Some Soil Basics

Extracted from Sustainable Nutrition Manual: Part 2  Healthy Environments

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Part 2, Topic 18: Soil Fertility

**Topic 18: Soil Fertility**

The methods discussed for soil conservation often help with soil fertility and structure, but we need to do more to feed and strengthen the soil so that it is very healthy and productive. This topic will look at more ways to heal and improve your soil.

There are lots of simple and easy methods to improve your soil, now that you understand how soil works and how to support the Nature Cycle. Over the next few topics we’ll cover a few of the common methods currently used in Malawi:

- Soil types
- Soil Nutrients
- How to avoid using chemicals
- Feed the soil with legumes
- Green manures
- Animals manures (Topic 19)
- Composting (Topic 20)
- Human manures (Topic 21)

**Soil Types**

Before doing anything to your land, you will need to look at the types of soil you have. Even the smallest piece of land can have different soil types (sand, rock, clay and / or loam). All types of soils have advantages and disadvantages, and there are different species that do well in different types of soil.

When you know about your soil types you can work with it so you can choose plants, trees and animals that are well suited to that type. (The appendix lists some of the species in Malawi and what conditions they tend to like.) There are also many things you can do to adapt the soil you have and make it more suitable for your needs but it is easier and better to work with Nature than to try and force your soil to be something that it is not!

**Sandy soil is light, loose and drains well**

It is good for coconuts, jujube (masawo) or melons. You can help sandy soil hold water and nutrients by adding lots of compost and organic matter. If you make the effort to dig down 50 - 100 cm under the planting area and put a layer of organic matter (even things like cardboard) it will help hold the water and nutrients in the planting area. This is a bit of work but it really can reduce the amount you need to water and feed the soil over time.

**Clay soil is heavy, dense and holds water well**

Sugar cane, coco yams, fish ponds, bee hives and certain tree species are all good on clay soil. You can loosen and lighten the clay if you need to, by adding lots of organic matter and / or digging sand into it.

**Rocky soil can be hard to dig**

It is good for vines and perennials like aloe, pigeon peas, pineapples, hardy climbing beans such as certain Lima beans (karumpanda), Hyacinth beans (khungudzu) and other vines. Rocks hold heat so these areas may be a little warmer than other areas.
If you need to move some rocks from the area try and use them in the same area, but for something else. Use rocks to stop water from running down a slope, to create terraces, to mark the edges of pathways or to make a stone path.

With rocky soil it is sometimes easier to build the soil up on top of the area than to dig down into it to improve it. If the area slopes, you can make rock walls along the contour lines, or in half circles against the slope, then add lots of organic matter and compost on the slope above your rock wall until it is half a metre or more deep, then plant. Make sure you continue to feed the bed with as much organic matter, mulch and compost as you can so that the good soil continues to build up and up.

**Loam is the ideal soil for most gardening**

If your soil is dark, soft, and crumbly you are very lucky! This is what every farmer wants. Loam has lots of organic matter and many animal, insect and plant types can live in it very well. Loamy soil holds water like a sponge and then releases it slowly to the plants. This kind of soil still benefits from mulching, compost and other good land practices to make sure it stays healthy and fertile.

**Soil Nutrients: Nitrogen, Phosphorus, Potassium**

Humans, as you now know, need about 46 nutrients. Plants and trees need about 15 nutrients. The following three nutrients are most important, as most plants and trees need them in large amounts:

- **Nitrogen (N)** for vegetation (leafy parts of the plant)
- **Phosphorus (P)** for healthy roots, flowers, fruits
- **Potassium (K)** for general health and strength

There are 12 other nutrients that plants need in smaller amounts, but all are important for strong, healthy, productive plants and trees:

- Aluminium
- Boron
- Calcium
- Chlorine
- Copper
- Iron
- Magnesium
- Manganese
- Molybdenum
- Silicon
- Sulphur
- Zinc

Different kinds of plants and trees need different amounts of nutrients. Some species (kinds or types of living things) do better in some places than others because of the nutrients there, as well as other factors, like the amount of sun, shade, and water in the area. In a healthy eco-system there are enough nutrients for the plants and trees to grow. These nutrients are recycled as part of the Nature Cycle and returned to the soil to grow more plants and trees.

Malnourished soil is like malnourished people. When the soil becomes unhealthy and there are not enough nutrients people often treat their soil with chemical fertilizers, but to solve the problem changes need to be made to the design and / or practices that are happening. This is similar to what happens when people have a poor diet that is not supplying all the nutrients they need. People often treat the problem by buying vitamins and minerals as pills, but these expensive products do not solve the problem. They only deal with the symptoms, not the cause.
Nitrogen (N) for vegetation

Nitrogen is one of the most important nutrients in the soil. All green plants use Nitrogen to keep growing and it is needed for development of the vegetation, which often makes up the largest part of plants.

Nitrogen in the soil is continually being used for plant growth and can be lost from the soil when soil is uncovered and open to the air. The level of nitrogen in the soil needs to be continually renewed. This can be done naturally by creating good designs to conserve soil, by feeding the soil a healthy diet and by changing unhealthy human soil practices to healthy practices.

