you.

Recommendation guild species for all the fruit trees suggested:

- Clover (Trifolium spp.)
  - Acts as living mulch / ground cover and fixes nitrogen
- Nasturium (Tropaeolum majus)
  - Acts as living mulch / ground cover
  - Edible
  - Lures beneficial insects for pollination and pest control
- Marigold(Tagetes spp.)
  - Plant within ring of garlic
  - Lures beneficial insects for pollination and pest control
  - Edible flowers
- Garlic (Allium sativum)
  - Plant in ring around fruit tree (1 meter away from trunk and garlic bulbs planted 1 inch apart from each other)
  - Suppresses grasses which compete with fruit tree for nutrients
- Fennel(Foeniculum vulgare)
  - Plant within ring of garlic.
  - Lures beneficial insects for pollination and pest control
- Chicory (Cichorium intybus)
  - Plant within ring of garlic
  - Nutrient accumulator of Potassium and Calcium

- It fixes Nitrogen and it has deep tap roots that break up and aerate compacted soils

- Comfrey (*Symphytum officinale*)
  - Plant within ring of garlic
  - Nutrient accumulator of potassium and Calcium
  - It has deep tap roots that break up and aerate compacted soils



An example of a fruit tree guild

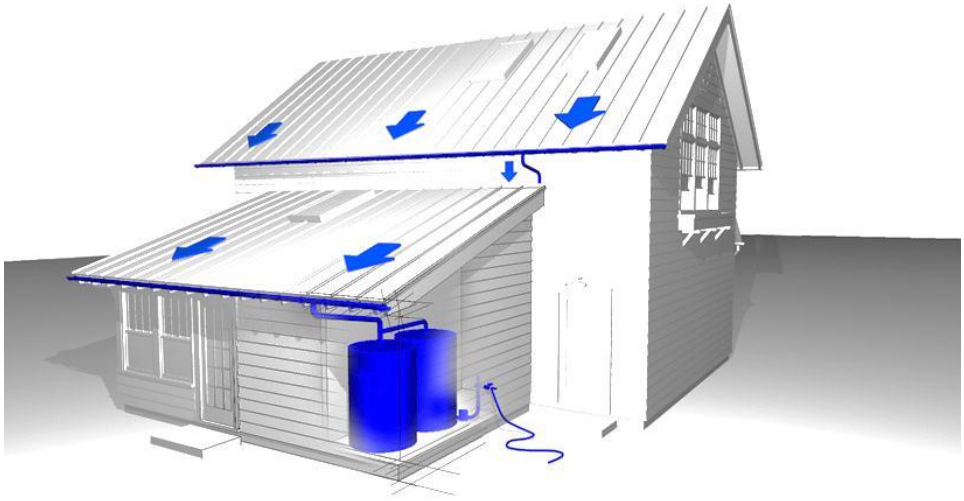
Note This guild has been especially designed for beauty, with all plants (except garlic) bearing beautiful flowers to please the community members.
* This guild will also support large bee populations within the orchard system to diversify yield*

Part Two – Water and Sanitation

Water Access

Rainwater Catchment
Although Okumura Farm has an abundance of water, when considering the permaculture principle of "Catching and Storing Energy", it is understood that no resource should escape the system without being put to responsible use first. For this reason, it is recommended to catch and store available rainwater.

Rainwater is clean, healthy and more suited for both the people and the animals. Thailand has a heavy rain season, approximately **2,400 mm!** It is more than enough to harvest all of the required drinking water off one rooftop. Any suitable roof surface — tiles, metal sheets, plastics, but not grass or palm leaf — can be used to intercept the flow of rainwater in combination with gutters and downpipes (made from wood, bamboo, galvanized iron, or PVC) to provide the site with high quality drinking water.



System size
The system required for **10 people**:
- 8 months of dry season -
- **4 liters of water** per **person** per **day**
The size of the rainwater tanks that provide drinking water for 10 people, during 8 months of dry season is 10 m^3.

Installing water points and safety valves

When installing water points, be generous! This report contains suggestions for placement and number of water points. These recommendations are based on the initial observation and design assessment, as the site develops these requirements will need to be continuously re-assessed, based on need or desired change.

Sanitation

Human sanitation will be one of Okumura Farm's most pressing concerns in the long term. The importance of this subject and its effect on health, morale and environment, cannot be overstated. The recommendations, below, will serve both immediate and long term needs.

