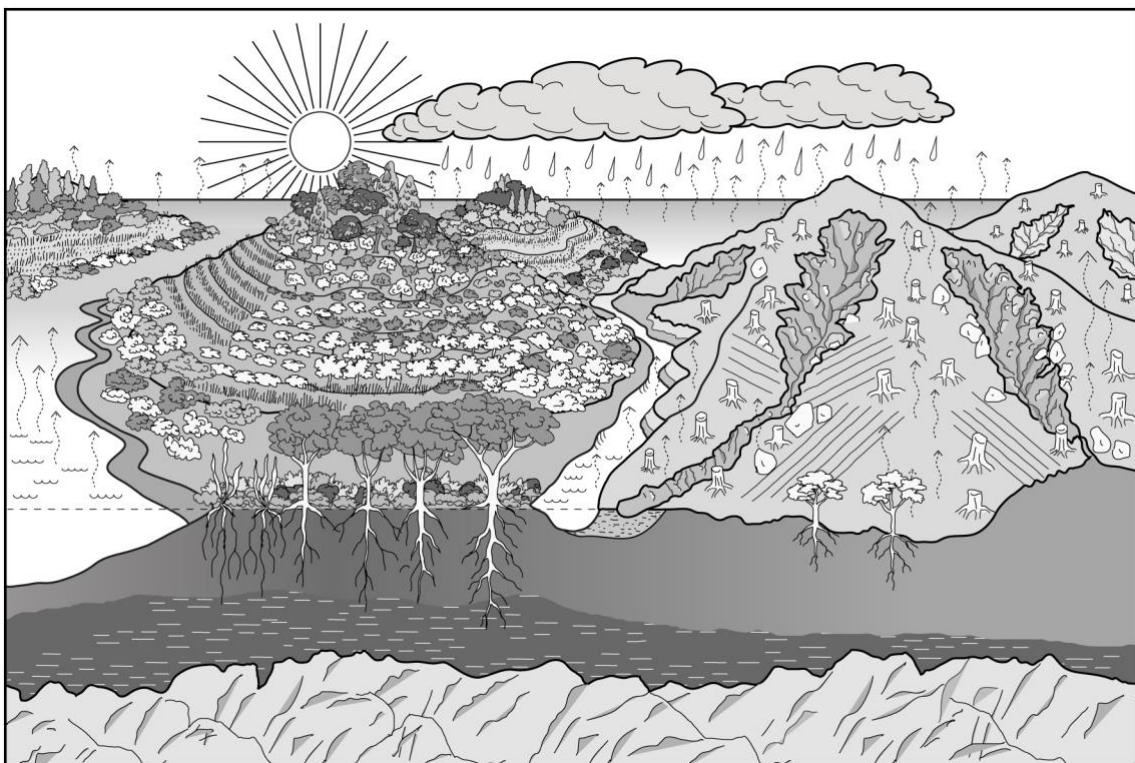


# Sustainable Nutrition Manual

Food, Water, Agriculture & Environment

## Part 2 Healthy Environments



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**World Food Programme**



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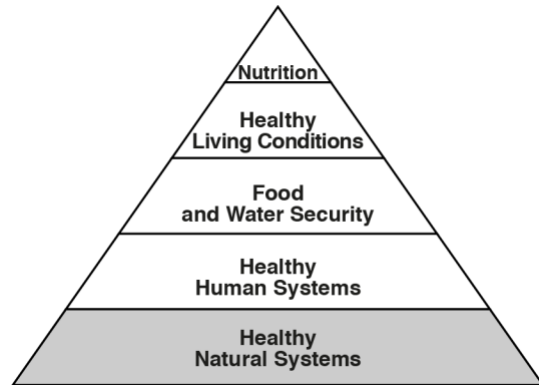
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## **Part 2                    Healthy Environments**

This part of the manual is about Natural Systems and Sustainability. You will learn about the Nature Cycle and the Water Cycle and an understanding about Soil Fertility and the benefits of Diversity in Nature will develop. You will be introduced to Permaculture designs and sustainable living practices. You will find out about renewable and non-renewable resources and begin to understand the wider issues of sustainability. This book can be used in your homes, offices, schools, communities, farms and gardens. You can discuss the ideas in it with others so that eventually your whole nation designs and lives sustainably.

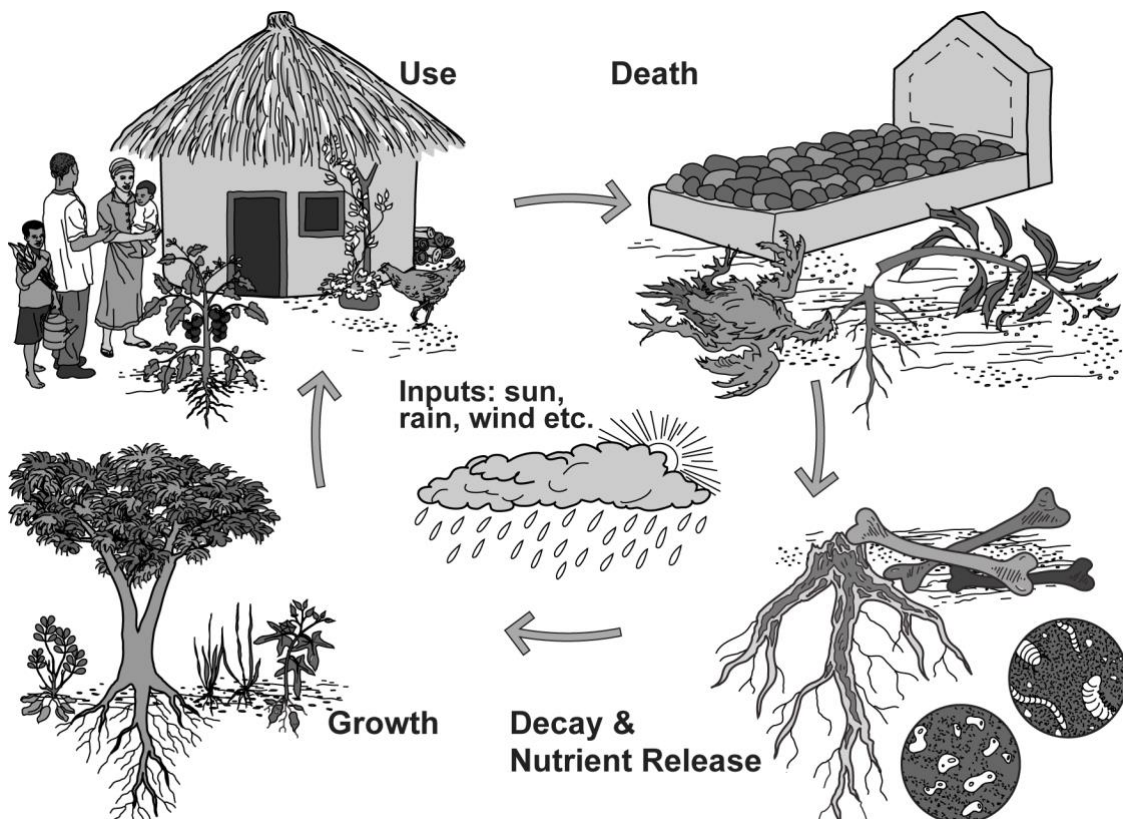
# Topic 15: Sustainable Natural Systems

From Part 1, Healthy Humans, you should be starting to understand the importance of making choices that strengthen humans and their systems to keep them healthy. Natural eco-systems – environmental areas that support and interact with all living things in their area – are experts at sustainability. Every eco-system has their own speciality (dry, cold, high, low), but each follows some basic natural laws that keep them going.



Sustainable Systems move from one stage to another in a circle - a never-ending cycle that has no beginning and no end. The Nature Cycle is the way that the Natural World keeps itself going. It has been doing this for millions of years and is the most Sustainable System ever. There are many cycles in natural systems that keep going forever, such as the Water Cycle, which recycles all the water on Earth to continuously provide the water needed to sustain life on Earth. We will cover the Water Cycle here and we will look at sustainable designs for water management, conservation and harvesting on page 67.)

## The Nature Cycle



If humans work with the Nature Cycles they will provide us with everything that we need to live. But if we break the circle, and destroy the cycle, it will not be able to give us what we need to live. What does Nature need if she is to provide us with food and nutrition security? Nature needs her nutrients too! This part of the manual will explain how the Nature Cycle provides these for the soil. It also will show what you can do to support and strengthen the Nature Cycle, instead of destroying or damaging it.



Ever since life began in the world the soil, water, plants, trees, animals and insects have all been working together sustainably in their eco-systems in a cycle. This is how the earth maintains its own health and develops the amazing diversity and the richness of Nature that we are able to use in our lives. Think back to Part 1 on the digestive system – the nature cycle and the human digestive system have a lot in common.

### ***Death***

The Nature Cycle can start at any point, and we will start with death, as it is such an important part of life. Death provides the food, the nourishment, for the whole cycle (very similar to the food that we harvest from nature for our nourishment). Death recycles all the natural organic matter of life on Earth. Think of a leaf or an animal that has died and fallen to the ground. What happens to it as time passes?

### ***Decay & Nutrient Release***

After death, the leaf or animal may be eaten by animals and insects and made into manure that returns to the soil. Or it may be crushed under a foot or paw (very similar to our teeth crushing our foods). After it is crushed it mixes with natural juices in the soil made by very tiny animals called micro-organisms (very similar to the enzymes in our digestive system, especially in our stomach). As the leaf decomposes the nutrients from it are released into the soil. Then they are absorbed by the roots of plants growing in the soil (very similar to how the intestines absorb nutrients).

### ***Growth of plants, trees and animals***

When the plants have all the nutrients, soil, sun, water and air that they need, they can grow strongly (just like people!). Different kinds of plants and trees (different species and different varieties) need different conditions and amounts of these inputs (just like different people!). Some plants need lots of sun or water, for example, and some need hardly any. Think about the differences between the plant and animal life in different eco-systems - from deserts to lakeside, or marshes to forests. Also think about people in different parts of your country, and different parts of the world.

### ***Use of plants, trees and animals***

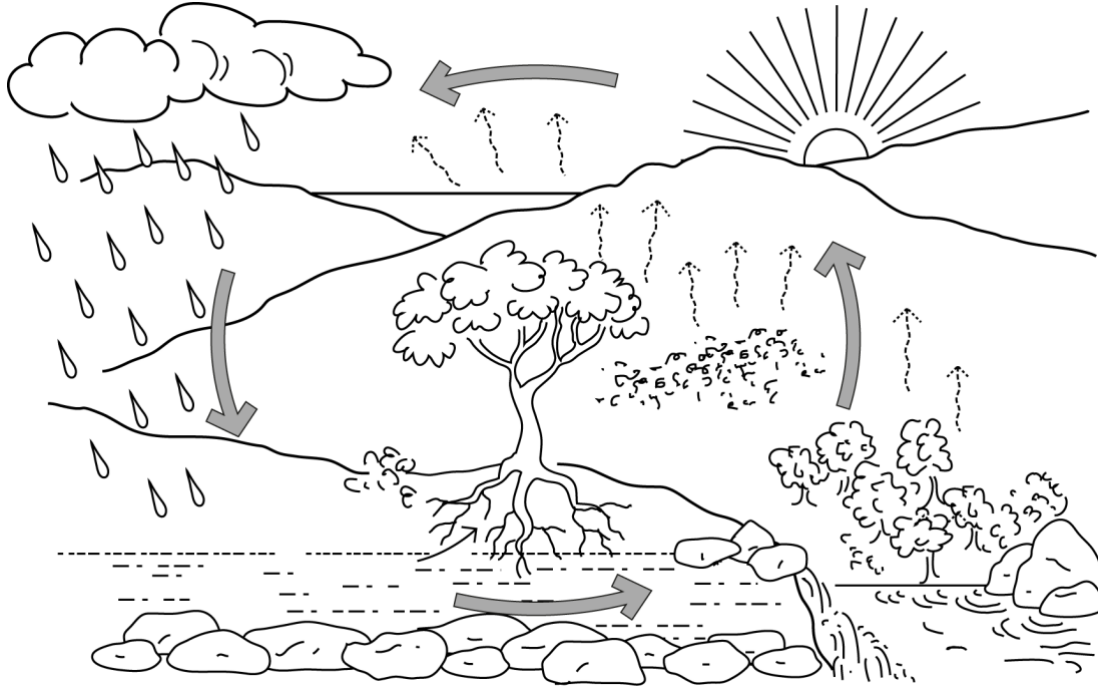
All the plants and trees that are growing in the soil are used, or eaten, by humans, animals, insects, birds and fishes. Plants and animals use each other in other ways too. A climbing plant might grow up a tall tree, for example, or a bird uses plants to build its nest. Humans use all this plant and animal life for eating, building, and making all the things we need for healthy and productive lives. While alive, all animals and humans make manure, which must be returned to the soil (just like at the end of our digestive system), and when living things die their bodies return to the soil too, feeding and strengthening the Nature Cycle.

### ***Inputs***

Just as death is a vital part of life, so are the natural 'inputs' of sun, water and air. These inputs are needed at every stage in the Nature Cycle. They help the breakdown of natural materials. They help the growth of plants, trees and animals. They help us wash, dry or cook the things that have grown, and they help us use other natural materials for building, energy and every other thing we create; nature is the provider.

## The Water Cycle

None of this can happen without water, which is one of the most important inputs in the Nature Cycle. We need to understand how water is continually recycled. Nature never runs out of water, except when humans destroy the cycle.



- **Rainfall:** Rain falls as clean water from the sky, onto the plants, trees and soil.
- **Filtration:** The water soaks (filters) through the layers of soil and rocks underground and fills rivers and lakes and the natural stores of water underground.
- **Absorption:** Plants and trees soak up the water through their roots and it helps them to grow
- **Transpiration:** The water used by the plants and trees is released from the surface of the leaves and rises into the sky as water vapour.
- **Evaporation:** The water is released into the air from bodies of water such as rivers, lakes and oceans, and also rises into the sky.
- **Condensation:** The water vapour collects in the sky in tiny droplets known as condensation. The droplets create a cloud, and when the cloud is heavy with water it falls back to the ground as rainfall, and the cycle continues.
- **Continuous:** Rainfall, filtration, absorption, transpiration, evaporation, Condensation, rainfall, etc.

This is how all the water on the planet is recycled continuously, all the time, forever. This is a beautiful and simple cycle and every part of it is important, but humans often disturb the Water Cycle which causes many problems.

The things that disturb the Water Cycle are the same things that disturb the Nature Cycle, which we will look at together in the next few pages, then we will spend the rest of this part of the book looking at positive behaviours to work with the nature cycle instead. Just as we can have a healthy or unhealthy human body, we can have a healthy or unhealthy environment.

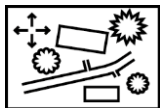
## Your Impact on the Nature Cycle



Think about this for yourself, and then discuss these questions with others. Does your community make the Nature Cycle stronger or weaker? Do you return what you use to the Nature Cycle, or do you break the Nature Cycle in some ways?



Write down your answers. Try and think of some things that you do that strengthen the Nature Cycle, as well as writing down the things that weaken it.



Look at your map and mark areas where there are problems that weaken the Nature Cycle, such as piles of plastic rubbish, bare hillsides, polluted water or air, erosion, etc. Mark on your map the areas where the Nature Cycle is strongest.

## Sustainable Resources

### *Waste is only Waste if it is Wasted*

Nature does not waste anything. Every part of Nature is a **resource**. This means it is something that will be used in the next part of the Nature Cycle. Humans waste so many resources. We need to learn from Nature and stop causing waste.

If we use too much of a resource (more than the resource can regenerate or remake of itself) it is not sustainable. For example, we cannot keep using trees for making things, or for firewood, if there are no trees left because we have cut them all down. But if we plant more trees than we use, or use the trees at a pace that nature can naturally regenerate them, then wood and timber is a **sustainable resource** and we can keep using trees forever!

If we use all our resources sustainably then we will be living sustainable lives, and we can have everything we need, now and in the future.

There are two kinds of sustainable resources:

- Biodegradable resources
- Renewable resources

### *Biodegradable resources*

Everything in Nature (wood, plants, roots, bones, fur, everything) rots down and decomposes back into the soil. This means it is biodegradable. Micro-organisms, weather and water break it down into small parts that become food for new things to grow. Can you think of anything in Nature that does not decompose eventually?

Things that are biodegradable take different amounts of time to decompose. Think of a leaf, a peanut shell, a branch or a dead animal... How long do these things take to decompose? The length of time it takes also depends on what else is happening. If an insect eats it, or if it is crushed and broken, it will rot faster. Water and warmth will speed the process, but being cool or dry will slow it down.

A straw broom, a wooden pencil, a paper book or even some tin cans are all made of biodegradable resources. When they have stopped being any use to us (because they are worn out or broken) they can be returned to the soil, where they decompose again, strengthening the Nature Cycle and growing more straw, wood or minerals so we can make the same products again. This makes more good soil for more things to grow. And this can happen forever.

### ***Renewable resources***

Biodegradable resources are renewable because we can keep getting new materials to use - if we plan wisely and have sustainable behaviour.

There are other resources that are renewable as well. These are the most important and the oldest resources in the natural world: water, air, sunlight and soil fertility are all resources that should be able to keep going forever. They have been going for millions of years already.

Unfortunately humans are breaking and weakening the Nature Cycle and this threatens these important renewable resources. If we pollute the air, poison the water, burn our landscapes (so the soil fertility goes up into the sky with the smoke) then we will suffer from many problems. We cannot drink dirty water, or breath bad air. We cannot grow food in dry and infertile soil.

We need to start looking at ways to make sustainable decisions, choosing products that are biodegradable and renewable, and this book is all about living sustainably. But before that, let us look at the opposite of biodegradable, renewable and sustainable resources. These are the things that are not helpful to the Nature Cycle. These things can damage and destroy it.

## **Non-Sustainable Resources**

We have many resources around us these days that do not help the nature cycle, but instead actually poison it. We also have many habits as a society that wastes the natural resources we have – by throwing them into areas that don't help us grow more resources, or by over-using natural resources so that regeneration can't keep up with us. We must slow down and think about what we are doing, because right now our resource use is unsustainable and the next generations here on earth will struggle to thrive. There are two kinds of non-sustainable resources:

- Non-biodegradable resources
- Non-renewable resources

### ***Non-biodegradable resources***

Non-biodegradable means that something does not decompose or rot down back into the soil again. Think about a plastic drink bottle. It gets used once and then thrown away. What happens to it then? Does a plastic bottle rot down and return to the soil?

Almost all plastics are non-biodegradable, meaning that they do not decompose. Some non-biodegradable products do break down eventually, but they take hundreds of years, possibly thousands of years to do so. Even when they have broken down they do not turn into useful nutrients for the soil. Sometimes they turn into toxic waste that harms the Nature Cycle. When non-biodegradable things are thrown away they block the Nature Cycle instead of strengthening it. Non-biodegradable waste is bad for our soil and our water, and if we burn plastic rubbish it is very bad for the air we breath.

There are many kinds of plastic but they are currently almost all made from oil that is drilled out from deep in the Earth. Oil-based products cause damage to the Nature Cycle from when they are first made in production, through to when we have finished with them. The industrial production processes and our burning of these products (driving our cars, burning coal, burning trash) are putting a harmful gas into the air called carbon dioxide. This gas is causing the temperature of our planet Earth to heat up, affecting our weather patterns, which is very dangerous. These changes are called climate change and global warming and they are bringing many problems with them, including more varied weather that is hotter, colder, drier and wetter.

## ***Non-renewable resources***

- **Fossil Fuels**

If a resource is going to run out, or if it cannot be made again, or if we are using it faster than it can be remade then it is non-renewable. Oil, coal and gas are non-renewable resources. This is because these fossil fuels take millions of years to make. When these fuels have been all used up there will be no more of them for millions of years.

Fossil fuels are used to make many of the things we use today: diesel, petrol, paraffin, fertilizers, tar for roads, plastics, and much more. Think of all the industries and human systems that use fossil fuels: transport (by land, water or air), food production, medicines, packaging materials, and many items around the home, office, school, factory, hospital, social and religious spaces.

- **Minerals**

Minerals are found in the rocks and earth. They also took millions of years to be made by Nature. We use them for many things; electronics, metals, cement, fertilizers, jewellery and energy sources (such as uranium). Computers, televisions, phones, radios, vehicles, planes, boats, buildings, and roads are all mostly made using resources that are non-renewable.

Often the ways we make and use these resources are harmful to us and / or the Earth while they are being mined from the earth, when they are being used in our lives, and when they are thrown away. These resources are truly being wasted.

## **Biodegradable and non-biodegradable 'waste'**

What is happening to all the non-biodegradable products that we throw away? Nothing good happens. They release the poison from the raw materials that they were made with very slowly, damaging the Natural Systems we all rely on.

Compare the length of time biodegradable products take to decompose with non-biodegradable products in the lists below.

### ***Biodegradable products***

All parts return to strengthen nature

- Paper towel or bag, newspaper 4 weeks
- Cardboard, an apple core, cotton 3 months
- Orange or lemon peel 6 months
- Wooden products (planks of wood) 2 years
- Woollen products (from sheep's fur) 2 years

### ***Non-biodegradable products***

Some are poisonous to nature

- Cigarette butts 10 years
- Metal cans, Styrofoam 50 years
- Plastic bottles and containers 450 years
- Disposable nappies, plastic, fishing line 550 years
- Plastic bags 1,000 years

## Part 2, Topic 15: Sustainable Natural Systems

We humans also have our own resources. We have knowledge, energy, labour, creativity and intelligence. We will need to use these to find ways of seeing all waste as a resource. If we can find ways of using resources sustainably, so nothing is wasted, we will be strengthening the Nature Cycle that sustains us.

We all need to stop using non-biodegradable and non-renewal resources and start making sure that all the resources we use are sustainable, renewable and biodegradable. It is possible, so read on and learn how!



Think about plastics made by humans from fossil fuels that came from deep in the earth. What happens to these plastic products? How can they be part of the nature cycle if they will not decompose?

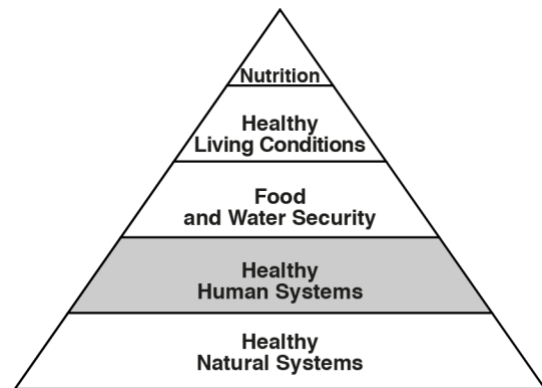


Write down the non-biodegradable and non-renewable resources that are used in your area. Do you have ideas already on how to reduce these and switch to biodegradable and renewable resources? Write those down too.

## Topic 16: **Permaculture**

Permaculture is a useful and practical way of designing human systems and thinking sustainably about our lives and our impact on the world. The word comes from the words *permanent* and *culture* joined together.

When Permaculture thinking and ideas first started in the 1970s it was focused on permanent agriculture. Now the ideas have grown and it is about designing and maintaining permanent cultures so that all our Human Systems are sustainable.



### **Permaculture Ethics and Principles**

There are **3 ethics** in Permaculture that help us to live sustainably together, with other humans, and all life on Earth.

- Earth Care:** Caring for our Earth
- People Care:** Caring for all our people
- Fair Share:** Sharing our resources fairly



If we apply these ethics to everything we do, every day, it is easy to make choices that are healthy for us, our society and our environment. To do this you need to learn what impact your actions and choices have on the Earth and its people and resources. There are new products being sold to us every day, all the time, and you should learn to ask where the products come from and what happens to them when they have been used. Are they from sustainable resources? If so, are we using them sustainably? This way of thinking gets easier the more you learn, and the more you are in contact with other people who also do their best to live sustainable lives.

#### ***Permaculture principles***

A principle is a guide for what we do. The Permaculture Principles are based on the Permaculture Ethics. These principles care for the Earth and all its people and share resources in a way that is fair to everyone.

In the 1970s there were lots of permaculture Principles (about 30!) but over time people who teach Permaculture Design have adapted them and work out which principles are most suited to the people they are training and the situation and conditions where they are working. Here are eight key Permaculture Principles that are a good introduction to Permaculture Design.

- |                                      |  |
|--------------------------------------|--|
| 1. <b>Observe, Learn and Share</b>   | Nature is the best teacher we have                   |
| 2. <b>Be Diverse</b>                 | Nature always has variety                            |
| 3. <b>Everything Works Together</b>  | Think co-operation, not competition                  |
| 4. <b>Be Efficient</b>               | Use everything to its fullest potential              |
| 5. <b>Conserve Energy</b>            | Let Nature do the work                               |
| 6. <b>See Solutions Not Problems</b> | Understand the problem to develop creative solutions |
| 7. <b>Think Ahead</b>                | Plan for the future                                  |
| 8. <b>See the Whole Picture</b>      | Stand back and look at everything together as one    |

### ***1. Observe, learn and share***

Nature can teach us a lot from the way every part of it works with every other part. Nature stays healthy and strong by itself, because it re-uses and re-cycles all its resources, all of the time. We can understand complicated ideas and gain inspiration when we spend time in nature, watching and learning. One of the things nature does really well is to adapt to changing situations and we can learn to adapt well too. What you read in this book will need to be adapted to your culture, your country and area, the time of year, the seasons and so on. When you have learned something useful you should try to share it with others. The more we share, the more we all learn, and the more we all know, the better we can make decisions about our lives and how to respond to the challenges of changing situations.

### ***2. Be diverse***

Diversity means having a lot of variety. A natural forest has many kinds of plants and animals and is full of diversity. A desert has less variety and diversity although there is more than meets the eye if you look more closely and learn about desert life. A field with only one crop (a mono-crop) has little to no diversity. Do you remember the diversity of the Better Meal, compared to the Current meal? Think back to the Cycle of Dependency. With this cycle many varied resources like local foods, trees, animals, cultures and knowledge are lost and their importance is being forgotten! The opposite is true in the Cycle of Better Living – this cycle is full of diversity. Diversity is vitally important to the health of everything on our planet. Diversity is exciting, interesting and beautiful and adds to the richness of our lives on Earth. We can also practice diversity in the way we do things and discover better methods in the process. There is usually more than one way to do something; you may not do things the same way as your neighbour, but you can both be doing things the right way for your situation.

### ***3. Everything works together***

Make connections between things as much as possible, because whatever you are doing, or talking about or looking at will have a connection to something else. If you see how things connect, you will begin to see how they could co-operate. These things could be any of the resources we have discussed. For example: a tree with a vine climbing up it can be co-operating with each other. Two people moving something heavy must co-operate. If a bird eats ticks or fleas from the hippo's back they are co-operating (though the ticks and fleas may not think so!). We can co-operate as development workers around nutrition issues by communicating with one clear voice on nutrition needs (healthy environment, systems for education, food, water, health, etc.). If we don't co-operate we don't help people; instead, we confuse them. It is important for you as a person to co-operate in your society, by being thoughtful, well informed, participatory and open minded. It is important to encourage others to do the same. Start with our smallest children at home and in our communities, up through all levels of education, work and retirement.



#### **4. Be efficient**

Everything in life needs inputs like food, water and air, or we would have no outputs like work, play, growth etc. The aim of efficiency is to achieve the highest output in yields or harvests using the lowest input of energy, money and time. You can greatly reduce your costs by making the most of everything, using all resources and wasting nothing. If you are going to put in extra input you must ask yourself if the outcome will be worth it? We can increase our efficiency by finding and using local resources, so we do not have to pay the extra costs of bring resources from far away.

#### **5. Conserve energy**

Nature is happy to work for us if we allow it to. We can get Nature to do our digging for us if we work with insects and animals to make healthy soil. Nature can give us enough water if we catch the rain from the roof and use it wisely. Nature can give us electricity if we build a hydro-electric power station and use the power of a flowing river, or we can use the power of the wind or sun. Animals can pull our carts for us if we care for them and treat them fairly. There are many ways we can work with nature to conserve energy, and the more you get to know and understand nature, the more ideas you will have.

#### **6. See solutions not problems**

Worrying does not help anybody to solve problems; but trying to understand the reasons for the problems, and thinking hard about possible solutions, does. Try to be really creative about solving problems. When you look for solutions you see the world quite differently. (Really, you do!) If you think you have too many snails eating your plants try to approach the problem differently. Think about the snails as a resource. Can you think of any animal that likes to eat snails? Ducks eat snails! The problem is not that you have too many snails; it is that you have not got enough ducks! (This is a famous saying from the founders of Permaculture.) Get yourself some ducks and they will eat the snails. You can eat your plants, and the ducks' eggs, and sometimes a duck as well! So ducks are one of the possible answers that you could choose. Keep your mind open, keep learning and sharing, and you will see that there are many solutions available.

#### **7. Think ahead**

People often do things without thinking. Someone might build a home in the wrong place or plant trees that have to be cut down because they are growing under an electricity wire. Sometimes we do things out of habit, even when the results cause problems – we often don't realise the connection because we aren't thinking about it enough. For example, people sweep the soil around their home until it is bare, uncovering the plumbing pipes buried underground causing pipes to break, then the same sweepers complain to the water board about the lack of water and lack of maintenance. We should put careful thought into everything that we do.

- **Think before you do something!**
- **Think while you are doing it!**
- **Think after you have done it!**

With Permaculture thinking the aim is to do 80 minutes of thinking for 20 minutes of work, or 80 hours of thinking to 20 hours of work! If you think really hard and plan well, especially with a diverse team of people, you can find ways to conserve energy, be efficient with all resources, and find creative solutions so that you have less work to do. The more you think, the better you become at it. The aim of this manual is to get you thinking through a plan for achieving Sustainable Nutrition, and then putting the plan into action, thinking and re-thinking all the way through.

