SUN FARM

A HANDBOOK

We came to Sun Farm to explore the basis and tools of Permaculture in January 2015. Since then we have evolved personally and professionally, as much as the place itself has. We have tried to share our journey, observations and learning on this land through this document. We hope this will be useful for the present and future members of this community and anybody/everybody who stumbles upon this place, in taking care of this land and its various ecological relationships.

In these pages, we also included research on some important topics. We, however, cannot take credit for all the knowledge and our learning has been collaborative with insights from locals and experts, specially our Permaculture guides, Rico Zook and Martine Bastide.
We are also aware that some of our observations or conclusions need to be tested with time and the changing landscape of Sun Farm.

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soil

Soil allows plants to grow and transform the energy from the sun to make food on which most humans survive. When we use the energy in the soil to make food for ourselves, we borrow a part of the soil. We can only have a good relationship with the soil if we return what we take. It takes some effort and time with the soil to understand it and start creating a healthy habitat for the soil organisms but the intention should be to heal the soil and not to make it productive. The more we learn, the further we find ourselves from complete in this knowledge.

By mimicking how nature provides nutrition for all plant life (trees, vines, shrubs, grasses etc.) in a forest, we can help to restore soil's health.

restoration

COMPOSTING

Composting returns the nutrients to the soil in a short time, making up for the degeneration over thousands of years.
We have been composting all the food waste generated from the kitchen and leftovers from workers after lunch.
The process of composting is simple, although the following points should be considered and taken care of:

1. The compost should regularly be watered to promote growth of microorganisms. However, the pile should never be too wet (Pick a handful of composting material and squeeze, water should not drip out). *Biomass turns into compost because of aerobic bacteria and fungi. Too much water will push the air out and the process will go anaerobic. A stinky compost pile is an indication of this.*

2. We often make layers of biomass (leaves etc.) in the food waste compost pile, which helps in maintaining a consistent medium or buffer for the microbes. (Food waste can be too acidic, spicy etc., sometimes too much or too less of something.)

3. Do not press the compost pile or weigh it down. It is important for the pile to have space inside for air.

4. We also add layers of biochar and sawdust whenever available.

5. A C:N ratio of 30:1 is recommended for good composting. While it is not absolutely important to get the ratio correct, adding more carbon (dry matter) than nitrogen (fresh matter) will yield better results.

GREEN MANURE

While composting speeds up the natural cycle of transforming energy and returning it to the soil, it can be very labour intensive to shift the compost to different areas, especially on a mountain. Also, at Sun Farm, it will take a lot of biomass to generate compost for the entire land. This biomass will too take a lot of time and energy to grow.
One of the more effective methods suggested by Rico and Martin, to maintain the fertility of the soil, is to grow green manure on fallow terraces or in rotation with grains and vegetables.
If we cut the plants before they flower and turn them into the soil, they will decompose into humus and improve the soil fertility and structure. Such plants are called **green manure**. Also since they maintain a cover on the soil for the their growing period, there are also sometimes referred to as **living mulch**.

<u>Choice of plants:</u>
1. Fast growing plants generate more biomass in less time.

2. Succulent plants are preferred to woody ones, since they decompose faster.

3. Plants with different root systems tend not to compete with each other and break the compacted soil.

4. A mix of plants from leguminacae and graminacae family is generally preferred to maintain a balance between the carbon and nitrogen being returned to the soil. (Legumes add nitrogen while cereals add carbon due to their high starch content).

We have been growing mustard, radish, peas and several kinds of beans mainly to propagate their seeds for green manure.
Buying the green manure seeds is expensive and also not sustainable in the long run. These plants were not turned into the soil. Rather, the plants were allowed to seed and the seeds were preserved.
To sow the seeds, we used seedballs.

A Seedball is basically a dry lump of soil protecting seeds inside them. These balls can be thrown away or rolled down to the place we wish to grow the seeds. Continuous watering or rains will dissolve the soil around the seeds and give them a medium to establish themselves. The use of seedballs eliminates tilling or any other kind of land preparation for sowing, and thus protects the micro life in the soil and saves time and labour.

The seedballs were thrown on the terraces by hand a day or two before rain was anticipated. The rains washed the seedballs, breaking them open and allowing the seeds to sprout. Once these seeds grew into mature plants, they were left to flower. The pods containing the seeds were left to dry (turn brown) and then harvested and dried for a couple of weeks before being opened. The seeds were stored in a cool, dark place until turned into seedballs again for multiplication.

MULCHING

Mulching is done to insulate the soil life from sun and cold by mimicking a forest floor of fallen leaves and biomass.

Mulching benefits the soil, and the plants in the following ways:

- Slow decomposition of the mulch will release nutrients in the soil over a long period of time thus maintaining a consistent supply of nutrients.
- Prevent erosion of soil.
- Retain moisture and help in infiltration
- Preventing growth of invasive grasses and plants and thus reducing competition for the desired plant.
- The mulch also helps to retain warmth and coolness in the soil, keeping the soil micro-biome alive and active.

We have been using all kinds of leaves (except for Eucalyptus leaves), bark of trees, cardboard, grass etc. for mulching.

DIVERSITY

By allowing plants with different root systems to grow, better use of the space and available air, water and nutrients in the soil can be made. Different root systems also help maintain a good soil structure. (We also plant root vegetables with leafy vegetables or beans). By creating a diversity in the garden, we increase the relationships existing between the soil, microbial world, insects and other natural elements making the system more productive while minimising our impact (we plant the vegetables with herbs, flowers, near fruit trees).

CONSERVATION

NO COMPACTION

Compaction affects soil structure by decreasing its porosity and preventing roots of plants from penetrating deeper into the soil and having access to more water, air and nutrients.
By sizing the beds appropriately and by making pathways in the garden, we can avoid walking on the soil.

REDUCING RUN OFF

Fast flowing water erodes the soil and carries away the nutrients. By slowing down the course of water, erosion of soil can be prevented and more water will infiltrate the soil.
Making swales, streams and ponds will not only protect the soil from erosion but also conserve water.

MULCHING

Regular mulching will conserve the soil and keep it healthy.