Human waste

By treating human waste (also referred to as **black water** or **night soil**), the community will reduce unpleasant odors on site, increase the quality of the soil and reduce health risks for both the people eating the produce and the farmers working on the field. In addition to that, it will reduce flies and bugs on site.

Introduction

Human waste adds fertility to the soil and does this for no cost (this is great in a world where fertilizer is getting more and more expensive). But for sanitary reasons and to make safe handling of Human waste possible, treatment is necessary. Human feces contain various kinds of pathogenic bacteria, virus and parasitic eggs.

When pathogenic raw human manure is applied to the soil, the pathogenic bacteria may continue to live in the soil for over a year. Roundworm eggs may even survive for many years, thereby maintaining the possibility of human infection for a long time. This is especially a risk for the people working with night soil. For these reasons, a potential health risk exists in the practice of reusing excreta without prior treatment. In addition to that, the application of raw human excrements on the fields also causes unpleasant odors for the community members, a lot of flies in the summer and is illegal. All of these problems can be solved by applying one or more of the following techniques:

Bucket toilet (Temporary)

A bucket toilet is the perfect solution to any temporary human waste needs. Although we are recommending a bucket humanure system as a temporary solution, this technique is often practiced as a permanent solution.

A bucket toilet is a simple system of discarding human waste in a bucket or barrel, covering the waste with carbon-based organic material (Dry crushed leaves, rice husks, saw dust or shredded straw) then emptying the contents of the full bucket in to a thermophilic compost pile to "sanitize". **This is important.**

A simple bucket system

The human waste in this system must be emptied into a thermophilic compost pile in order to eliminate potential pathogens. *(see compost section)* The system can be as simple as that, but more often the bucket is incased in a more aesthetically pleasing box with a toilet seat fastened over the bucket. This gives your system a more contemporary feel. *See photo for example*.

Compost toilet

In a compost toilet, everybody covers their excrement with a handful of organic material. This can be sawdust, rice husks, leaves, straw, pine needles. These materials are high in carbon and will therefore balance the carbon to nitrogen ratio. When there is excess nitrogen, it will not escape as ammonium gas (smelly) but be captured in the carbon material. The design that is most suited to meet the community's needs is a dry compost toilet with a big chamber under the toilet.

A compost toilet with a large chamber under the toilet

When the chamber is full with human excrements and organic material, it is closed for one year and another chamber is opened / used now. Typically, a compost toilet like this has four toilets with each a big chamber and two toilets are used at a time. After one year, it is opened from the side and the compost can be used. There are many advantages to this kind of compost toilet:

- It is very easy to build and use
- No handling of raw human excrements
- Gives you large amounts of high quality long-term compost
- Does not smell
- Uses no water

This toilet has four big chambers of 12 m^3 each. When two chambers are used at the same time, this will allow 50 people to use the toilet for one year. When the toilet chambers are full, approximately one year, the toilets must be closed and the two other chambers are now being used. It is recommended to build multiple units with four chambers for the community (ideally one unit per 15-20 people).

Biogas toilet

BIO-GAS is the FUTURE! It is safe and requires zero energy while producing an abundance of fuel. The most progressive and largest populated countries in the world use this method with less concern for health issues than all other current, conventional methods.

Okumura Farm already encases human waste in an anaerobic container, which simply allows the valuable by-product (methane) escape into the atmosphere. Okumura Farm should be capturing this fuel for its benefit and the benefit of the local environment.

Sweden operates multiple, integrated bio-methane plants for **vehicle fuel** and **bio fertilizer** production. In Stockholm, about 10 thousand tons of sewage sludge is used to produce biofuel, annually. This fuel is used to power city buses and heat, the remaining material is sold as fertilizer.

Germany is Europe's biggest biogas producer and the market leader in biogas technology. In 2010 there were 5,905 biogas plants operating throughout the country.