## **8. See the whole picture**

It is important that you take time to stand back sometimes and look at everything as one. Think of things near and far, think of now and the future, think of the big and small things, and try to see the whole picture instead of just your little part of it. Sometimes we forget that we are just one part of a much bigger whole thing and if we are going to live sustainably we need to be painting the same picture, developing the same ideas together about what we want our world to look like with other people in our family, community, in our country and the whole world.

Think of the different groups of voices in a choir: the Bass, Alto, Tenors, Sopranos all sound fine on their own, but the music is not complete until they sing together. Every singer must understand their own part, they must understand the other singers' parts, and all the singers must know what the whole song should sound like. If each one learns and practices what they are meant to do, and they practice together, the music can be wonderful. Think what would happen if they do not co-operate; if they all sing different songs; or they sing same songs but with different rhythms - the results would probably sound terrible, not musical at all!



Nature is our best teacher! Take a walk outside and look at the eco-systems near you - the plants and trees that are living or dying, the animals, the insects and anything natural. Look at the effects of sun, water and air. What uses these plants and trees?



Make a list of good things that you see: a beautiful view, a tree full of fruit, someone catching fish to eat or children playing.... Now make a list of harmful things: plastic waste, an eroded hillside, poor air quality, etc.

## **Sustainable Thinking and Action**

We have talked about sustainable, biodegradable and renewable resources, and outlined some new ways to think about things in your life. Now use your imagination to make the most use of everything that is available to you. Here are some ideas to get you started:

### ***Reduce, re-use, repair and recycle***

Many things that we think of as rubbish can be repaired, re-used or recycled. People who use their imagination and creativity can make really beautiful, useful new things with things that are just thrown away. If you can think up some income generating products and you make and sell them for extra income, you will truly be turning waste into wealth, and often for no more cost than your time and effort!

Look around you to see what resources are lying about un-used. What could you make with these resources? At the same time as making something out of what was considered nothing, you will be improving the environment and strengthening the Nature Cycle. There are many ideas in this book to reduce, re-use, repair and recycle things but see what other ideas you can come up with. Plastic bags, bottles and containers, tin cans, paper, wire and rubber tyres are all things that are often thrown away as waste, but they are resources, so make the most of them!

### ***Plastic bags***

There are many plastic bags around and most of them are non-biodegradable plastic. How many ways can you think of to reduce, re-use, repair and recycle them? If you bring re-usable cloth bags or baskets to the market instead you will reduce the use of the plastic bags. Re-use each plastic bag as many times as possible, then think of something else you can use the plastic for when it can't be used as a bag any longer. One thing you can do is make *plarn* (plastic yarn). Wash the plastic bags and cut them into strips, so they similar to yarn. Use the plarn to knit, crochet or weave useful things like bags, purses, hats and mats, etc. Or shred clean plastic bags to make a soft stuffing material for pillows, mattresses, toys, insulated baskets, or compress them with a machine into bricks for building. New developments in the larger cities are companies that are buying up plastics and recycling them with machines. Another new development, but not yet in Malawi, is making plastic from starch instead of fossil fuels – either from potatoes, cassava or starchy grasses. These bio-degradable plastic products can be purchased on the internet.

### ***Plastic bottles and containers***

Plastic bottles can be re-used in many ways, for irrigating plants (page 83) or making a tippy-tap (Part 1, Topic 9: Food Hygiene and Safety) or for building things: buildings, greenhouses, chairs, boats, solar water heaters or even gutters! People have had all sorts of clever, creative ideas already that you can learn about and try. Will you be the next one to come up with a fantastic idea that turns waste into a resource to improve your life and the environment around you?

### ***Metal and wire containers***

Metal is a valuable resource that can be made into many different things. The '*galimoto*' toy cars made of wire are very cleverly made and high quality items like this are exported from Malawi all around the world! Tin cans can be cut, woven and re-shaped into all sorts of useful and pretty pots and containers. So get creative and use what is around you!

### ***“Waste” paper***

There are many ways to re-use or recycle “waste” paper. You can make paper briquettes (Part 1, Topic 12: Energy Use in the Kitchen) to cook your food or heat your bath water so you do not have to chop down so many trees. You can make little containers for planting seedlings out, so you do not need to buy plastic tubes. You can use old newspapers to help to make new beds for growing food plants. What else can you think of?

## **Population Growth**

The examples of Sustainable Thinking and Action given above are very practical ones with ‘things’; another area of life that we should think about is population. Every population of plants, trees, animals, fish, insects and birds needs to be balanced with the other populations that share the same eco-system, including human population.

In Malawi in the 1980s there were about 3 million people. The population now is 16 million. So in the last 30 years we have 13 million more people to feed, house and educate. That is a lot of people! Are there connections between this big growth in human numbers and the problems in our lives and the environment?

Many people in Malawi are farmers, but farmers need land to grow their crops. Can the same amount of land provide enough food for 16 million people? Can the same

amount of land provide enough trees for everyone to burn for fires, cook their food, and build their houses with? If people do not change the ways they are living, ways that are harming our eco-systems, then the answer to both questions is 'no'. But changing our behaviour is only half of the answer; the other half is in thinking, planning and designing for the future to manage and support our population in a sustainable way.

In the process we should be asking and developing sustainable designs for questions such as: What areas of the land should be left for other species than humans? How many humans should be different eco-systems in order to be balanced with other animal, plant and insect populations? What should be the limit of our human population? Do you need to plan how much you personally contribute to the population of the world? These can be difficult questions to discuss, but we need to talk openly about them and take action before we are faced with even bigger problems.

## **Changing Attitudes**

We know that people have habits that can be hard to change (ourselves included!). People often don't like change. They can be suspicious, and sometimes they act badly when they see other people making changes that they do not understand. You have read this far in the manual and maybe you know now that your habits need to change, but you might need to be quite strong to do this. You should take pride in the fact that you are open-minded and thoughtful enough to change the way you live your life, to change your diet and your household so that you can have a better future.

Here are a couple of stories to encourage you. These people found that the biggest problem was other peoples' attitudes, but they persevered and overcame the problems and were able to share what they were learning with those other people eventually.

Mrs Mwale, a teacher in Lilongwe, was learning about Permaculture. She learned that when she swept the ground around her house she was sweeping away good soil that could grow food plants. So she stopped sweeping and marked out areas that the family would walk on as well as a couple of beds for growing food in – areas which were previously wasted space. She began pouring used washing water on these beds and started growing good things to eat, right by her front door.

Her neighbours thought this was very strange behaviour. They called her names and said she was the 'Dirty Teacher' because she didn't sweep the way everyone else did. But she was strong and carried on what she was doing, trying to explain why she was changing her ways. After a little while she started harvesting good foods and medicine plants near her house. The plants growing there looked good, smelled nice and provided some cool shade on her khonde (porch) as well as helping her to feed her family nutritious food. She was making very efficient use of her resources. Before long her neighbours started asking her for vegetables and stopped calling her names. They started watching and asking what she was doing and eventually they began to do the same themselves.

Another example was Mr. Christopher Singini, an agricultural officer in Kasungu, who was part of the development of the first Sustainable Nutrition manual. Mr. Singini was practicing everything he was learning. He saw the huge potential in the resources that his community were just wasting. He was excited by all the possibilities and helped his family to understand the ideas too. Together they he started re-designing the family home, which was in quite a public area along a busy road near the area's agricultural office.

He and his family made changes at the front of the house first, where they wash the dishes. All the washing water was used to water seedlings and food plants right in front of his home. These provided beauty and shade as well as food for his family. By having beds of plants growing near the foundations of his house, they were protected, not

getting swept away with a broom and the rains. The family used dried leaves and grasses to mulch the beds, to make the most of the little water that they had and to protect the soil.

His neighbours did not understand what he was doing. His house began to look different and people mocked the family so much that the family grew tired of the ridicule. They put up a fence round their house so the scornful neighbours could not see what they were doing. This man and his family knew that they were making their lives better! With the fence in place only visitors to their home could see what they were doing. However before long, they were growing enough food near their home to share with others. After a while the neighbours began to understand what they were doing. Over time they began to admire them, ask their advice and even started copying their ideas for sustainable living.

Those first days were difficult but the people were strong! They thought hard about the changes they made and eventually won the respect of their neighbours, and were able to share what they had learned about designing for sustainable living. A more positive attitude towards change and improving ourselves needs to happen as soon as possible, spreading out to many more people and communities. It can start with you and your family and friends, and it is starting now, even while you read this manual!

## Choosing your Site

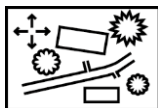
You have already started sketching the area where you live. This is to get you thinking about the environment all around you and how things connect together there.

Now it is time to choose a small part of that area to work with as you design for sustainable living. An area around your house, workplace or school is a good place to begin with. Start with about 20 x 20 metres of space. (It does not have to be square or rectangular in shape. Very little in Nature is square!). The idea is just to start small until you get the hang of designing, then you can work up to larger and larger spaces – even your whole community or city!

Try to find one or two larger pieces of paper so you can plan a new map that will be the beginning of your Personal Design for Sustainable Living. Think about drawing this new map, but only think about it for the moment.... You don't need to draw it out just yet. We will keep working on notes and sketches for now.



How much space on the paper will you need? How much of the area around your site should you include? You will need to mark in other things which affect your site; sun, wind, rain, roads, buildings etc.



Have a look at your map sketch. It should be full of information! Have a look at the information about map-drawing in Part 3, Topic 36, Mapping your Site, so you can be thinking about your design for sustainable living.

**Remember the 80:20 rule!** Spend 80 minutes thinking about something and 20 minutes actually doing it. Keep adding information to your notes and your first sketch map. It should look a real mess by the time you come to drawing up another!

## **Topic 17: Soil Health & Conservation**

Almost all food comes from the soil. Most living things come from the soil and eventually return to it.

Healthy soil is productive, fertile and good for raising food, but unhealthy soil is unproductive, infertile and is not good for growing anything.

Soil is a bit like a savings account in a bank. The more you pay into the account the more you can take out of it to use in your life. But, if you take more out than you put in, you will end up with nothing, or worse, with less than nothing.

What you must pay in to the 'soil account' is the natural organic material that returns to the soil as part of the Nature Cycle.

At the moment large areas of the soil are infertile, degraded, broken and bankrupt. In the past, communities could move to new areas to live and farm if the soil stopped being fertile. But with 16 million people living in Malawi everybody cannot just move somewhere else!

Fortunately, we know much more now about the science of how soil works and what keeps it fertile than our ancestors did, when they started farming here thousands of years ago. (Although we don't always care for the soil as well as our ancestors did!) Nowadays we know that we can restore the soil by feeding it a better diet. This is like restoring someone's health by feeding them good food. The soil needs care and different nutrients, just as the human body does.

So what can we do to restore the health and fertility of our soil? This does not mean lots of hard work and expensive costs! Much of what we need to know and do we can learn from Nature and, in many cases, the thing we most need is to *do less*! For example, stopping harmful practices such as: over-tilling, over-sweeping, and over-using chemicals. This next section will help us better understand how the soil works and what practices and designs we can put in place to restore soil health, structure and fertility.

### **How Soil Works**

Think of any wild natural areas. Do you see many different plants and animals living there? Do people have to go there to dig the soil, put seeds in the ground, water the plants, spray on chemicals, and feed their animals? No! It is Nature that keeps these areas so full of life and fertility. Nature does it all!

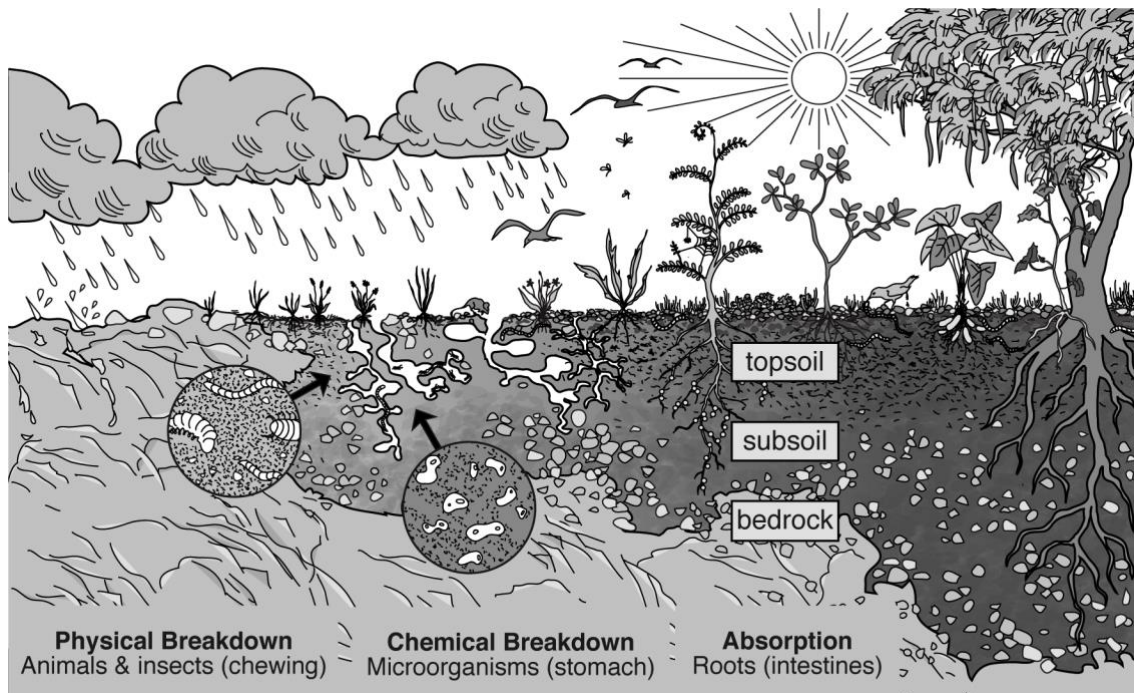
In Nature digging is done by the roots of plants and trees, by animals scratching the surface, or insects burrowing underground. Animals often help, carrying seeds around on their fur or in their stomachs, ready to deposit (along with a dose of manure) back into the soil. The watering is done by the weather and the Water Cycle (see page 3). The animals find food to eat from the diversity throughout the seasons. In some years there is more food than others and the animal populations will naturally reduce in these years, as everything in Nature is balanced.



## Part 2, Topic 17: Soil Health and Conservation

- The soil provides nutrients to the plants.
- The plants provide nutrients to animals and humans. (As well as animals providing nutrients to other animals / humans.)
- The plants, animals and humans provide nutrients back to the soil.

If we do not co-operate with this process the soil becomes unhealthy. It will not have enough nutrients and will grow fewer, lower quality foods for us to eat. There will not be enough of other things as well: energy, medicines, building supplies, water quality, or even good, clean air to breathe. The soil turns organic matter into nutrients for energy, growth and the health of plants and animals. The soil digests organic matter just as our bodies digest food. (See Part 1, Topic 1 Food and Nutrition, for a reminder of the human digestive process.)



- **Physical breakdown of organic matter.** This is similar to how we chew our food with our teeth. Animals and insects do this work for the soil by chewing and digesting the food and their waste comes out as resource (manure) for the soil. Animals also help the breakdown of organic matter when they step on fallen plant material, breaking it into smaller pieces. The wind, sun and water also break down organic matter into smaller pieces.
- **Chemical breakdown.** This is like when food enters the stomach where digestive juices break the food into even smaller pieces. In the soil, tiny micro-organisms break down the organic matter into nutrients that plants use for growing. Small animals like worms, termites, snakes and mice burrow in the ground so the soil has air holes running through it. This also helps water get into the soil. These inputs of water and air help the chemical breakdown to happen.
- **Absorption of the nutrients.** The nutrients from all the broken down organic matter is released into the soil where it can be taken up by the roots of the plants, along with water and minerals that are in the rocks and earth itself. The plants use these nutrients for growth, health and energy. This is similar to when our food leaves our stomach and enters our intestines, where the nutrients are absorbed by our bodies and used for growth, health and energy.

It is variety and diversity in Nature that keeps soil healthy. The picture shows these processes happening. **In healthy areas the soil will be covered with plants**, leaves, twigs and all sorts of organic matter. There will be many different animals, birds and insects living there. When rain falls it soaks deep into the ground so the plants can use it now and in the future. **In unhealthy areas the soil will mostly be bare**. There will not be much animal life or plant life, and you probably will see more stones and rocks because the soil is eroding away. The soil is often so hard that water will not soak in well when it rains, instead it runs off the land quickly, following any slope to the lowest point of land, eroding the soil away with it. This causes both droughts and floods. The little water that has made it into the soil dries off the bare soil quickly in the heat of the sun.

## What Damages Soil?

What are the things we are doing to cause the problems we just described? There are many things that we do to harm the soil:

- **Burning organic matter** kills the wildlife, pollutes our air and water, exposes the soil to winds that blow it away and water that washes it away, and it destroys the organic matter that is food for the soil.
- **Using chemicals on the soil** (like artificial fertilizer and pesticides) can harm the insects and the delicate micro-organisms that the soil needs to work properly.
- **Mono-cropping** (growing only one crop in a field) destroys all the natural diversity in the area and damages the Nature Cycle and the natural balance of the ecosystem.
- **Over-grazing** (when animals are allowed to eat and walk too much in one area) takes away the plants that hold the soil together and keep it there, so it can blow or be washed away with wind or rain. The soil can become compacted (packed hard) with the weight of too many animals in one area.
- **Sweeping the earth** removes organic matter (the food for the soil) and it sweeps away the soil itself. It also usually adds to a female's workday, is unhealthy for her to breathe the dust and to bend over (usually) a small broom for sweeping.
- **Digging the soil** breaks up soil structure and disturbs life underground.
- **Compacting the soil** (squashing it so it becomes hard, like dry clay) makes it difficult for roots to reach down and find the water and nutrients they need deep underground. Even humans walking on the soil can do this, which is why sticking to well-designed pathways will be important.
- **Cutting and clearing** too many plants and trees, especially when the roots are removed as well, exposes the soil so it can be washed or blown away.
- **Planting crops on steep slopes** can cause soil erosion
- **Paving the earth** stops anything from growing, adds chemicals to the area (from the concrete and cement) and stops water soaking in to fill the underground water stores.

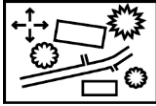
This list could go on for much longer. How many of these things are causing soil to be simply washed or blown away? We are losing the very resources that we need to grow our food! These things are happening in every country in the world, but solving these problems must start at home, with your actions in your life. From there you can spread it through your community, your region and your country, changing our habits so we protect our soil instead of damaging it. Share what you are doing globally to help make a difference everywhere.



So what can we do to care for our soil? We can adapt so we work with the Nature Cycle, not against it. Two things are very important for healing unhealthy soil and the next topic will look at conserving the soil (keeping it strong, safe and in the place we need it) and soil fertility, or how to make sure soil stays healthy and productive.



Go outside and look around. Look for an area with healthy soil and an area with unhealthy soil. What is the main difference between the two areas? What is causing this?

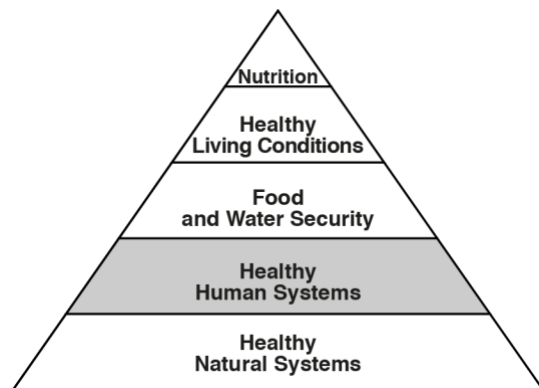


Note on your sketch map where your soil is degraded and where it is particularly healthy. (Don't start the actual map yet, just be thinking about it and taking notes. Remember 80 minutes of thought and 20 minutes of work!)

## Conserving the Soil

Good soil is being washed or blown away from our land every day in Malawi. As it leaves the places it is supposed to be, it covers everything with dust, and fills the up the waterways with silt. Good soil is no use in the river!

This soil loss can be prevented, and the damage can be repaired, if we do a few simple things. The methods are not hard or costly but you have to think about them, cooperate with each other, and use your intelligence and creativity to create sustainable designs and practices:



- Mulching
- Sweeping less
- Stop burning
- Less tilling and hoeing
- Clearing land carefully
- Taking care of slopes
- Planting perennials
- Using windbreaks

Often the hardest part of changing unhealthy habits is that other people do not understand why you are doing things differently. They may feel uncomfortable with your changes, or left out, and they might start talking negatively about what you are doing.

Be strong if your efforts are mocked! Explain to as many people as you can what you are doing and why, and encourage others to make healthy changes too. Join together with other people who are trying to make improvements to share ideas, have a common message in the community, and to strengthen and motivate each other personally. It might take time for others to understand that what you are doing makes sense and that it is making lives better.

## Mulching

Think again about the healthy natural area. Was there any bare, uncovered soil? What was all the soil covered with, between the growing plants and trees? Mulch is a layer of natural material that protects, feeds and keeps moisture in the soil. It is like a blanket that protects your body from cold or a hat that protects your head from the sun. In a sustainable design, mulch is generally put between the growing plants or trees, in pathways or in animal pens.

### ***Mulching materials***

- **Dead organic matter**, such as dried leaves, grass, sawdust, crop residue or plant trimmings. These all protect the soil and feed it as they decompose.
- **Creeping plants** like pumpkins, melons, sweet potato vines and some herbs are living mulches. These crawl across the soil between the other plants. They shade the soil from the sun, the roots hold the soil in place, and they protect the soil from the wind and the rain.
- **Mineral mulches** can be small stones or gravel. These also protect the soil and are very useful in protecting small plants when there are chickens about. A layer of organic material underneath the mineral mulch adds extra nutrition for the soil.

### ***Benefits of mulching***

- **Protects the soil** from rain and wind so it is not washed or blown away.
- **Adds nutrients**, depending on what kind of mulch you choose.
- **Keeps the soil cool and moist**, so you do not need to water your plants so much (even in the dry season).
- **Holds water**, releasing it slowly like a sponge. This protects soil from drought or flooding much more efficiently than bare soil.
- **Makes the soil under it soft**. Soft soil is easy to plant into. In Malawi this is being promoted with conservation agriculture to ‘throw away the hoe’.
- **Protects plants from soil splashes** from rain or other watering.
- **Stops unwanted plants from growing** between the things that you want to grow.
- **Best of all, it means less work for you** to do each day – conserving your energy.

## **Myths about Mulching**

### ***Mulch is messy and dirty***

Bare soil is dirty – it is either dusty or muddy. Choose mulch wisely for different places. Use the neatest, most attractive mulches around your home, office and other public areas, and use messier mulches (mixed crop residue) in your fields and orchards. Later you’ll also learn about edging, which, combined with neat, appropriate mulches, you can make things look really pleasant and heal your soil at the same time.

### ***Mulch will bring snakes***

Snakes prefer to be in quiet, wild places – depending on their species they would like to move into a pile of rocks or wood, or in a hole or up in a tree. When snakes have their own preferred place to live they are more likely to stay away from us. When we destroy all the of the snake’s habitats then they may try move into your home instead! Learn about the snakes in your area and understand their habits so that you can care for yourself and nature at the same time.

### ***Mulch attracts termites that eat our plants***

Termites are important to the Nature Cycle. They work to break down dead organic matter and turn it back into soil. Many people in Malawi know that termite mud is full of nutrients. They collect the mud and put it in their garden because it is such healthy fertile soil. Termites do not want to eat live healthy plants and trees unless we have cleared away all their food; their preferred food is something that is sick, dying or dead. So the first line of defence is to keep your plants and trees as healthy as they can be,

which we are learning about in this book. Mulch feeds the soil, including the termites. Mulch usually gives them their preferred food, and, they are working for you to make your soil healthy – that conserves your energy so you don't need to buy artificial nutrients (fertilizers)! Termites will eat whatever dead organic material you put on the ground, so of course it makes sense to keep mats, baskets and other things out of their reach.

### ***People need bare ground for meetings***

Really? Who wants to stand or sit in the hot, bare dust and dirt? No one does! People nearly always choose an area with trees for shade, or they prefer to sit on short grass. With a little thought you can design areas that are good for meetings, with shade and benches, logs or rocks to sit on while chatting and discussing things or having school assembly.

## **Stop Over-Sweeping!**

In Malawi people are taught that sweeping around their houses or schools is 'clean'. Children spend hours of their lives sweeping. Women get up every morning and bend over their brooms. Sweeping in Malawi is a habit, but let us think about what happens when we sweep such large areas of our land.

What is so 'dirty' about the leaves and grass that are being swept away? Leaves and grass do not cause disease or health problems. They do the opposite; they feed and protect our soil, which can then feed us more efficiently, so our immune system can help us stay healthy.

- **Sweeping removes organic matter** from the top of the soil. This is actually the food and protection that our soil needs to stay healthy.
- **Sweeping makes the earth hard**, and water cannot sink into hard earth. This causes wind and rain to wash away our soil, and reduces the amount of land that we can use for growing food (or grass in a meeting area).
- **Sweeping causes erosion**. Sometimes so much soil is swept away that the foundations of our houses are damaged and plumbing pipes get broken. Lots of healthy soil is swept into a pile or pit and not used – a resource that is wasted.
- **Sweeping makes us cough, and hurts our eyes**. The dust (soil) rises up into the air and covers clothes and houses with dirt. That is not clean or healthy!
- **Sweeping can cause back pain** when the traditional short brooms are used.
- **Sweeping wastes time** while damaging soil fertility and structure.

**So, shouldn't we be tidying up the really unhealthy things?** Things like animal manure in the wrong place, plastic waste which is blocking the nature cycle, and food scraps left around attracting flies which spread disease, and so on? Sweeping large areas of soil away is one of the most unhealthy habits in Malawi. We can easily take steps to do this less. Here are four ideas:

**1 - Reduce sweeping little by little:** As you sweep less and begin to change things, the area will look different while you get new plants and trees growing in the mulched areas. Explain to people what you are doing and, like construction workers, put up a sign saying something like: 'Construction in Progress. Please pardon our appearance!' This way you will be sharing your knowledge with others.

**2 - Mark out some 'no sweeping' areas** with rocks, or logs, or soil piled in mounds and ridges. Make it look nice, so people know you are doing this deliberately.

- When you tidy up your surroundings, put all organic matter into that area. This 'waste' is now mulch, which you have turned into a resource to help you grow food. Clever!
- Pour your used water into these 'no sweeping' areas, water that you have left from washing clothes and doing the dishes (known as grey water, which we'll look at later).
- Soon these areas will be healthy enough to support plants or trees. Choose a mixture of plants that that will look attractive, smell nice and taste good, too. Shortly we'll learn about designing using mixtures of species like nature does (guilds) that will help you put the right things in the right place.
- Plant some more! Over time increase the size of the un-swept area and make your gardens even bigger.

**3 - Use a rake or a broom that is coarse** (rough, less fine and less soft). When you are neatening up your areas, try to remove the larger pieces of organic matter that you find 'messy', without damaging the soil or making dust. If plants grow in the pathways they can be slashed so people can walk or drive through, instead of pulling out the plants that are holding the soil place. It does not take long to slash and trim plants two or three times a month to keep an area tidy. Sweep only where you really need to sweep such as inside your home and conserve your energy!

**4 - Put things in the right place to start with.** Food scraps should not be thrown on the ground in pathways or in areas that will attract flies. Organic scraps should be put into a compost pile (more details on page 43) or under the mulch in your garden beds. Plastic should not be thrown onto the land, or into water or burned. Gather all plastic and think of something to do with it. You can use soft clean plastics as a stuffing for dolls, cushions and pillows. Even just stuffed into an old sack it makes a comfortable cushion to sit on. (See page 12 for more ideas.)

## **Stop Burning the Land and 'Trash'**

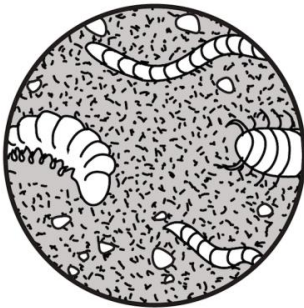
From June to November, every year, almost all of Malawi is filled with smoke from burning to clear land for planting. Burning is very harmful to the soil and air and interrupts the Nature Cycle. Burning kills animals, insects, trees and plants that we can use for food and that the soil needs for its fertility. Many people agree that burning is harmful and unpleasant, and a few people are changing and speaking up to help others change, too. We need everyone to change! There are other, much better ways to prepare agricultural land, to hunt and manage our 'waste':

- Clearing land can be done carefully by hand (there will be more on this subject in a moment) or being even more careful if you are using a machine.
- Trim or slash plants that are in your way. Use the trimmings as mulch or put them on a compost pile (more about compost later on page 43).
- Hunting can be done by understanding the prey better and using trapping or being more stealthy instead of burning large wild areas to see the game better.
- Do not burn synthetic (non-biodegradable) waste, which produces poisonous smoke. Think of ways to use the waste, to recycle it.

**There are many ways you can get these messages out:**

- Start with your own life and habits, then work with family and friends to help them understand the harm that is done by burning.
- Burning really affects people with asthma, people who need thatching grass, people who keep beehives and people who harvest natural medicines. Join together and cooperate on natural resource protection issues.
- Youth groups, schools, colleges and universities tend to be interested in and understand these ideas quickly. The Wildlife and Environmental Society of Malawi supports school clubs and community activities.
- Your District Information Officer can help you to communicate messages about air quality, soil health and bio-diversity, if you ask them.