Considerations:

- *When young succulent material is chopped, it should be left on the soil for at least a month before a new crop is sown. This is because in the initial phase of decomposition some substances are released that can affect the seeds and young sprouts and make them sensitive to pathogens. If the material chopped onto the soil is older and woody, it will decompose much slower and supply nutrients to the soil over several seasons. To decompose old, woody material, many organisms are needed. Before these organisms start to digest the organic matter, they need to multiply themselves for which they use available nitrogen in the soil (this could lead to competition with the plants, nitrogen immobilisation). Thus a good C:N will allow nitrogen for both young plants and the microorganisms decomposing the dead organic matter. Or the plants should be grown after the decomposition process is over, about two months.*

- *Bacteria can feed only on exposed surfaces of organic matter. Hence, bacterial growth is slow until the worms/insects chew their food and fragment the matter into smaller bits. The fungi however can extend their hyphae to penetrate through matter. Also fungi have evolved over time and have an enzyme to break down lignin, a chemical complex in the plant body (wood). Thus fungi are more effective in decomposing plant matter. It can be said that bacteria are the primary decomposers for most animal matter while fungi are the primary decomposers for most plant matter. While building soil, the quantities of animal manure and plant waste should be balanced (if you have both) to provide food for both bacterial and fungal colonies.*

Besides the technicalities, if our work with the soil is honest and not motivated by production alone, the soil will respond. We do use scientific understanding while working, but the best indicators for us have been the sight, feeling and smell of the soil.

VEGETABLES

In last one year we have grown and harvested the following vegetables in the garden:

Cabbage	Corriander	Leeks
Cauliflower	Beat Root	Garlic
Broccoli	Chard (Acelga)	Tomato
Radish	Peas	
Kohl Rabi	Beans (several kinds)	and several local leafy
Turnip	Potato	vegetables (keerai)
Carrot	Onion	

These vegetables were planted in the vegetable garden zone 1 along with different aromatic plants and flowers.
Also, based on plant family and part of the plant used (root, leaves, fruits, stem), the crops were rotated in successive planting to not deplete the soil in a particular nutrient and prevent pests.

Companion planting
Vegetables can be planted together in a way that they take care of each other, deter pests, attract pollinators and share resources (space for roots, nutrients in the soil, water and sun) optimally.
For example, onions, garlic and radish deter most insects because of a strong aroma, pea grows well with all veggies and adds nitrogen to the soil, and cabbageworms can be prevented by planting aromatic plants near the plant.
The image shows how we grouped the veggies.

FRUIT TREES

Following is a list of trees, including newly planted and fruit bearing, existing on the farm:

Pear		
Plum	Lemon	Banana
Peach	Orange	Papaya
Avacado	Pomegrenate	Tree Tomato
Custard Apple	Guava	Passion Fruit

For care of these trees, we have been following these tasks:

MULCHING

Things to take care of:

- The mulch can be 10 -15 cm thick around the trees.
- Leave a gap of about 20 cms between the tree trunk and the mulch. This will keep the base of the truck dry and give it space to breathe.

Time of the year:

Proper mulching twice a year should be enough.
Good time to start would be March/April after the pruning and pest/fungus management is done.

The second round of mulching can begin in August/September, just before the monsoon so that all the water from the rains can be conserved around the trees. This will also give 6 months between each mulching.

Over a period of time, mulching twice a year might not be necessary and only some trees would require new mulch every once in a while.

PRUNING

Pruning has been an ethical issue at Sun Farm. Various people have given different opinions about it and the advantages and challenges of each approach. In the period from January-February 2016, we pruned every alternate pear tree in the fruit valley. Our initial observation is that shoots come out from the same place where a branch was cut on the tree. This would mean that the same shoot would be pruned again next year.

The trees have to be observed for a few seasons and assessment made on the basis of tree growth and health.

Mistletoe (or parasitic plants growing on the fruit trees) is a problem. In the period January-February 2016, we cleaned all the trees on the farm of mistletoe. Attention has to be paid on re-appearance in the following years.

Time of the year:
January to February

PEST AND FUNGUS MANAGEMENT

Monsoon is followed by intense sunny days in January. This is the time when fungus and aphides proliferate on the trees.
Appearance of aphides is the first sign of fungus infection as the fungus grows on the sweet secretions from the aphides.

To prevent/control this, use a mix of ***lime and water*** in the following ratio:

For painting the trunk from the base upto a height of 5-6 feet
5-10 % Lime solution
Water 100 litres
Lime 500 gms- 1 Kg

For spraying the high branches
2% Lime solution
Water 100 litres
Lime 200 gms

If some trees show black fungal growth, use a ***solution of cornflour (maida), neem oil and water*** in the following ratio:
1 kg cornflour (maida)
30 ml Neem oil
10 litre water

Spray this solution on the infected areas of the tree. The solution will stick to the fungus and harden in a few days and fall off from the tree.

If aphides or other sucking pests, defoliators appear on the tree, ***ginger, garlic, chili extract*** can be used.
At Sun Farm, we have had some fruit trees with black fungal growth after the monsoon. This fungus grows on the sweet secretions from the aphides. However, we observed some fungal growth even before the aphides appear. To control these aphides, we applied this extract. The recipe for the ginger, garlic, chili extract is given in the recipe section of this document.

Time of the year:
The application of bio extracts and solutions to control/remove pests is best done alongside pruning, if significant pruning is required on the trees.
Else, this can be started towards the end of December once the rains stop completely.

COMPOSTING

Adding compost to the basins of the tree will supplement nutrients and improve the soil around the trees. The frequency and quantity of the compost on each tree will depend on the total available compost and the size and health of the tree. It's best that the compost is added at the time of mulching (first compost and then mulch on top of it).

PANCHAGAVYA

Panchagavya is an organic growth promoter being used at Sun Farm for application on tree leaves. Making of Panchagavya has been explained in the recipe section of this document.

INDIGENOUS MICROORGANISMS (IMOs)

Indigenous microorganisms are a mix of beneficial microorganisms living in a particular region or ecosystem or on a specific plant/animal. These microorganisms live in close associations with the local plants and animals and play a crucial role in decomposition, releasing nutrients from organic matter and preventing the soil/plants/animals from diseases.

The IMOs can be harvested easily, cultured and proliferated in the soils that seem to be lacking them. Harvesting IMOs is done in the presence of oxygen so that beneficial microorganisms are favoured over the harmful ones.