A healthy nitrogen balance in soil means that plants are a deep, rich, green colour. If there is not enough nitrogen the plants become weak or stunted and turn pale green or yellow. If there is too much nitrogen plants may look big and healthy but they can grow too quickly, becoming weak and vulnerable to disease or insect attacks.

Nitrogen is the ‘Protein’ for the soil and helps plants to build and grow, just as protein helps humans to build and grow. The Natural world has many sources of nitrogen because Nature can take nitrogen from the air, from manure and urine, and from plants called legumes and put it back into the soil where other plants can use it to grow. (See page 34 for more information.)

Nitrogen-fixing plants and trees are any plant, tree, or bush that has its seeds in a pod, like beans and peas – they are also are called legumes. Edible legumes provide protein in the human diet, and protein also provides your body with nitrogen. Some legumes are not edible for humans, but are still very good for the soil so include legumes in your designs just for their nitrogen-fixing properties. We will learn more about how to use these as part of this topic in the manual.

Nitrogen is found in plants and trees that are called legumes. Legumes are easy to identify because their seeds are enclosed in a pod. These plants are the same ones that provide protein in the human diet, and protein also provides your body with nitrogen.

Nitrogen also comes from animal sources. All parts of an animal are high in nitrogen: such as manure, urine, hair, feathers, blood, bone, hoofs and horns. This means that any type of animal (fish, worms, chickens, pigs, goats, cattle, dogs, cats, insects, rabbits, etc.) in your design will help make sure there is enough nitrogen. People are a type of animal and can also return their nitrogen to the soil.

Most people in Malawi buy sacks of artificially made NPK and, if they can afford it, they will also buy urea. But there is absolutely no need to buy this! NPK is found in many sources and urea is found in urine, which there is plenty of around, although it is often in the wrong place! We will learn more about this on page 47 when we talk about composting toilets.

Phosphorus (P) for healthy roots, flowers and fruits

Phosphorus helps the healthy growth of a plant's root system, in the development of flowers, in the production of fruit, and it helps plants to fight diseases. Without a healthy level of phosphorus, plants cannot provide us with many of the foods that we like to eat.
In nature, phosphorus is released through the decomposition process. As organic matter decays, special acids are produced that make phosphorus available to plants. If there is not enough organic matter the soil is starved of phosphorus. This problem is made worse in Malawi where so much organic matter is burned. Phosphorus is also found in most parts of an animal. Poor fruit development and disease are signs of low phosphorus levels.

**Potassium (K) for general health and strength**

Potassium is also referred to as potash and helps a plant protect itself from diseases. Another very important function of potassium is to balance the soil if there is too much nitrogen. (Everything works together!) If there is not enough potassium plants will often have weak stems.

A high source of potassium is ash, so chemical NPK fertilizer in Malawi does not have any potassium (K = 0%) as there are plenty of ashes in the environment already.

Tobacco stems and molasses are high in potassium. Molasses contain all the best parts of the sugar cane and is a by-product from sugar factories. Molasses also contains calcium, magnesium and iron, which are important in the human diet. One tablespoon of molasses provides 20% of an adult’s daily needs of these nutrients. We do not use this nutritious product enough. Instead we feed molasses to cows, turn it into alcohol and throw on the road to keep the dust down. What a waste!

**Chemical and artificial sources of NPK**

The most common type of chemical or artificially made fertilizers that people buy are sacks of nitrogen, phosphorus, and potassium, called **NPK**. The packaging gives information about the amounts of **N**, **P** and **K** in the fertilizer. In Malawi the most common fertilizer is 23-21-0 +4S. This means that it contains 23% nitrogen, 21% phosphorus, 0% potassium and 4% sulphur.

The remaining 52% of the bag is just filler. This is just something bland and neutral which makes a more bulky product. The reason to include this is because it makes it easier to spread the product over the soil and not put too much of the fertilizer in any one place.

The whole process of making NPK artificially is harmful to the earth with the amount of fossil fuels needed from production, through transportation and in use. NPK is not as healthy for the soil as the many diverse nutrients that are already in the natural world, which includes plenty of nitrogen, phosphorous and potassium.

Once you understand the importance of each nutrient and where to find them, you can use what you have in your area already. There is no need at all to buy artificial fertilizers if we look after the soil properly and use all our resources efficiently.

**Natural sources of NPK**

Each item listed in the table below contains NPK plus other useful nutrients and fibres (hair, fur and feathers, etc.) that really help the soil’s structure and micro-organisms. You do not get all this in a sack of NPK!