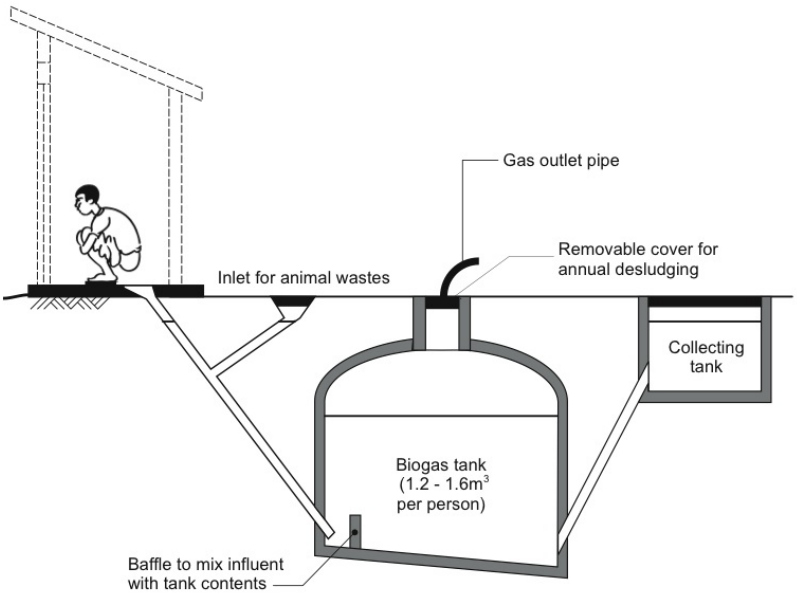
China has experimented with the applications of biogas since 1958. By 1970, China had installed 6 MILLIION digesters.
In a biogas system, waste is allowed to sit in an anaerobic biogas digester for 2-3 months. This process is extremely effective at destroying pathogens (After 70 days, nearly 100% is destroyed) and the odors will be reduced by 80%. In contrast, septic tank systems are teaming with dangerous,

disease-causing pathogens and produce very unpleasant smells. There is little physical difference from current septic-tank systems, but bio-gas systems are sealed and require no human handling they are far safer, healthier and nearly zero-maintenance.

Moreover, during the anaerobic process, biogas is being produced. This biogas can be used for cooking, vehicle-fuel or power generation. This solution offers multiple functions that meet several needs of the farm. It sanitizes manure, provides gas to cook on, reduces odors and produces high quality slurry, used as fertilizer. Biogas toilets would vastly benefit the farms' and local communities' over-all health, well-being and quality of life.

Advantages of anaerobic digestion:

- Biogas is a local, **renewable fuel**
- The **quality of the fertilizer** after anaerobic digestion is **higher** than the raw product
  In comparison to raw night soil, it increases yields with 15 to 25%
- Surplus food scraps or organic matter can be fed to the digester in addition to the human excrements
- There is no longer a health risk involved
- Anaerobic digestion gets rid of most of the smells
- Less flies in summer due to the fact that the digester is closed



A standard Bio-toilet

The design

It is advised to contact a professional when building biogas digesters. Biogas is a flammable gas and therefore caution is required. The biogas digester design for Okumura Farm will be dependent on the specific site conditions and the volume of available human excrements. For a retention time of 70 days, a tank volume of approximately **1.2 to 1.6 m³ per person** is advised. This will yield 20 liters of biogas per person per day. Fifty people will generate **1000 liters of biogas per day**. This will give the community approximately **5 to 7 hours of cooking time**.