Periodic application of beneficial microorganisms is believed to have helped in increasing the diversity of microorganisms in the soil, which supports a diversity of plants that can grow in it.

Different kinds of plants require different kind of microbial ecology around them. The vegetables grow in a largely bacterial soil ecosystem while trees grow in a fungal dominated soil ecosystem.

We have been culturing and adding IMOs to the soil around the fruit trees on a regular basis. The recipe to culture IMOs is given in the recipe section of this document.

This chart summarises how different tree management tasks can be planned in a year.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
COMPOSTING/ MULCHING												
PRUNING												
FUNGUS/PEST MANAGEMENT												
PANCHGAVYA												

We experienced heavy monsoon in the months Oct/Nov/Dec and thus no tree management tasks were carried out in that period.

nursery

The decision to whether to put the seed in the nursery or not can taken by keeping the following things in mind:

1. The size of the seed. If the seeds are too small, it is difficult to sow them at uniform distances and they can easily get lost, or eaten by worms, insects, and birds. In such cases, we prefer to start the seeds in the nursery and transplant outside once the first true leaves appear.
2. If we only have a few seeds to try out, it's better to do it in the nursery. That way intensive care can be taken of the seed and the plant and seeds be saved for propagation.

Ingredients for nursery soil:

- 1 part good soil from an existing bed
- 1 part freshly sieved compost
- 1 part coarse sand

Seeds have enough nutrients stored in them to germinate; therefore seeds do not need to be planted into a very rich soil in a nursery.

Things to take care:

Air

Keep the soil moist but not wet. Too much water in the soil doesn't leave space for air/oxygen.
Also, don't plant the seed too deep in the soil.

Drainage

Sand is added to the soil mix to facilitate good drainage and prevent water getting clogged in the soil.

Warmth

The filtered sunrays from the nursery roof will keep the seeds/seedlings warm but not burn/dry out as direct sunlight would.

Transplanting

The seedlings should be transplanted as soon as the first leaves (true leaves) appear. The more you wait, the more damage you can cause to the stem and the roots while transplanting.
A couple of days before transplanting reduce the water supply to the seedling. This will prepare them to deal with the uncontrolled nursery environment outside.
Also, the seedling can be watered shortly before removing the seedlings from it so that enough soil will cling to the roots to help prevent transplanting shock.
Care should be taken to not leave the seedlings without soil for too long (in between removing from the nursery soil and transplanting elsewhere).
Even a few minutes of air-drying could adversely affect those delicate roots.

preservation

When we started growing food, we realised the importance of preserving food also. We never have a precisely consistent harvest from the garden, which means we sometimes have more of a certain vegetables, and some time less. Also, not all vegetables grow throughout the year.
If we could preserve the vegetables/fruits in the season, it would be possible to enjoy their taste and derive their nutrition all year round.
For this we turned to **fermentation**.

Food storage can be done by drying and cooling, but it requires some amount of technology to achieve ideal conditions for storage.

Fermentation is a historical method of preservation of food (bread, wine, kimchi etc.). The traditional rituals of fermentation have evolved over thousands of years by careful observation of natural phenomenon and trial and errors.

Fermentation is essentially transformation of nutrients by microorganisms. These microorganisms (bacteria or fungi) can either occur on the food naturally (*wild fermentation*) or can be introduced as starter cultures (*an established ferment or microbial community*). Every raw food (fruits, vegetables, milk etc.) is host to a diversity of microorganisms. By manipulating the environment, we can favour the desirable microorganism to transform our food into a more stable, nutritious form with a characteristic ferment flavour, which is usually very different from the original food.

Fermentation is largely understood as an anaerobic process, that is the fermenting bacteria/fungi are cultured in an environment with no air/oxygen. On a cellular level, fermentation is a way of obtaining energy without using oxygen.

Fermented food and nutrition
Fermented foods are pre-digested by the enzymes produced by the microorganisms, and hence are easy to digest and have more available nutrients. Also the bacteria in the live culture foods (like curd, kimchi etc.) contain lacto bacillus bacteria (LAB), which enrich our microflora (several kinds of bacteria in our gut), discourage pathogen build up in the intestine and help in digestion.

Thus fermentation not only helps us preserve food for longer, it improves the nutritive quality of the food. In most cases, it also enhances its flavour.

FERMENTING VEGETABLES

Salting

Vegetables are first cut into small pieces and salted. The more the surface area the better, so the finer we can chop the vegetables the better. Salt facilitates vegetable fermentation in a number of different ways:

- Salt pulls the water out of the vegetables because of osmosis, which keeps the vegetables soaked in their own juices.
- It makes the vegetables crispier by hardening plant cell compounds and prevents them from getting mushy.
- It creates a selective environment and favours the salt tolerant Lactic acid bacteria.
- Salt extends the potential for preservation by slowing the fermentation and natural decomposition processes.

Although, in some traditions fermentation is done without using salt. The choice of whether to use salt or not, and if yes, how much, depends on personal preference and taste.

We have been using rock salt / himalayan salt (as opposed to iodised salt) as they contain essential minerals which add to the nutritive richness of the ferment.

The salted vegetables can be left in a container covered with a piece of cloth for a couple of days.

Squeezing

In a few days, enough water would have gone out of the vegetables. They can then be squeezed between the palms to extract their juice further.
This juice will be medium in which the vegetables will ferment.

Packing

Pour the vegetable juice in a glass jar and add the squeezed vegetables in the jar, pressing them hard so that air bubbles come out. Keep adding the vegetables bit by bit while pressing them down in their juice every time. More spices, salt can be added in between layers at this time.

Since fermentation is an anaerobic process, it is absolutely essential that the vegetables be completely submerged in their juice cutting them off from air.

Fermentation process also releases considerable CO2. Take care that the jar is not full up to the neck. Leave some space to accommodate the CO2 build up and open the jars once in a while to release the pressure. If the jars are left unattended for months together, they can literally explode.

The ferments can be savoured within a few days. The longer they are kept for, the more characteristic their fermented taste becomes. The ferments can be eaten as raw pickles or cooked.

Though we can keep certainly keep them for a year, fermented foods will not last forever. Their longevity depends on the type of food, salinity, water and its pH, humidity in the air and one's tolerance for strong fermented tastes.

After our spring harvest, we fermented broccoli, cabbage, carrot, turnip, kohlrabi, beetroot, radish, green leaves, and achieved some delicious results.