These are the three most important nutrients, but remember that all 15 nutrients are important for the soil. Your soil will have all the nutrients it needs if it gets a diverse diet, supports many types of plants, trees and animals (appropriate for your area) and if you take care to conserve your soil.
<table>
<thead>
<tr>
<th>Nitrogen (N)</th>
<th>Phosphorus (P)</th>
<th>Potassium (K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Sources</td>
<td>Decomposition of all sorts of organic matter</td>
<td>Ashes</td>
</tr>
<tr>
<td>Manure and urine of small animals: bats, pigeons, rabbits, worms, etc.</td>
<td></td>
<td>Molasses</td>
</tr>
<tr>
<td>Human manure and urine, fish and blood, hoofs, horns, animal hair and</td>
<td></td>
<td>Tobacco</td>
</tr>
<tr>
<td>feathers</td>
<td></td>
<td>Blood</td>
</tr>
<tr>
<td>Leguminous plants, tea leaves, tobacco</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium Sources</td>
<td>All parts of small animals and manure</td>
<td>Urine</td>
</tr>
<tr>
<td>Manure and urine of medium sized animals: chickens, dogs, rabbits, etc.</td>
<td></td>
<td>Potato tubers, some grasses, straw</td>
</tr>
<tr>
<td>Bones, coffee grounds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Sources</td>
<td>Manure from larger animals: cows, goats, horses, pigs, sheep</td>
<td>Animal manures</td>
</tr>
<tr>
<td>Manure and urine of larger animals: cows, horses, sheep, pigs, ducks, etc.</td>
<td></td>
<td>Plant scraps</td>
</tr>
<tr>
<td>Egg-shells</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Organic Agriculture**

To have sustainable nutrition and a sustainable lifestyle you will want to avoid poisonous chemical products (fertilizer, pesticides, fungicides and herbicides) as much as possible. These can harm the Nature Cycle, are produced and transported using non-renewable sources, and disturb the balance of insects and micro-organisms in the soil.

**Organic Agriculture is when people produce products without using chemicals.** Organic farms need to be inspected and certified before the food can be exported with the label saying it is organic, and it is often more expensive to buy in other countries. Here in Malawi it can actually cost you less to make your food organic. If you are thoughtful and clever in how you do things you can avoid all these problems:

- **Chemicals are expensive to make**, costing money and other resources. Non-renewable fossil fuels are used when making or transporting them.
- **Chemicals do not feed or heal the soil.** They treat the symptoms of poor soil health but they must be given again and again because they do not solve the problems that cause the poor soil.
- **Chemicals are often poisonous** to humans, especially children, old people, and people with weak immune systems (like those with HIV). Special training and equipment is needed to use chemicals as safely as possible.
- **Chemicals can kill beneficial insects, worms, micro-organisms and other parts of the nature cycle.** This can happen either directly during application of the chemical, or indirectly through the effect that the chemicals have on the ecosystem that the insects / worms / micro-organisms rely on.
- **Chemicals often stop working** as insects and diseases get used to them. Then people have to make new, stronger formulas that are often even more toxic.
This does not need to happen if we heal the eco-system and look after it properly. We can design our agricultural systems, homes and lives so there is no need for toxic chemicals. Chemicals are generally used when the soil is degraded, or the plants, trees and animals are unhealthy, but this manual shows you how to restore soil health and design environments that are healthy for all living things. The rest of this topic about soil will be about Legumes and Green Manures, then we will look at some other Soil Health topics that need more space: animals for soil fertility, composting and composting toilets.

**Legumes**

Legumes help other plants by fixing nitrogen. These plants and trees take nitrogen from the air and make it accessible in the soil so other plants can use it. As we pointed out when we talked about the plant nutrient, nitrogen, legumes are any plant, tree, or bush that has its seeds in a pod.

- **Edible legumes:** These legumes are great for human nutrition and soil nutrition:
  - Beans, peas, ground nuts, ground beans, etc. (*kamumpanda, kabaila, nzama, mtedza*, etc.)
- **Non-edible legumes:** Acacia species (*msang, mtete, etc.*) tephrosia, leucaena, cassia (some can be eaten by animals but not by humans.)

Using legumes gives you more variety in your gardens, farms, and in your diet and it can help to keep Nature and your family healthy at the same time. Nature is the best teacher and she has two useful practices that we can copy:

**Inter-planting**

This means mixing up the plants you grow with other kinds of plants in an organised planned way. We have seen that nature is always diverse and this includes legumes and / or animals. To copy Nature in your design you can plant a bean, pea, groundnut or other legume between other plants like millet, maize or sorghum. Plant legumes around the edges of your beds, or alternating in strips across a slope. Think about what kinds of plants go well together. Pigeon peas (*nandolo*) or Lima beans (*kamumpanda*) grow well with maize, for example. (There is more information about which plants go well together on page 90 when we learn about Permaculture Guilds.)

This means growing plants in different places over time in an organised, planned way. Planting the same thing over and over again in the same place uses the same nutrients every year; soon all of that particular nutrient is gone. There is nothing to replace them so the natural balance is destroyed. Even if you replace the nutrients with chemical fertilizers it is likely that diseases and pests will catch on to your monotony and find your plants, so then you will have buy treatments and pesticides. This leads to the Cycle of Dependency that we looked at in Part 1, Topic 2, The Impact of Food Choices.

**Crop rotation**

Most agricultural systems and advisors recommend *Crop Rotation*, but many Malawians do not do it. This may be because they do not know about it and how good it is for the soil, or because they only have small areas of land and they seem to only want to grow maize or for some other reason, which you need to find out about if you are to help them adapt.
As we now know, less maize and more of everything else would be healthier for you and the Natural World! If you plant legumes in a bed this year and then a grain crop in that bed next year the grains will do much better because they went into soil where legumes grew before, which improved the nitrogen in that area, especially if the other healthy soil practices are being used (designs for soil conservation, mulching, etc.). Most plants will benefit from being planted in a place where legumes grew.