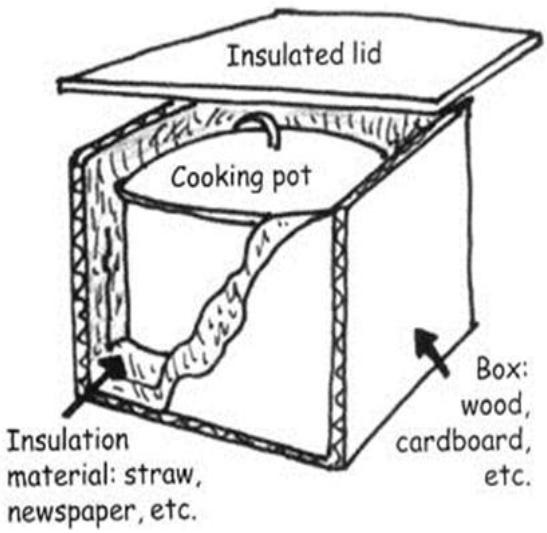
Kitchen and Food Preparation

Kitchen

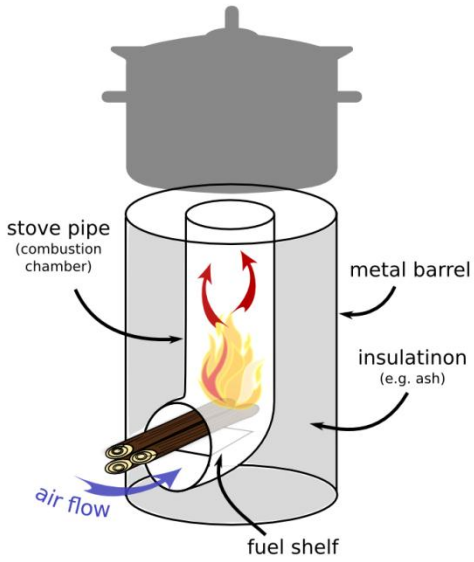
Appropriate technologies, such as a **rocket-stove** and **hay box cooker** can eliminate the need for commercial fuel and minimize the use of wood. These simple technologies will reduce the amount of wood/fuel needed, improve over-all health and quality of life as well as give the sense of self-reliance. Open-fire cooking is extremely inefficient and causes health problems. According to statistics, almost 3 billion people around the world still use wood in open fires to cook, leading to rampant deforestation, respiratory disease (like asthma, pneumonia, lung cancer, bronchitis) and worsening poverty.

The figures from World Health Organization (WHO) are stark:

Half the world population spends a huge percentage of their week to collect wood or spend up to 35% of their income on purchasing fuel; we expose ourselves to harm and smoke the equivalent of 40 cigarettes a day according to the (WHO) just to cook.



HayBox Cooker



Rocket stove design

A **hay box cooker** is a simple insulated container that works much like a modern rice-cooker. By placing a heated pot of rice in a tightly insulated container, it retains heat for hours, cooking rice without additional heat, requiring less cooking fuel.

A **rocket stove** is an intelligent and simple cooking device that cooks far hotter and with far less wood than an open-air fire. Some rocket stove designs claim 80 to 90% efficiency over other wood-burning methods.

Smoke inhalation from cooking over an open fire kills 1.6 million adults and children yearly. In Africa women walk up to 15 miles each trip to find wood for cooking, deforesting already strained environments.

Power and electricity

Solar Panels

Solar Photovoltaic Modules is one of the 20th Centuries most hyped "off-grid" solutions. Once installed they produce a minimal amount of hazardous waste and current technology allows for a life-span of twenty years or more.

Solar power is already used for lighting at Okumura Farm. We believe this is a very appropriate use, although, the use of compact-florescent lighting is discouraged. It is old, inefficient (8-15watt) technology made with toxic chemicals such as mercury. Investing in the most **efficient LED lighting** (2-5watt) will stretch your power out by two or five times and they have a lifespan of up to 20 years, with no mercury.

Part Three – Earthworks and Animals

Terracing

Terraces have the following positive effects:
- Increase surface area
- Catch and store water higher in the landscape
- Keep nutrients distributed throughout the property
- Reduce erosion
- Infiltrate more water into the ground and recharge the groundwater table
- Create high moisture micro-climate for flora and fauna

Design

Terraces are small earthworks that capture rainwater running from a broad area, hold the water for a time and allow it to infiltrate the soil. They can be dug by large or small machines or built by people with hoes, spades and rakes. They are built on contour, using survey equipment, a water level or an A-Frame Level.

Integration in current landscape

To function optimally, terraces should be on contour. If swales are not on contour, they do not confer the same benefits of water absorption.

Finding the contour lines has to happen with surveying equipment and stakes have to be put in every 5 to 10 meters. A freeboard should be designed into every terrace as an overflow area, minimum of 30 cm lower than the berm height. This freeboard allows the terrace to overflow in case of catastrophic rain.

Rocks on contour

Okumura Farm may have an excess of large boulders and rocks on site. By placing rocks on contour of the slope, the water is being slowed down minimizing erosion. In addition to that, these long lines

of rocks on contour will collect organic material and start building soil. We suggest one long line of rocks along contour, every 5- 10meters if possible.

Pond

The pond is a freshwater ecosystem that is tremendously useful in permaculture practice. They can provide food, medicine, water storage, sun reflection, filtration for waste, recreation and aesthetic value. A wide variety of edible species of plants can be grown in and around the margins of a pond.

Beneficial Pond species

Certain species of plants provide more functions and benefits than others in a pond. Multi-functional species are preferred in a permaculture system. Below is a list of possible plants for your pond.

- Cattail (*Typha* spp.)
  Shelter and nesting sites for small fish, amphibians and birds. It has many edible parts.
- Watercress (*Nasturtium Officinale*)
  Edible leaves and flowers. Good habitat for small fish and amphibians.
- Wild Rice (*Zizania Aquatica*)
  Perennial grass that produces edible seeds and habitat for insects, small fish and amphibians
- Taro (*Colocasia Esculenta*)
  Edible roots, leaves and tubers.
- Waterlilies (*Nymphaea* spp. and *Nuphar* spp.)
  Provide shade and shelter to many kinds of fish, amphibians and invertebrates.
  Have beautiful and fragrant flowers and some edible seeds or roots.
- Water Fern (*Azolla* spp.)
  Provides cover for many small animals, shade for a pond and food for waterfowl. This can be fed to ducks.