FERMENTING FRUITS

Fruits too can be fermented using the same principal, as vegetables but, of course, there are several other ways. We fermented a batch of plums but we added honey and cinnamon while packing. The result was a tasteful jar of sweet and salty plums.

Reference:

The Art of Fermentation by Sandor Ellix Katz

Food Resilience

We have been encouraging the workers to share harvests. Every time a worker takes leave from work to harvest something on his/her farm, s/he comes back with a few kilograms of the same produce for us. We in return gave them milk or vegetables/herbs from the garden. Also, we share small quantities of seasonal harvests from the garden. The idea was to not pay by money and by something that is equivalent in energy terms.
(Our ecosystem works on energy exchanges and value in money doesn't really tell too much about the real value of something.)

This has started a culture of sharing vegetables, fruits, seeds and flowers between the workers and the farm.

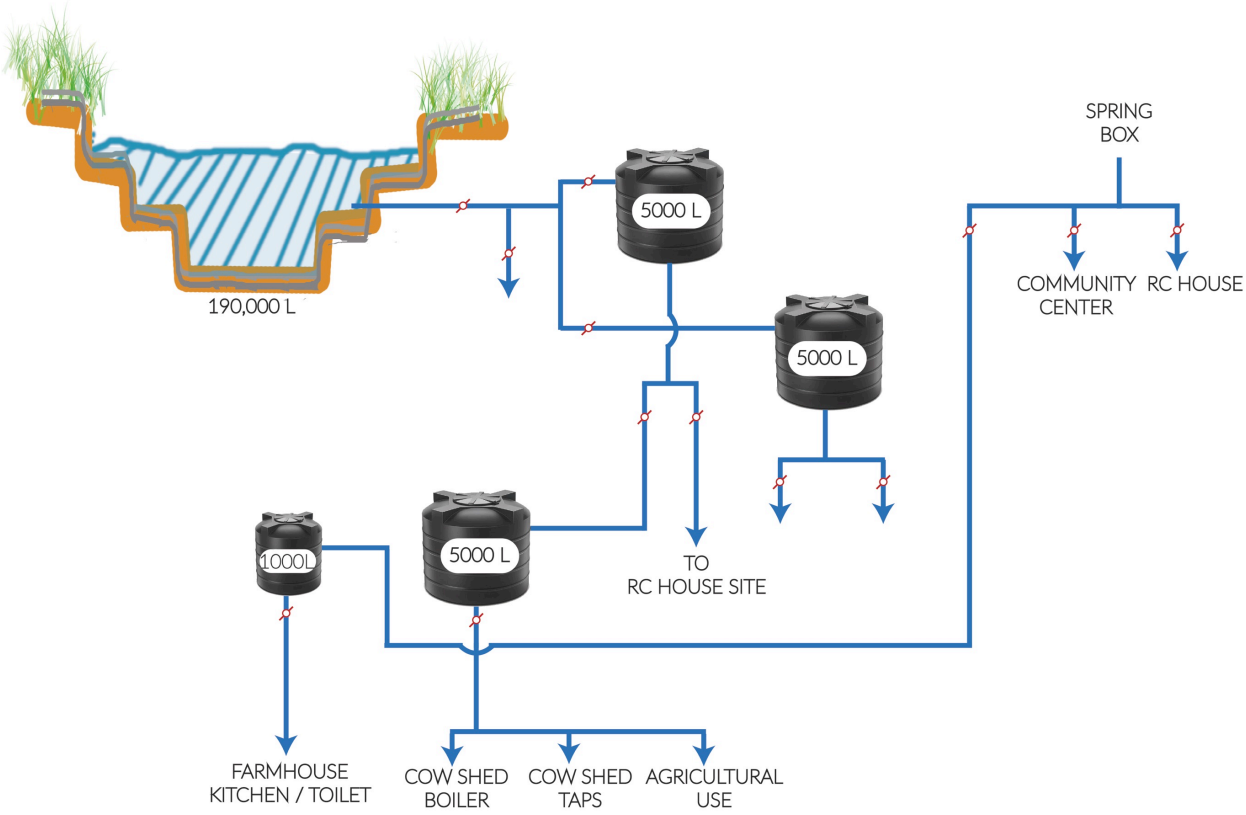
Our wish is that this will help build a food network between Sun Farm and Vilpatti and eventually inspire the farmers in Vilpatti to switch to ecological / natural/ organic methods of farming.

WATER

The existing water systems and their designs have been illustrated below.

UPPER POND SYSTEM

Source: Rain/ Sub-surface flow



KITCHEN GREYWATER SYSTEM

Source: Farmhouse kitchen

Grey-water is any wastewater except water from toilets (which is called blackwater). It is estimated that 70-80 % of the waste water coming from a household is greywater. Conventional plumbing systems dispose of greywater via underground septic tanks or sewers which often get overloaded, are difficult to maintain and have poor treatment, spewing it into lakes and rivers. For all the planning of a modern world, we are still throwing our waste in our water sources.

Grey water is rich with nutrients (mainly nitrogen and phosphorus), bacteria and toxins depending on what the water was used for. When this water is expelled into fresh water bodies, these excess nutrients cause rapid algal growth (algal bloom). When these algae die, numerous bacteria and fungi feed on them, taking excess of oxygen from the water and smothering the aquatic life within (eutrophication). High levels of nitrogen in the form of ammonia ($NH4+$) can also extract oxygen from the water to form nitrates ($NO3-$). Toxins too affect the aquatic life and enter the water cycle polluting the entire entity of water. Thus, it is important to reduce both the nutrient levels and the toxins level of the wastewater before it is disposed.

The most effective way of disassociating nutrients from the greywater is to allow the microbes in the system or biologically active soil to devour the organic matter in the water. The nutrients released by these microbes can be used for agriculture; forest and landscape irrigation while the water either infiltrates the soil or is re-used.

One important aspect of water conservation is allowing water to infiltrate into the ground wherever possible. When water passes through the soil, it cleanses itself and recharges the ground water table. We should, however, be careful of the quality of the water going down the soil, or we risk polluting our groundwater reserves.

Design considerations

The existing farmhouse has a single kitchen, which generates about 100-120 litres of greywater everyday. We had initially put this water around a group of banana trees, but due to slow drainage in the soil, there was always some water that was either standing in the trench or had to be channelised to flow through the garden. A more effective and less demanding system was needed to deal with the greywater and make optimum use of its nutrients.