This four-step rotation is easy to remember as it uses NPK, then adds N again:
1) Leaf / grain uses N nitrogen
2) Fruit uses P phosphorus
3) Root uses K potassium
4) Legume adds N nitrogen back into the area

The example below looks at just one bed, over an unspecified time frame, depending on the length of time and season that each species needs in that area. You might even leave the bed to rest with mulch on it before starting the four step rotation again. Using mulch and other permaculture methods will replace the P and the K naturally, conserving the natural fertility of the soil.

1. First, plant a leaf or grain crop that uses a lot of N, such as amaranth or sorghum;
2. After harvesting the leaf or grain, plant any type of fruit in that bed. You can use fruiting plants from any food group, such as cape gooseberry (jamu) or cucumbers or chipwete;
3. After harvesting the fruit, plant a root crop, again from any food group, such as onions, garlic, ginger, yams or sweet potatoes;
4. Finally, plant a legume or put an animal in that area to replace the nitrogen, such as ground beans (nzama), cowpeas (khobwe), a non-edible legume or an animal such as chickens.

Then start the cycle again with a leaf or grain crop, possibly a completely different one from the first time around, or let the bed rest before starting again.

Green Manures
Green manure means feeding the soil nutritious green plant matter. Green manures are often legumes, but not always. As well as legumes, there are other types of plants called nutrient accumulators, like tithonia or amaranthus (bonongwe) that gather together different nutrients in their leaves and stems. Feeding these plants to your soil gives it extra vitamins and minerals. There are many ways to use green manures.

- Mulching with green manure trimmings is when fresh green material is trimmed off plants and trees and laid on the ground as mulch. Green manures can be interplanted or put on the edges of gardens and farms to make it easy to add green mulching all year. They could be added as hedges, contour strip planting or dotted throughout your design. They are especially useful when they are leguminous species.
• **Incorporating the whole young plant into the soil** - plants are allowed to grow for a while and then they are cut down when they are still green and either used as mulch or dug back into the soil. With this method you do not eat the plant, or you only eat a little of it. Most bean leaves are nutritious food that can be shared with your family and your soil!

• **Cover cropping** is often used to protect the soil after the main crop is harvested. They are usually legumes but not always. It keeps the area covered in the ‘off’ season, protecting the soil from wind and water erosion, and it boosts the fertility of the soil for the next season. Which plants you use as cover crops would depend on the weather, the amount of water available and which seeds are available. They are often dug back into the soil when the next cropping season arrives, or cut back drastically and used as mulch. The timing of all this would depend on the species, area and farm designer.

• **Green manure tea** is when green plant material is put in water and allowed to sit until it ferments. Use about 1 handful of green material per litre of water. The green manure is stirred occasionally (usually every day) to make sure the plant material mixes well with the water. It is usually quite smelly! After 2-3 weeks you can start using it by diluting it at about 250 ml of green manure tea to 10 litres of water. This same recipe can be used with animal manure or with compost.

  What type of soil do you have? Sand, clay, rock, or loam? What can you do to improve it? What chemicals do you use? Why? How much do you spend in time and energy on chemical applications? Where do your chemicals come from (locally and original production), and how were they made?

  Write down ways that you could add fertility to your soil. List resources you are wasting at the moment (manure, urine, organic matter, etc.)

  Note on your sketch map any nutrient-rich areas, e.g. sweeping piles, piles of crop waste, and areas rich in manure, etc. Mark on your sketch map which crops grow there and think about rotating these.
Topic 19: Animals for Soil Fertility

In this topic we will look at animals and soil fertility and how we can manage them differently to solve some of the problems we have. Later in the manual we will look at other ways of including animals in our designs.

All types of animals, including humans, fish, bees and other insects, can provide manure, urine, hair and nails to feed our soil so we will think about these. Human manure is available wherever humans are but, most of the time, it is wasted.

Manures are such an important and under-used resource that they will be covered in three topics: Animals in this section, then Composting (Topic 20 page 43) and finally in Human Manures (Topic 21 page 47.)

Animal Manures

Different manures have different strengths but, very often, the smaller the animal (worms, bats, termites) the stronger the manure is; using manure from small animals makes a big impact! The manure of large animals like elephants and cows have much more fibre in them and is not as nutritious for the soil, but it still adds a variety of nutrients in smaller amounts, and improves the soil structure.

Using animal manures

Use well-rotted manure. Most fresh manure, especially from the stronger manures, must have time to fully decompose or ‘age’ (rot down) before using it on plants and trees. This so the nutrients have time to change into a form that plants can use easily.

Always wash your hands after handling fresh manure because it has germs, and can carry plant and human diseases. When manure has been composted properly the germs are killed, leaving only nutrients for the soil. You should always wash your hands after working with soil (even if you have not been using manure) because there might be germs in it.