Animals

Ducks

Healthy ducks provide people with healthy eggs. To consciously redesign the living spaces and feeding regime so egg production is maximized and the general well-being of the ducks increases. Turn the pond in an aesthetically pleasing area that, at the same time, provides food for the ducks.

Food

For maximum health and egg production laying ducks should be provided 80 g to 120 g of food per day per duck. Ducks should have access to food at all times as they are grazers and eat all through the day and night. Under the correct feed regime, there is food in the containers all day and night, but not excessive waste.

10 ducks x 100 g per duck

1 kg per day

If **plant material** is added to the diet, the amount of processed food can be reduced. Ideal dietary supplements are kitchen scraps, green weeds, crop residue from gardens and living plants growing within the enclosure.

Water Plants

Grow these plants in the duck pond so that ducks have free access to them. Plants can be started inside a netting to stop ducks from eating everything. As the plants grow and expand outside the netting, the ducks will eat them.

- Water hyacinth (*Eichhornia spp.*)
- Duckweed, also functions as a bioremediator by effectively filtering contaminants such as bacteria, nitrogen, phosphates, and other nutrients
- Water lilies – any plant with floating lily pads
- Arrow Arum (*Peltandra virginica*)
- Wild Celery (*Vallisneria Americana*)
- Arrowhead (*Sagittaria latifolia*)

Duck pond with water hyacinth

Land Plants

Grow these plants outside the duck enclosure and use as food supplement.

- Banana stalk (*banana spp.*)
- Taro leaves (*Colocasia esculenta*)

Ducks will most happily eat most of the weeds. Their normal diet consists out of weeds so you can experiment with different weeds and see what ducks like. They will also keep the weeds in their living area under control. If ducks are allowed to free range through the orchard area, they will eat the weeds and fertilize the trees.

Water

Ducks should have access to clean drinking water at all times. In addition to the pond, water containers should be provided at all time within the ducks yard and sleeping coop. If water is not present where ducks are fed, they have a hard time processing their food and do not feed effectively.

Habitat

A pond is not necessary for ducks but greatly increases their happiness. Add aquatic plants to the pond to balance nitrogen levels from duck manure as well as provide supplemental food. Plants will also help to provide shade for ducks. Ducks cannot withstand full sun all day long and egg production will suffer if ducks are exposed to sun over 21 degrees Celsius.

Nesting Boxes (for egg laying)

One nesting box per three to five hens should be provided.

- Branch 2 and proposal for branch 3

    60 ducks

    12 nesting boxes

Box dimensions

- Height: 30 cm
- Width: 30 cm
- Depth: 25 cm

An enclosed nesting box will stimulate egg laying for all ducks.

Grit
In order for ducks to process their food via their gizzard they must have access to grit. The grit is stored in their gizzard and helps them to grind down the poultry feed in the same way we use our teeth to grind down our food. If you do not allow your ducks to have access to poultry grit you may find they suffer from compacted crop because they cannot digest their food properly. Grit should be supplied in the form of large grain sand, crushed limestone, or store bought chicken grit. Your ducks will probably find grit in their yard, but some may be provided for them in a small container near their food.

Bedding material in coop
Bedding is an important part of keeping your ducks happy and healthy. On the coop floor, the bedding will provide a soft surface for your ducks to walk on and will absorb droppings and odor. Bedding should be provided at a depth of 5 cm. Bedding should be kept dry to prevent ducks from getting sick. Example of bedding material: Pine needles, dry leaves, rice straw.

Chickens

Healthy chickens may provide people with healthy eggs and meat as well as benefit the local eco-system. Their living space and feeding regime should be consciously designed so egg production is maximized and the general well-being of the chickens increases.

Food
For maximum health and egg production laying hens should be provided 115g to 150 g of food per day per chicken. This should be supplemented with crushed egg shells to increase calcium intake. Do not feed whole egg shells as this will teach chickens to peck their own eggs after they lay them. Diet should also be supplemented with daily kitchen food scraps whenever available. In a well-designed system most, if not all, feeding requirements can be supplied through food-scraps and the local ecosystem.

Additives
Salt should be added as a supplement to daily food at a rate of 1 g per day per chicken. Although, if you are feeding chickens foods waste, they will probably be getting the required amount.