- It was important that the greywater doesn't flow into existing drains and swales to prevent contamination of water bodies.

- We had initially installed a grease trap in the system. However, a grease trap can really be a trap. It involves regular maintenance (every week in our case). Since there wasn't any grease disposal system from the grease trap, this grease would end up in the compost, which got us wondering why do we even need to separate the grease in the first place.
- A lot of greywater designs suggest use of perforated pipes for distribution of water across the length of the pipe. In our experience, they clog pretty often, from grey water sedimentation, earth, mulch etc. and we wanted to avoid this in our solution.
- We wanted to keep the system simple and working at all times, so that users are encouraged to participate rather than dismiss the system.

Grease and oil cause clogging in sewer pipes by accumulating on the inside. Over time, these deposits get larger and reduce he sewer pipe capacities and lead to overflows (potential cause of diseases). The cleaning of these deposits is not easy and can be very toxic. So a grease trap is essential in homes cooking with lot of oil and meet, and, of course, in restaurants.

Mulch pits

Greywater mulch pits are an easy to build and maintain solution for re-using greywater in a garden. Mulch pits are really a hole in the ground filled with mulch where the greywater can be directed from a kitchen or other source. The nutrient rich water provides food for the microbial life feeding on the mulch and the solid food wastes carried along with the greywater. The water loses part of its nutrients as it passes the mulch and finally infiltrates the soil. Thus mulch pits help in filtering water before it soaks into the ground.

Mulch pits can either be dug close to trees so that the nutrients released from the water and decomposing organic matter are available to the plant (along with the water going down the soil), or the mulch can be allowed to decompose completely in the pit and be used as compost. This compost can again feed trees or vegetable gardens (preferably not for root crops). Mulch pits also prevent evaporation of the water, keeping it in the system for longer and thereby helping in restoring its quality.

Based on the daily greywater generation and drainage of the soil, multiple mulch pits can be dug for a system to prevent water logging in a single pit.

Design

We decided to build two mulch pits for the kitchen wastewater around a pair of banana trees that already existed. When one pit gets full, we shift the water to the other pit and let the first pit sit for a while to let the excess water seep down and the mulch and organic matter to decompose. The idea is to use one mulch pit for about 4-6 months and then change to another for about the same time. The durations can be adjusted as per the need and state of the pit. Also, banana is a heavy feeder and soaks in a lot of water and nutrients.

Thus, the mulch pit in this case will serve two functions:
1. Generate compost
2. Generate biomass

The volume of each pit (160 litres) is about 4 times the peak flow (40 litres) that leaves the kitchen wash area at any given time. This is to allow for the space taken up by the mulch, food waste and a bit extra. The mulch pits are about 100 cm deep. The increased depth was to account for the volume as we could not increase the surface area due to space constraints.

The main outlet pipe is connected to a flexible hose that can be shifted to either of the mulch pits.

For grey water systems, pipes of diameter 1.5" to 2" are recommended. Any smaller and clogs are more likely. Any larger and solids might stick on the bottom of the pipe. The outlet pipe already in use in the kitchen is 2.5". Because of the short distance between the source and the outlet and a fall of about 10 feet (3 metres), we decided not to change the pipe. The fall will keep the greywater flow gravity fed. Where the pipe is horizontal, it slopes down by about 2%. At this slope, the water and solids move more or less at the same speed. If the slope is lesser, the water doesn't flow well, and at greater slopes, the solid waste lags behind the flowing water, building up over time and clogging the pipes.

We also introduced worms from our compost piles to the mulch pit. These worms will help in tunnelling through the mulch and grey water residue deposition, creating more air spaces and favouring aerobic decomposition. The worms also have the ability to kill some pathogenic microorganisms.

Greywater systems also require a change in behaviour. We have been using mild, natural substitutes to the easily available, cheaper and stronger soaps and cleaners.

Future considerations

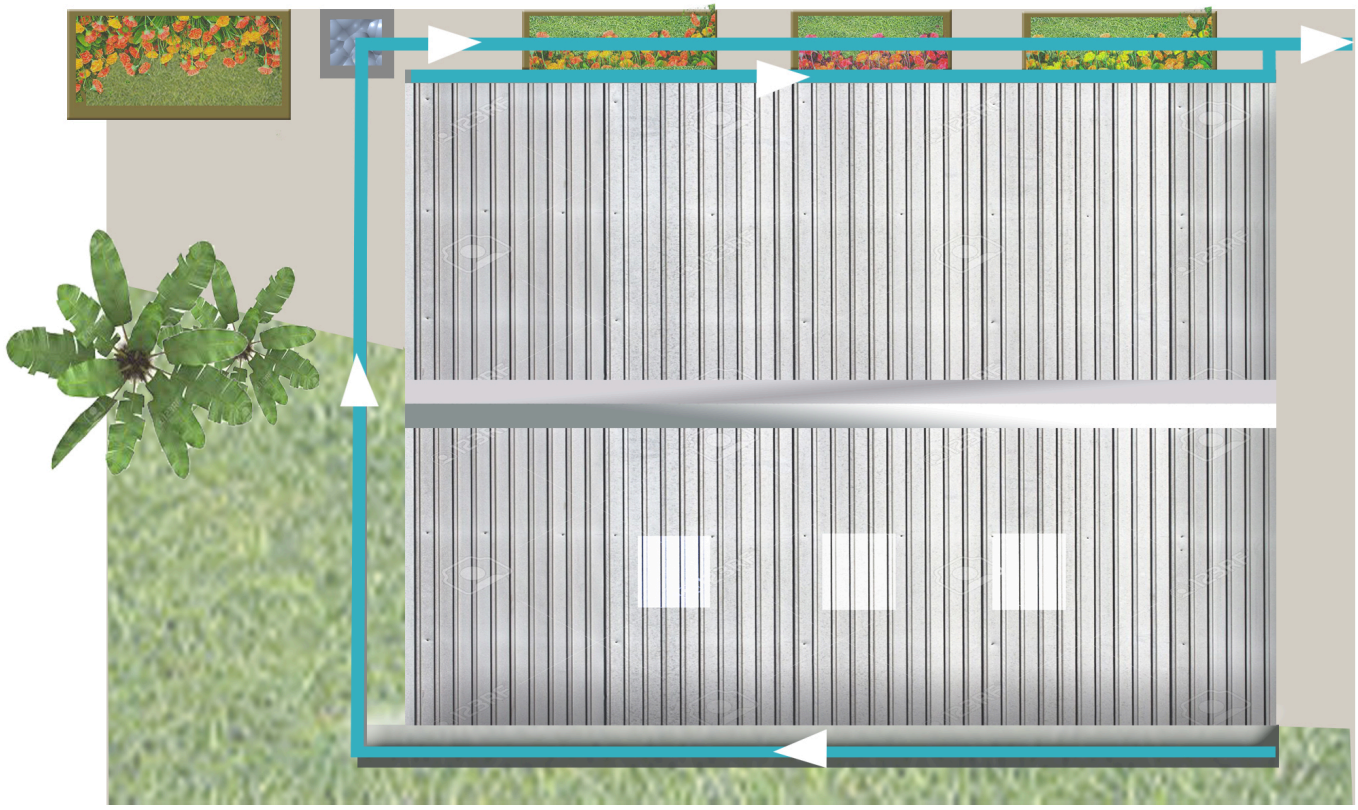
The performance of the mulch pits has to be observed in monsoon and cold season (October- January). Too much water from the rain could leave the soil saturated and the infiltration could be slow. Also low temperatures could decrease the microbial activity taking longer for the mulch and other organic waste in the pit to decompose.