Manure should be used as a layer in compost piles. Composting is covered in more detail on page 43, but basically you make piles that are layers of different types of plant organic matter and animal manures. Never use fresh manure or fresh kitchen scraps as the top layer as it attracts flies, and easily loses its nutrients to the air, heat and water / rain (the same inputs we talked about that harm or steal nutrition during food processing and storage) so always cover it with soil or dry organic matter.

Using bedding (straw or dry plant material) in animal pens to help soak up urine and make it easier to collect the manure. After some time, take out the used bedding and use it as a layer in the compost pile or as mulch directly on your field. Put another layer of mulch over it to help the nitrogen to enter the soil and not be lost to the air. Add new fresh bedding for animals. Different animals will need different types of bedding and different timings for changing the bedding.
Make liquid manure using a similar process as for green manure teas (see page 36). Add a 10 L pail of manure to a 50 L drum of water and stir it every day for 30 days. It is easy if you put the manure in a cloth, mesh or net bag (or plastic with some small holes in it) and hang it in the water so you do not have to strain the manure out at the end of the process. It will smell so put the drum somewhere that you do not mind having the smell! Make sure the drum is covered to keep insects away. After about 30 days, dilute it at about 250 ml of manure tea to each 10 L of water for application – depending on the crop it is being applied to.

**Animal pens and tractors**

Animals wandering around freely are a big problem in Malawi.
- Animals can damage plants and trees
- Animals pollute water sources, pathways and school yards with fresh manure
- Animals can cause accidents on the road

It is common for people let their animals roam free and to put fences around the plants and trees to protect them, but it would make much more sense to fence the few animals and let the plants be free! Animals are managed better with fencing, pens or tethering (tying with a rope), which also makes it much easier to collect and use the manure efficiently.

Here are some design ideas for managing animals efficiently and making the most of their manure. Think ahead and be creative so that everything works together for a healthier environment and more food and money!

**Build animal pens using live poles**

If pens are built with several separate areas you can alternate the area you keep your animals in, and use the other areas for growing food or letting the area regenerate. After a few months the animals and crops change places or rotate in a pattern depending on how many pens you have.

The animal's manure will have fed the soil and the leftover plant material can be used as mulch or for animal food. If you use live poles then you do not need to keep rebuilding, you just need to maintain the fence to make sure there are no gaps.

**Raised animal pens**

Pens can be lifted off the ground on legs and made with small gaps in the floor so that it is easy to collect and use the manure that falls through.

These are becoming common in Malawi for goats, pigeons, chickens, rabbits and small livestock, but they are not often used fully by integrating them to use the manure most efficiently.

Think carefully what each animal species (animal type) needs and discuss with local people / extension staff that know about that animal if you need ideas.
Animal tractors

These are moveable cages that are open on the bottom to allow the animals to graze. They are good for small animals such as chickens, guinea fowl, ducks, guinea pigs, and rabbits. The animals can scratch the surface of the soil to aerate it (depending on the species’ behaviour), and they leave behind manure, urine, fur, and feathers to feed the soil.

After grazing in an area for a while, the cage is moved to another area. Tractors can be large or small, any shape or size that suits your purposes, made of whatever is available locally (chicken wire, bamboo, wood etc.) and with handles or wheels to move them around, making sure the animals can’t crawl out through the bottom.

Free range animals

If you do not keep your animals in a pen, then you can manage your animals so that they range where you want the manure to drop – such as in a field, an orchard, or other area they will not destroy. You will need to design a way to keep them in the area you want them – either with a herder, or a moving fence. If you want free range manure to be moved to a different area, you can collect the manure by walking around and scooping in up into a basket or pail and carrying it to where you want it.

Fish Ponds, Worm Farms & Bats

Fishponds

Fish ponds can be designed to work well with other animals, and be an integral part of your gardens, orchards, fields and forests so that all parts of the system benefit from each other. Some ideas include:

Keeping ducks with fish. Duck manure in the water feeds the fish, and the ducks will keep the area free of too many plants, weeds and snails by eating them.

Animal houses with ponds. If you build animal houses on the edge of the pond, or even right over it, you can easily get the manure straight into the ponds to increase the fertility, but be careful not to put in too much. For 100 square metres of pond, you get the right amount of manure from 4 or 5 ducks, 5 to 8 chickens, or 1 or 2 pigs.

Put water-loving plants like rice, bananas, and sugar cane at the edge of the pond where they can use the nutrient-rich pond water. These plants will not need to be irrigated if your design is well thought out. You can design a channel coming out of the pond (the design would depend on the source of the pond water) to guide the water gently into appropriate plants and trees.
The plants and trees near the pond can be trimmed to use as food or bedding for your animals, or they can be put into your ponds for your fish. If you drain the water from your ponds (to harvest fish or for any other reason) the soft mud on the bottom of the pond is an excellent fertilizer for your plants and trees.

Worm farms

The manure of worms (called castings) is very rich in nutrients and micro-organisms, making it extremely good for the soil. Worms can produce their own weight in castings every 24 hours and they can eat through fresh organic matter very quickly, given the right conditions.