Water
Laying Hens require .25 liters of water per day. For every 20 laying hens, one water dispenser is required. Water should be changed every day.

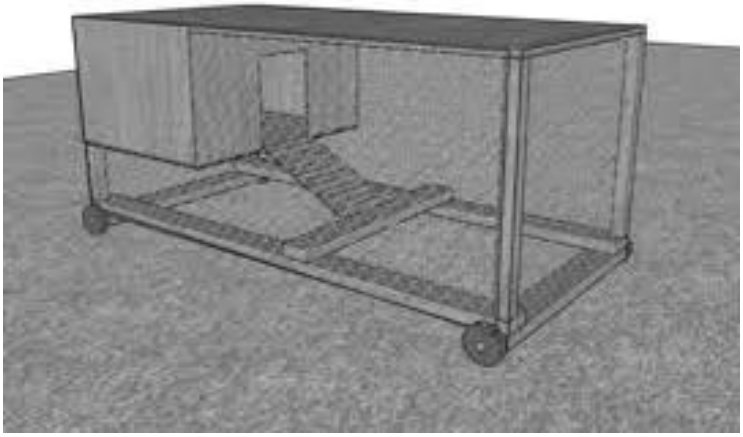
Chicken Habitat
Roosting
Chickens **prefer to sleep off the ground at night** to feel safe. They should be provided with a bar to perch on while they sleep with enough space to stand shoulder to shoulder. All bars should be at the same height to prevent fighting and pecking of the weaker chickens. Proper roosting, if provided, will minimize or prevent most fighting and pecking.

Nesting Boxes (for egg laying)
One nesting box per three to five hens should be provided.

Nesting box dimensions:

Box dimensions	**Entrance**
Height = 30 cm	Height = 22 cm
Width = 30 cm	Width = 22 cm
Depth = 25 cm	

A Chicken Tractor or bamboo cage will allow you to place chickens in gardens allowing them to eat old growth, dig, scratch and supply manure to only a desired location, therefore, minimizing human labor.



An Example "Chicken Tractor"

Appendix 1

List of Companion Plants

Plant	Likes to grow together with
Asparagus	Parsley, capsicum, basil, lettuce and tomato
Basil	Tomato, most vegetables and herbs
Beans	Potato, corn, lettuce, eggplant, cucumber, strawberry, celery, carrots, cauliflower, radish, spinach,
Beetroot	Onion, lettuce, spinach and silver beet
Broccoli	Onions, leeks and celery
Brussels Sprouts	Potato, oyster mushroom
Cabbage	Onion
Carrot	Peas, leeks, lettuce and chives
Cauliflower	Onions and leeks
Celery	Tomato, leeks and beans.
Corn	Lettuce, peppers, cucumber, beans and peas
Cucumber	Radish, lettuce, beans, peas and artichokes
Eggplant	Beans, peppers and lettuce
Leeks	Cabbage, celery, onion and celeriac
Lettuce	Beetroot, strawberry, radish and corn
Mint	Cabbage and tomato
Onion	Lettuce, cabbage and carrots
Parsley	Tomato, asparagus, carrot and peppermint
Parsnip	Shallots, chives and lettuce
Peas	Cucumber, radish, turnips, corn, carrots and beans
Pepper Chili	Cucumber, squash and lettuce
Potato	Tomato, cucumber, sunflower, green beans, peas and broad beans
Pumpkin	Corn
Radish	Peas, lettuce and nasturtium
Shallots	Carrots, beetroot and mint
Silver beet	Parsnip and beetroot
Spinach	Strawberry and most plant
Strawberry	Borage, lettuce, silver beet and bush beans
Tomato	Asparagus, peppers and basil
Zucchini (Courgette)	Parsley, tomato, silver beet, spinach, squash, corn and capsicum