Reference

Create an Oasis with Greywater by Art Ludwig

COW SHED RAINWATER HARVESTING SYSTEM

Source: Rain



Fire

How man must have felt when he discovered fire for the first time, has always intrigued us. Domestication of fire is probably the most crucial of all human discoveries. Fire has helped us to keep ourselves warm, protect ourselves from predators, cook food and create light. Now, of course, fire lies at the heart of modern industrial age.

In Sun Farm, firewood is abundantly available from the eucalyptus forest cover. The wood is used to fuel fire for heating and cooking.
To make a stove that uses the firewood efficiently to turn it into heat and doesn't give out smoke, we need to first learn about fire.
When we burn wood, the wood itself doesn't burn. Because of very high temperatures, the wood releases a glass called wood gas (a mixture of hydrogen, nitrogen, carbon monoxide and traces of methane). Wood gas is combustible and at high temperatures in presence of oxygen and it bursts into flames. The remaining solid residue, char, is then combusted to form carbon dioxide. Complete combustion of wood (or wood gas) results in two byproducts: carbon dioxide and water vapour. In contrast, incomplete combustion creates unburned particles that cause pollution and health hazards for users. The smoke coming out of the wood is really wood gas that doesn't burn, which can be due to several reasons discussed below.

A hot/clean fire (without smoke) can be made by keeping the following things in mind:

1. Metering the fuel
   cutting the wood into small pieces and feeding them to the fire at regular intervals. A big log of wood will cool down the combustion chamber, restrict passage of air and create smoke.

2. Forming a grid of firewood
   A good fire needs a good amount of oxygen. By stacking the firewood such that enough air passes below and above it, will help in complete combustion.

3. Making a hot combustion chamber
   While starting a fire, smoke cannot be avoided. It takes a while for the combustion chamber to heat up and burn all of the wood gas. By insulating the combustion chamber properly, high temperatures can be achieved rather quickly.

4. Keeping the wood gas in the chamber for longer
   By increasing the time for which the wood gas is in the combustion chamber, complete combustion can be achieved.

5. Creating a draft
   By creating a draft in the combustion chamber, the velocity of the incoming air can be increased. This will create a turbulence in the combustion chamber allowing for better mixing of the wood gas and oxygen.

ROCKET STOVE

A rocket stove is called so because of the rocket sound it makes while in operation. The sound is an indication of the turbulent mixing of the incoming air with the gases released from the wood on fire.
The principal and design of the a rocket stove is simple and that is what makes it a great substitute for traditional stoves.

The rocket stove consists of a combustion chamber and a riser. The height of riser is about three times the height of the opening of the combustion chamber. This is to allow for the gases released from the wood to combust completely till they travel to the top of the riser (hot air rises) and before they could escape, they are turned into heat. The rising hot air also creates a strong draft pulling the cold air into the combustion chamber keeping a good supply of oxygen and high turbulence for mixing of gases.
The result is a clean combustion chamber with high efficiency and very low smoke.
A rocket stove, however, cannot be smokeless if the basic principals of making a clean fire are not considered.

Reference:
Combustion Engineering, Borman & Ragland, 1998

Cow shed construction

STRUCTURE

The structure of the cowshed is made of red gum eucalyptus wood cut in year 2015 from the forest above the farmhouse Most of the wood used is about 15-20 years old and has been seasoned for 6 months or more after cutting. All the wood being used was painted with Neem oil and diesel (in ratio 1:1) several times, with a final coat of only Neem oil. Neem oil will protect the wood from termites and also prevent absorption of water in the wood.

WALLS

The walls of cowshed are 2.20 meters high. The lower 1 m is built out of stones and mud mortar. The upper 1.20 meters is built as per a tamil traditional building method, ***varchee***. In varchee A framework is created using tree branches which is then plastered on both sides with mud.
The method was used for the north, east and west walls of the cowshed.

The lower wall was built out of stone to protect the upper mud wall from rising damp and splashes from rain. A roof overhang of 1 m was also provided on the north wall for protection from rain.

To keep the cowshed warm, we tweaked the varchee method a little. The wooden wall panels have been sandwiched with stones and mud in between them.
This increases the thermal mass of the wall, which means that the wall will retain heat for longer because of the stones/mud in it.
To space between the horizontal wood sticks was filled with a mix of mud, cow dung and eucalyptus bark fiber.

The eucalyptus-bark fiber was separated from the bark simply by hand. This was added to the mud mix to give it tensile strength and prevent shrinkage/ cracking without decreasing the bond strength much; as opposed to sand which reduces shrinkage but also reduces bond strength.

The following layers of plaster on the wall were done with mud alone. Once this layer dried and shrank, the cracks were filled with finely served mud.
This was repeated several times, filling smaller and smaller cracks every time.
Finally when the cracks were negligible, the wall was rubbed with a wet cloth.