For this reason they are perfect for processing your kitchen scraps into highly nutrient-rich soil. Worms are also Nature’s diggers, making little tunnels in the soil that allow air and water in, as well as leaving their wonderful manure behind them. Worms and their castings can be added to any soil that needs extra nutrients. Castings can be used to make manure tea as well (see the recipe in Green Manures page 35).

To increase the number of worms in your garden you can make a worm farm. It can be any size, from very small worm farms in your kitchen, to very large ones for processing lots of food scraps from large kitchens.

- **Find a bin** for the worm farm that can withstand moisture (getting wet). The bin needs to have enough room in it for some of your kitchen scraps, though some of them can go on the compost heap too.

- **Make small holes in on corner / edge at the bottom** of the container, so you can drain off the liquid fertilizer that the worm farm produces. You can put mesh or netting over it to keep the worms in the bin and stop them crawling out.

- **Put the bin somewhere warm** but not too hot. (And not too cold, as it makes worms work more slowly.)

- **Put the bin at a slight angle** with a slight slope towards the corner / edge that has the holes you made so that liquid drains out easily.

- **Place another container under** the drain to catch the liquid fertilizer.

- **Line the bottom of the bin** with some dry organic matter and soil. This makes a good home for the worms that will protect them from too much liquid.

- **Find some worms** and put them in the worm farm

- **Put in some kitchen scraps** and cover it with a bit of soil

- **Feed them every day or two** by adding more kitchen scraps
- **Keep the bin moist**, but not wet. Usually your kitchen scraps have enough moisture in them to keep the bin moist without adding extra water.

- **Add a layer of soil** from time to time. For example, if there are fruit flies.

- **Use the liquid fertilizer**, which is rich in nutrients, and can be used to enrich the soil. There is usually some liquid fertilizer to use every day or two.

- **Use the worms** as they multiply as food for poultry and fish and add worms to different areas of your garden, orchard or fields to carry on working for you to improve the soil.

- **When the bin is full**, separate the worms from the rest of the organic matter and castings, and use it in outside where you grow food.

- **Start again!** Make the worm bed again, add back the worms and carry on!

**Bat Houses**

Bats are very good for the environment and agricultural systems, but they are currently under threat because their eco-systems have been reduced by human behaviour.

- Some bats eat 1000 insects per hour! When you see bats flying, they are probably eating mosquitoes for us.

- Nectar-feeding bats pollinate plants like bananas and cashews. Fruit-eating bats spread seeds so plants grow far and wide.

- Bat manure, called guano, is very high in nitrogen so it is a great fertilizer.

- **Be sure to handle bat manure with care - wear gloves and don’t breathe the fumes.**

It is easy to build homes for bats and they can be designed so that it is easy to collect the manure. Bat houses should be high up, at least 12 to 15 feet off the ground, built on a pole, or the side of a building, or on tall mature trees. They are basically wooden boxes, with a small hole as a doorway, for the bats to fly in and something up high inside the house for the bats to use as a roost.

There are many different types of bats that like different designs, so you’ll need to ask local experts on the type of bats near you.

- What wild or domestic animals do you have on your site? Are the domestic animals wandering free or are you using them efficiently, and getting them to help you improve your soil fertility?

- Note on your sketch map where you could build animal pens, or use animal tractors. Note where there are wild animal homes (anthills, birds’ nests, etc.) or if you know of any animal tracks and paths.
Topic 20: Composting

Compost mimics nature to put together a mixture of different types of organic matter that breaks down quickly, decays and becomes nutrients for the soil and for the plants that grow in that soil. Compost is food for the soil. Composting is very important in Permaculture and Sustainable Nutrition but is not, on its own, the answer to most soil problems. Composting will have little effect on soil fertility if people carry on burning, over-sweeping, mono-cropping, and throwing plastics into the soil. So it is best to improve the site in many different ways. Reduce the amount of sweeping, tilling, burning and increase the amount of mulching, using nitrogen-fixing legumes and animal manures of all kinds. Remember that Nature always has diversity!

Compost: Nature’s Digestive System

Let us remind ourselves of how the Nature Cycle and Human Body digest and absorb the nutrients from food. Composting speeds up this process:

- **Food variety**: Nature covers the soil with lots of different organic matter (dead plants and trees, animals and insects). Nature, like humans, gets all the nutrients it needs when there is a variety of different foods to eat.
- **Chewing**: Insects and animals, weather and climate ‘chew’ the organic matter into smaller pieces, as we do with our teeth. When moisture is present from dew or rain, the organic matter disappears into the soil quickly. This is just like the juices in our mouths, with the saliva helping us to swallow food.
- **Digestion**: The smaller pieces mix with micro-organisms in the soil and release the nutrients from the organic matter. This is similar to the chemicals (enzymes) in our saliva and stomach that mix with the foods and break it down to release the nutrients.
- **Absorption**: Most nutrients go in to the plants and trees through the roots. They give the plant energy to grow, flower, make seeds and fruits and protect itself from disease and insect attack. This is similar to how we absorb nutrients in our intestines to give us the energy we need to grow, work, play, heal ourselves or fight off illness.