Appendix 2

Perennials

Profusion' sorrel - *Rumex acetosa*
Aloe vera
Asparagus - *Asparagus officinalis*
Canebrake bamboo - *Arundinaria gigantea*
Clumping bamboos - *Bambusa spp.*
Comfrey
Cuban Oregano - *Plectranthus amboinicus*
French sorrel - *Rumex acetosa*
Gai lon - *Brassica oleracea alboglabra*
Garlic chives - *Allium tuberosum*
Lemon verbena - Aloysia citrodora
Lovage(a perennial celery substitute)
Nasturtium - *Tropaeolum*
Okinawan spinach *Gynura bicolor*
Perennial broccoli - *Brassica oleracea botrytis*
Perennial cilantro - *Eryngium foetidum*
Perennial kale - *Brassica oleracea acephala*
Perennial leek - *Allium ampeloprasum*
Potato onion - *Allium cepa aggregatum*
Saltbush - *Atriplex halimus*
Sea beet - *Beta vulgaris maritima*
Shallot - *Allium cepa aggregatum*
Sheep sorrel - *Rumex acetosella*
Sissoo spinach – *Brazil spinach*
Spineless nopale cactus - *Opuntia spp.*
Thyme – *(Thyumus plant)*
Tropical tree kale - *Brassica oleracea acephala*
Vietnamese coriander - *Persicaria odorata*
Walking onion - *Allium cepa proliferum*
Welsh onion - *Allium fistulosum*
Wild cabbage - *Brassica oleracea*
Yellow asphodel - *Asphodeline lutea*
'Celery Stem' taro - *Colocasia esculenta*
Air potato - *Dioscorea bulbifera*
Arugula - *Diplotaxis muralis*
Branching bush kale - *Brassica oleracea ramosa*
Bull nettles - *Cnidoscolus palmeri*
Bunching onions - *Allium fistulosum L.*
Chicory - *Cicorium intybus*
Cranberry hibiscus - *Hibiscus acetosella*
Daylily - *Hemerocallis*
Dragon Fruit - pitaya
Fragrant spring tree - *Cedrella sinensis*
Garlic chives - *Allium tuberosum*
Globe artichoke - *Cynara scolymus*
Good king Henry - *Chenopodium henricus*
Malabar gourd - *Cucurbita ficifolia*
Musk mallow - *Malva moschata*
Pokeweed - *Phytolacca americana*
Rosselle - *Hibiscus sabdariffa*
Sativa chufa - *Cyperus esculentus*
Sea kale - *Crambe maritima*
Sunchoke - *Helianthus tuberosa*
Taro - *Colocasia esculenta*
Turkish rocket - *Bunias orientalis*
Water celery - *Oenanthe javanica*
Water lotus - *Nelumbo nucifera*
Watercress - *Nasturtium officinale*

Appendix 3

Common Name	Scientific Name	Height	Spacing Required	N fix	Light Requirenments	Water Requirenments	Uses	Other
Emergent								
Coconut	*Cocos nucifera*	12 m	6 - 9 m		Full	Medium	Seed	
Canopy Species								
Umbrella Thorn	*Acacia planiformis*	30 m		yes	Full	Drought Tolerant	Fodder	Deciduous
Beal tree	*Aegle marmelos*	9 - 12 m	4 - 6 m		Full	Medium	Fruit. Medicinal	
Jackfruit	*Artocarpus heterophyllus*	8 - 25 m	6- 12 m		Full	Medium - High		
Neem	*Azadirachta indica*	12 m	3 - 5 m		Full	Drought Tolerant	Medicinal. Polinator attracter	
Palash/ Flame of the Forest	*Butea frondosa*	9 - 12 m	9 - 12 m	Yes	Full	Medium	Fodder. Polinator attracter	Deciduous
Rock-Break tree	*Hardwickia Binata*	20 - 30 m		yes	Full - Partial	Drought Tolerant	Fodder. Soil Builder	Can be planted directly into rock soil
Mango	*Mangifera indica*	35 - 40 m	5 - 10 m		Full	High	Fruit	
Sapodilla	*Manilkara zapota*	12 m	5 - 10 m		Full	Medium - High	Fruit	
Avocado	*Persea americana*	40 m	6 - 9 m		Partial	Medium	Fruit	
Indian Goosebeery	*Phyllanthus emblica*	8 - 18 m	5 -10 m		Full	Medium - Low	Fruit	
Sandlewood	*Santalum album*	4 - 20 m	2 - 5 m		Full	Drought Tolerant	Wood. Medicinal	
Sesbania	*Sesbania grandiflora*	8 - 15 m	4 - 6 m	yes	Full	Drought Tolerant	Edible leaves + flowers. Fodder	Not suitable for direct grazing. Do not coppice until 2 m tall
Paradise Tree	*Simarouba glauca*	7 - 20 m	5 - 9 m		Partial	Drought Tolerant	Oil from Seed. Fruit	
Rose Apple	*Syzygium samarangense*	9 - 15 m	6 - 9 m		Full	Medium - High		
Tamarind	*Tamarindus indica*	12 - 30 m	9 -12 m	yes	Full	Drought Tolerant	Fruit	
Understory								
Starfruit	*Averrhoa carambola*	3 - 5 m	2 - 4 m		Full	Medium - High		
Papaya	*Carica papaya*	5 - 9 m	2 - 3 m		Full	Medium	Fruit	
Pomelo	*Citrus maxima*	5 - 10 m	6 - 9 m		Full - Partial	High	Fruit	
Madre de cacoa	*Gliricidia sepium*	2 - 10 m	2 - 5 m	yes	Full - Partial	Drought Tolerant	Fodder. Organic Material	Deciduous
Macadamia	*Macadamia integrifolia*	6 - 10 m	5 - 9 m		Full	Drought Tolerant	Fruit	
Moringa	*Moringa oleifera*	10 m	2 - 5 m		Full	Drought Tolerant	Seed. Leaves. Fodder. Medicinal	
Bannana	*Musa sp.*	3 - 5 m	2 - 5 m		Full	High	Fruit. Poultry Feed	Stalk fed to poultry
Guava	*Psidium guajava*	3 -10 m	4 -6 m		Full	Drought Tolerant	Fruit	