## Reduce Hoeing and Tilling



What does a hoe do to the soil? It breaks it up and disturbs (and maybe kills) all those insects, worms and micro-organisms that are working underground, breaking down organic matter into nutrients for the plants, adding manure, making little tunnels that allow air into the soil, and keeping the soil in a good, healthy condition.

Cutting into their environment with a hoe stops them doing this valuable work. It would be much more efficient if you feed them organic matter so they can work for you!

In Nature the roots of the plants dig the soil. Wide roots open up the soil and let in water, air and oxygen. Some roots go really deep down and break up rocks. These roots absorb minerals from deep underground and bring them to the surface. When the leaves fall from these trees the minerals in the leaves get returned to the soil and other plants can use the minerals. Animals scratch on the top while insects, worms and animals make tunnels below the surface.

We can copy Nature by doing the following things to dig our soil:

- Planting trees and deep rooted plants in places where we want to get deep underground to improve soil health.
- Planting root crops such as yams or ground beans (*nzama*) to dig the soil at different levels.
- Letting chickens scratch around mature plants and trees that they cannot harm.
- Keeping the soil covered with organic matter (mulch) to protect and feed the little creatures that look after the soil.



In some areas where soil quality has been destroyed, and the ground is hard, there will not be many worms and insects. The best thing to do here is cover the whole area with a thick layer of mulch and leave it alone for a few days or weeks, depending on the state of the soil and how soon you need to plant. If you really need to plant the area sooner than that, dig the ground to about 50 or 60 cm deep. Put organic matter into the ground, then cover it and mulch it. If you look after the soil well from now on, using nature as your best teacher, you will never need to dig deeply there again. The worms and insects will come back to help.

## **Clear Land Carefully**

When people prepare land for a garden, farm or building, they often get rid of every single living or dead thing through slashing, burning and / or using machines and then flattening the land. When it is all cleared the people then plant new seeds and new trees. This is a lot of work! Once they have cleared everything and the fertility of the soil has been disturbed they also feel they need to put chemical fertilizers on the soil. This is expensive! While doing all these things they often complain about how much work they have to do and how hard it is and how much it costs!

In Malawi clearing the land usually means destroying Nature without thought, but Permaculture guides us to think through our work before doing it (80 / 20). This means thinking for about 80 per cent of the time, and then working the other 20 per cent. This could be thinking for 80 minutes and working for 20 for a small job. A larger job might take 8 hours or even 8 days of thinking with working for 2 hours or days. If you think ahead and plan well, clearing the land carefully can be much less work and give a much better result.

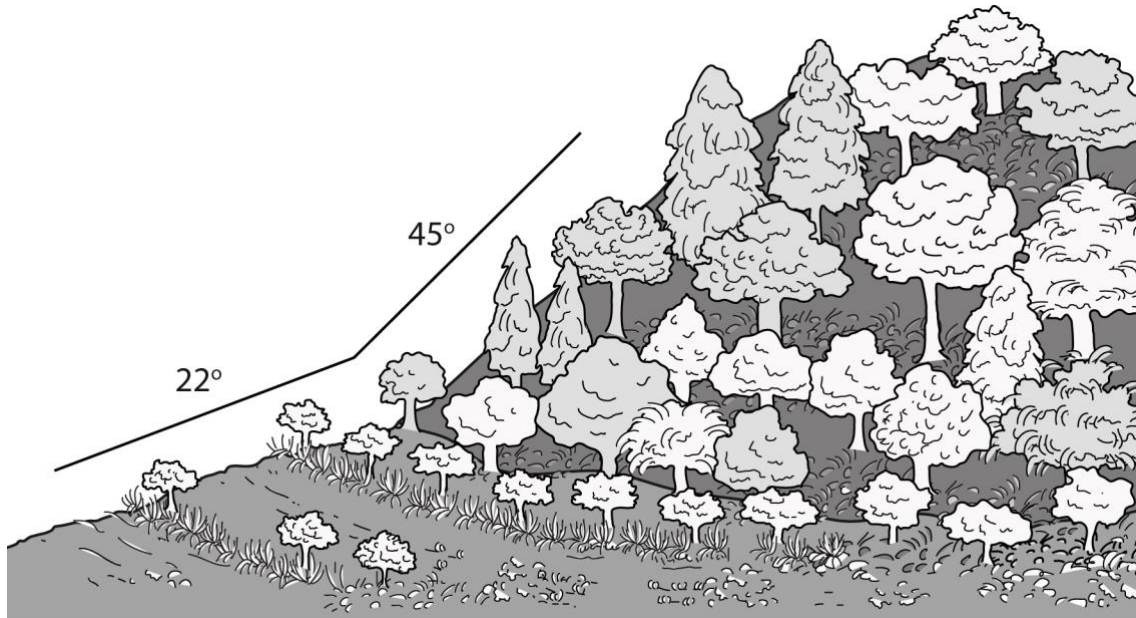
Instead of cutting out the trees, keep them as shade and protection for the house you are building. Perhaps the little hill of raised land would be a good place to put a bench and trees to enjoy your view better. Perhaps the little dip in another area would be a good place to dig a pond to keep fish and ducks?

Using your eyes, and your brain, saves you lots of time and effort. Before you start clearing anywhere stop and think for a while. Here are some ideas to consider in your thinking:

- **Assess the site carefully.** List the plants, trees and the animals living there. If you don't know them ask other people for help. Try to keep one of every kind of plant already growing there. Even if you do not know its name or use, eventually someone will know and you will probably be very happy you have it. Try to design around any unique item, or move it to another place in your design if you don't want to keep it where it is.
- **Use hand tools.** Use a sickle, or other hand tool, that allows you to work carefully about the plants and trees that you have decided to keep for foods, medicines, building materials, etc.
- **Keep the Roots.** If you decide that you really do not want a plant or tree, cut it close to the ground and leave the roots in the soil if you can (though some building work will require large roots to be removed). If you can, mulch heavily at the surface, so the plant is less likely to grow back. As the roots rot down they release nutrients and let water and air into the soil, helping that area of soil to be healthier and stronger.
- **Cover the area you want to plant with heavy mulch,** and let it remain there for a week or more before planting, depending on what you are putting in that area.
- **Only dig where you really need to.** Is digging really necessary? You may need to dig small holes here and there to put in tree seedlings. Think before you dig!
- **Start small and work bit by bit.** Clear enough space to start planting, and mulching. After the first areas are done, then carefully clear and plant some more. This way you will be able to start eating sooner, from the first section, then the second and so on. Your harvests will come one after another (staggered harvests) instead of everything being ready at once. This is good for your Food Security!

## Care of Sloping Land

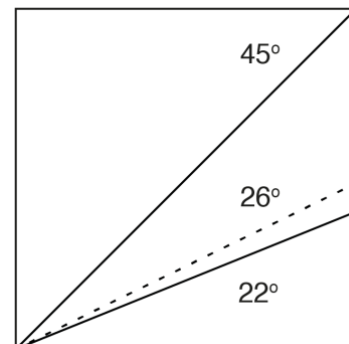
Land on slopes and hillsides need special care because it is easy for the soil to slide down the slopes. You do not want to cause erosion and make any problems worse. **Steeply sloping land should not be disturbed.** Nature can manage these areas better than humans so steep hillsides should generally be left natural. If erosion is already a problem there are some things we can do to improve the land, which we describe here.



**Slopes up to about 22° (22 degrees) are fine to cultivate as long as you take care to prevent, stop or repair soil erosion.** Erosion happens fast on hillsides, and as soon as you disturb natural plant life, it can quickly get much worse. If you are new to Permaculture start with designs for gentle slopes that are less than about 22°. Wait until you have more experience before you design land steeper than 22°, or ask someone with lots of Permaculture experience to help you.

Before you decide what to do you must work out roughly what the angle of the slope is. Land that has a steep slope, more than about 45° (degrees), should never have crops grown on it. Here is a way of finding out what 45° degrees and 22° degrees look like.

- Draw a square. All the edges must be the same length to be a square.
- Draw a line from one corner on the bottom edge to the opposite corner on the top edge. This line is 45° degrees. (You can start from either corner at the bottom and end at either of the top corners.)
- Mark halfway down the edge. Draw another line from the bottom corner up to the halfway mark. This line is about 26° angle.
- Make another mark a little bit below the halfway mark. Draw another line. This line is roughly a 22° angle. It is not very precise but it is good enough as a guide to estimate the angle of the slope.
- Hold the paper up in front of you, and compare the angle you have drawn with the sloping land (viewed from the side) that you are thinking about. Again, it is just a guide; if you want an exact slope, call in an expert to assist you.



### ***Water erosion causes soil loss***

Some of these ways of preventing soil loss will be discussed in more detail when we talk about Water Management (page 54), but here are some good ideas to start you thinking about soil conservation on sloping land.

### ***Changes to the sloping surface to stop erosion***

You cannot change the angle of the hillside but you can work with the surface of the hill to slow water down and give it time to soak in to the soil as it should.

- **Swales** are ditches across a slope with ridges on the low side of the ditch to catch every drop of water and soil and prevent it from moving down the slope. We talk more about these on page 75.
- **Rock walls** can be built across the slope or in half-moons below the trees, on the lower side of the tree (down the slope), which works very well in rocky areas.
- **Terraces** are areas that you flatten out on the side of the hill, each one a bit higher or lower than the other. The edges of the terrace are held in place with a wall or earth with very strong plants.

### ***Using plants to stop erosion***

Planting in lines that go downhill is very common in Malawi, but it is a harmful habit that is very damaging to the soil, water and the infra-structure downhill, such as roads and bridges. Rows pointing downhill makes soil roll, or wash off the hill, even faster. Here are some techniques using plants, which can stop the damage and heal the soil. Mulch can also help hold the soil in place. It needs to be a thick layer, and is not usually strong enough to work on its own on slopes but can be useful with some of the following techniques.

**Strong plants can be planted across the slope** in lines going round the hill. This is called Contour Planting and it slows the water down, gives it time to soak into the soil, and stops the soil from being washed away. It can be done with vetiver grass, shrubs of different sizes, thorny vines, and many other strong species.

**Plant Perennials.** These are plants that continue to grow, year after year. As they grow they get bigger and stronger, and their roots get bigger and hold on to the soil, keeping it on the hillside. Trees, shrubs and bushes are all perennial plants. Plenty of other plants, large and small, are perennials too, and many of them are food plants (listed on in Part 3, Appendix 1).

**Perennials are very good for slopes, for many reasons:** the roots go deeper into the soil than plants that only live for one or two years (called annuals and biennials). This helps hold soil and water. Perennials often cope and survive even if there is lots of rain, or hardly any rain. Tall perennials slow the wind down so it cannot blow your soil away or dry your crops out too much (more on Windbreaks below). Perennials are planted only once, but can keep being harvested for many years, so they conserve energy as well as preventing soil erosion.

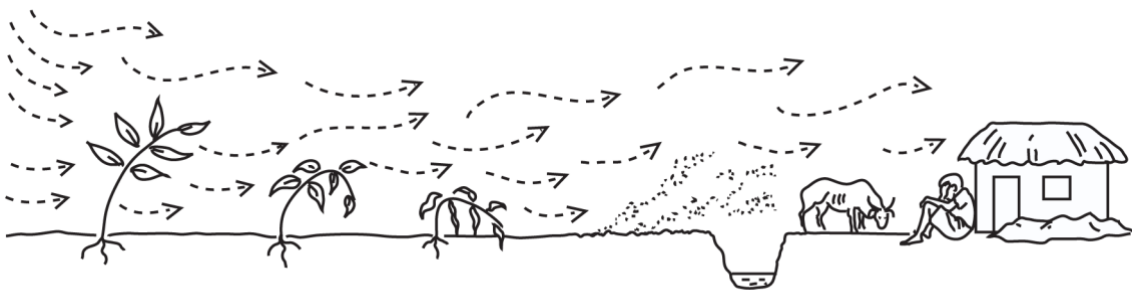


## Using Windbreaks

It is very windy in Malawi during the dry season. The wind can be helpful: it spreads seeds around, blows fruit down from high places, blows the leaves off trees so that they feed the soil, and wind can provide us with energy. But it can also stunt the growth of plants because they dry out too quickly, which means they do not grow well. Often plants, trees, buildings and people are covered with dust. That dust is our soil that is being blown away from where it is really needed (on the ground, growing plants). A windbreak can be made from a group of plants and trees that slows down the wind, makes it more gentle, protects crops from being stunted, prevents soil from being blown away and protects our roofs from being blown away as well!

- **Which direction does the wind blow from** the most around your area? Which side of the plot does it come from?
- **Plant a thick row of mixed height perennials** (plants that continue to grow for several years) along that edge of the plot. Windbreaks might take up anywhere from 1-10 meters along the edge, depending on the local conditions and needs.
- **Choose tall trees of different shapes, shorter shrubs, climbing plants**, etc. to make a growing wall to stop the wind blowing hard on your crops. The different heights should be mixed, so the wind is broken low down as well as high up. The strongest plants should be on the outer edge, where the wind is strongest.
- **Think hard about what you choose.** Remember 80:20? (80 minutes of thinking for 20 minutes of work?) You only want to plant this windbreak once and you want to benefit from it for years, so design it to provide fruits and berries, beautiful flowers and scents, places for birds and small animals to live, somewhere to hang a beehive and a shady spot to sit in.
- **A windbreak can improve the soil, too.** If it has any legumes (any kind of plant with pods for their seeds) it will provide an important nutrient for the soil called Nitrogen. (More about this on page 31.).

### ***Without a Windbreak***



With no windbreak the wind dries the water from the plants' leaves and they wilt. The soil dries up and blows away. The rivers and streams dry up and get full of silt. With less to eat the cattle get thin, and the people are more likely to get tired and ill too. Compare this with the situation in the next picture.

### ***With a Windbreak***

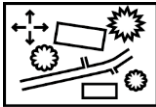


With a windbreak the strong wind is slowed down by the tall trees, then slowed some more by the shorter shrubs. The plants hold the soil in position, the soil is more fertile, the water stays in the soil longer, the crops do well and the harvest is good. People eat lots of different foods and are healthier and happier.

If you have a lot of wind, a windmill could also be built into your design. Windmills can be used for pumping water for use in the home, drinking, washing or for irrigation. Wind energy can also be used for cooking, lighting and all your energy needs.



Think some more about the soil in your area. Think about sweeping, hoeing, burning the land and erosion. What are the problems that these things cause?



Mark erosion problems on your map. Think about how you can show sloping land? (Map-makers use 'contour lines'. See page 72). Where would a windbreak be useful?

## 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 (*kamumpanda*), 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 | • Copper    | • Molybdenum |
| • Boron     | • Iron      | • Silicon    |
| • Calcium   | • Magnesium | • Sulphur    |
| • Chlorine  | • Manganese | • 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 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.

	<b>Nitrogen (N)</b>	<b>Phosphorus (P)</b>	<b>Potassium (K)</b>
<b>High Sources</b>	<ul style="list-style-type: none"> <li>• Manure and urine of small animals: bats, pigeons, rabbits, worms, etc.</li> <li>• Human manure and urine, fish and blood, hoofs, horns, animal hair and feathers</li> <li>• Leguminous plants, tea leaves, tobacco</li> </ul>	<ul style="list-style-type: none"> <li>• Decomposition of all sorts of organic matter</li> </ul>	<ul style="list-style-type: none"> <li>• Ashes</li> <li>• Molasses</li> <li>• Tobacco</li> <li>• Blood</li> </ul>
<b>Medium Sources</b>	<ul style="list-style-type: none"> <li>• Manure and urine of medium sized animals: chickens, dogs, rabbits, etc.</li> <li>• Bones, coffee grounds</li> </ul>	<ul style="list-style-type: none"> <li>• All parts of small animals and manure</li> </ul>	<ul style="list-style-type: none"> <li>• Urine</li> <li>• Potato tubers, some grasses, straw</li> </ul>
<b>Lower Sources</b>	<ul style="list-style-type: none"> <li>• Manure and urine of larger animals: cows, horses, sheep, pigs, ducks, etc.</li> <li>• Egg-shells</li> </ul>	<ul style="list-style-type: none"> <li>• Manure from larger animals: cows, goats, horses, pigs, sheep</li> </ul>	<ul style="list-style-type: none"> <li>• Animal manures</li> <li>• Plant scraps</li> </ul>

## 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, kabaifa, nzama, mtedza, etc.*)
- **Non-edible legumes:** Acacia species (*msangu, mtete, etc.*) tephrosia, leuceana, 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 to 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 inter-planted 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.

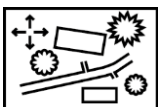
- **Incorporating the whole young plant into the soil** - plants are allowed to grow for a while and then they are cut down when they are still green and either used as mulch or dug back into the soil. With this method you do not eat the plant, or you only eat a little of it. Most bean leaves are nutritious 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.)

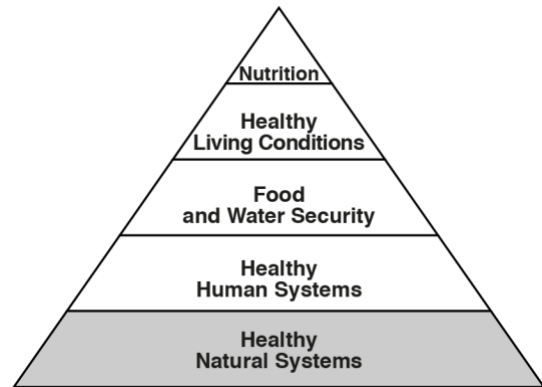


Note on your sketch map any nutrient-rich areas, e.g. sweeping piles, piles of crop waste, and areas rich in manure, etc. Mark on your sketch map which crops grow there and think about rotating these.

## **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 of 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.

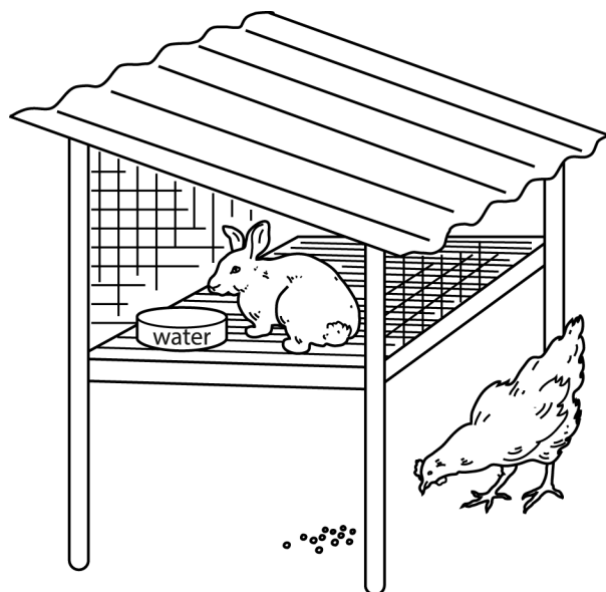
The animal's manure will have fed the soil and the leftover plant material can be used as mulch or for animal food. If you use live poles then you do not need to keep rebuilding, you just need to maintain the fence to make sure there are no gaps.

### ***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.

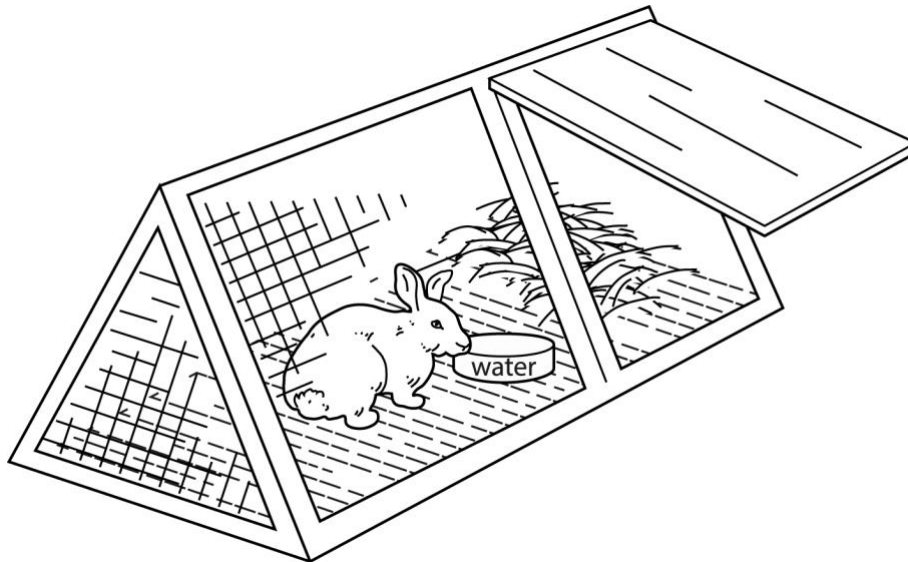
These are becoming common in Malawi for goats, pigeons, chickens, rabbits and small livestock, but they are not often used fully by integrating them to use the manure most efficiently.

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 it 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.

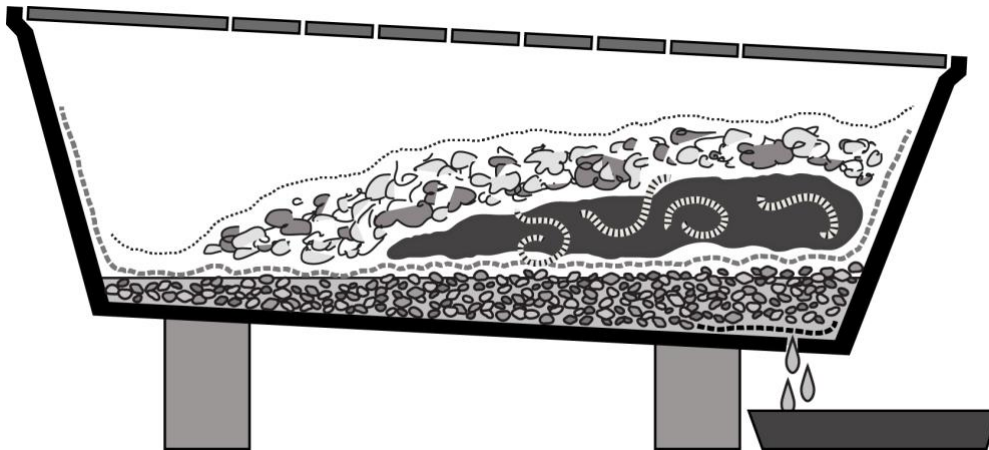
### ***Worm farms***

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.

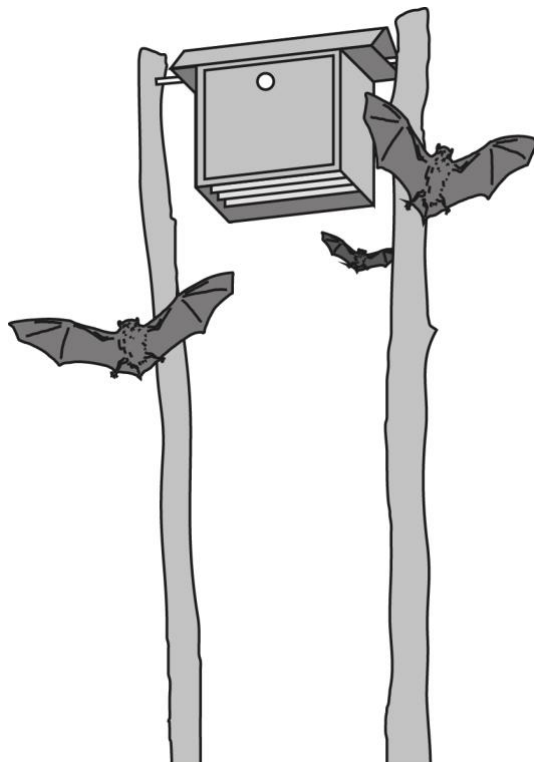


- **Find some worms** and put them in the worm farm
- **Put in some kitchen scraps** and cover it with a bit of soil
- **Feed them every day or two** by adding more kitchen scraps
- **Keep the bin moist**, but not wet. Usually your kitchen scraps have enough moisture in them to keep the bin moist without 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 breath the fumes.**



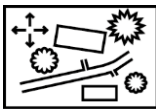
## Part 2, Topic 19: **Animals and Soil Fertility**

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?

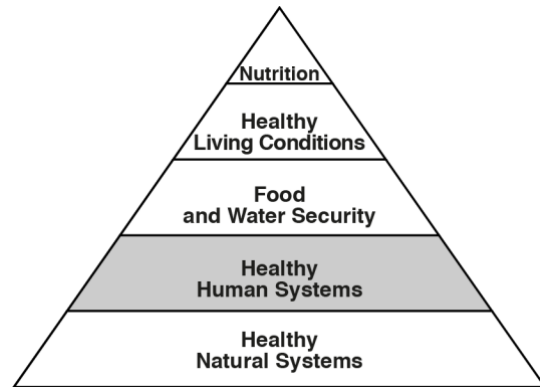


Note on your sketch map where you could build animal pens, or use animal tractors. Note where there are wild animal homes (anthills, birds' nests, etc.) or if you know of any animal tracks and paths.



## 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.)

- **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 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.

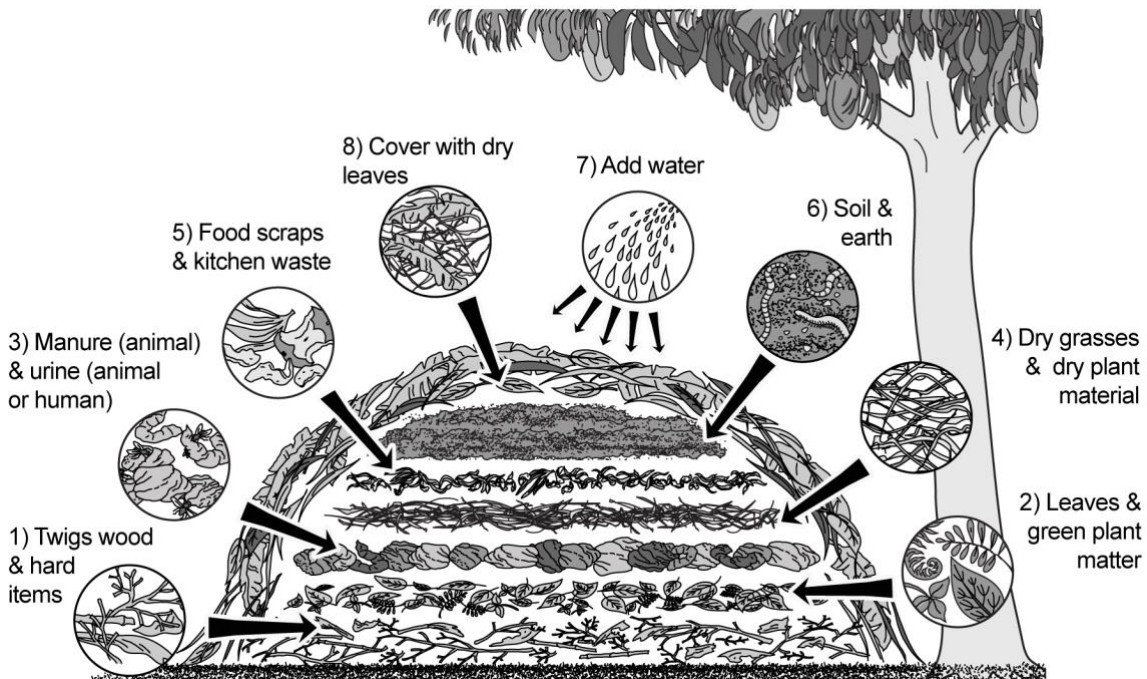
Make the first bottom layer out of the largest pieces of compostable material as they take longest to decompose, like large bits of wood and tin cans. Big pieces help to let air into the pile, which is needed for the process. If the pile is too compacted it will just sit there doing almost nothing. For 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 it 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:

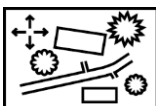
- A compost pit does not need to be turned over, but it will usually take longer to decompose than a pile (12-16 weeks).
- A compost pit does not need water added every week because the pit does not dry out as much as a pile, but adding water every few weeks can help. Adding urine directly to the pile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

## **Topic 21: Composting Toilets**

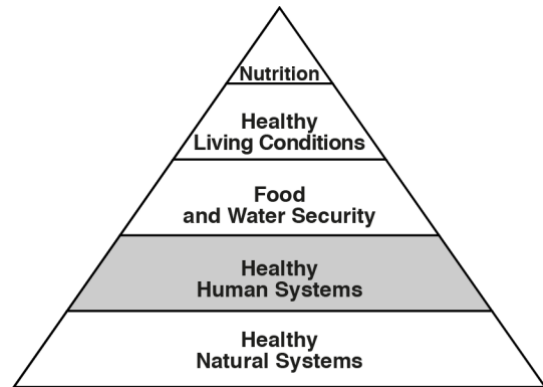
In Permaculture there is no such thing as waste. Everything is a resource, including human manure.

An adult human produces enough NPK in a year to grow about 250 kg of maize. This is more than enough for 4 adults who eat a balanced diet! We could stop using artificial fertilizer if human manure and urine was used properly and not wasted.

Composting toilets are designed to return human manure and urine back into the soil where it belongs (according to the cycles of nature).

Composting toilets make a healthy and nutrient-rich fertilizer for healing and enriching the soil. It is a totally natural, sustainable, biodegradable resource. (Composting toilets are not the same as using 'night-soil', which is when human manure is used without composting it first – night soil is usually an unhealthy and dangerous practice.)

The number of people in Malawi using composting toilets has grown in recent years. There are excellent composting toilets in schools, hospitals, businesses, markets, offices and homes. Composting toilets are included in the School Health and Nutrition guidelines (2010) and are promoted in Malawi's Sanitation Policy (2008).