**What to put on compost piles**

- **Almost all natural (organic) materials** can be composted: leaves, grass, sticks, kitchen scraps, manure, urine, bones, blood, feathers, fur, hair, natural man-made items such as baskets, mats, rugs, cloth, wool, leather, paper, cardboard and metals that can rust. They all take different amounts of time but will all break down eventually and feed the soil. (Glass and broken pottery could go in a compost heap but they break down slowly, they might be coated in chemicals, and can be dangerous when people handle the compost. So be sure to consider each item before adding it.)
Part 2, Topic 20: Composting

- **Artificial materials should never be put on the compost pile**: fossil fuel based plastics, nylon, Styrofoam, batteries, chemicals or mineral oil products. They will not decompose properly and if they do break down the smaller parts are likely to be poisonous to your plants.
- **Air, water and heat are vital to the composting process.** If one of these is missing or there is not enough, or too much, the process will not work or it will be slow. The amount of air, water and heat should be well balanced, a skill that will be learned with time, practice and monitoring the compost.
- **Micro-organisms speed up the decomposition.** These could be taken from nature as humus (the organic-matter rich top layer of soil) or using compost from another pile, or from worm castings.
- **Chopped up materials will make decomposition work faster**, but the chopping is more work so decide if it is worth it. (It is good exercise if you need to be more active!) 
- **Adding a little charcoal** can also help the composting process.

**Where to build the compost sites**

Choose one or a few sites for your compost and think about where you put them carefully. (Remember the 80:20 rule!) Make them easy to make, manage and use, so you can make best use of the nutrients.

- **Near your kitchen** so you can put kitchen scraps on easily. The finished compost can be used on the food beds near your kitchen.
- **In the orchard and under trees** so the compost will be shaded. It will not dry out so fast and it will feed the trees as nutrients seep out and into the soil.
- **On fallow beds** in your garden or fields, while the soil is ‘resting’ or lying fallow. Add nutrients to the area by building compost piles. You can leave an area fallow for just one season or for several years.
- **In your fields.** As you are harvesting the crop residues can be layered in the compost and spread out in the field at the start of the next season.
- **Near animal pens or edges of ponds.** To make the easiest use of your animal manure the compost can be made inside animal pens. The animals help in breaking down the organic matter by digging, scratching, chewing and adding their urine, manure and feathers.
- **As part of your family's, or community's, toilet system.** We will look at composting toilets in detail in the next topic.

**Making and using compost**

Composting is so easy! There are many methods and whether you compost in a pile, in bins or in a pit, all composting is done using the same principles. We will begin with a compost pile, as it is usually the easiest one to make. If you have enough composting materials get several piles going at once. If you can start a new compost heap, pile or pit every week, you are likely to always have a supply of wonderful compost to feed your soil.

Make the first bottom layer out of the largest pieces of compostable material as they take longest to decompose, like large bits of wood and tin cans. Big pieces help to let air into the pile, which is needed for the process. If the pile is too compacted it will just sit there doing almost nothing. For the next layer, add dry materials like grass, crop residue, leaves, etc. Then add a layer of wet materials like kitchen scraps, manure, urine, etc.
Lay alternate wet and dry layers until the pile is a metre or 1.5 metres tall. The compost pile in the picture is just an example, but every compost heap is a bit different.

**Include a lot of nitrogen material** in your mix, like leaves, seeds or pods from legume plants, as this is the nutrient that plants need the most.

**Add a bucket or two of water** to get the compost heap started; if the pile is dry the materials won’t break down quickly. Re-used water from washing clothes or dishes or from cooking is less wasteful.

**Finish with a layer of dry mulch** so that the wet layers do not attract flies and insects. If your area is very dry, you might want to cover the pile with large fresh banana, palm or papaya leaves, or with mud to help keep moisture in the pile.

**The different layers are listed from the ground up:**
- On the bottom of the pile: Large pieces
- Organic matter (dry)
- Manure (wet)
- Grass (dry)
- Kitchen scraps (wet)
- Soil (dry or wet)
- Repeat until it is a height that is comfortable for you (1.5 meters or so), the pile will reduce by almost half as it breaks down into soil.
- Pour on water so everything gets damp, or even better, put urine on it, which is wet, full of nitrogen and speeds the decomposition
- Cover the whole pile with leaves to hold in the moisture and protect the pile from losing nutrients to the air and sun. The leaves can be a layer of dry mulch or use large leaves such as banana leaves.

**Temperature stick:** Take a long wooden pole or branch and poke it into the middle of the heap. After few days pull the pole out and see if it is hot or warm. As the pile decomposes it generates heat, so if the pole is hot, it is working nicely!
Put some water on the pile about once a week in the dry season. Re-use washing water from the kitchen or laundry. You can also put urine straight onto the pile.

After about 3 weeks turn the pile. Use a spade, or other method useful to you, to turn it upside down while moving it from where it is to the space next to it. Move the top of the pile and put it on the ground next to the pile, then continue moving the pile, layer by layer, until it is all in the new place, next to where is was before. Essentially you turn the pile upside down. This copies what animals do in nature to mix up the materials with fresh oxygen and help the decomposition.