Common Name	Scientific Name	Height	Spacing Required	N fix	Light Requirenments	Water Requirenments	Uses	Other
Shrub								
Prarie Acacia	*Acacia angustissima*	2 - 5 m	2 - 3 m	yes	Full - Partial	Medium	Fodder. Organic Material	Deciduous
Pidgeon Pea	*Cajan cajanus*	1 -4 m	.5 - 2 m	yes	Partial	Drought Tolerant	Seed. Fodder	
Cofee	*Coffea arabica*	2-4 m	2 - 3 m		Partial - Shade	Medium	Seed	
Wild Hops	*Flemingia macrophylla*	.5 - 3 m	.5 - 2 m	yes	Full - Partial	Drought Tolerant	Fodder. Mulch material	Leaves slow to decompose, good mulch.
Phalsa	*Grewia asiatica*	2 - 5 m	2 - 3 m		Full - Partial	Drought Tolerant	Fruit. Fodder. Medicinal. Dynamic Accumulator	Deciduous Accum. P, K
Shami	*Prosopis cineraria*	3 - 5 m	2 - 5 m	yes	Full - Partial	Drought Tolerant	Fodder. Organic Material	Extremly deep taproot, not compete w/ other tree.
pomegranate	*Punica granatum*	3 - 6 m	4 - 6 m		Partial	Drought Tolerant	Fruit	
Sesbania	*Sesbania rostrata*	1 - 3 m	.5 - 2 m	yes	Full - Partial	Medium	Fodder. Organic Material	Short lived Perennial
Tropical Comfrey	*Tithonia diversifolia*	1 - 3 m	.7 - 1 m		Full	Medium - Low	Fodder. Organic Material. Polinator attracter	Phosphorus accumulator
Herbacous								
Lambs Quarters	*Chenopodium album*	.5 m -1 m		yes	Full	Medium	dynamic accumulator	accum. N,C,P,K,Mg
Lemon Grass	*Cymbopogon flexuosus*	.5 m -1 m			Full- Partial	Low	Medicinal. Mulch	soil stablilizing root system
Citronella	*Cymbopogon nardus*	.5 m -1 m			Full- Partial	Drought Tolerant	Medicinal. Mulch	soil stablilizing root system
Wild Tantan	*Desmanthus virgatus*	.5 m -1 m		yes	Full- Partial	Drought Tolerant	Fodder. Forage	Specific rhizobium association
Fennel	*Foeniculum vulgare*	1 m			Partial	Medium	Seed. Pest Deterant. dynamic accumulator	accum. Na,S,K
Holy Basil	*Ocimum tenuiflorum*	.2 - .6 m			Full- Partial	Medium	Edible Leaves. Medicinal	
Groundcover								
Perrennial Peanut	*Arachis Pintoi*			yes	Full - Partial	Medium - Low		
Sweet Potato	*Ipomoea batatas*				Full	Medium	Leaves. Tuber	
Root								
Turmeric	*Curcuma longa*	1 m	1 m		Partial - Low	Low	Spice	
Taro	*Colocasia esculenta*	.8 - 1.5 m	.5 - 1 m			High	Tuber	
Ginger	*Zingiber officinale*	1 m	1 m		Partial - Low	Low		
Climber								
Winter gourd	*Benincasa hispida*				Partial	Low	Fruit	
Passion Fruit	*Passiflora edulis*				Partial	Medium	Fruit	