### ***Problems with flush toilets***

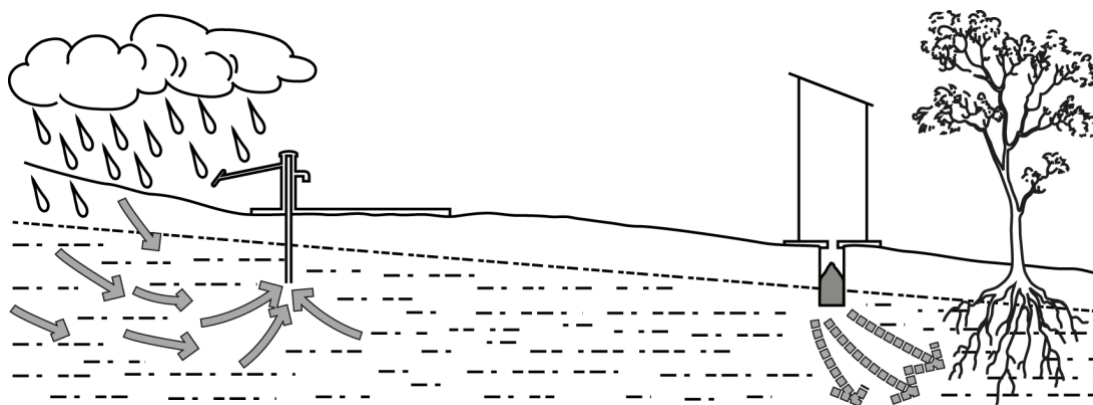
- Flush toilets are hard work and take a lot of resources to build
- Flush toilets waste a lot of water
- Flush toilets waste the manure and urine
- Flush toilets can pollute water supplies

Flushing toilets are only sustainable if the water source is sustainable and if the resources from the toilet are put through a composting or bio-gas system to produce energy and / or fertilizer. (See Part 1, Topic 12, Energy use in the Kitchen).

### ***Problems with pit latrines***

- Pit latrines are hard work to build
- Pit latrines risk collapsing
- Pit latrines can pollute the water supply
- Pit latrines must be dug again when the pit has filled
- Pit latrines smell bad and attract cockroaches and other insects

Pit latrines are very common in Malawi. They must be built at least 30 metres from any water supply (according to the national sanitation policy), and should be sited down hill, away from water sources. Otherwise, the water you drink may be contaminated with the manure from the toilet.



The manure in the pit decomposes very slowly because there is no diversity of organic matter to balance it. If you add organic matter you reduce the smell, and help it rot down, but the pit fills up quicker.

### ***Composting toilet systems***

Composting toilets have many benefits, which are attracting more people to use them:

- **They can be less work** to build, especially the designs that are permanent shallow pits, buckets / bins, or small temporary holes. There are also higher input designs.
- **They supply endless free fertilizer** as the 'wastes' from humans are continually returned to the Nature Cycle as nutrients. Say good-bye to wasting money on sacks of NPK!
- **They do not smell or attract insects.** Because the manure and urine is covered with organic matter after each use, there is no smell and decomposition is quick.
- **They greatly reduce (if not eliminate) the risk** of contaminating underground water, but should still be built more than 30 metres from any water source, to be safe.
- **They do not need water** to make them work
- **The designs are more stable** than pit latrines and less likely to collapse.

## **How Composting Toilets Work**

All composting toilets work the same / similar way with the same principles.

Every time you use the toilet you cover the manure and urine with a handful or two of organic matter and soil. The manure, soil and organic matter builds up in layers and micro-organisms digest the manure and other organic matter to create healthy soil. Very simple! Within 4-6 months the manure has completely gone, replaced by wonderful rich soil for your plants.

A container of organic matter is usually kept next to the toilet or behind it. Crushed dry plant matter mixed with soil is the best combination. Sawdust, peanut shells, rice husks, crushed leaves and/or dry grass all work well mixed with an equal amount of soil or half-finished compost. Use enough organic matter to cover the manure and soak up any urine. (Some designs separate manure and urine, because urine can be used directly without composting first and you want to avoid getting the compost too moist – it depends on the system you design.) People usually scoop the organic matter with their hands and doing this is a good reminder to wash them! Make sure you design a place to wash hands near to the toilet.

Once the compost toilet chamber is full, close it and leave it for 6 months to compost. After 6 months, the compost can be taken out and used like any other compost. It looks like, and is, good, rich compost and it will be wonderful in your garden, farm, orchard or forest!

With some designs, when the hole is a little over halfway full, cover it with soil and add a tree with some helpful plants around it. You do not have to wait 6 months and you do not harvest the compost because the roots use the nutrients on their own.

## Designs for Composting Toilets

There are several ways to make a composting toilet. Some are extremely cheap; others are more expensive. Make your decision based on your resources and creativity. We will look at a few designs in use already but you can adapt them to your own situation.

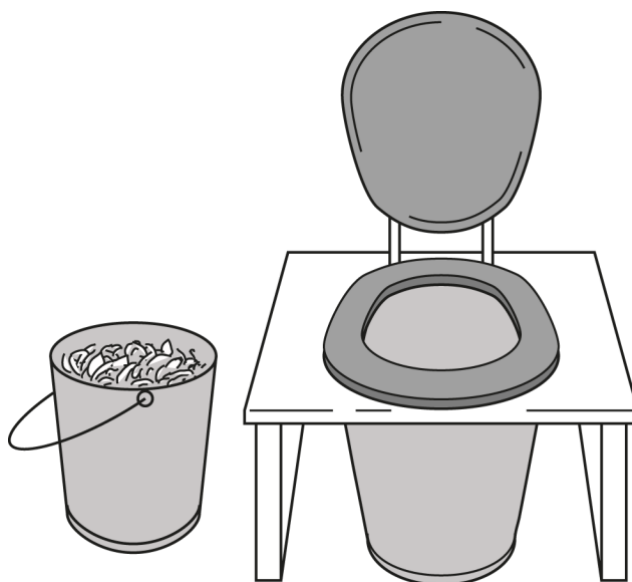
With each composting toilet design you need a container with a mix of organic matter and soil next to the toilet. This is for covering the manure and urine. You also need somewhere to wash your hands after using the toilet, and a few plants growing where they can benefit from the hand-washing water, of course!

### ***Bucket system (loveable loo)***

This system is the cheapest and can be used by just about anyone, anywhere. You do not need much more than a bucket and somewhere to empty the bucket when it is full.

You can easily make this design comfortable, private and pleasant to use. This system is great for a family but can be adapted for larger groups.

**Use a 20-litre bucket.** Build a toilet seat frame around it. You can make a wooden box, or take the seat out of a chair that fits over the bucket. Or you can just squat over the bucket (as over a pit latrine).



**Privacy shelter.** The toilet can be put inside a house in a private place, or you can make a special shelter outdoors. The toilet will not smell when used properly (except when someone is actually using it, which is normal for any toilet.)

**When you use the loo make sure that you cover the manure** and soak up the urine with the dry organic matter / soil mix. If the toilet starts to smell you need to use more covering material. Make sure your covering mix both covers manure and soaks up urine.

**When the bucket is full** (in about 2 days for a family of 5), it needs to be emptied onto its own compost pile. You can dig holes in the ground, use old drums, create bins, or make heaps on the ground. Put it out of the way somewhere. It is safe as long as the compost is covered well and left alone, so no one digs in it. It needs to be undisturbed for 6 months.

### ***The 3-bin system***

This organises the compost well and makes good use of space. (A compost pile tends to spread out a bit, but a bin holds the compost together). The bins can have a door or gate that can open on the front of them to hold even more compost in.

- **One bin** is being filled with the manure from the toilet bucket.
- **Another bin** is the compost that is maturing (when that bin has been filled).
- **The third bin** holds organic matter for covering the fresh manure after it is emptied into the first bin. This can also be used for re-filling the container (for covering materials) that is next to the toilet.



**After emptying the bucket into the compost bin, rinse it** with a little water and pour it on the compost. All the manure and moisture in the compost bin should be covered with dry organic matter so there is no smell or flies.

**When a bin has been filled, let it mature for six months.** Start putting the manure into the other empty bin. By the time this second bin is filled the first one should be ready to use in gardens, fields and orchards. Always keep lots of organic matter in the middle bin so you do not run out.

**Each bin gives the equivalent of two bags of NPK, which would cost about USD100!** But this natural fertilizer is much more valuable than a bag of chemical NPK, and has many more nutrients, micro-organisms and organic materials that are much better for the soil and improve its water holding capacity

So, when you have your compost toilet working, invite some guests over to learn about your new system and to help you fill it. Every guest can add to your resource!

### ***Moving shallow pits (arbor loo)***



This toilet is moved every few months and a tree is planted each time the toilet is moved. This is where the name comes from, as 'arbor' means tree. This is good for people who want to plant trees and have the space for it



- Dig a small pit (usually 60 cm x 60 cm is good but it depends on your design).
- The toilet (san-plat or chair with no seat etc.) is placed over the pit – the san-plat will often determine the size of the pit, to make sure it doesn't fall into the pit.
- Cover your manure / urine with organic matter after each use. The urine will sink into the ground and any plants or trees around will drink it up.
- Wash your hands after each use.
- When the pit is almost full, cover it with soil and plant a seedling in the centre.
- Dig a new pit somewhere else and start again.

Many builders in Malawi know how to make a **san-plat**, which uses about ¼ of a bag of cement and some sand. Make sure that you can move the san-plat when it is done! Make it strong, but as light as possible. It helps moving it if you design it with handles and make it round so it can be rolled.

For privacy, create a lightweight structure that you can move, using poles, mats, sacks, cloth etc.

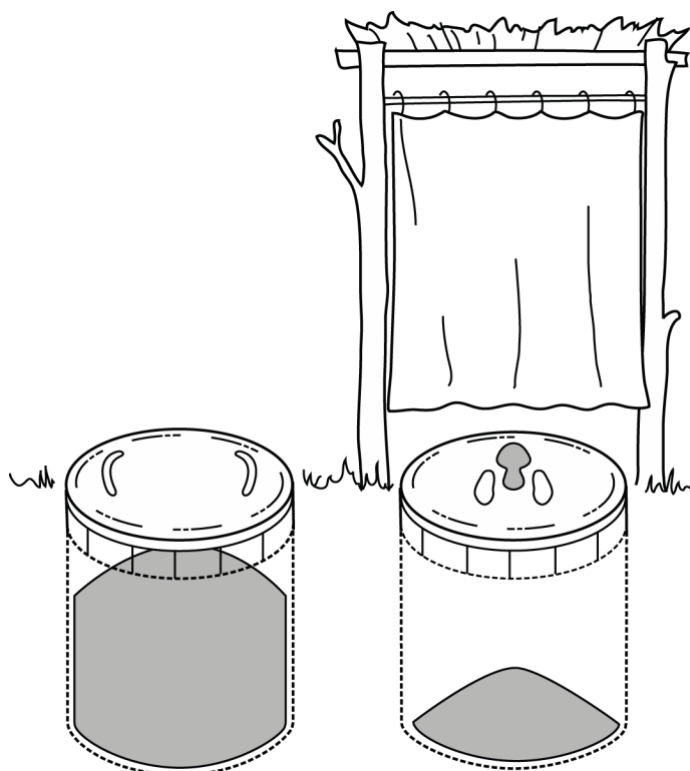
### ***Permanent shallow pits (fossa alterna)***

For this you have two or more holes in the ground that are used over and over again. This is where the name 'fossa alterna' comes from as it means 'alternating pit'. While one pit is filling up, the others are closed and composting for 6 months.

The pits are shallow so that the compost can be dug out of them when it is ready. Usually they are 1 x 1 x 1 metres or less in size. The pits need to be strong enough to hold the san-plat so they are usually lined with bricks, clay or mud.

You can either have a moveable san-plat like in the arbor loo, or you can make a san-plat for each pit that is lifted up to empty the pit.

You need to make it clear which toilet is in use and which toilet is closed and in the composting process. (You could just put something heavy, such as the filler bucket, on the toilet that is full and turning into compost. This will remind people to use the other one!)



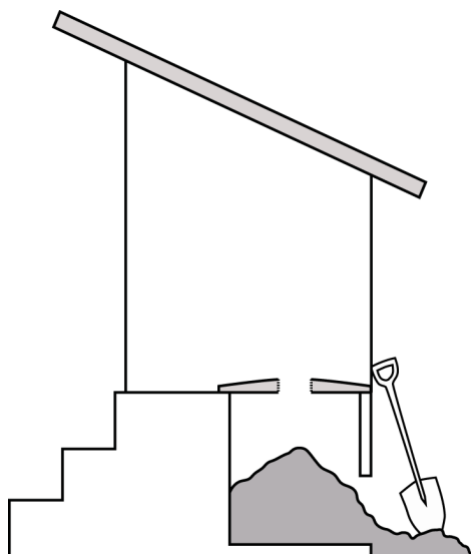
### **Permanent chambers (sky loo)**

This toilet is called a Sky Loo because the toilet (the 'loo') is above the ground, in the 'sky'. They are good for institutions that have lots of people, as the bins can be made quite large, are easy to maintain and access the compost.

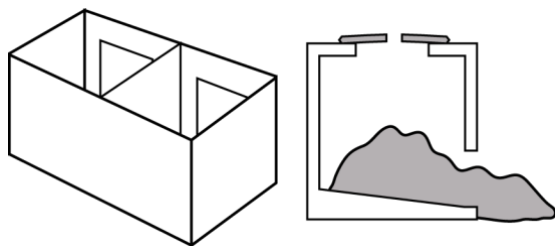
They are also good for people who can afford to build them at a family level, as there is more input that will need to be considered if it is worth the extra effort.

This system is gaining recognition for use by schools, health and other public places.

Two cement chambers are built with doors for taking the compost out of the back. This design can be built quite large to hold lots of compost.



These systems often channel the urine away to a container or banana-pit, depending on how the chamber is designed to manage moisture. Diverting the urine also allows you to use the urine more quickly (because it does not need composting first).



As with most other models, one chamber is used until it is filled up and then closed and then the other chamber is used, while the first chamber composts for 6 months. When the compost is ready, the back door is opened for easy harvesting.

### **Urine**

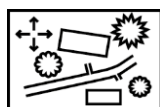
About 15-17% of your urine is nitrogen and can be used fresh, without composting. The amount of nitrogen will vary with the quality of your diet, so be sure to balance the food groups you eat and drink enough water every day.

Urinals can easily be made for people to use with buckets or jugs. In Malawi it is a "gututu". In some countries it is a 'chamber pot'.

Using urine: Mix 1 part urine with 5 parts water and pour it around plants and trees that need it.



Where is your toilet? Is it a toilet that cares for people and the earth? If not, what can you do to improve it?



Note on your map where your toilet is and what kind of toilet it is.

## **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.

## Topic 22: **Water Management**

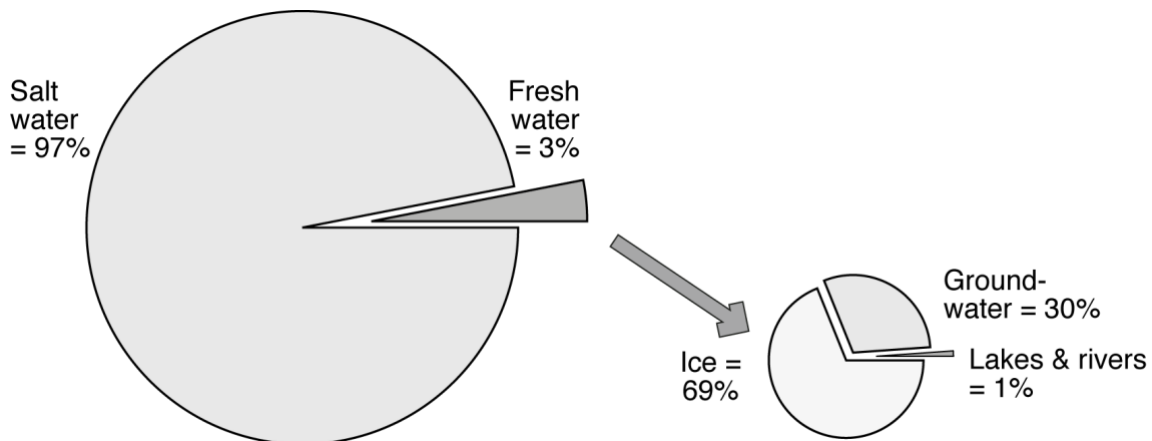
### Water on Planet Earth

Water covers nearly three-quarters of the Earth's surface. (This is just like our bodies, which are three-quarters water!) It is vital for all life on earth, but there is very little fresh water for us to use.

#### ***Fresh water is very precious.***

97% of all water on Earth is SALT water.

Only 3% of all water is FRESH water. But much of this fresh water is hard to access: only 1% of this Fresh water is easily accessible in fresh water lakes and rivers, the rest of it is frozen or stored underground.



- 69% of fresh water is frozen in the North or South Poles
- 30% of fresh water is stored in the rocks underground. Lots of ground water is much too deep to get to, even with wells, pumps and boreholes
- 1% of fresh water is in rivers and lakes

Think about everything we need fresh water for. 80% of our fresh water (in the world) is used for agriculture. Industries use lots of water and people use it in their homes, for drinking, cooking, bathing, cleaning, washing, irrigation, filling ponds, pools and so on.

All this water for agriculture, industries and home use has to be from our fresh water resources. We must make sure water is conserved (without using more than there is) and used efficiently (use it to its fullest potential). It should not be poured away and wasted after one use and should not be polluted with chemicals, poisons and toxins.

#### ***Sharing water fairly***

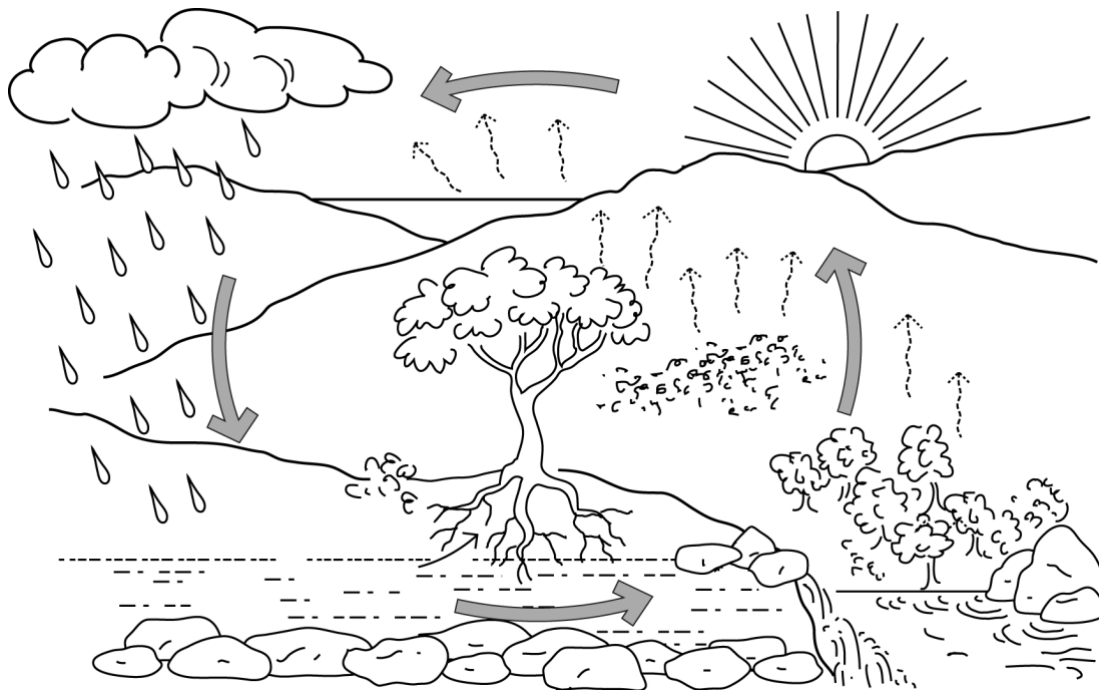
It is shocking that a quarter of Malawians today do not have access to enough safe water. It is not fair that some people use more water than they need, often wasting and poisoning it, while some people have no water. How can we make better use of the water we have and share it fairly? Fortunately, there is a lot that can be done to organise sharing and managing water more efficiently and there will be immediate results when you start to use the techniques in this manual.

First we need to understand how water works on Earth, as the Water Cycle. We need to understand how important good water management is to the health of the soil and vice versa (soil management is vital to water health) as well as the plants that grow in the soil and need the water. Everything works together. We know how important water is in our lives, but we also need to understand how it works within the Natural World. Then we must find ways to protect our natural systems and build sustainable human systems.

**Let us do a simple experiment before we go any further.** Take a clear plastic bag and tie it around some green leaves in a sunny place, then leave it for a while. We will come back to the bag and talk about it soon, and it will demonstrate very clearly how one part of the Water Cycle works.

## **The Water Cycle: Healthy or Unhealthy?**

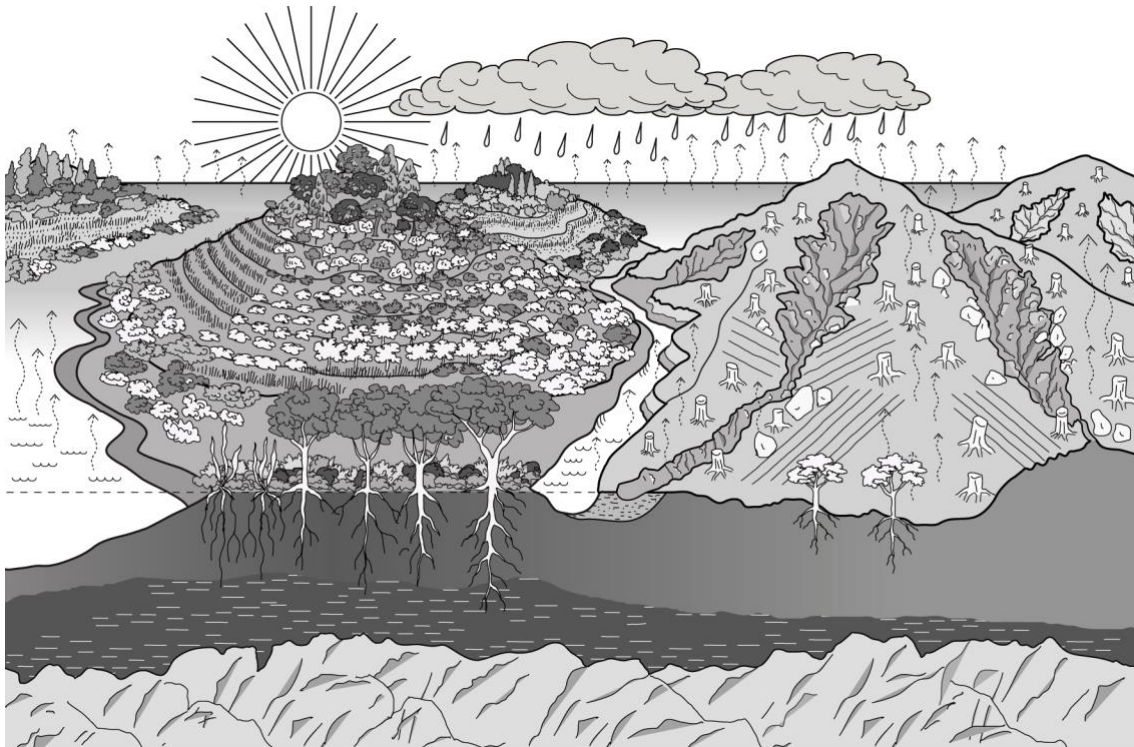
Let us remind ourselves about the Water Cycle that we saw previously in Topic 15 (page 3). The cycle follows the same pattern day after day, year after year.



### **Rainfall, filtration, absorption, transpiration, evaporation, condensation, rain, etc.**

It is important to humans and all living things to have a healthy Water Cycle and the way humans manage water has a big impact on this. These processes can be very easily disturbed and disrupted by human activity.

Each stage is very important for a healthy water supply and for water security. Humans have control over how they affect each stages in the process. The results affect individual lives and the whole of the environment that we live in.



### ***Healthy Water Cycle = Absorption***

A healthy Water Cycle is shown on the left side of the picture.

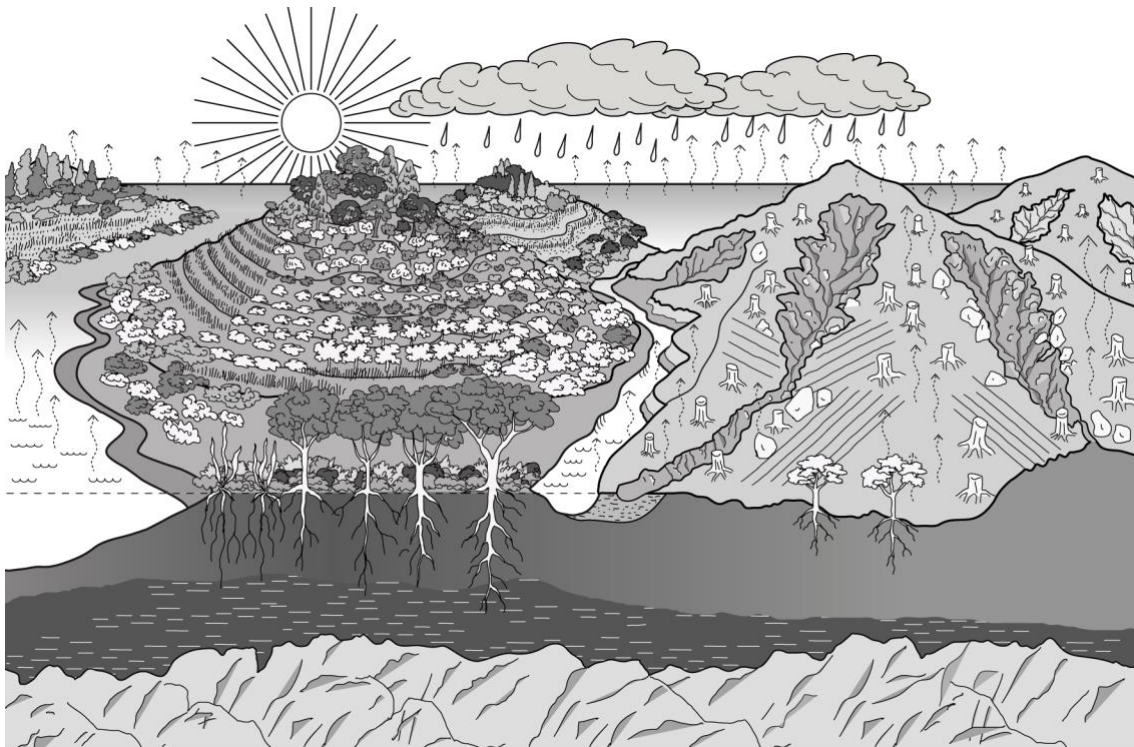
- **Rainfall**  
Clean water falls from the clouds as rain, or settles on the ground or plants as dew. It falls or collects onto the leaves of trees and plants then slowly rolls off onto the natural organic materials covering the soil: the leaves, twigs and smaller plants. The plants and trees stop water from moving quickly down the slopes. Instead it spreads across the surface of the earth so that it can soak into the ground.
- **Filtration**  
The water sinks slowly into the earth through the different layers of soil, sand, rocks, etc. It is filtered along the way, leaving any dirt and micro-organisms near the surface to help with organic matter decomposition. Natural layers of mulch made of dead plant material, live plants and mineral mulches, help shade the soil and keep the moisture in where it can be used by plants and trees.
- **Absorption**  
The plants absorb some of the water, drinking it up through their roots and sending it into their leaves. The rest of the water sinks further into the rocks deep underground, filling up our water table. This water is called ground water. It is where water comes from for our wells, bore-holes and springs. Some of the water comes out of the ground again as springs and rivers, flowing towards lakes and oceans. This is the water that we use in our lives, for growing plants and trees, drinking water for our animals and ourselves, washing water for health and sanitation.
- **Transpiration**  
The water that has gone into the leaves of the plants and trees slowly rises back into the air (transpires) as the sun shines on the plants. This means the leaves are drying out, and losing their moisture to the air around. The leaves would dry out completely if their roots did not supply them with more water that they get from underground. The water that transpires out is beautifully clean, naturally filtered water, and is going to make more rain to fall to earth.

- **Evaporation**

Water also rises from springs, rivers, lakes and oceans and goes into the air, drying out some of the water source, which is refilled by the water cycle continuously. This evaporation happens more quickly in direct sunlight and strong winds. Evaporated water is made of tiny drops, so small that you cannot see them. There is always some moisture in the air around us, however hot and dry it feels!

- **Condensation and Rainfall**

The clean water from transpiration and evaporation combines in the air and condenses into clouds. When a cloud is big enough, the water in it turns into bigger drops and falls as rain. It falls onto the leaves of trees and plants and gently rolls off into the mulch below and into the soil again, and so the cycle continues.



### ***Unhealthy Water Cycle = Erosion***

An unhealthy Water Cycle is shown on the right side of the picture which tells a very different story. What are the differences between the left and the right sides? What problems can you see on the right-hand side? Which area would you prefer to live in?

The main difference between the two sides is that on the 'unhealthy' side there is no vegetation: no trees, very few plants and no organic matter covering the soil as mulch. This is causing erosion (soil loss) for a number of reasons, making it difficult or impossible for plants and animals, including humans, to live.

- **Rainfall**

The rain falls onto bare soil. It falls hard and there are no plants to slow it down. It pours straight down the hillside, sometimes guided by poorly made planting ridges that make the water run even faster down the hillside.

- **Filtration**

The water does not soak into the earth, or very little does, because the ground is too hard, the water is moving too fast and there are no plants and trees to slow it down.