For finishing, cow dung mixed water was applied with a cloth to the wall. This helped by filling the few minute cracks in the plaster and creating a hydrophobic layer on it, protecting it from moisture.

When working with mud, empirical formulations are not as important as what feels right. Mud gets under your fingernails, into your bones and deep in your heart.
It is important to understand that a good balance of sand and clay is needed in building. The clay binds really well, but expands and contracts in presence or absence of water. Sand alone is really strong but it doesn't stick together.
For a structure to be solid, it should be able to resist both compressive and tensile forces. Sand provides compressive strength while the clay is responsible for tensile strength.

Recipes

INDIGENOUS MICROORGANISMS (IMOs)

Following is a simple way of harvesting IMOs by Rohin Dsouza and Rico Zook (www.i-permaculture.org).

Material:

1. Non metal container with a lid/cover (we used empty coconut shells in the beginning. We are now using banana leaves since they can hold much more rice)
2. Day old cooked rice
3. String
4. Jaggery /whole sugar / sweet fruit pulp

Recipe:

Harvesting the IMOs

1. Loosely fill the cooked rice in a non metal container and cover with a lid so that there is some space to air to pass through but not enough for the insects to get in.

2. The rice should be firm so that it has air around it. The rice can be moistened just a bit before it's filled in. Soft rice with too much water will not allow room for breathing.

3. Bury the container/shells with rice in a moist place that has good rich soil, such that the top of the container is just below soil surface. Moisten the soil if necessary but do not pack the soil. Access to air is crucial. If air temperature is cold a place in the sun might be suitable, like a shaded place if the sun outside is too intense. Mark the spot for easy identification.

The place of harvesting will determine the dominant microorganisms that will grow on the rice. Rice buried in a forest will potentially have more fungi than bacteria. Plant specific microorganisms can be harvested by burying the rice close to the growing plant or in a heap of freshly cut plant.

4. Wait 5 to 7 days depending on soil temperature and richness of soil. If necessary keep soil moist during this time.

5. Dig Up and Open. If it worked you will find moulds of different colours, some fuzzy, some not, giving the sweet fermented smell. These are the IMOs feeding on the rice. If it stinks putrid and turns the nose it has gone anaerobic and should be thrown out since it wont be of much use.

If it smells ok but does not have much growth it can be closed back up and reburied for a longer time.

Multiplying the IMOs

6. In a non-metal bucket mix molasses or raw sugar (about the same weight as the rice) with tepid water (not hot or cold to touch). We need a rich mix of molasses and water to begin with, so be careful with how much water you add.

7. Add the molded rice to the liquid mixture. Break up all clumps well and stir mixture thoroughly so all grains are individuals. Finished mixture will be like thick soup.

8. Cover the bucket/container with a shade net, old cloth or any other breathable sheet. This is to keep insects and unwanted animals out while still allowing oxygen in. Place bucket in a quiet place at room temperature out of the direct sun.

9. Wait 5 to 10 Days depending on the temperature outside.

10. When ready it will have the sweet fermented smell. It should also be very fuzzy. If not fuzzy enough and/or smell is weak, recover and wait some more days. If it has stinky putrid smell throw out and try again.

Storage

Using an old cloth or net strain well to remove all rice particles. This culture will last 4 to 8 weeks. If a culture is stored for long, more sugar should be added to keep the IMOs from starving. After awhile the strain will weaken and a new batch will need to be harvested.

Usage

1. These IMos can be diluted with water (1:10 for mature plants and 1:20 for young, sensitive plants) and sprayed on the soil or leaves for growth promotion and helping fight diseases.

2. They can be added to compost and greywater systems to accelerate decomposition and prevent bad odours from decomposing material.

JEEVAMRIT / AMRUT JAL

Jeevamrit or Amrut jal is an organic growth promoter which can be applied to the soil. It is essentially a rich culture of beneficial bacteria cultured from cow dung, cow urine and a handful of healthy soil.

Ingredients:

- Cow dung
- Cow urine
- Water
- Jaggery / whole sugar / papaya pulp / banana pulp
- Gram flour
- Good garden soil

Recipe:

1. Fill 200 litres of water in a drum/tank kept under a shaded place.
2. Add 10 Kg cow dung (as fresh as possible) and mix thoroughly.
3. Add 5-10 litres cow urine (as old as possible) and mix.
4. Add 1 Kg jiggery and mix.
5. Add 1 Kg gram flour (besan) and mix until you dissolve all the lumps.
6. Add a handful of good soil from compost and mix.
7. Stir this mixture for about 5-10 minutes continuously clockwise and anti-clockwise.
8. Cover the drum/tank with a breathable fabric to allow the aerobic bacteria to proliferate.
9. Stir the mix again the next morning and evening.
10. After 48 hours, you will see the mix bubbling. This is the methane coming out of the mix.
11. The remaining mix is an organic fertilizer rich in nitrogen and bacteria.
12. You can sieve this mix with a cloth or green shade net (so that your sprayer doesn't get clogged) and spray on the soil.

A mix made in 200 litres of water can be sprayed over an acre of land. If you are working on a smaller piece of land, reduce the quantities accordingly.

PANCHAGAVYA

Panchagavya is an organic growth promoter and can be used on both soil and foliage, depending on the soil and plant health.

This recipe is from Annadana Seed Bank at Botanical Gardens, Auroville.

Ingredients:

- Fresh cow dung- 5 Kg
- Ghee- 1 Kg
- Cow's urine- 3 litres
- Cows milk- 2 litres
- Curd – 2 litres
- Tender coconut water- 3 litres (about 4-5 coconuts)
- Mashed banana- 12 numbers
- Jaggery solution- 1 Kg dissolved in 1 l water
- Honey – 50 ml OR fermented coconut juice- 2 l

Recipe:

Keep adding the ingredients in the above order and stir well each time.

Stir the final mixture continuously for 1-2 minutes in clockwise and anti-clockwise directions.

Cover with a shade net and let it ferment. In hot regions, the fermentation might happen in about 3 weeks. It Kodaikanal it took about 10 weeks. You will know when it starts smelling sweet (It will still smell really strong). Also you will see bubbles appearing on the surface of the mix. Once the bubbles die out, the fermentation should have completed.

For spraying, filter a couple of times with a cloth or shade net.