Put large un-rotted pieces, and hard items like metal, in another place to become the bottom layer of a new pile. Let chickens and other animals scratch around in the compost. It helps mix up the different materials and the chickens get to eat a very good diet and add their manure and feathers. Add some water when the pile has been turned. Leave it for another 3 weeks and turn it again.

The compost will probably be ready to use after 1-2 turns (6-9 weeks), depending on your local weather conditions and what you’ve used to make the pile.

**Compost pit**

A pit compost is just the same but you put the compost in a hole in the ground instead of on top. Digging the compost out of the hole is harder work than the pile method, but if there is already a hole left from brickmaking or some other purpose, it may be a useful way to use the space. There are also other benefits to having a compost pit:

- A compost pit does not need to be turned over, but it will usually take longer to decompose than a pile (12-16 weeks).
- A compost pit does not need water added every week because the pit does not dry out as much as a pile, but adding water every few weeks can help. Adding urine directly to the pile is easier when it is in a pit, especially for women!

So think about it first, then choose the method that is right for you, or choose several different methods!

**Using finished compost**

The amount of nutrients in the compost depends on what it was made with. The more diverse the ingredients, the more diverse the compost will be. Good compost will be a dark colour, it will feel crumbly, a little bit damp and it will smell rich and earthy. Compost can be used like this:

- **Dig a handful or more of compost into the soil** when planting seeds or seedlings to give them a really good start.
- **For a tree** dig a bucketful or more of compost into the planting hole.
- **As a top dressing.** Spread the compost on top of the soil around growing seedlings or plants. Then cover the compost with some mulch to protect the nutrients from sun, wind or rain. This called top dressing.
- **Make compost tea** using the recipe for green or animal manure tea. You will have a really good liquid fertilizer for areas that need extra nutrients.
- **Put compost in paper or cardboard tubes or directly in a seed nursery bed.** Seeds will be given a healthy start to life.
- **Use a bit of compost in fishponds** to enrich the water for the fish.

Note on your sketch map where there are compost piles or where you could put some. Think of two or three good places with reasons for choosing that site - e.g. it is near the kitchen so it is easy to add to, or it is in the field so can use crop wastes efficiently.
Maintaining Good Soil

Do not tread on the soil or compact it
Now that you have made fertile and well-structured soil, do not ruin it by walking on the soil and squashing it!
When a path is walked on over and over it gets really hard. Water cannot easily soak into it and roots find it hard to grow through it. Little creatures will go somewhere else where the soil is easier to tunnel through. You do not want this to happen to your soil if you want plants and trees to thrive!
Make well-marked pathways and roads for people, bikes, carts and motor vehicles. We will discuss this more under design, but it is good if you start thinking about it now.

Do not dig or hoe unless you really need to
Hoes, spades, forks, shovels and tractors all disturb the soil and animals, roots and insects that keep soil crumbly so it can absorb water. If you mulch, compost and plant a good variety of plants and trees and mix in some animals, you will hardly need to dig at all.

Look after the land whether you own it or not
All land belongs to all of us in the world and future generations. If your parents and grandparents took care of your area and thought ahead, then you may have a nice area to live. If not, then you have a lot of repair work to do so that you leave things better for your children or whoever takes care of your land after you.
Treat the land with care and respect, and encourage others to do the same. It would be good if every person who lived in a place could improve it. You do not have to spend a lot of money – sometimes the changes that need to be made are completely free! You just have to take care of it, improve it for your own benefit and for the people that will live there in the future.
Your notes
Your notes
Sustainable Nutrition Manual

Food, Water, Agriculture & Environment

This manual is for people who eat, grow or buy food and who want to improve their lives, their community and the environment that they live in. It has been written for, and by, people living in Malawi. It will show you how to eat and live better and guide you in designing a sustainable future.

The manual aims to show that by thinking differently and thinking sustainably you can improve your health, diet, lifestyle and surroundings easily and cheaply and gain an understanding of the term Sustainable Nutrition.

Use the ideas in this manual and you will be able to:

- Improve your diet and health
- Save money that was spent on food, medicines and chemicals
- Double or triple yields and harvests (or even more!)
- Reduce the amount of watering in your gardens and orchards
- Reduce the amount of work done on your land and in your home
- Have healthier plants and animals
- Reduce infertile and unproductive areas of land
- Use free resources to improve soil and water in your area

Part 1 - Healthy Humans is about the human body and nutrition. You will also learn about food choices and the benefits of diversity in diet. It has lots of useful ideas to improve life and many delicious recipes and suggestions for tasty, healthy meals.

Part 2 - Healthy Environments is about natural systems and sustainability. You will learn about the Nature Cycle and the Water Cycle and natural sustainable systems. You will be introduced to Permaculture ideas and gain an understanding of the benefits of diversity in Nature.

Part 3 - Healthy Designs is about designing for sustainable living. This book brings parts 1 and 2 together and guides you to make a personalised plan for Sustainable Nutrition. This book is a practical one to use to design everything on your land. There is lots of information in the appendices about foods of Malawi and other resources that will be useful as your design develops.