- **Erosion not Absorption**

Little, if any absorption takes place because the water has not soaked into the underground water stores (the water table to fill wells and boreholes and feed springs and rivers. These water sources dry up, so more and more of the water is either in the sky or in the surface water of lakes and oceans. As the water runs downhill, it washes away the soil, roads and paths. It blocks drains and gutters and erodes the foundations of buildings. The soil washes into rivers, streams, and drainage ditches, which fill with silt. Hydro-electric power stations and dams are damaged. Rivers and streams flood and cause landslides downhill, which can further damage lives, the natural environment and local infrastructure.

- **Transpiration**

There are very few plants and trees to absorb the tiny amounts of water that have soaked into the ground, so there is very little transpiration.

- **Evaporation**

Water that falls on the ground evaporates very fast from bare soil. Surface water (lakes and oceans) that is in direct contact with the sun also evaporates really quickly.

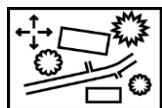
- **Condensation and Rainfall**

The rain that falls from the sky is probably poor quality. This is partly because it has not been filtered through the rocks and plants naturally. It is also likely to be polluted with smoke and poisonous chemicals (called acid rain) from unsustainable farming and industrial practices. This poisonous cycle also continues as hard rain, fast erosion and evaporation.

The water on the 'unhealthy' side of the picture is no longer making a positive impact on our lives. This is because the Water Cycle has been disrupted and this can make life very difficult. This damage can be undone if we take care of our soil and encourage diverse environments.



Go and look at the plastic bag you tied round some leaves. What has changed? While the sun was shining the leaves were slowly releasing the moisture into the air. This is transpiration in action!



Look at your sketch map and mark in some of your trees. What sort of trees are they? What uses do they have, apart from for burning? Where else could you plant trees? What kinds of trees would be good to plant?



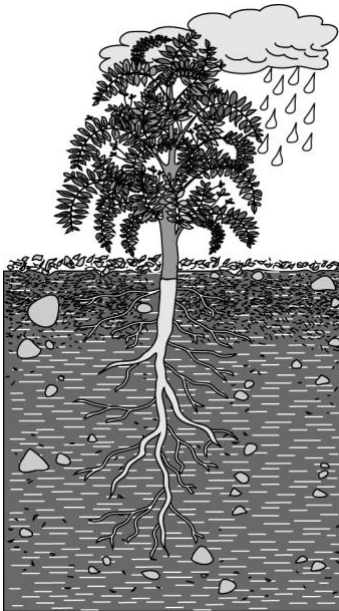
## The Water Table

A third of the fresh water on Earth is stored underground. This store of water is called ground water. The top level of this store of water is called the water table. This is a measurement of how far down you have to dig to find water.

A high water table means the water is not very far down. A low water table means the water is quite deep under the ground. How far down you have to dig to find water depends on several things:

- The kinds of soil and rocks in the area
- The number and variety of plants and trees in the area
- The local climate, the season, how much rain has fallen in the area and how long ago it fell
- What is being done to help (or harm) the Water and Nature Cycles

### ***Healthy water table in the rainy season***



This picture shows a healthy water table in the rainy season.

The rains have soaked deep into the soil and the soil is as wet as it can be. The dark colour under the plants shows how high the water table is; the soil is fully saturated.

The soil is in good condition, with a soft layer of humus and full of small creatures with their tunnels underground helping the water to soak in deeply.

The soil is covered in mulch so, as the rain falls gently, it soaks in and then is also shaded with the mulch and does not dry up quickly.

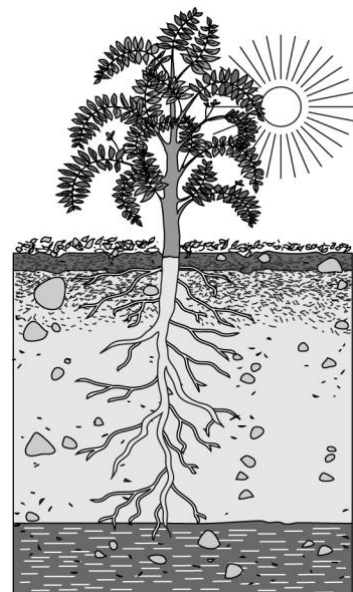
The roots of plants and trees are able to reach deep down into the soil. They can reach plenty of water and can grow healthy and strong.

### ***Healthy water table in the dry season***

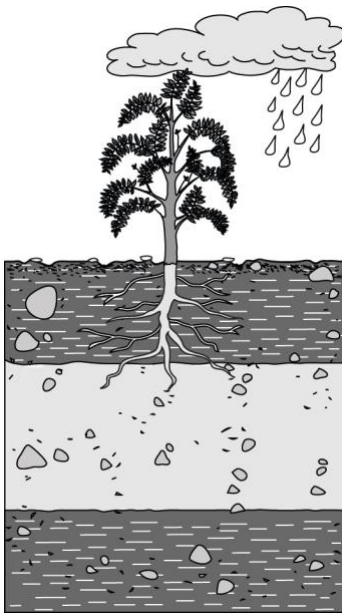
The water table is lower in the dry season, but deep-rooted plants and trees can still reach it. As the roots absorb water the level of the water table gets even lower. The plants draw water from deeper and deeper.

Leaves may naturally drop off and die, mulching the soil surface and slowing down evaporation from the soil's surface. Healthy trees and plants with deep roots (especially perennials) go on taking water from deep underground until the next rains fall.

The dark colour under the plants shows how high the Water Table is. The pale colour is dry earth and soil.



### ***Unhealthy water table in the rainy season***



The water has not been able to sink deeply into the soil because the soil is bare and hard.

The soil has absorbed only a little bit of water, but most of the water has been washed away, down the slope.

You can see there is a dark wet area of soil, near the surface, but the pale soil under this is dry and hard because the water isn't sinking into the soil properly.

The soil has no mulch or plants for ground-cover so rain falls hard, compacting the soil as well as washing it away.

The roots of the plants and trees cannot grow deeply because the soil is too dry and hard.

These plants and trees are stunted and weak and more likely to die if there is a dry spell.

### ***Unhealthy water table in the dry season***

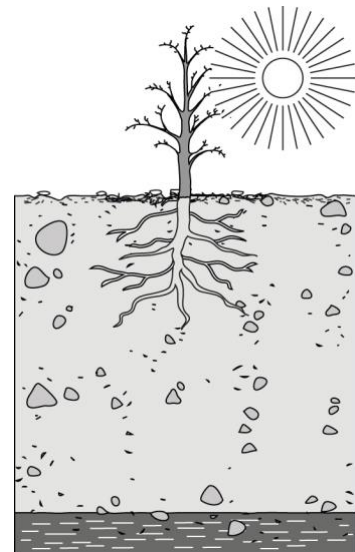
Now the dry season is setting in, and in this unhealthy situation, the plants and trees have short, stunted roots that cannot make it through the dry season.

The soil is too hard and dry for the roots to reach any water. Even with irrigation they will struggle to thrive because they are weak to start with.

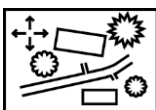
Because the water has not soaked fully into the soil the water table has not filled up, so wells and boreholes, springs and rivers will dry up.

Humans are doing many things to harm the Water Cycle and the Nature Cycle and an unhealthy water table is just one of the problems that we cause.

This unhealthy situation can be improved if we repair the damage we have done and re-design our systems to help the Water Cycle and the Nature Cycle to work properly.



Is your water table high or low? What happens to the water that falls onto your site?



You have already noted on your sketch map where the water comes from. Now note the areas where erosion is happening, note where the soil and water management are good.

## **Four S's: Slow, Spread, Sink and Shade**

Many of the suggestions for water are the same or similar to the solutions for conserving soil. We will discuss more detailed water design ideas for making the most of different water sources, but will start with the 4 S's that mimic nature: Slowing, Spreading, Sinking and Shading water.

Here are some suggestions for the 4 S's. Some of these ideas are harder work than others. Make your decisions after doing lots of thinking. (Remember the 80:20 rule and save yourself lots of time and energy and money!)

### ***1 - SLOW the water down***

This gives water more time to soak into the soil. In the past few pages, the words slowly and gently were used a lot. This is how Nature makes sure that the water has time to be absorbed into the soil so it filters through the layers fully and fills up the underground water stores.

### ***2 - SPREAD the water out to make the most use of it***

After the water has been slowed down, it needs to spread out so that all parts of an area get some water when it rains and there is not too much water in one place. Too much water in one place causes floods, bursts riverbanks and results in other problems.

### ***3 - SINK the water into the ground to filter and store it***

Healthy soil is alive, with many tunnels in it from insects, animals and from the roots of different plants and trees. This helps the water to soak in easily. The soil also filters the water so that it is clean by the time it reaches the ground water stores deep underground.

### ***4 - SHADE the water to reduce evaporation***

Nature plants lots of trees and bushes, climbing and creeping plants that protect the soil from the sun, wind and rain. Lots of low growing plants cover the ground and keep large areas of soil cool and shaded, so any rain, dew or moisture can soak in. You can copy this process with mulch, ground-cover plants, and many bushes and trees.

Once water has sunk into the soil, or been collected into a tank or a pond, keep it shaded it as much as possible. If you have water in a tank make sure it is covered with a lid as this reduces evaporation and prevents mosquitoes from breeding.

### ***Use mulches***

In natural areas, there is always a layer of mulch on the ground. Mulch helps with all the 4 S's by slowing down water, helping it to sink in the soil, spreading it out and shading it. The faster the water is moving the stronger, heavier the mulch you will need. (See page 20 for mulching ideas.)

### ***Dig small channels***

Water can be slowed down and guided with even quite small, shallow channels scratched into the soil surface. Water will always take the easiest route downhill; you can use this information to guide water wherever you want it to go.

- **On roads and paths:** Water that is running off paths and roads can be guided with little channels so that it can be used for watering appropriate plants and trees nearby. The channels are small enough that people, cars and bikes can still pass on the path, but so that the water will move slowly to areas where it can be used. These small channels can even be designed as part of the tarmac or cement surface of the road.
- **Grey water from drains:** Use the water at the end of boreholes or from drains (kitchens and bathing areas) by guiding it gently across the surface of the soil through shallow channels to reach as many trees and plants as possible.
- **Materials for guiding water:** There are many ways to make channels using bamboo, wood, or metal if you are guiding water from a roof. Small stones or earth can be used to guide water across the ground.

### ***Sloping land (planting along the contours)***

Nature slows water down and spreads it out by having plants, trees and rocks spread over and across a slope, preventing water from rushing down them. We can copy this in our designs by using various measures:

- **Swales** are permanent trenches across a slope, following the contour. (There is more detailed information about swales and contours on page 75.) In addition to the trench there is a ridge on the lower side of the trench planted up with strong plants and trees both on the ridge and on the downhill side of the trench to make use of all the water captures in the swale and sinking into the soil. Swales conserve soil by slowing water down, spreading it out and encouraging it to sink into the soil. The water pouring down the hill fills the trench, which is also filled with mulch. The size of the trench and ridge, and the varieties of plant you grow will depend on how steep the slope is, how much water falls in that area, the local climate and your preferences.
- **Perennials and sturdy grasses** that clump together (like vetiver) can be planted in lines across slopes (along the contours) to slow water down and hold the soil in place. A mixture of different plants and trees works best to cover different areas.
- **Check dams** are a barricade of rocks, large stones, logs, branches or sandbags that slows down larger amounts of fast-moving water. It does not completely stop the water moving downhill, but keeps it in 'check'. Check dams usually work best on contours, going around the slope. Sometimes a wire cage or fence is built to hold the whole check dam together. Check dams are often used at the sides of roads and paths, slowing the water down, but allowing it to eventually pass or move off to the side of the road / path when able.

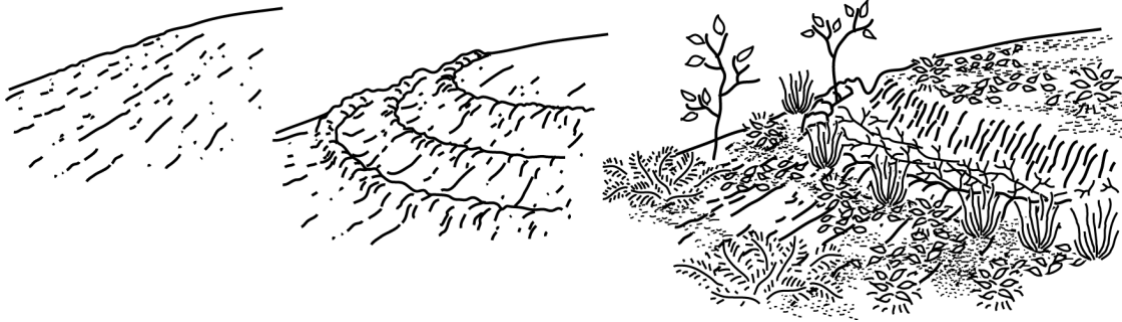
### ***Save the water by harvesting it***

Another way to slow water down is to stop it flowing and collect it all in one place. Water can be guided from roofs, roads, or other surfaces and caught in tanks, drums, pots, pits or ponds. If you know where there is some clay soil you can dig a pond to collect water. This is like a tank dug into the ground. Put water-loving plants around the edge. Water can be encouraged to sink into the ground near plants and trees by designing sunken planting beds for trees, gardens and fields. This can be very good in dry areas.

## 4 S's Demonstration

To show the effectiveness of the 4 S's you can create three areas the same size (50 x 100 cm) with a similar slope and compare what happens between areas that are:

1. Completely hard and bare;
2. Cleared bare with ridges going round the contour, as is often promoted in Malawi, and as we explain in this manual.
3. Designed to copy Nature and with permanent contour ridges held in place with plants and trees and well-mulched to slow the water down.



### ***To set up the demonstration:***

- Clear a small area of a slope so that it is bare and hard, about 50 x 100cm.
- Clear another area the same size and the same way, then add regularly spaced ridges as you would find in a maize field at the start of the rains.
- On the last area, again the same size, dig a swale and plant small plants along the ridge. Put some mulch in the ditch. Cover the whole area in mulch and add some other, slightly bigger plants, or bushy leafy twigs to be trees.

### ***To do the experiment:***

- Pour equal amounts of water on all three areas, trying to use the same pouring method each time.
- See how long it takes the water to get to the bottom of the slope. See what happens to the water and soil. If you can collect the water at the bottom of the slope, look at the colour of the water that runs off.

### ***Discuss the results:***

Ask what people noted about the three areas, and what lessons can be drawn from it. The most water and soil loss will be from the first area that is hard and bare. This mimics the impact of sweeping, clearing and burning. The second area (prepared with ridges) will have less loss of water and soil than the bare area – but usually the ridges break and there is still a significant amount of loss. Is ridging annually the best option? Usually not. There are better practices that can be used. The third area, the Permaculture area, with plants and mulch, should have either no loss or very little loss of water, and the water should be almost clear. This is the system that works best with nature, and is better for us as well!

Ideally arrange this a few days (or even a week or two) before doing the demonstration, the mulched side will soak up even more water because insects will already have started working under the mulch to loosen up the soil, but the bare side will just get harder. You will be sure to see a big difference in the three areas!

## Assessing your Water Situation

Before you design the way that you are going to manage your water, you'll need to think about the source of your water. Is it free from pollution, dirt or chemicals? You would not drink polluted water but you can still use it in many other ways.

Think about how much water there will be so that you can catch it in the right sized tank or area. If you do not think this through, you can cause flooding or other damage, so be careful.

Take a walk around your site and see where water comes onto the area, what happens to the water and where it goes. Observe everything closely so you can learn from it. Think through every single drop of water that is in your area. Where does it come from and what happens after you have used it? People in Malawi get their water from many sources: the rain, lakes, rivers, marshland or ground water.

Some people use wells or boreholes, many collect water from the lake, rivers, springs or *dambos*. A few people have taps or collect and store rainwater from their roof. Do not limit yourself to fresh water sources as you assess water availability. Do not forget the dew that collects around the home in the mornings from the roof or on plants. Do not forget all the grey water that comes from cleaning jobs (people, cars, floors, clothes, dishes, etc.).

Once your eyes open up to all these sources you will see that there is a lot of water that is often wasted. A great deal of time, money and human energy is spent getting water for people to use, so let us make the most of free rainfall!

### ***Rainwater calculations***

Before you can make a plan for rainwater, you will need to know roughly how much rainwater to expect in each area. The calculation to work this out is simple:

Multiply the number of square metres of hard surface that the rain is falling on by the amount of rain in millimetres (per day, or per year) to find out the number of litres of rain you receive (per day or per year).

So if you have 1 m<sup>2</sup> of land and 1 mm of rain in a day the amount of water would be 1 litre per day.

The two things you need to know are how big the area is, in metres, and the amount of rainfall in a day (or in a year).

<b>Size of area</b> in square metres	X	<b>Amount of rain</b> in millimetres	=	<b>Litres of rainwater</b>
1 m x 1 m = 1 m <sup>2</sup>		1 mm		1 litre of rainwater

This area could be a roof, a road, a parking lot, or a piece of sloping land. There are several ways of measuring things if you have not got a tape measure:

- A metre is about one large step (of an adult) or the distance between an adult's nose and the tip of their own finger with their arm stretched out.
- A *chitenje* (cloth wrap) is usually 1 metre by 2 metres;
- A piece of roofing tin is often 1 metre wide by 3 metres long;
- A piece of rope is often sold in 1 metre lengths
- A wooden plank from your local carpenter is often 6 metres long.

A rope or string can be marked off at regular lengths, using any of these items, by tying a knot, marking with a pen, or tying on pieces of cloth at measured intervals. (They do not have to be perfectly measured intervals, because we are using an estimate, if you need a better calculation, buy proper measurement tools or consult a professional).

Your local agriculture extension officer will be able to say how many millimetres of rain falls in your area. In Lilongwe, the average rainfall is 800 – 1,000 millimetres of rain in each rainy season. One single rainfall is often 30 mm.

So for an example think about a roof that is 10 metres long and 2 metres wide. That part of the country gets 30 mm of rain in a day, so how much rain falls on that roof?

Size of roof (or any area) in square metres	X	Amount of rain in millimetres	=	Litres of rainwater (in one day)
10 m x 2 m = 20 m <sup>2</sup>		30 mm		600 litres

The same roof (10 metres long and 2 metres wide) gets 1,000 mm of rain in a year, so you can work out how much that surface could collect for you over the whole year.

Size of area in square metres	X	Amount of rain in millimetres	=	Litres of rainwater (in one year)
10 m x 2 m = 20m <sup>2</sup>		1,000 mm		20,000 litres

Doing sums like this will help you work out what you need to do and what is possible. How many rainfalls can be caught, held, or re-directed somewhere useful? Could you build a tank or dig a pond big enough to catch and save all the water from the whole rainy season, so you can use it all year through?

## How Much Water do People Need?

It is really useful to work out how much water your family needs per day, month or year. The minimum amount of water for one person's needs is about 40 litres per day for drinking, cooking and cleaning. Ideally you would have 50 to 100 litres per person, per day.

So, how much water is needed for or a family of five people?

Water per person per day		X	Number of people	=	Water needed per day
Minimum	50 litres				5 people
Ideal	100 litres	500 litres			

According to this calculation it works out that for a family of 5, the ideal amount is between 250-500 litres a day.

**That is a lot of water for someone to carry home on their head!** It is often women and girls that have to carry water. If someone goes to the water source 10 times a day and gets 20 litres each time they will bring home 200 litres of water. That's a lot of work and doesn't even collect the minimum amount the family needs.

Water sources in Malawi are usually far from the home and if each trip is 30 minutes, it might take 5 hours a day just to get water for the family that is not even the ideal amount of water. So it would make really good sense to be more efficient!

- Make the best use of every drop of water
- Harvest water from a roof or a slope, or from run-off
- Protect the environment so that we can all have more fresh, clean water

### ***Sharing water fairly***

In most areas of Malawi people find it difficult to have enough water, but some people and organisations use much more than this (hotels, businesses, offices, wealthier homes and buildings with flush toilets and swimming pools).

This is not to say that we should not have these things, but we can be wiser and more efficient if we design cleverly for water use and recycling, and if we are not wasteful of this precious resource. No matter where you live, or who you are, using water wisely is important. Try to keep your water use to 50 - 100 litres per person per day.

If you do not yet have 50–100 litres of water a day then it is something to aim for.

If a small roof (10 x 2 metres) can give us 600 litres a day then harvesting the rainwater can save a lot of human time and energy.

If you already have this amount of water, then think about how you can conserve your water use and make the most of every drop.

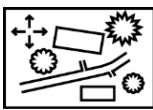
Design domestic and farming systems that need less water.

Share where you can and encourage everybody use water sources responsibly and sustainably.

Agriculture uses the most of the World's fresh water and it is often not used efficiently and wisely. We will look at much better designs for helping your agricultural systems to be efficient later in the manual.



How many litres does your family need per year as a minimum, and how many would be ideal. What is the difference between these two figures in litres? Could you capture this amount from your roof? What other solutions can you think of?

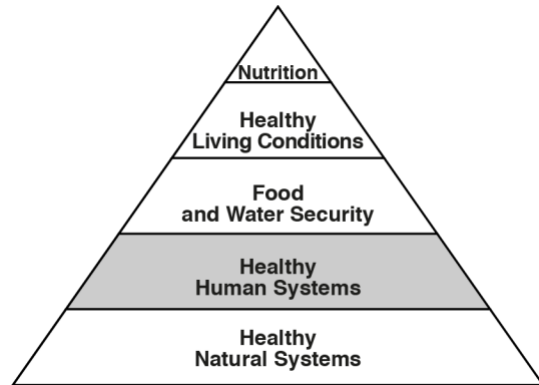


Mark on your sketch map where you could put a tank or pond to collect water or where you can harvest water straight to food plants (borehole or well). Where could you put a garden bed near the house to use grey water on thirsty plants like tomatoes and peppers?



## Topic 23: **Water Harvesting**

A lot of water falls in the rainy season. It runs off our roofs and roads and down the drains that we spent lots of time and money making to push water away. Instead of spending time and money pushing water away, we can design our systems to catch water and use it. These two pictures show the same kind of home, in the same location, but the people living in the two houses have used the same resources very differently.



### **Wasting Water**

This family did not think enough before they built their home. The home pushes all the water away really quickly. The trees are stunted, hungry and thirsty. The surrounding area is bare and hard. The family is wasting water, time, money and energy.



*(Adapted from images by Brad Lancaster, with permission: [www.HarvestingRainwater.com](http://www.HarvestingRainwater.com))*

- **The soil is bare with no mulch.** Soil health is poor and water does not soak in.
- **Paths channel water off the site,** moving it faster as it flows down the path.
- **Raised beds around the trees** encourage water to flow away from them. In most cases it takes nutrients and soil with it.
- **The site gets dry quickly after rainfall or irrigation.** This is because the soil, plants and trees are all unhealthy and all the water is pushed away from the site instead of harnessed.
- **Ground water is pumped in to replace the free water** that has been wasted. This expensive water is used for drinking, washing and irrigating plants and flushing toilets when much of this water could have been supplied free on site.

## Wise Water Use

This second family thought hard when they designed and built their house. They planned carefully to keep the rainwater and use it. Everything is designed to **Slow, Sink, Spread and Shade** so water does not just rush off this site and away downhill.

They are also saving the water that falls on their home. All water can sink into the ground and this is very good for the soil and is important for soil health. The environment is rich and lush because they are making efficient use of water and caring for the soil, while saving time, money and energy.



*(Adapted from images by Brad Lancaster, with permission: [www.HarvestingRainwater.com](http://www.HarvestingRainwater.com))*

- **Raised paths and sunken beds slowly guide water** off the path, towards plants and trees, which are planted in sunken beds.
- **Mulches are used so the soil is healthy.** It is able to hold water and nutrients on the site to feed the plants.
- **Rainwater is being harvested** from the roof for use in the dry season.
- **Grey water is re-used** on food plants near the house.
- **Less ground water is needed** because the family is allowing nature to work for them. They do not have to buy water for irrigating their food plants.

You can redesign things to work better and you can design things from the start, which will work with Nature. We need to communicate with the people who design and build schools, hospitals, government houses and other buildings so that they are all designed to harvest water from the beginning. This would do so much to use water efficiently, to share water more fairly and to improve the environment.

## **Harvesting Rainwater from a Roof**

There are several options for harvesting water from a roof.

### ***Channels***

One of the best places to harvest your rainwater is directly into the soil for the roots of plants and trees growing nearby. Scratch shallow channels in the soil to guide the water to where you want to use it – the width, depth and length of the channel will depend on the amount of water coming off the roof. You can plant along the channel, but do not block the water from moving slowly as far as it can go. Be sure to guide the water a little bit away from the building foundations.

### ***Pits***

For larger amounts of water you can dig a pit in the ground to capture it at the end of the channel. Fill the pit with organic matter. Plant appropriate plants and trees around the edge, such as bananas, sugar cane, coco yams, lemon grass and / or pigeon peas. All the run-off water will soak into the ground and feed the plants, even for a while into dry periods. You may need more than one pit, depending on the amount of water coming into the area. You can create a series of pits that overflow into each other, connected by channels.

### ***Tanks***

Water tanks are becoming much more available in Malawi now from hardware stores, or you can build your own from cement. Tanks usually have a tap built into them so the water can easily be used. Tanks for larger buildings are sometimes built underground and accessed with a pump. In Malawi they are usually used with a treadle pump. Large tanks are most appropriate for larger institutions such as schools and hospitals. The water in the tanks can be used as it is for irrigation, or it can be filtered and cleaned for drinking, cooking, washing and bathing. People might say they cannot afford to build a tank, but then they build a drainage ditch out of the very same materials in order to push water away from their area! Instead, use those same resources more wisely and have a much better result!

### ***Containers***

If you cannot build a tank, you can harvest rainwater with any containers you do have: *mtsuko* (large clay pots), drums, or any kind of container. Many Malawians already do this during the rainy season, but efforts can be made to improve and expand.

**Remember the 80:20 rule** while you think about harvesting rainwater from the roof directly onto plants and trees. You want to protect the foundations of your house and not cause more problems!

- If your plan involves trees make sure there is plenty of space between the house and the trees. If trees are too close to a building's foundations they can crack or damage them. Do not plant trees near your house or where you park cars that will drop large fruits onto your roof. Remember to think ahead!
- Keep the foundations of your building dry. Small plants that need a little water usually grow without problems near building foundations but foundations should not sit in heavy moisture or they can crumble.

## **Harvesting Rainwater from Roads and Paths**

Slowing and using the water as it goes down the slope prevents it from building up in speed and quantity, because this can cause flooding further downhill. Water should be guided off roads and paths into areas where it can sink into the ground. Planting the right kinds of plants and trees helps absorb the water, increases natural diversity and can give you more things to eat.

Think about how the area is used by other people, too. Drivers need to see the roadside clearly so do not plant things that will block the view. People need clear paths so be careful where you dig channels and avoid thorny plants that can scratch people and make holes in bike tyres, for example.

In Malawi we cause erosion of the sides of our roads and paths by hoeing, sweeping and burning any plant trying to grow there. This destroys the plants and roots that were holding soil together and the soil washes away. This damages the road itself. It is much better to slash plants along roads and paths. People, cars, bikes, and ox carts can easily pass through short grass. It can stay there, holding the soil together!

Water harvesting is really important in urban environments with all the hard surfaces for water to run off and be collected from. We should create many places within our cities where water can soak into the soil, increasing the numbers of plants and trees in the city. All the organic matter that is generated in our markets and restaurants should be recycled to feed the soil. This will turn our cities into beautiful, healthy spaces for people to live, shop and work. It just takes thought, design, action and co-operation!

## **Re-using Grey Water**

Water that has been used for washing or cleaning is called grey water. It is not clean enough for humans to drink but it can be used to water plants and trees, for making paper charcoal and many other things.

Grey water does not include water from a flush toilet or sewer, which contains faeces (manure); this is called black water. (See Composting Toilets on page 47.)

People in Malawi often go very long distances to get water or pay a lot to get it from a tap. They often wash something with it once, and then throw it away onto the bare ground. What a waste! Grey water can be used to grow plants or trees for food and to create a beautiful environment. It takes the same amount of work to put water onto plants and trees as it does to throw it onto the bare ground.

### ***Take a look around your home, work place & community...***

Look at the use of water here. Is water being wasted? Can the water here be used more than once? Is there any water that could be guided into a garden area, or be used to water trees? What is the easiest way to get it into a useful area? Often you will see that there is a lot of water thrown on bare ground or down a drain that we could be using to grow food and make money.

### ***What was the water used for?***

Do not use water that might have strong chemical cleaners in it on plants. Bleach and chlorine can easily kill plants. Use natural cleaners in your house (washing soaps that are high in phosphates, wood ash that works like a scrubbing powder, sand, etc.) and then the grey water will be fine for your plants. Some plants make very good cleaning products, like lemon juice for example.

### ***Re-use grey water on the right kind of plants***

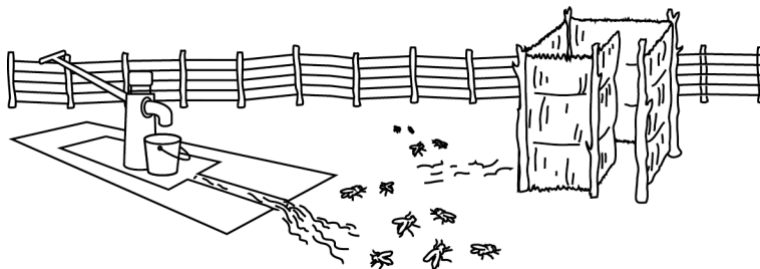
Grey water poured on the earth around plants is filtered by the soil and by the plants themselves through their roots. Use grey water on plants where the food is higher off the ground like taller plants, climbing vines, small bushes or trees. It is probably best not to use grey water on short leafy greens like mustard greens, cabbage or lettuce.