For using, mix 300 ml Panchagavya in 10 litre water (3 % solution)

GINGER GARLIC CHILI EXTRACT

Application of ginger garlic chili extract is used for aphides and pest control. We have been using this for the fruit trees.

This recipe is adapted from Annadana Seed Bank at Botanical Gardens in Auroville.

Recipe:

1. Crush/grind 25 grams of ginger, 25 grams of green chilies and 50 grams of garlic.

2. Put the crushed ingredients in a cotton cloth and soak the cloth in 500 ml of warm water.

3. Leave the cloth in the water for about 30 minutes.

4. Squeeze the cloth to get the remaining extract from the crushed ingredients in the same container.

Usage:
This extract can be mixed with 5 liters of water and 100 ml of soap solution. The soap solution is added to increase the surface tension of the mix. After adding soap solution, the mix will stick to the tree much better.
Use a brush/stick to paint the affected areas.

SEEDBALLS

The simplicity and effectiveness of seedballs was popularised by Masanobu Fukuoka in his practice and teachings of natural farming. Fukuoka believed that seedballs have the potential of turning deserts into forests.
This is simple way of making seedballs adapted from the Fukuoka's recipe with additions from Rico Zook (i-permaculture.com).

Ingredients:

- Red clayey soil (the more red the better. white or grey clays can become brittle and disintegrate easily on drying)
- Ash
- Aged cow manure / Compost
- Red Chill powder
- Seeds

Recipe:

1. Mix 5 parts finely sifted dry red clayey soil with 3 parts finely sifted compost or aged manure. *(It is important to sieve the soil and the compost to make nice firm seedballs.)*

2. Add 1 part finely sifted ash (wood ash/volcanic ash). Ash is a great source of minerals for the young sprouts.

3. Add a little red chilli powder to protect the seedballs from being eaten by animals, or pecked on by birds.

4. In this mix, add 1 part of seeds. (we mix different kinds of seeds together. A single seedball can have several seeds and of several kinds depending on their size and shape).

5. Mix thoroughly.

6. Keep adding little water as you mix until the soil and the seeds start lumping together.

7. Make small, firm balls or dumplings or pellets and leave them to dry in shade (sun drying could cause cracking of the clay).

8. These seedballs can be broadcasted by hand or a catapult. The number of seedballs being thrown in an area will depend on the seeds and the purpose.

9. Water once daily or wait for the rains and watch the seeds sprouting magically from the disintegrated balls.

LEMON SOAP

This is a recipe of making soap from lemons from the tree in the grain field, which can be used for washing vessels and bathing.

Ingredients:

- Fresh lemons
- Water
- Turmeric
- Baking soda
- Wood ash

Recipe:

1. Cut and squeeze lemons in a bowl with water. Boil this lemon water with the cut lemons so that all the lemon pieces are soaked well. The boiling is best done on low flame and with the vessel covered. This will keep the lemon extract from escaping as steam.

2. Let the water boil on a low flame for about 30 minutes (the more you let it boil, the better).

3. Leave it overnight to cool (with the lid on the vessel, so that the condensed extract will fall back into the water).

4. The next morning, you would observe that the water has turned a bit yellow and it feels oily. This is the oil from the lemons. The lemons can be removed from the water and squeezed so that most of the oil/extract is obtained.

5. The lemons can be stored separately for pickling.

6. The lemon extract water can be stored in glass/plastic bottles.

Usage:

The lemon water can be mixed with wood ash or baking soda for use to clean dishes.

Soap is made by reacting animal or plant fats with an alkali, such as lye. In this case, the lemon oil is the fatty part while wood ash or baking soda provide the alkali part.

For bathing, mix this lemon water with turmeric and baking soda.
Adjust the quantities of baking soda/ash/turmeric as per need and how it feels!

Recipe for pickling lemon:

1. Add salt and other spices (chili, cloves, pepper etc.) to the lemon pieces taken out from the water.

2. Put the lemons in a glass bottle and pound them down. Leave top 1/4th of the jar empty. This will ensure that the pickle has some space to breathe.

3. Store the jar in a cool, shaded place.

4. After 2-3 weeks, the pickle can be used to eat raw or can be cooked with other vegetables. The pickle can be stored for several months. As it gets older, the bitterness of the lemon changes to a fermented sweet taste.

EUCALYPTUS BARK

We have and will have a lot of stripped bark from the eucalyptus trees. After soaking in the rain and sun for a few months, it can be used in the following ways:

MULCH

Pathways

Because of its thick and fibrous nature, the bark acts as great pathway mulch. It keeps the paths dry by soaking in water, prevents soil erosion on the paths, keeps them clean of grasses and feels great under the feet.

Trees

It was long debated that the bark might be harmful to the trees because of the oil/tannin concentrations. We used the bark for mulching established trees after drying in sun and soaking in rain for about 8 months. Even after months, the trees haven't shown any signs of harmful effects from the bark.

FIBRE FOR BUILDING

This was an interesting discovery. We are replacing straw in cob with the fibre from the bark to add tensile strength to the mix. We have used this cob for the cow shed walls. The strands of the bark are seperated simply with hand and left to cure with the earth and cow dung for about a couple of days before using. We have been using the fiber from the bark to make cob for the cow shed walls. The fiber is separated simply with hand from long pieces of the bark (around 20 cms long).

BUILDING WITH LIME

Lime has been our primary choice for building. We like working with lime because of its raw nature and ability to bind well with soil. Also, it has a much lower ecological footprint than cement. Though, it can be difficult to work with because it requires attention to be paid to how it behaves, more so, because it behaves differently in different conditions of humidity and temperature.
We have used a mix of lime, sand, soil and *surkhi* (red brick powder) for construction of the cascade system next to the pond, the cow shed and other small constructions. We have also used a mix of soil, lime and ash for plastering the pond.

The surkhi and ash are pozzolanic materials (active aluminates and silicates) which make it possible for lime to set in presence of water.
Lime by nature sets with air as it transforms back to its orginal limestone form by absorbing carbon-dioxide.

Reflection

Sun farm has been a great learning opportunity for us, and not just from the point of view of Permaculture. Living on the land, in the mountains, without access and in the neighborhood of a farmers' village has taught us how simple life can and should be. The more we understood the land and the ethics of permaculture, the more we appreciated natural forms and processes and the less need we felt there was for human design.