### ***Boreholes, wells and taps***

Areas where people go to collect water often have puddles of standing water. Standing water is a breeding ground for malaria-carrying mosquitoes. If it is thrown on bare ground and just evaporates without being used. It is a waste of a resource.

Turn the puddle into a planting pit by digging it a bit deeper, filling it with organic matter, and planting around it. Or channel the water in several directions towards a tree or other food plants making the most out of every drop of water. If it is a community water site the committee overseeing the water point could sell food grown there and use the money raised for community projects, or to pay for maintenance and repairs to the water point.

### ***Bath areas***



Drains from bathing areas are very easy to turn into small gardens and this water will have more nutrients from the soap, dirt, hair and, possibly, urine (full of nitrogen) from the people bathing.

Direct the flow where you want it and plant food vines, trees and plants. Also have live fencing around your outdoor bathing structure to improve your privacy while bathing! Plant a loofa sponge and you will have one whenever you need it.



### ***Sink drains***

If you have piped water, perhaps you can redirect the used water pipes into your plants or garden. Like bathing water, this water will be nutrient-rich but it will have different nutrients from food scraps and dish soap.

Take a look at where the water comes out of the house to see if the pipes can be adapted. If it is not your house, ask the owners first. This is a great teaching opportunity and you can explain how it will benefit the owner.

To adapt your pipe you can be clever with plastic bottles, bicycle tyre tubes, bamboo, old garden hoses, and various other odds and ends that you can find and use – just make it look nice so that others will admire your work and want to try it as well.

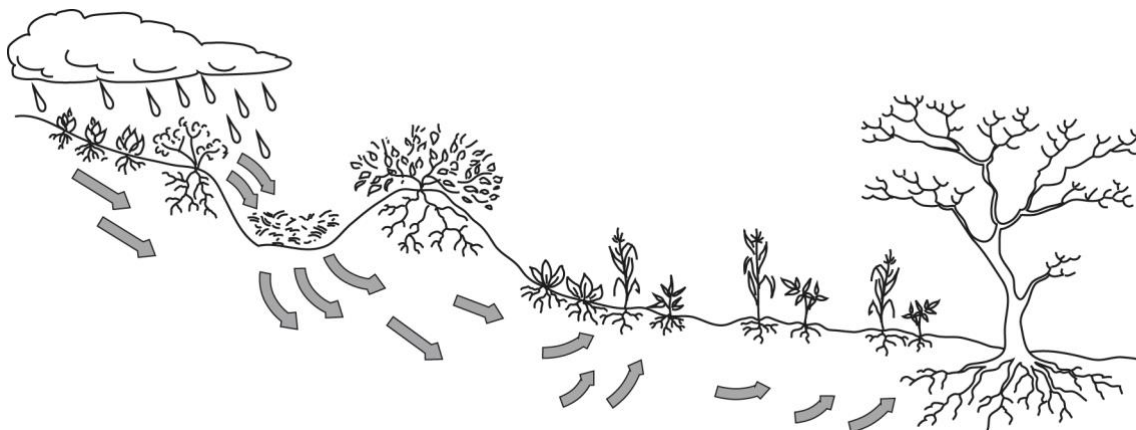
### ***Dish drying racks***

Most people in Malawi build a '*tandala*' rack to dry their dishes. The washed dishes are put on the rack wet and the clean water drips onto the ground. This area is perfect for growing plants that like moisture and a bit of shade. Sweet potato vines work well as you can eat vegetables while keeping your stems healthy for the next cropping season. There are many species that can do well like this: herbs for flavouring meals or using for tea, flowers for a pleasant smell in the area, vegetables that you use often, etc.

### **Swales on Slopes**

A swale is a permanent trench or ditch dug along the contour of a slope. Swales are designed to slow the water down and spread it out so it can sink deep into the ground. As the water is absorbed by the soil, it feeds the roots of plants and trees. Because it has soaked into the soil it stays in place.

Swales can be very useful for protecting a slope from water pouring downhill, helping to protect the natural and man-made structures downhill as well.



Once a swale has been made, it never has to be re-made. Swales just need a little maintenance so that they can be used permanently for food, water, soil fertility and water table health.

Not all sites need swales, but many slopes can benefit from them. Remember not to work any slopes that are more than 22° unless you are experienced in what you are doing. And never work any slope above 45° (See page 25).

### ***Marking contour lines***

To work out where to put swales you must mark level lines on the ground around the slope you are working on. Contour lines are level as they go round the hill, but each is higher than the other. The ditches you dig for swales must be level too.

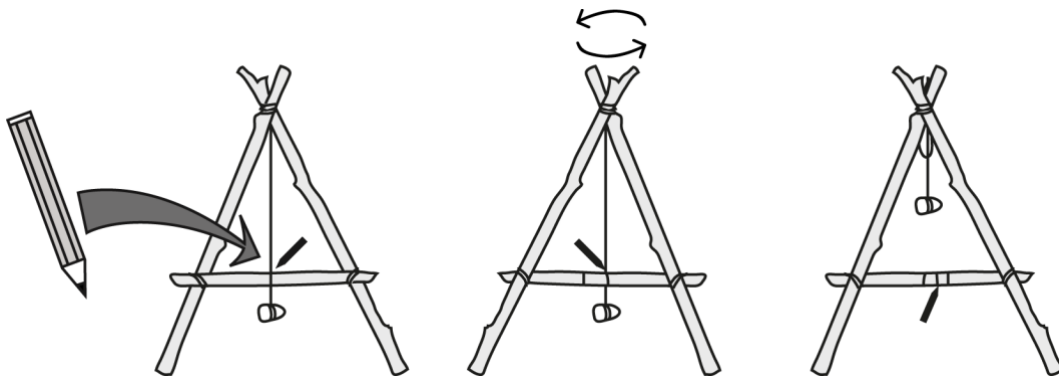


To find the contour lines on the hillside itself you can use An **A-Frame** , or a line-level or some other device to mark the contour lines around the slope or hill. This is the line that the swales ditches should follow.

### ***Making an A-Frame***

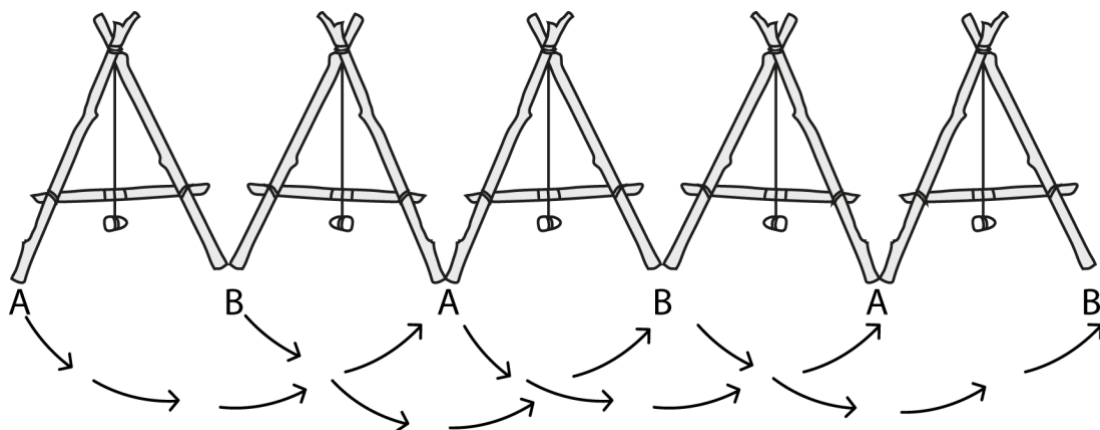
Take 3 poles about 2 metres long, some string and a small stone. Tie the poles firmly in the shape of the letter A with the stone hanging from the top.

- Hold the A-Frame upright on flat ground. Mark where legs A and B are on the ground. Mark where the string crosses the horizontal pole.
- Turn the A-Frame around so the legs have swapped position.
- Mark where the string crosses the horizontal pole again. Mark the place in between these first two marks.
- Make this third mark really clear and easy to see from both sides. This mark is the centre point of the A-Frame. When the string hangs over this mark the legs of the A-Frame are level.



### ***Using the A-Frame:***

You will find it easier if there are two people using the A-Frame together to mark the contour line on the ground. Start above an area of erosion, starting at the source of the problem. Dig more swales further downhill if the slope is steep and there are still problems with erosion.



- Get the frame standing so that the string with the stone hangs directly over the middle mark on the cross-bar.
- Mark a line on the ground between legs A and B. (Scratch a line or use sticks or stones to mark where A and B are level.)
- Swing leg A, so the A-Frame turns and is facing the other way. Make sure leg B stays in the same place.
- Adjust leg A so the string hangs in the middle again. Mark the spot where the legs are, or ground between legs A and B again.

- Swing leg B, and adjust the position so the string hangs over the middle mark. Mark the spot where the legs are, a line on the ground between A and B again.
- Keep swinging / walking the A-Frame around the slope, marking the ground between the legs as you go. This line on the ground is your contour line.

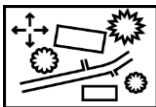
The line of marks travels across the slope, round the hillside, in a line that may go from side to side, but will be flat and level. This line shows you where to dig swales or gives you a planting guide to follow when planting on sloping land.

### ***Making the swale***

- Use an A-Frame to mark the line on the slope above an area of erosion damage.
- Dig a trench or ditch along the line. The width, depth and length of the trench will depend on the slope of the land and amount of water that needs to be slowed down. You need deeper, longer trenches that are closer together when you have steeper slopes.
- Pile the soil from digging into a ridge along the downhill edge of the trench.
- Fill the trench with organic matter (leaves, dry grass, plant cuttings etc.). This will feed and protect the soil, help the water sink in and it will shade the water.
- Plant strong-rooted perennials along the ridge to hold the soil. Choose a variety of foods for people and the soil. Continue planting down the slope for another a metre or two with plants and trees. They will benefit from the water that has soaked into the soil and encourage even more water to soak in. This will refill the water table to healthy levels, too.



Think about your land. What happens to water that falls there? How can you harvest more water to make use of every drop?



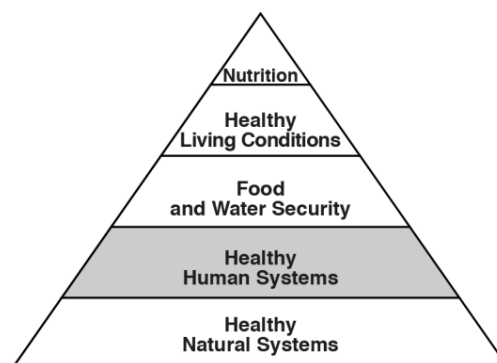
Note on your sketch map places where there are erosion problems and places where it would be useful to dig a swale or two.



## Topic 24: Irrigation & Water Sources

Irrigation systems don't have to be expensive or difficult to use. There are many effective and efficient low-input irrigation methods that work well.

These need very little time, energy and money, as long as you think enough first! Harvesting water from rain, water points and grey water can take care of some, even a majority, of your watering needs.



### How Much Water is Needed?

All plants and trees need water to grow. Getting the amount of water right is important, and it depends on several things:

- Climate and weather
- Soil type
- Time of year (the season)
- Your designs and plans
- The plant and tree types (species)
- The age of the plants

A healthy, well-mulched garden needs water every day or every few days to keep the top 20-30 cm moist. It will take about:

**10 litres of water (one large watering can) for every 1 square metre**

This means that a garden 5 x 2 metre (10 m<sup>2</sup>) might need 10 watering cans (100 litres) either every day or every few days depending on your conditions, for example:

- 3 times a week in cool dry seasons = 300 litres a week (30 watering cans)
- 5 times a week in hot dry seasons = 500 litres as week (50 watering cans)
- 7 times a week in hot areas with poor soil = 700 litres a week (70 watering cans).  
If you improve the soil quality and health this amount can be reduced considerably.

Watering more often with less water is needed for small seeds and seedlings, just to keep the first 10-20 cm of the soil moist.

Watering less often with more water is needed for deeper-rooted plants and trees, to allow the water to penetrate 30-60 cm or more.

### ***Learn from nature when plants need watering***

Both under-watering and over-watering will reduce the health, growth and productivity of your plants. Observing nature will help you fine-tune what your area needs. The leaves of most plants and trees will tell you when they are thirsty when they start to wilt slightly. When you water them they stop wilting.

In hot areas it is natural for some plants to 'rest' by wilting a bit in the hottest part of the day. They then 'cheer up' in the evening even if they haven't been watered. If they stay wilted in the evening then they really do need some water.

### ***Think first! Will extra irrigation make a difference?***

Before you put extra time and energy into watering, think things through. Will the extra effort give you a better yield and a bigger harvest? Is the extra time, energy and cost of the extra watering worth the result?

### ***Follow nature's seasons instead of irrigating***

Design your land to work with the natural cycles and season. Some people have to do this as they have no extra water for irrigation but these tips are useful for anyone to make the most of every season and every day:

- **Soil and seed health:** The Nature Cycle does not stop working during the dry season. Nature is busy dropping natural mulch on the soil and getting seeds ready for the next growing season. When the rains come the area is well fertilized and protected and the seeds are ready. We can make this work on our land too.
- **Seasonal harvests:** In most areas nature has something ready to harvest during every season. Plan with nature so that you have food all year round, without doing any irrigation. Use the Food Availability Calendar (Part 3, Appendix 2, Menu Planning) to design for natural harvests all year round.
- **Water harvesting:** Combine soil and seed health, seasonal harvests and water harvesting so that many people can get what they need for the whole year, without extra irrigation.

## **The Water Needs of Plants, Trees & Animals**

It is important to learn what kinds of plants, trees and animals are suited to your area. Some species prefer lots of water and other species prefer a more dry and sandy environment. Sometimes poor harvests and sick animals are blamed on droughts and floods but often the problem is that the wrong types of animals and plants have been chosen for that particular situation and the problem is made worse by using poor soil and water management practices.

People who know the area well, and have lived there a long time, will often know what species thrive there, so ask them and learn from their experience. Keep in mind that some local knowledge may have been lost with the cycle of dependency, so do your own research, keep an open mind and keep trying new things on a small scale at first. There are also many foods listed in the appendix and many books and free websites for learning about different species.

For a general look at some of the common species:

- **Very high water needs:** Marshy areas are great for water loving plants like bananas, figs, sugar cane, coco yams and rice. These all love growing in marshland. (If you were going to plant these in dry areas they would need a lot of irrigation.) Ducks and fish can be encouraged in this kind of area, and bees thrive on diverse plant life found in marshy areas. If you were going to plant these in dry areas they would need a lot of irrigation.
- **High water needs:** Most types of maize, and most foreign vegetables, need a lot of water every day. Most cattle need to drink a lot of water every day compared to other animals. This group can be irrigated, but they will need more care than the next group of species.

- **Lower water needs:** Indigenous species (local, native plants and animals) are well-adapted to local conditions; amaranth, blackjack, melons, sorghum, millet, traditional yams (air potatoes and large underground yams), *kalongonda* (*mucuna*), *mkhungudzu* (lablab) and *chimbamba* (lima beans) are some examples. Some naturalized species have low water needs, too: cassava, sweet potatoes and pigeon peas for example. Some of these species will do well in irrigated systems too, but others are better left to grow naturally. All animals need water too, of course and their needs vary. Chickens and goats need water but not as much as the bigger animals.

## Designs Beds and Stations to Manage Water

In agriculture a bed is an area of ground that is prepared for planting a number of different plants, trees are usually planted in individual planting stations. Beds tend to be as wide as you can reach across and as long as you like. They do not have to have straight but can be curved, or any shape that suits the situation and you. Some agriculture also uses thin rows, but this is usually an inefficient use of space.

Think about different bed designs for very dry or wet places. If you design well you can create permanent beds (creating them only once). After that you will just do care and maintenance. (Remember the 80:20 rule; think ahead!) Sometimes you do not need a whole bed; you only need a planting station. Planting stations can be as small as 3 x 3cm for a seed or seedling, or as large a 90 x 90cm or more for planting a tree.

### ***Sunken planting in dry places***

These can be made in several different ways so that water collects close to the plants and trees. They can be any size and are often used for planting tree seedlings.

- **Below the earth:** Beds or stations can be made lower than the earth's surface by 5-10cm. Dig your bed or station and re-fill the hole with compost putting less soil back in than you dug out.
- **Edges:** After making your bed or station either level with the earth or raised, then use some of the dirt, rocks or any other material you have to make a raised edge around every side so that it holds water near the plants or tree. If you are working on a slope the edge may only be on the downhill side of the bed or station to allow water to flow naturally into it.

### ***Raised beds and planting stations***

Raised beds and stations are helpful where your soil has a lot of water and you do not want the plants and trees sitting in the water.

Raised beds are often used in gardens. These work by building up strong healthy soil above the general level of the ground. It can be useful to have an edging as well.

Raised beds can be made quite high so that people do not have to bend over so much.

Planting on raised, thin ridges is common in Malawi, but it is often not good use of the land. In Part 3 you will find out how to easily convert raised ridges to either raised beds or another type of bed that makes more efficient use of the space and which is better for soil health and water management.

### ***Level beds and planting stations***

Sometimes the best option is to plant at the same level as the earth, not raised and not sunken.

## **Irrigation Techniques**

### ***Irrigate more foods and less grass!***

We must be thoughtful about making the most of our precious water. Why are grass and flowers watered but food and medicine species are not, when water is so scarce and many people are hungry, thirsty and unhealthy? We need to include more sensible, useful species and practices, with fewer grasses and a balance of flowers. Perhaps we should learn to love and work with the natural look of brown grass in the dry season? Or, instead of so much grass, we need more useful landscaping with local, native (indigenous) food and medicine plants, especially perennials that need very little water but still look good all year.

### ***Irrigate the roots not the leaves of plants and trees***

Plants and trees drink water from their roots, so getting water into the ground near the roots helps the plants to drink. Watering the leaves occasionally keeps them clean, but plants do not drink water through their leaves. Plants and trees want water where they can drink it, through their roots.

Shape the edges of beds and planting stations to guide water towards the plants and trees and keep it there while it sinks in to the roots.

- **Use mulch** to keep the water on the soil and hold it there for longer.
- **Water to the right depth** for the type of plant to be sure water reaches their roots.
- **Give an area as much water as it can absorb.** Do not keep pouring if the soil is full of water and the water starts running away. Let it soak in and then come back if you need to and pour again until you are satisfied the water has reached the depth needed. The information below on drip irrigation helps with this.
- **Do not waste water** by pouring it on pathways. You can take the rose or sprinkler head off the watering can and instead pour the water slowly around the base of the plants and trees, right onto the mulch, so that it gets near the roots.

### ***Deep watering***

This means watering slowly for longer to soak deeply into the earth instead of watering just a little bit in a short time, which only reaches the surface. Deep watering allows the water to filter down to the lowest part of the roots to encourage deep and strong growth. When you irrigate deeply, the area can go for longer without watering, as long as the soil is healthy (well fed, well mulched, etc.). Plants and trees with healthy, strong roots tolerate dry spells much better.

Watering an area slowly makes sure it is thoroughly and deeply watered. Try this when you are watering:

- Slowly pour 10 litres of water (1 large watering can) over 3 square metres of your beds. Start on one side and slowly work your way across to the other.
- Go back to the start and pour another 10 litres on the same area, starting again on that side and moving to the other (as before).
- Go back to the start and add another 10 litres on the same area in the same way.

**This means that each square metre gets the 10 litres it needs** but allows water to sink in deeply without run-off. Depending on your soil, if you just quickly pour 10 litres on 1 square metre it is likely that some of it will run off the bed and be wasted.

**Occasionally check the soil** to see whether the area has really had a thorough watering. Dig down with a stick or a shovel to see how deeply the water has soaked in. With deep watering the soil should be damp down to the depth that you are aiming for (10-20cm for seedlings; 20-30cm for most gardens; 30-90cm for deeper rooted species). Over time you will learn how much water different areas need and you will not have to dig to check as often.

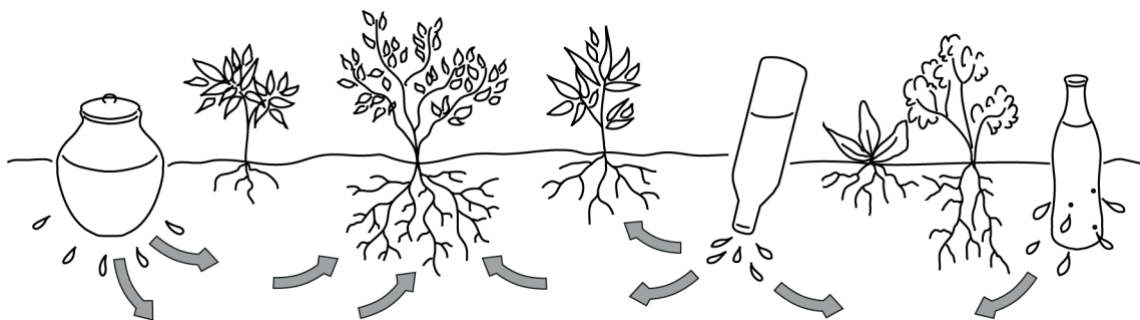
**Pipes with holes for watering deeply:** Dig a hole to the depth you would like the water to reach. Put a hose or pipe with small holes in its sides into the hole, all the way down, packing the soil gently around it. You can then pour water into pipe and the water will slowly drip out of the holes into the soil deep down.

**Avoid evaporation and build up of mineral salts:** Poor watering can cause the soil to have a mineral imbalance. When the water evaporates quickly the minerals can be left behind as a white layer, which looks like salt on the surface of the soil. Mineral salts make it difficult for many plants to grow well. The roots need the minerals deep down in the soil not on the top!

- **Never water your plants in the hottest part of the day** as the water can quickly evaporate. Water in the morning or evening when it is cool so the water and minerals can soak into the soil together.
- **Deep watering three or four times a week** in a garden is most effective at getting the water and minerals deep into the soil. This is better than a little sprinkling of water every day. Avoid sprinklers or anything that sends the water high into the air because the water has more chance of evaporating, leaving the minerals behind.
- **Mulch** reduces evaporation by up to 90 per cent
- **Compost helps** the soil hold water
- **Think about what and how you plant.** Trees can provide shade and wind protection to reduce evaporation. Group plants according to how much water they need. Perennial plants can be dotted all over the area.

### ***Drip irrigation***

Drip irrigation feeds small amounts of water directly to the roots of the plants. These techniques reduce evaporation of water into the air. This saves time, water, and energy. These methods can also be used with green manure, compost or animal manure teas (page 36) to provide extra nutrients to the roots of the plants.



**Bury unglazed clay pots** in the ground up to their rim, in the middle of a circle of 5 or 6 plants. Fill the pots with water and cover them to prevent evaporation. The unglazed clay lets the water seep into the ground very slowly. Refill the pots every few days.

**Glass bottles** can be filled with water and then pressed tightly into the ground upside down so the opening of the bottle is in the soil. The water from the bottle will slowly drip into the soil. The trick is to get the bottle pressed into the soil just right: If it is pressed too tight the water can leave too slowly or not at all, if it is too loose the water leaves too fast. Refill the bottles every week or so, depending on the conditions.

**Plastic bottles:** With a needle, nail or thorn, poke two or three very tiny holes in the bottom of a plastic bottle or other container that can hold water and have holes poked into it. The open side of bottle or tin sticks out of the soil so that you can refill them with water occasionally.

### ***Diverting water for irrigation***

A small amount of water may be diverted from a stream to build a fishpond, or irrigate a garden or an orchard, but it must continue to flow back in its original direction. If you take too much water or block it completely it will have a very negative effect the lives of people, plants, and animals further downstream. Think through the design very carefully and discuss everything with others before diverting any water.



When you have a water source uphill from your plants, you can use channels to guide the water throughout the area you want to irrigate. Dig shallow channels that 'snake' their way back and forth at a slight angle to the slope. You should not have to use any other watering if this is successful. Some people use sunken beds at intervals, down the slope, so the water fills one area then keeps moving to the next.

If your water source is lower than the area you are irrigating then you need to pump the water up the slope first, then let it move slowly down through channels or beds. If your water source is a steady stream, or river, you might need a system for shutting the water off so that plants and trees do not get over-watered.

It takes some practice and observation to learn how water follows down the slopes across the land. Before you do anything pour some water and watch where it goes. Water always takes the quickest path downhill. You want to slow it down and make it take a longer path so you can make the most out of it.

An excellent example of this is Freedom Gardens in Dowa (see Part 3, Appendix 4 Sustainable Nutrition Sites in Malawi). This family restored a degraded wetland by healing the soil, building up bio-diversity and making the most out of every drop of water available. They started in the 1990s and took a few years to get the Natural Cycle back in balance, but they benefited from this work and now the area is thriving with all-organic produce. There is an amazing water management system that guides part of a small stream through 10 hectares of ponds, gardens and orchards. Freedom Gardens now provides tours and trainings, wonderful foods and drinks and sustainable sanitation that feeds the resources back into the land. Nothing is wasted!

### **Pumping Ground water**

If there is no fresh water available above ground it might be possible to dig down and find a source of water. Care needs to be taken in tapping into ground water as people can make problems for themselves if they use more ground water than the earth can supply or if they dig wells and boreholes in the wrong place. The impact of each method needs to be considered.

People who know the area often know what the local water table is like. Different types of plants and trees growing in an area can show how much water is underground. Some people have a special skill called water divining. They can find water using divining rods, made from copper or the sticks of some trees, like peach trees. They hold these in their hands and can tell by small movements in the rods or sticks whether there is water underground, as well as an estimate of how much water there is and how deep it is. People in Malawi are much more likely to identify underground water sources by looking at the kinds of rocks, soil, plants and animals living in the area.

#### ***Protecting shallow wells from collapse***

If a drill is used to bore into the ground for water, the pipe that is put into the hole supports the walls of the hole. In a hand dug well, the earth walls may need brickwork or some other stabilizing structure, to stop the walls from collapsing. Many people in Malawi know how to dig a shallow well, so there will probably be someone in your area with experience.

#### ***Protecting shallow wells from contamination***

- **The well should be dug uphill from any latrine** and at least 30 metres away (according to the Malawi Sanitation Policy). Even though a composting toilet is unlikely to cause problems it should still be sited 30 metres from a water source.
- **Build a small wall around the opening of the well and cover the top.** This helps protect the water from dirt, germs and pollution, and prevents children and animals from falling in.
- **Growing plants, shrubs and trees around the well** helps keep dust and dirt down. The natural plants that grow close to these water sources filter the water naturally so they should be disturbed as little as possible.
- **No chemicals should be used** on land near these water sources because the poisonous chemicals can leak into the water in the well.
- **Animals must be kept away** from the well so manure cannot get into the water.

## Pumps

How ground water is accessed will depend on how deep underground the water is, the amount of water in the well, how fast the well refills when water is taken out and the resources you have. A bucket on a rope is possible for shallow wells (1-15 metres or so deep) but it takes a lot of human energy to get each bucket of water out of the well. The bucket can scrape the side of the well on the way up, putting dirt in the water and damaging the wall of the well (and hauling up heavy buckets of water can be very bad for a person's back too).

We will look at four ways to access ground water that are fairly simple and are becoming more popular in Malawi.

- Rope and Washer pumps
- Solar and Wind pumps
- Treadle pumps
- Artesian wells and springs ('natural pumps')

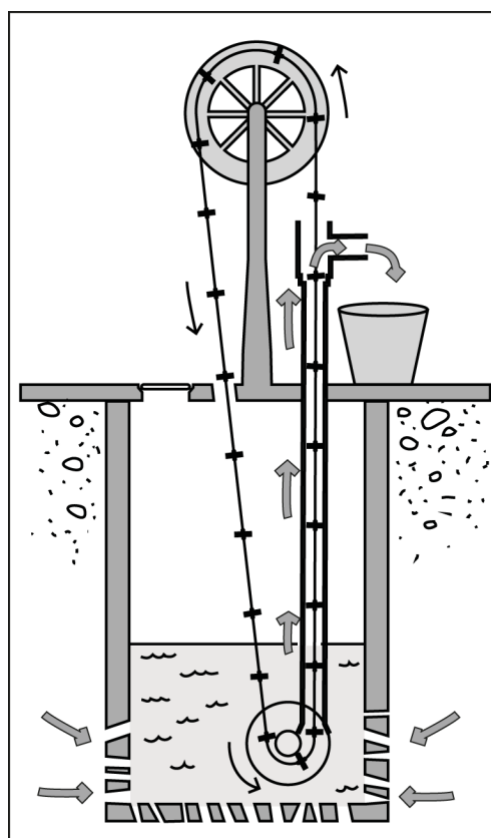
### ***Rope and washer pumps***

These are one of the simplest ways to access ground water. They can pull up water from more than 15 metres deep. Rope and washer pumps can also be powered by wind. The basic principles are covered in this section.

You can make a well like this yourself and there are a number of organizations listed in the appendix (Part 3, Appendix 4, More Information) that can help.

You can buy these ready made, but the materials you need are easy to find or adapt:

- A length of pipe a metre longer than the depth of the well
- Lots of rubber washers the same size as the inside measurement (diameter) of the pipe. The washers need to be spaced evenly along the whole length of rope
- Strong rope that is twice as deep as the well, plus a bit extra.
- A hand crank on a bicycle wheel makes it easier to pull the rope and washers up.
- The rope is threaded through the pipe and the ends are tied together.
- The lower end of the pipe is put into the well and fixed in position.
- Turning the hand crank pulls the rope through the pipe, which causes the washers to trap water in the pipe and lift the water to the top of the pipe where it is released.





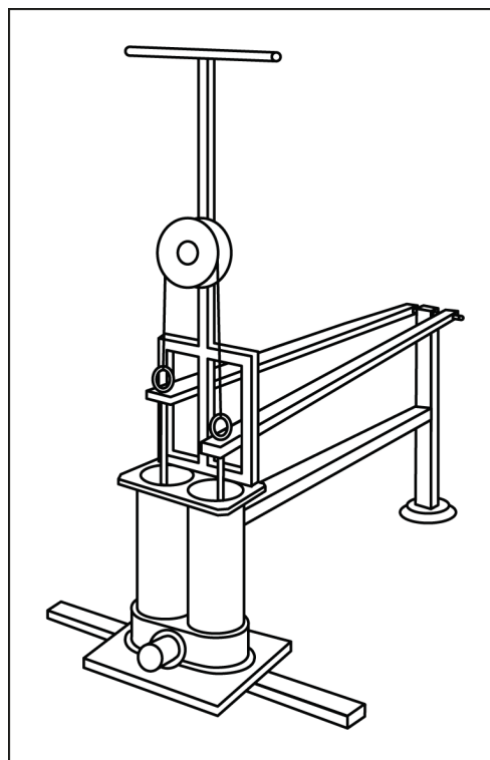
### ***Treadle pumps***

These are well known in Malawi and they work well with very shallow wells, up to about 7 metres deep.

Treadle pumps are also good for pumping water up from rivers or marshland.

Treadle pumps can pump the water very strongly, so take care not to damage or drown plants and trees by hitting them too hard with the water.

The water can be pumped into a small pit above the area to be irrigated and then you can use gravity and channel irrigation.



### ***Solar or wind pumps***

The energy from sun and wind can be used to run water pumps and they are powerful enough to work on deep wells that have been drilled (bored) or dug by hand.

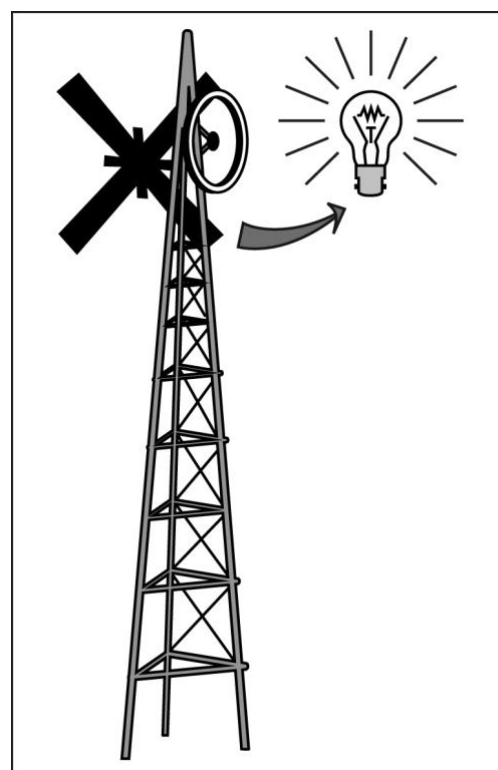
Solar pumps are usually more expensive and need more inputs, like technology and equipment than wind pumps but afterwards there is no pumping work as the sun does the all work for you!

They are becoming more popular and are sometimes funded by aid organisations and charities. The Kusamala Permaculture Centre in Lilongwe has a large solar pump that allows them to run a produce business.

Here at Never Ending Food we have a household solar water pump for our water needs. There is a wind pump at Kuti Wildlife Reserve in Salima. (See Part 3, Appendix 4 Sustainable Nutrition Sites in Malawi).

Dedza has a famous wind pump, made by a young Malawian called William Kamkwamba, a few years ago. He read everything he could find and worked out how to make his wind pump from materials he recycled that his community didn't find valuable.

William was mocked to begin with, and things did not work right first time, but eventually he made his windmill work very well. He has written a book telling the story of his windmill and has now become well known for speaking about renewable energy and creativity.



### Artesian wells and springs

An Artesian well is a hole dug or drilled into the ground until it reaches ground water that is held naturally under pressure, in the layers of rock. The depth of the wells can vary greatly depending on local conditions.

The water has filtered slowly through many layers of rock, sand, gravel, etc., and collects deep below the surface of the Earth. Underground pressure forces the water out through the hole that has been drilled. Some natural springs are like this without drilling or digging.

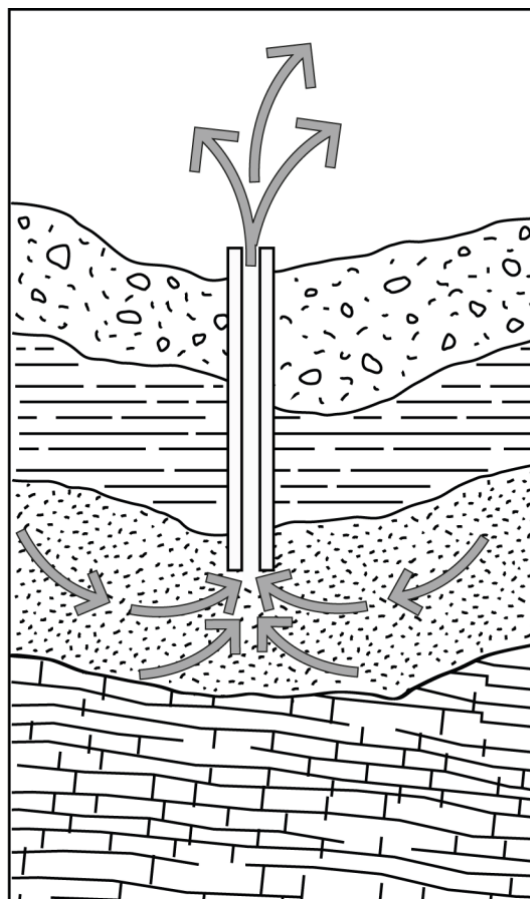
Artesian wells can supply water endlessly only if the soil and the water table are healthy, and if the water is not taken out faster than the well can fill up again.

Be careful when you take water out of the ground, or river or any water source - if you take more water than the earth can replace in the well it causes problems.

Drilling for an Artesian well needs very good understanding of the geology of the region (the different layers of earth and rock) and someone who can work out where the water is trapped underground, such as a water diviner.

There are several Artesian wells in Malawi that have been functioning for decades. (See Part 3, Appendix 4 Sustainable Nutrition Sites in Malawi.)

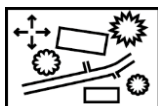
The impact of each method needs to be considered. If we think ahead, sometimes putting in the extra input now (time, work, energy and money) means reaping greater benefits for a long time with very little input in future.



Make sure the methods you choose care for the earth, its people and shares resources fairly so that it will fit in with the Design for Sustainable Nutrition that you will be making in Part 3 of the manual.



What kind of pumps and wells are there in the area where you live? Go and visit some different sorts of water sites if you can and see what advantages and disadvantages there are to the different methods.



Note any water points on your sketch map that you have not already marked. Note any water points that are faulty and need to be improved.

## Topic 25: **Species Health**

There are billions of different kinds of living things on our earth. To make it easier to learn about them we organise them into groups of different **species**.

A species is a group of similar things that can breed together and produce fertile offspring. For example: all dogs are the same species, even though there are different breeds. Dogs breed with other dogs and they produce puppies (baby dogs) that can grow up and produce their own puppies.



Horses breed with horses and make foals, which are baby horses. But if a donkey breeds with a horse they make a mule. Mules are very strong animals but a mule cannot have its own babies. Donkeys are not the same species as horses, even though they are quite similar. Maize breeds with maize, but not with wheat or oats or tomatoes or fish.

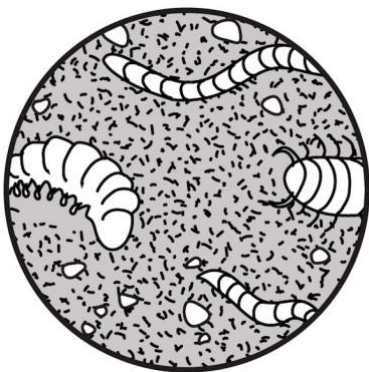
Any species, any kind of living thing, can be healthy or unhealthy, just like any other part of the Nature Cycle. We have already discussed the health of human beings, soil health, water table health and environmental health. Now let us look at the health of the species that we eat; plants, trees, fungi, animals, birds, insects and fish.

If the plants, trees and animals in your area are healthy, strong and productive the Natural System is probably working well. If there is a lot of disease, insect damage and low yields, something is not right. The system needs to be looked at carefully and changes need to be made. People often just look at the symptoms and try to fix problems with medical and chemical treatments, but pills and powders do not usually solve the actual problem. We must think harder and make changes to the system itself and the mind-sets and behaviours of people.

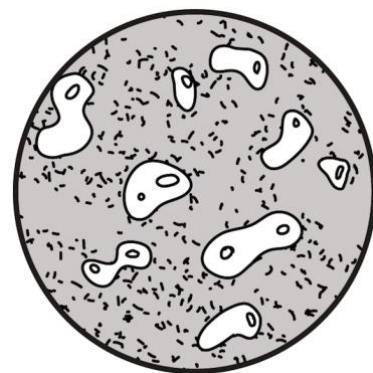
### Millions of Species

There are about 9 million different species in this world that can be seen with the human eye. Humans have named 1.5 million plants, trees, fungi, animals, birds, fish and insects. These are the species that we need for our nutrition and for everything else in our lives.

In addition to what we can see, there are billions of micro-organisms. These are too small to see with your eyes. You would need a microscope!



In just one teaspoon of healthy soil there can be 50 billion of these tiny micro-organisms working for the health of the soil, and the health of everything living on this planet.



More than half of the 9 million species are insects. Insects are a vital part of the Nature Cycle. They pollinate plants and trees to make seeds, and they recycle dead organic matter and return the nutrients to the soil.

Within any one species group there will be varieties. For example: rice is a plant species but there are thousands of different kinds, or varieties, of rice. Dogs are an animal species and there are many different breeds of dogs. The different varieties have different needs and provide us with different things. Some rice plants need more, or less, water than others. Some will do better in cooler or warmer climates, some are brown and others are red or white. Some dogs are well adapted to live really hot countries and others live best in freezing cold climates.

## **Over 40,000 Things to Eat!**

That's right! Out of the 1.5 million species named, over 40,000 are known to be edible!

But the world relies mostly on only 3 species (wheat, rice and maize) for more than half of the calories we need. Just three foods! So what about the other half of what we eat? We rely on only 30 other species to provide all the rest of the nutrients we need. Out of one-and-a-half million (1,500,000) species we are only eating about 30! The whole world is missing out on a great deal of diversity in its agriculture and in its diet.

There are some indigenous and traditional communities in the world that eat more than 200 different species throughout the year. These diets provide many more nutrients and food security than relying on just a few different plants. This diversity is better for environmental health and sustainability as well. Remember the Current Meal compared to the Better Meal? (Part 1, Topic 2, The Impact of Food Choices.)

The industrialized world is using less and less diversity and developing countries, like Malawi, are following their lead. This is not healthy for the environment or for people. We need to alter our food systems to increase species diversity and to share all of our resources more fairly. Nature is rich enough to feed all of us if we all work towards increasing the diversity in our agriculture and in our diets.

Malawi is just a small country but it has over 300 species (plants and animals) that are edible, and many more if you count all the variations of species. The Appendix lists over 600 different foods in Malawi that come from those 300-plus species (Part 3, Appendix 1, Common Foods of Malawi).

As well as food species, there are many more other species to use for things like fuel, raw materials, building supplies, fun, celebrations and decorations. Even companionship is provided by domestic animals, and inspiration is provided by the Natural World around us. Bio-diversity is so much more exciting, interesting and useful than uniformity!

## **Protecting all our Species**

If the health of one species suffers it is likely that other species will suffer too. Humans are just one of literally, a billion, species that are all connected to each other and rely on each other.

But human activity is destroying many other species. When a species has been destroyed it becomes extinct. This means that all that of that one, unique species, is dead. They cannot reproduce to make any more. Species can be destroyed by ruining their homes (a species' habitat) through clearing areas; poisoning the land, sea or sky with pollution; over-hunting, over-fishing, and / or over-harvesting.

If we do not think a species is important, then it is more likely that we will destroy it, often without even thinking about what we are doing. In some instances there so few of a species left that they are considered 'at risk' or 'under threat' of extinction. Some people are working hard to protect those and increase their populations, but there are still not enough people that understand and protect our diversity, and we can all help.

All species have their uses, and we will never know what we have already lost! It is time we started protecting and promoting the wonderful diversity of Nature, and the best place to start is here and now.

### ***Nature is the Best Teacher!***

Let us do an exercise that helps us understand more about the importance of diversity and species health using the Permaculture Principles, especially the first one: Observe, Learn and Share with Others

### ***Go outside. Take a walk....***

Go to a, quiet natural area and sit for a while to think and watch. Write down your thoughts in response to these questions:

#### **Focus your eyes on one thing, anything, and think about it.**

It could be a river, a cloud, a flower or an insect – anything. Write down what the thing is. What does this thing need for its health? Write down a second thing. What does that second thing need? Write down a third thing.... Keep writing this list, even if you are thinking of things that are too small to see or that are out of sight. How long can you go on seeing all these things linking up? How has Nature arranged it so that everything works together so well?

#### **Do you see just one type of plant, tree, insect or animal?**

Nature is always diverse and puts many different species all in one area. What can you see to eat in this natural area? Can you find all of the 6 food groups? Can you see any plants with medicinal properties? Earlier in the manual you began making lists of available foods. How many species did you find? Now that you know more about where a healthy diet comes from could you find more things to eat?

#### **Does the area look healthy?**

How much insect and disease damage do you see? Is there any rubbish? Is it really rubbish or is it one of Nature's resources? Where did it come from? Are there any dead animals or plants? How did these things die? Was it part of their natural cycle or did something else happen? How does Nature keep everything so well balanced? Nature sees solutions not problems, and we can learn to do the same.

#### **If you are with a group, think about these things on your own first.**

Your life is different to everyone else's. Write down your thoughts. Then come together and discuss what you have observed with other people. Write down everyone's thoughts and ideas so that you can build on the discussion, and any good ideas, later.

### ***Nature gives us all the solutions we need***

The work of the Nature Cycle is done because **Nature uses everything** to the maximum, from the biggest animals and trees, to the smallest insects and tiny plants. Different species, sharing the same space, support each another's existence. Even eating each other for food maintains the balance of different species. We can learn from this to be **as efficient as possible** and we can conserve energy if we design sustainable human systems and let nature work for us.

If we think hard about how to repair our human systems and encourage other people to think ahead and plan for the future themselves, too, new, better solutions are just waiting for us and you may be the one to discover them.

We have been looking at, and thinking about, some individual things in this natural area. Now take a step back and try to **see the whole picture**. Was any part more

important than the others? Does everything depend on something else? If some part was missing what else could do the same job? No part is more important the other parts and every part has many roles to play. This includes human beings.

**You have started observing and learning, now continue by sharing** what you have learned. Discuss all this with as many people as you can, from the youngest to the oldest, visitors or village elders, people who are richer and poorer than you, healthy people, people who are sick and anybody else you can think of.

Make the discussion as inclusive as you can. These issues affect everyone and everyone has understanding, intelligence and creativity to contribute to the discussion. Humans have not always done what is right for Nature but we have the power to change that. You have the power to change, starting at home and in your community.



Write down your responses to the questions asked above and ask other people their responses. This should be a long discussion and it will be useful for you to make notes to remember what everybody said, so that you can think about it further.

## Topic 26: Permaculture Guilds

All living things need good nutrition for health, strength and productivity. Every species has its own food and water needs. Also species have different likes and dislikes for where they live and who they live with, just like humans.

The important thing to understand is that if the right species lives in the right place that has the right living conditions (climate, water, etc.), along with the right groups of other suitable other species (for food, medicines, etc.), they can help each other to thrive.



The more you learn about the different habits, the different likes and dislikes of the species in your area, the better you will be able to arrange things efficiently!

### ***Guilds: diverse species working together***

In Permaculture a group of plants and animals living well together is called a **guild** – it mimics a healthy eco-system where plants, animals and environment work together to thrive in their environment. Each species contributes different things that are helpful to the other members of the group. The common goal is to thrive and be healthy, fertile, productive and efficient together.

In human society a group of people that join together to work toward a common goal is also called a guild. In Malawi women form guilds called *chigwirizano* or *mvano*. The group comes together to co-operate around a common goal of helping people in need, like orphans or the elderly. In business and trade, people join together in guilds or unions, to co-operate in order to market their products or to protect the rights of the workers.

Permaculture guilds will help you to efficiently organise your gardens, orchards, ponds, fields and forests with your infrastructure, needs, local conditions and activities. Nature's guilds are for the benefit of all species. Permaculture guilds are designed with human needs in mind. They care for the Earth, for all its people, and they are a good way of using resources efficiently, which helps with sharing resources fairly.

## **Guild Functions**

There are 7 **functions**, or jobs, that different plants, trees, animals or infra-structure fulfil in a permaculture guild. Many species fulfil more than one of these functions. Well-planned permaculture guilds have species (plants and animals) that do all 7 of these things between them, sometimes with infra-structure assisting (a wall or fence to support climbing plants, or shelter a delicate plant from animals, wind or sun).

### **Human Needs**

Anything that is useful to humans fulfils this function. Many species are food for us, but there are other things we need too: medicines, fuel, timber, fibres, etc.

### **Soil Food**

The most important food for the soil is nitrogen. Species do this job either by fixing nitrogen in the soil or by adding nitrogen as mulch, manure or urine. A large number of species do this job.

### **Soil Cover**

These are plants that cover the soil and hold it in place. Good examples are pumpkins or melons that creep over the soil to create good groundcover. Other low growing plants spread and make good ground-cover too, such as different herbs. Mulch, whether plants (dried leaves or grass), or mineral (stones or gravel) is also ground-cover.

### **Diggers**

Diggers keep the soil open letting water and air in. This helps water soak in and keeps the soil soft and healthy. Tree roots bring up minerals from deep underground and return them to the soil when the leaves die and fall. Plants with large tubers like cassava, yams or *mlozi*, are good diggers. Some animals, like pigs, chickens and earthworms, are great diggers too.

### **Climbers**

These species climb up walls, trees or any other support. Climbers are plants like beans, passion fruit (*magalagadeya*), loofa (*chinkupule*), air potatoes, cucumbers (*zipwete*, *minkhaka*), etc. They can also provide food, using the space available between the ground and the tops of trees or buildings. Some animal species are also climbers, like monkeys, snakes and ants. Climbers often protect whatever they are climbing from wind, rain or pests.

### **Supporters**

Supporters help the climbers, giving them something to climb. Trees are often supporters but any shrub bigger than the climbing plant can be a good supporter. A dead tree, the walls of a building or a fence are also supporters that can be useful in a Permaculture Guild.

### **Protectors**

These species protect other things from damage, like disease, pests or theft. Smelly or fragrant species can keep pests and insects away. Medicinal plants are protectors for humans. Some species are believed to protect us from thieves or people trying to do any harm to us. Plants with thorns protect property from roaming animals or people. Some protectors, like marigolds, work by attracting pests and predators to themselves and away from your crops.

## ***Put the right species in the right place***

The continents, landscapes and climates of the world are incredibly varied and there are species adapted to fit perfectly in all these environments. Within any area there may also be micro-climates. These small areas within a larger area have a slightly different climate because they get more or less shade / light / water / shelter from wind, etc. and you can take advantage of these when you plan what to plant.

Many things affect each different landscape and climate, like the seasons, the temperature, sunlight, shade, the amounts of moisture, types of rocks and soils and different ground heights like mountains or valleys or even the ocean floor.

Plants and trees have adapted to grow to different sizes, to climb up each other, to grow underground or across the soil. Animals and insects have adapted to be different sizes, fast or slow, to swim, breathe under water or fly in the air. Each species, and the different varieties within species, need special conditions to thrive and other species to thrive with.

The more you learn about your local species, how they grow and where they thrive, the better your results will be. People who have lived in your area longer than you have (usually the older people), or who know different parts of your environment (herders, firewood collectors, herbalists), are good people to talk to so you can increase your knowledge.



### ***Put the right species together***

All species interact with other species in many more ways than just eating each other!

- Bees and insects pollinate flowers and trees and they 'like' to be together.
- Little birds feed on the fleas and parasites on large hippos, so the birds help the hippo and the hippo provides the birds with food. The fleas may not 'like' being food but they are also feeding on the hippo!
- Climbing plants use trees for support, which is sometimes good for both the plant and the tree, and at other times it can harm the tree.
- Animals use plants and trees to make their nests, which can help the plants in having room for new leaf growth and getting animal manure for improving growth.
- Some plants (legumes) help other plants by fixing nitrogen in the soil.
- Some plants will do well with many growing close together, but usually the same species need its' own space (maize will compete with any other maize plant that is growing too close to it). Other species are not a good combination at all if too close together and one will dominate and kill the other or they will both do badly together (passion fruit on a sorghum).

## **Benefits of the Guild System**

Once your guilds are set up, you will find that the area needs less work to maintain health and productivity. If the area is well designed, each year it will grow stronger and stronger with a little maintenance. A guild is beneficial to the soil, water, air and all living things. Current agricultural practice is often the opposite, with a high use of energy, money and inputs. The chemicals harm and degrade the soil, air and water.

	<b>Maize Acre</b>	<b>Permaculture Guild Acre:</b>
<b>Human Energy</b>	Hard work several times a year: re-planting, hoeing, weeding, adding chemicals, etc. Soil and species often worse each year, needing more input.	Less work every year if using native species. Also strengthening soil and species health every year.
<b>Money</b>	Expensive new seeds, labour, and increasing amounts of chemicals	Seeds usually free. No chemicals or decreased use with improving soil and plant health, and less labour costs as nature does some of the work.
<b>Weather</b>	Must have consistent weather, with rains just right.	Withstands a variety of different weather conditions.
<b>Weeds Pests Diseases</b>	Weeds, pests, and diseases thrive and farmers rely on chemical inputs.	Balances a variety of different insects, prevents diseases, etc. Recognises weeds as resource and uses them to advantage. Natural methods to deal with weeds, pests and disease.

	<b>Maize Acre</b>	<b>Permaculture Guild Acre:</b>
<b>Soil Health</b>	Degrades each year and needs heavier and heavier inputs of fertilizer and tilling.	Improves each year with a variety of species using and returning different nutrients to the soil. Keeps soil soft with organic matter and natural diggers.
<b>Harvest</b>	Harvest all in one month with intensive input. Attempt to store for the whole year.	Harvest for many months reducing need for storage, spreads work throughout the year
<b>Nutrients</b>	Provides very few of the nutrients we need for all the hard work!	Provides us with many different nutrients so we have a healthy and diverse

### ***Building Guilds***

**Keep the 7 functions of a guild** in mind and practice putting productive combinations together. The Guide to Foods helps you with some of the guild functions (Part 3, Appendix 1, Common Foods of Malawi) so browse this and try imagining different groupings.

**Don't regard anything as a weed** (not needed) until you are sure it doesn't help the guild in some way. A weed is simply a good plant where you don't want it. Every plant has a purpose, our job it to find out what it is and utilize it to its fullest potential. The more you think about this the less work you will have to do in the end. (Remember the 80:20 rule!)

**Here are a few tips for building a guild:**

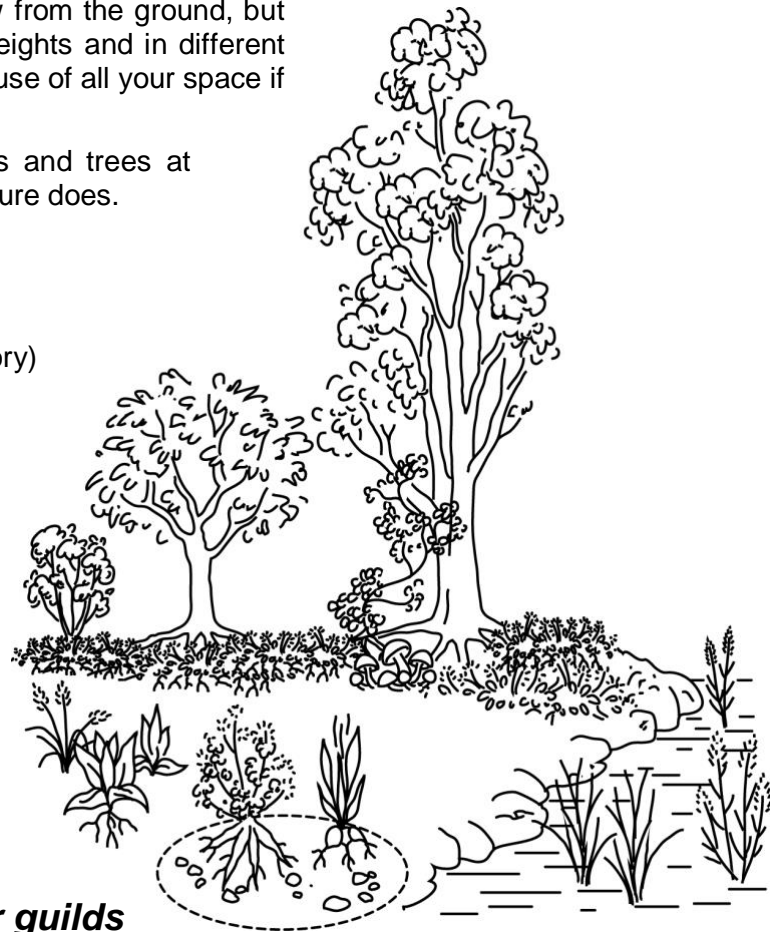
- **Any species can fit into a guild system.** Think about how your guilds fit into your area and your life. There will be several different guilds in one garden, village, field, or pond, etc. Every area will have different guilds depending on the conditions of that particular area.
- **The conditions can vary even within a small space.** We will talk more about the different areas of your site when we learn about Zones in Topic 29, on page 117
- **Guilds change over time.** The plants and animals of guild systems will change during the seasons as you harvest, trim plants back, mulch and add new things. Some plants, trees and animals in the guild will be there for a long time, such as long-lasting perennials. Other plants will be short lived, such as annuals that take a few months or a year, but you may decide to let their seeds continue growing within the guild, or you may decide to change what is in the guild.
- **Not everything will be established on the first day.** It takes time to grow living fences, animals, orchards, ponds, gardens and trees. Guilds are an important part of crop (and animal) rotation because the different species come after one another, not all at once.

## ***Stacking: plants growing at different heights***

Most plants and trees grow from the ground, but they all grow at different heights and in different styles. You can make best use of all your space if you think about stacking.

This means growing plants and trees at different heights just as Nature does.

- Tall Trees (canopy)
- Short Trees (understory)
- Shrubs and bushes
- Herbaceous plants
- Groundcover
- Underground
- Climbers
- Aquatic
- Fungi



## ***Suggestions for guilds***

The suggestions in these tables will start you thinking about possible ideas. The 'x' marks in the tables show which functions the species fulfils. The species you choose will depend on your situation.

As you are building your guilds, you'll put a lot of information to practical use:

- Remember to think of guild functions, food groups, stacking and all the other information you've learned up to this point, not just in this book, but from other parts of your life too!
- See if you can think of something else that could be added to each list
- What functions do your additions fulfil?
- Try designing some guilds for yourself in the blank tables
- Work with someone else so you can discuss the possibilities
- With these examples we will start close to home and then move out further

***Porch guild***

This guild for the porch of your house provides yams, spinach, herbs and pigeons to eat, add beauty and nice noises from the birds. The climbing plants will shade the house that supports them. Herbs and flowers keep insects away and some can be used for medicine as well. The pigeons drop manure and feathers on the ground and mulch is added frequently to cover the manure and protect the soil. Add your own notes about plants and animals that could be included in the guilds described here.

<b>Porch Guild (<i>Khonde</i>)</b>	<b>1 Human Needs</b>	<b>2 Soil Food</b>	<b>3 Soil Cover</b>	<b>4 Dig</b>	<b>5 Climb</b>	<b>6 Support</b>	<b>7 Protect</b>
<b>Coco yams</b>	X			X			
<b><i>Ndele</i> (climbing spinach)</b>	X				X		X
<b>Herbs</b>	X						X
<b>Pigeons</b>	X	X					
<b>Mulching (organic)</b>			X				
<b>House walls</b>						X	
<b>Flowers</b>							X
<b>Bench (support for people!)</b>						X	

***Bathhouse guild***

This guild is made out of live tree poles, hedged with climbing plants for privacy. Vines give food (passion fruit), and the loofa gives cleaning equipment for the bath! Flowers attract pollinators and smell good. The *khungudzu* (lablab) fixes nitrogen, and the dirt, hair and skin that is scrubbed off during the bathing will also add nitrogen for the plants. Urine will help the plants, too. Pebble mulch provides ground-cover, and drains water away, towards the channel and pit around which these plants are growing.

<b>Bath House Guild (<i>Bafa</i>)</b>	<b>1 Human Needs</b>	<b>2 Soil Food</b>	<b>3 Soil Cover</b>	<b>4 Dig</b>	<b>5 Climb</b>	<b>6 Support</b>	<b>7 Protect</b>
<b>Passion fruit</b>	X				X		
<b>Loofa vine</b>	X				X		
<b><i>Khungudzu</i> (lablab)</b>	X	X			X		
<b>Organic mulch</b>		X	X				
<b>Pebble mulch</b>			X				
<b>Bath house's live poles</b>				X		X	
<b>Flowers</b>							X

***Field guild***

This guild provides lots of food. There is something from all the food groups during almost every season. The sorghum is a staple and a supporter for the cowpeas, which climb while fixing nitrogen and providing protein. The sweet potatoes are a staple and vegetable. They are also soil cover and diggers too. The pumpkin is covering the ground and providing food from its fruit, leaves and flowers, and fat from seeds. The baobab tree is a fruit, vegetable and a high fat legume (the seeds provide protein and oil), as well as a digger and a supporter. The cow provides manure and milk. Basil is dotted throughout the guild, but particularly near the cowpeas, pumpkins and sweet potatoes to protect them from pests.

<b>Field Guild (Munda)</b>	<b>1 Human Needs</b>	<b>2 Soil Food</b>	<b>3 Soil Cover</b>	<b>4 Dig</b>	<b>5 Climb</b>	<b>6 Support</b>	<b>7 Protect</b>
<b>Cowpeas</b>	X	X			X		
<b>Pumpkin</b>	X		X				
<b>Sweet potatoes</b>	X		X	X			
<b>Baobab tree</b>	X			X		X	
<b>Sorghum</b>	X					X	
<b>Minty basil (mpungabwe)</b>	X						X
<b>Cow</b>	X	X					

**Office guild**

This guild for a workplace welcomes everyone with a good-looking display of useful plants. Rock mulch on the paths and surrounds will stop mud being walked in during the rains and keep dust down when it is dry. Groundnuts and sweet potatoes can be planted in succession to harvest monthly. Mint and lemon grass makes good tea. Peaches, passion fruit and the cape gooseberry provide a sweet treat. Seeds can be shared and water from cleaning the office can be recycled into the gardens.

<b>Office Guild</b>	<b>1 Human Needs</b>	<b>2 Soil Food</b>	<b>3 Soil Cover</b>	<b>4 Dig</b>	<b>5 Climb</b>	<b>6 Support</b>	<b>7 Protect</b>
<b>Ground-nuts</b>	X	X	X	X			
<b>Sweet potatoes</b>	X		X	X			
<b>Mint</b>	X		X				X
<b>Peaches</b>	X			X			
<b>Passion fruit</b>	X				X		
<b>Lemon grass</b>	X						X
<b>Cape gooseberry (<i>jamu</i>)</b>	X						
<b>Rock mulch</b>			X				

***Build a guild at the water point***

Think of water-loving species to plant around a pit bed, irrigated by the run-off. Think about plants and animal species and the functions they perform. Think about how they can fit within any of the structures on your sketch map.

<b>Water Point Guild</b>	<b>1 Human Needs</b>	<b>2 Soil Food</b>	<b>3 Soil Cover</b>	<b>4 Dig</b>	<b>5 Climb</b>	<b>6 Support</b>	<b>7 Protect</b>



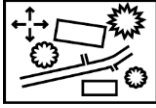
***Build a guild, any guild!***

Can you think of other guilds that would work where you are, and with what you have?

<b>Guild</b>	<b>1 Human Needs</b>	<b>2 Soil Food</b>	<b>3 Soil Cover</b>	<b>4 Dig</b>	<b>5 Climb</b>	<b>6 Support</b>	<b>7 Protect</b>

## Part 2, Topic 26: **Permaculture Guilds**

You are now beginning to use your knowledge and your intelligence to design sustainable systems that can help you achieve the health and happiness that comes from a good diet and a healthy environment. This is a good start to sustainable nutrition, but there is more to learn so keep reading and thinking!



Note any guilds that already exist on your map. Would it help to organize other areas of your map by guilds? If your species and infra-structure work more co-operatively and efficiently how much energy could you conserve? Write down some guilds you are thinking about and how they would help you.

## Topic 27: Seeds and Propagation

This section of the manual will help you to understand natural reproduction and how species get stronger.

Most species (plant or animal) start with a seed of some kind. There are other ways to re-produce plants and trees which we will discuss a little later, but let us look at seeds first. After the seed matures it is fertilized, fed, watered and cared for, so it can grow from the seed into a plant, tree, animal, insect or human.



How well the seed grows depends on the health of the seed to start with, the nutrients it gets and the environment in which it grows. These same things are all important for human health.

The growth of the seed into a mature plant or animal happens because of cells, which are the tiny building blocks of the organism (made from protein / nitrogen). Inside the cells are the instructions for what that cell should grow into. These instructions are called genes. These genes decide everything about how the species looks and behaves as a member of that species, as a variety of that species and as an individual with unique genetic variations.

This genetic diversity keeps the Nature Cycle strong and adaptable to changing conditions. If one variety of a species does very badly one year, it is likely that there is another variety of that species that will do much better. Species have adapted themselves, with each reproductive cycle, over thousands of years, to become stronger. The strongest survive and carry on. This has come about mostly through species' own reproductive methods.

Ever since humans began farming thousands of years ago selective breeding has been used to select varieties that are preferred. Certain seeds are chosen, or different varieties put near each other, to encourage them to crossbreed naturally. These are called Open Pollinated Varieties or Heirloom Varieties.

In recent years crossbreeding has been done in plants and animals that would not normally have crossbred in nature, creating Hybrid varieties. Hybrids take an extra year to make and they tend to be very strong for one cycle, but they cannot continue into another cycle – they get weaker instead of stronger – so new seeds have to be crossed again before starting another cycle.

Even more recently, people have started moving individual genes between species that are not related at all. Scientists have learned how to engineer combinations between plants and animals to create **Genetically Modified Organisms** (GMOs).

As with hybrids, GMOs have to be artificially created for each reproductive cycle and farmers are required to buy new seeds each year. The strongest seeds no longer adapt and survive. Farmers no longer selectively breed what is doing best; humans choose what survives and when to adapt them further. Let us look closely at these seed types.

## **Heirlooms and OPV Seeds**

The billions of species that we talked about at the beginning of this section have adapted slowly over thousands of years, mostly through their own reproductive methods. Humans have adapted some by selecting the species and varieties they prefer. The offspring of these seeds are able to reproduce, strengthen and adapt on their own, without any dependency on human intervention. These are the **Open Pollinated Varieties (OPV)**.

Many OPVs have been passed down through many generations and are considered **heirlooms**, a treasure passed from one generation to the next. OPV seeds often do not cost anything, although they are sometimes packaged and sold to share the treasure more widely. There are some organisations that protect, save and preserve heirloom species because they are so important for genetic diversity.

The heirloom species in your area are designed by Nature (sometimes with human selection) to work well in your landscape and climate. It makes good sense to use OPVs and to encourage these varieties as they will continue to strengthen themselves if they are given a healthy environment in which to grow and reproduce. Most species in the world are heirlooms, but people are forgetting their value, so this is changing. Malawi has a few small genetic seed banks, herbariums and botanical gardens to preserve and document some of these, but much more could be done to use and preserve more heirloom varieties in human systems.

## **Hybrid Seeds**

**Hybrids** are created by humans by crossing two genetically-related species. A hybrid variety is made to carry a unique quality for its first offspring (the first generation) known as hybrid vigour. The quality could be a larger seed, a shorter harvest period or tolerance to dry weather, etc. The offspring of the hybrid, the second generation, will not continue to produce this way. Farmers should not save seeds from hybrid varieties to replant them. Hybrid seeds have to be artificially bred each cycle and then bought again for each planting cycle. You will have to plan for this expense every year if you plant hybrid varieties and depend on the companies to develop and breed new varieties. Hybrids are not specific to your area, but generalized for many farmers in a region or globally. The seeds are not able to adapt and strengthen to local eco-systems and get stronger, as an Heirloom or an OPV seed can, so there is less resilience than in natural systems.

## **Genetically Modified Seeds**

With **genetic engineering** individual genes are altered within a species to artificially enhance a particular quality such as: to grow bigger and faster, to withstand chemicals, to be tolerant of poor environmental situations or to artificially add nutrients or medicinal properties. These are called **Genetically Modified Organisms** or **GMOs**.

Genetically engineered (GE) seeds are generally designed to be combined with chemicals, such as herbicide resistant seeds. GMOs usually address a symptom (like disease or pest) but it does not address the root-cause of the problem itself; so the problems still exist. This adds to dependency on chemicals and fossil fuel, and doesn't address the problems of environmental degradation, poor dietary diversity, and poor health. The solution is to address the problems head on by healing and caring for the environment and restoring bio-diversity in agriculture and diets. The solutions are actually pretty simple if we all work together towards them!

Unlike hybrids, several types of GE seeds will produce for more than one generation, but saving and replanting GE seeds has been made illegal in countries that allow GE seeds. Companies who make GE seeds claim to own the seeds. Farmers in several countries have been fined when second-generation GE seeds are discovered on their farm. This could happen even if you did not plant it but the seed came on to your land as a result of natural processes such as the wind or animal transfer of the seeds.

Malawi does not allow GE crops in its agriculture or food systems but there are no clear systems in place for monitoring. In 2013 Lilongwe University of Agriculture and Natural Resources (LUANAR) began to run trials with GE cotton to see if it does well in Malawi.

Researchers in other countries are starting to connect some of the problems they see in our environment (e.g. with bees and butterflies) and in human health (e.g. cancers) with the chemicals used in genetic engineering. Many countries have banned genetic engineering from their agricultural systems until more research proves them safe for people, animals and environments, and fair to societies. Other countries use them widely, such as South Africa and the USA, though some citizens are protesting against them and demanding labelling on GMO products so consumers are able to avoid them if they don't want them.

### **Sourcing Good Quality Seeds**

OPV seeds work with natural systems and provide us with extensive genetic diversity tailored to local eco-systems. OPV seeds can be found in many places, from wild natural areas to local markets. Most gardeners, farmers and naturalists are often happy to share and exchange seeds with others. Other organisations that might be useful to you are listed in Part 3, Appendix 4, Sustainable Nutrition Sites in Malawi.

It is not difficult to keep your eyes open and ask around. You will build up your supply of OPV seeds very quickly and, if you exchange seeds with others, it will increase genetic diversity in Malawi for the benefit of everyone.

#### ***Selecting OPV seeds to save***

Careful observation will help you decide which seeds to save. The best seeds come from the best plants or animals and the best plants or animals come from the best seeds. The highest quality plants or animals are grown in the best conditions for that species.

- Examine the parents as they grow to choose seeds from the healthiest and strongest sources. Save the seeds from several healthy parents, not just one. This increases the genetic diversity of your own personal seed bank, and increases resilience.
- Examine the seeds (the offspring) to select the best ones, in your opinion. Select the seeds that suit your needs in terms of taste, size, productivity, health, water needs or tolerance to drought, etc.

#### ***When to harvest seeds***

Each species has its own way of multiplying and this can guide you in how to harvest its seed. It is easy but, as with anything new, you will have to learn as you read, discuss and try things out, and, as always, be guided by Nature. Some seeds:

- Are ripe when the food is mature and ready to eat. Most beans are like this.

- Need to ripen past the eating stage. Cucumbers and eggplants are like this. The vegetables are good for eating before the seeds are ready, i.e. the seeds mature after the vegetable is past a good stage for eating. So choose a few foods just for seed and let them stay on the plant until the seeds are mature.
- Need a period of hibernation, like sleeping through the colder winter months.
- Need to be soaked in water, or partially digested in the belly of an animal, before they are ready to germinate and start growing again.

### ***Processing seed for storage***

Seeds usually need to be separated from their plant, pod and / or fruit and dried out before storage so that they do not grow too soon, rot or attract pests. Here are some hints for different types of seeds:

- Matured grain and legume seeds like maize, beans or other plants with seedpods, like *chidede*, or un-covered seeds, like blackjack, are usually easy to separate and dry.
- For seeds that are covered in moist flesh, such as guava, tomato or eggplant:
  - Leave some fruit on the plant until it is mature (it may shrivel). Separate the seed out, dry and store it. This can work well for many fruits.
  - For fleshy fruits you can also put the fruit in a container, add water and mash gently without breaking the seeds, but just to loosen the fruit. Let it sit in the water for a day or two. Healthy seeds will sink to the bottom and unhealthy seeds will float. Scoop away the unhealthy seed and the pulp (put them in the worm farm, on the compost heap, or in the garden just in case there some good seed). Rinse, dry and store the healthy seeds.
  - A traditional way of saving seeds is to smear the fruit on a wall. The fruit juices keep the seeds stuck to the wall as the fruit and seeds dry together. Carefully scrape the dried fruit and seed off the wall when you are ready to plant.
  - Squash fruit onto a sheet of paper / tissue and let the seeds dry there. At planting time the paper is torn and planted along with the seed. (The paper will decompose).
- Roots, tubers or bulbs, like potatoes and garlic, need to be harvested at their peak maturity and stored in a cool, dry, dark place. The traditional method of digging a pit in the earth and smearing it with clay works well.
- Some species can be grown from stems, like cassava, sweet potato and some trees. The stems need to be kept alive and must not dry out. (There will be more information on growing from stems on page 112).
- Some species can reproduce using more than one method. Garlic flowers make seeds, but garlic also can be multiplied by planting the individual cloves of the whole bulb.

### ***Storing seeds for future use***

Harvested seeds need to be protected from pests, moisture, heat or light, just like harvested food. Your seed storage method needs to protect the seed's viability – its ability to germinate. Some seeds can be stored for more than a year but others need to be used up quite quickly.

Many different types of recycled containers (bags, jars, clay pots, etc.) can be used to store your seeds.

Mix dried 'protectors' with the seed (like strong smelling plants) to protect the seeds from insects. Certain plants are known to have pest protection properties, like seed from *chisoso* (blackjack) or leaves from tephrosia. These can be crushed into a powder and mixed in with your stored seed. Wood ash mixed with the seeds is also a good protection against insects.

Label your seeds well so you know what species and variety it is and when you harvested it (what month and year).

You are ready now to share or sell your seeds or just save them until you need them. Always save a bit more than you need, just in case you lose some or are ruined by accident, or you need extra for sharing, selling or planting.



What are your seed sources? Does your community understand different types of seed? What can you do to help more people understand the importance of access to diverse seeds?



Write a list of all the seeds you save. Note other seeds that you have access to and could save. Which ones do you have enough of to share or sell? Who do you know who might exchange some good OPV seeds with you so that you both have more diversity?

## **Propagating Plants and Trees**

Any method of starting a new plant or tree is known as propagation. There are many ways to propagate plants and trees, and, as always, watching nature can provide useful lessons. This section will review some propagation techniques to help you increase the diversity of your environment and your diet. Part 3, Appendix 1, Common of Foods of Malawi gives suggestions about the ways that the different species can be propagated.

You can often find free plants and seedlings that propagated on their own if you check compost heaps, sweeping piles, the edges of roads and paths, and anywhere that people discard food scraps and seeds (bits of tomatoes, onion bottoms, mango seeds, papaya seed, etc.). Carefully scoop around the plants or seedlings and put them where you want them in your guilds.

There are also a few species that grow from themselves (i.e. from a part other than their seed) that you can get from your kitchen as you are preparing foods. If you plant the root-end of onions, the tops of pineapples or carrots, or the eyes of potatoes they will often produce new plants very well and for very little effort. Get more out of them by planting them again.

## **Annuals and Perennials**

### ***Annuals***

These are plants that live for one year, or less, before they produce seeds and die. Examples are *chisoso* (blackjack), kidney beans, onions and maize. Short-lived species like this usually take a week (or a few weeks) to germinate. They produce seed after about 3 months, and are dead and decomposing in 4 or 5 months.

An annual plant will only give one harvest from each seed, but if you plant them in succession, called staggered planting, you can get a staggered harvest. This means planting a few seeds, waiting a few weeks and then planting some more, then waiting another few weeks and planting some more. Because the plants were started at different times, they will ripen at different times too, so you get harvests coming one after another, as many times as you planted – this can go on endlessly if you plan well and have the right conditions.

## ***Perennials***

These are plants and trees that live for many years. Baobab and other huge trees can live thousands of years! Perennials have large, deep root systems and can survive in harsh conditions that annuals would die in, like floods or droughts. Perennials need less maintenance and care than annuals, but they often take longer till harvest time, and they usually only give one harvest in the year, during their proper season – though there are some that can be manipulated to bear more often with extra food and water (irrigation).

Some perennial species are treated as annuals instead of letting them live on, as perennials should do. *Chidede*, peppers, okra, sorghum, pigeon peas and lima beans (*kamumpanda*) are examples; they will grow hardy stems and continue to bear if allowed. When harvest time comes don't rush to cut these plants back and make sure that goats, pigs and cows are well managed so they don't eat them! Let them live and give you food for another season or more, especially the plants that are most healthy and productive.

## **Direct Seed Planting**

When seeds are sown into the place where they will grow into an adult it is called direct planting. This copies Nature, which does not start its seeds in little pots and transplant them into the ground later! Direct planting saves time and energy, and works well for many species and situations. Use direct planting at the right time of the year and provide the right conditions for each species. This will help you get high germination, good survival rates and high yields.

### ***Broadcasting small seeds***

Scattering small seeds like Amaranth, blackjack, *limanda* (vegetable hibiscus), *zumba* (rattle box) or millet, over an area on the soil's surface is called broadcasting and it is very simple. Just lightly toss seeds into the areas where you would like them to grow. Once the seedlings start to grow, the strongest ones will grow the best. To keep the species healthy, make sure each seedling has the space it will need when fully grown. Pull out the smaller ones and use them as mulch, or transplant the healthy ones into another area, or give them away, or feed them to your livestock or yourself!

### ***Large seeds***

Most grains, roots, tubers, beans, nuts, and most perennials have large seeds and can be planted in the place you want them to grow. Some tree seeds survive better when they are raised as seedlings in a nursery and planted out later. The care that you can provide many trees in a nursery is often easier than trying to feed, water and protect young seeds and seedlings that are scattered around a large area. There will be more about seedlings and nurseries shortly.

### ***Hard seeds***

Seeds with very hard coats or shells can germinate more easily if they are cracked a little so that water can get inside, this is called scaring.





In nature these hard coats are broken down by insects, micro-organisms and moisture in the soil, or by passing through the digestive system of an animal or bird.

Copy nature by soaking seeds in room-temperature water for a day, or in hot water for 4 or 5 minutes. Do not cook them though! As the seed soaks, it will shrivel a bit. If they do not shrivel the water has not soaked in enough. Make a little cut or scratch in the seed (on the smooth side, not the side with the 'eye') and soak the seed again.

## **Vegetative Propagation**

Using the plant or tree itself to create a new plant or tree is called vegetative propagation. Sometimes this can happen in natural settings.

### ***Root division***

Some plants grow in clumps like mint, chives and other herb and flower species. Each year the clump gets bigger. Most plants like this are perennial and produce seed but keep growing as well. To use root division to propagate plants carefully loosen the soil around the plant and lift it out of the ground. A garden fork, either a small, handheld one, or a larger one, works well, but even your hands can get the job done in good soil. Gently split the clump of roots into two or more separate plants and re-plant them in the soil in several different areas. Give them a good drink of water when you have finished. Aim to do this type of job when it is cool in the morning or evening. Avoid doing this when the day is at its hottest or the roots will dry out.

### ***Suckers***

Bananas, coco yams and bamboo produce small babies that come up as new plants next to the parent plant. Sometimes there are several 'baby' suckers. They can carefully be separated from the parent and moved to their own space to start their own family. Usually the plants will produce best if there are only a few of their kind together. For example, with a banana the practice is to have an adult bearing fruit, an adolescent and a baby in one location. Once the adult bears their bananas, cut it out and use the banana stem for something creative, allowing the adolescent enough space and nutrients to bear its fruit.

### ***Cuttings and truncheons***

These are commonly used in Malawi. Cuttings and truncheons produce new roots directly from the stem or branch. A cutting is the stem of a plant that is cut into a few centimetres, or half a meter. A truncheon is a thicker, woodier cutting, often from a tree branch and often a metre or more long. Truncheons work well as live poles for fences, animal pens, bathhouses or dish racks.

Remove most of the leaves from the cutting, or truncheon, so that the plant or tree can use most of its energy to make roots (instead of trying to keep leaves alive). Push the bottom end of the cutting, or truncheon, into soft ground or a prepared planting station, water it, leave it alone and it should take root from there.

Several species grow well from stem cuttings and truncheons. jatropha, moringa, mulberry, figs and peach trees can be propagated as truncheons. Cuttings include cassava, sugar cane, sweet potatoes, several flowers, aloe and some hibiscus. In the life cycle of the species there are certain times that are best for taking cuttings, usually when the plant is growing vigorously (growing well and strongly), but each species has its own preference.

### ***Air-layering***

Many perennial plants can be propagated with air layering. This means getting some roots to grow from a branch of the mature plant. The plant or tree continues to provide nourishment to the air-layered branch while it is making the new roots.

Choose a branch of a mature tree or plant. Make some cuts or scratches through the bark / stem on the under-side, where you want roots to grow. Wrap that bit of the branch up with good moist soil held in place with a cloth or clear bag. You will be able to see through the clear plastic when the roots have grown, but only use it if you have plastic that needs to be recycled! Once the roots have developed (you can peek carefully inside, or you might see a root poking out), cut the branch off the tree with its roots and cloth / bag of soil and remove the cloth / bag very gently before planting so that the young roots are not disturbed. Plant into a prepared planting station.

### ***Ground layering***

Plants that have vines or runners can be ground layered. This is when the stem of a growing plant is laid across the soil and soil is put on top. The stem develops new roots under the soil. After the new plant has established itself, cut the stem joining it to the parent plant so that the new roots that developed are part of the new plant, then transplant it to another place. You can do this with many kinds of plants including tomatoes, cape gooseberry and sweet potato vines. Nature will show you other species that can ground layered. If you watch closely you will see plants or trees that start growing this way naturally.

### ***Budding and grafting***

These methods allow a young tree to bear food more quickly by adding a small branch or bud from a mature tree.

- **Budding** takes a bud of new growth from a mature tree and inserts it into a slot cut into the branch of a young tree where it starts to grow.
- **Grafting** is when a stem cut from a mature tree is put onto a young seedling. The stem from the young seedling and also the mature stem are cut at an angle. These cut surfaces are tied tightly together until they join together and start to grow. When they are joined and growing together well, the tie is carefully removed.

The bud or graft from the mature tree is older than the young seedling so it will bear fruit more quickly. Care needs to be taken so that the fruits do not break the young tree. Species in similar families can be mixed together so you can have a citrus tree with different branches bearing oranges, lemons, tangerines and grapefruits. Perfect for a small family! It would not happen in nature, but it works. A local horticulturist, forestry officer or anyone working in a tree nursery will be able to teach you budding and grafting.

## **Nursery Planting**

A nursery is a place where you take care of the young – you can care for young plants, trees, different animals or even humans! Plant and tree nurseries allow you to grow many seedlings from seed and take care of them until they are strong enough to plant out where you want them. It is easier to water and care for seeds and seedlings if they are all in one place. Nurseries are a good idea if you have a large area of land to plant and want to get the species started before it is time to plant them out. A nursery can also help in getting a tree from seed to seedling size during the dry season so that when the rainy season comes it is strong enough survive through the next dry season.

Make sure a nursery is what you need though, because they do require daily care and the plants get a bit of a shock when you move them from their nursery home as a “baby” home to their new “adult” home (plant them out). A small nursery when you are starting out can help you with some species, getting to know the different species, but later you may decide to use more of the direct planting methods.

### ***Choosing a nursery site***

Your nursery should be easy to get to every day, be protected from animals, wind and other things that can harm the young seedlings and close to a water source. The ground should be level so water seeps into the planters evenly and easily. Most seeds and seedlings like to have some shade while they are young. Seeds should have a soft, nutrient-rich soil that it is easy to push new roots through and there is plenty of food for promoting fast growth

### ***Get creative with your planting containers!***

There are so many things that will work as seedling containers that there usually is no need to buy anything. The containers can be:

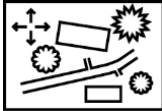
- **Recycled containers:** bags or sacks, basins, bathtubs, buckets or jars. Containers made of natural materials are biodegradable and can be planted out with the seedlings. This disturbs the seedling less and can give extra nutrients to the plant. The shell of a pumpkin works well, even recycled papers, or large tough leaves, like banana or *chikwatu* leaves, can be made into excellent natural planters. Use natural fibres like sisal to tie the leaves together.
- **No container:** some seeds can be started directly in a bed or a planting station. For some plants, like leafy vegetables, you can put several seeds in one container, or no container just in a portion of a planting bed to get them started. When the seeds have sprouted and have a few leaves each you separate them gently for transplanting, pulling out any weak seedlings. This is called ‘thinning’ out the seedlings. But other plants, especially tree seedlings, prefer to have their own space for root development while they start growing.

### ***Caring for the young seeds and seedlings***

- **Small seeds need very gentle frequent watering** to keep the soil moist around the seed and protect the seeds from damage. As the seedlings grow and develop roots, watering should still be gentle, but will become longer so water reaches the deepest roots. Watering can take place less often as growth continues.
- **Plants and trees with deep roots should be in tall containers.** If the roots start coming out of the bottom of the container trim them off with a knife (if the seedling is not ready to be planted out yet) or move the pots every few days so that the roots do not grow into the ground while still in the nursery. Some people prefer to create their nursery on a raised shelf so that the roots don’t grow into the ground.

### ***Planting out***

After a few weeks, when seedlings have 2-3 sets of healthy leaves, they are ready to be transplanted (planted out) to their final destination. Trees take longer to grow strong enough for transplanting, usually a few months. Young trees need protection from roaming animals and may need watering and care before they can take care of themselves. There will be more information about transplanting and care in the next section.

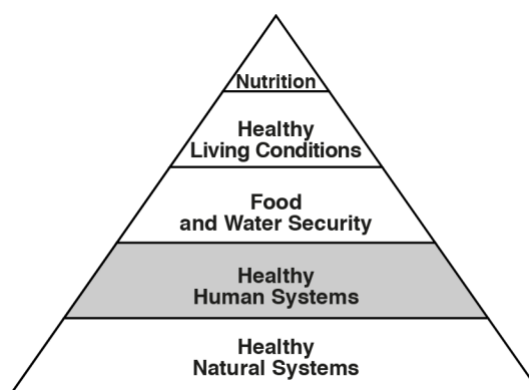


What methods do you use to propagate your plants and trees at the moment? Where on your map might be a good place to start your own nursery for raising small seedlings from seed?

## Topic 28: **Animals in Guilds**

Animals are important in eco-systems, sustainable agricultural systems and food systems.

Animals support many of the guild functions and are an important part of an integrated guild system of plants, trees, animals, humans and infrastructure.



- **Human needs** provided by animals: Food (meat, milk, cheese, eggs, fat, honey, etc.). Company and entertainment (pets like dogs, cats or fish in tanks). Clothing and raw materials (leather, fur and wool). Money: Tourism is dependent on the beautiful, wild, natural landscape we have and the animals that live here. (It is a growing industry in Malawi.)
- **Soil fertility** is helped by manure, urine, fur, feathers, bones, etc.
- **Diggers:** Many animals and insects are diggers naturally, helping keep the soil in good condition. Working animals can be trained to till the soil, pull carts or be used in other ways.
- **Protectors:** Insects usually do pollination and many animals help to spread seeds. Protection can be provided by animals, especially guard dogs. Dogs can be trained to guide the blind or rescue people.

**Malawi is rich in animal life:** birds, mice, porcupine, wild pig, antelope, buffalo, hippopotamus, caterpillars, crickets, grasshoppers, lake flies, termites, bees, fish, chickens, ducks, guinea fowl, pigeons, guinea pigs, rabbits, goats, pigs, sheep and cows, to name but a very few of them! The list goes on and on. Some of these are wild animals, some are domesticated and many can be both, such as bees and fish.

Think for a moment about which animals are important to you and how you use them in your life. Which of the animals listed above would you eat? Which would you avoid eating? Why? In Asia people eat spiders and snakes, in Europe and West Africa they eat snails and frogs. In some countries horses, dogs, cats, turtles, eels, and crabs are all part of a normal diet. Whether an animal is thought of as food, or not, is usually more of a cultural habit than a reflection of how edible the animal is.

### **Wild Harvests**

Some of the wild animals and their products listed (bees, fish, pigs, rabbits, guinea fowl, birds) could provide a larger part of our diets if more sustainable systems that encourage them were designed.

The numbers of wild animal populations in Malawi are going down fast. Some of the causes include loss of habitat due to the spread of human settlements, mono-cropping, de-forestation, careless and unnecessary use of chemicals (this is especially bad for bees) and un-managed hunting and fishing (poaching). These things reduce animal populations dramatically. There are laws in place to protect wild animals but if people do not respect them, or if they are not enforced, then they do no good. Big reductions in the numbers of bees, fish and birds are a matter of concern, but solutions exist and you are part of the solution!

Wild animals must have healthy, diverse natural environments, free of poisons and toxins. Our designs for sustainable living can make certain we provide these environments. Many communities now have natural resource management committees or environmental clubs to help their community understand the importance of wild areas and wildlife.

## **Domesticated Animals**

Animals that are tamed, bred and cared for by humans are called domesticated animals. Humans have bred the animals to have the qualities they want, like high milk production, fast growth, large size, etc. These animals often cannot live in the wild because they have lost the skills and strengths needed for survival in the wild and they are dependent on humans.

### ***Benefits of domesticated animals***

Having domesticated animals has many benefits for humans:

- **Time is saved**, as you do not have to go into the wild, hunting animals for meat, milk, honey, hides or feathers.
- **Manure is easy to collect** if animals live in well-designed pens where manure is all in one area or designed to fall right where it is needed. Animal manure is a superb fuel for a bio-gas system, giving gas for domestic use and fertilizer for the garden.
- **Animals can provide so much:** protection, company, entertainment, transport and warmth. People who live in cooler places or have a cold side of their home can design carefully to use the warmth of animals living right next to them to keep their houses warmer.

We will look at these common groups of domesticated animals: poultry, mammals, bees and fish to see what we need to do for each of them and what they can supply for us in return.



## **Poultry**

### ***Poultry needs:***

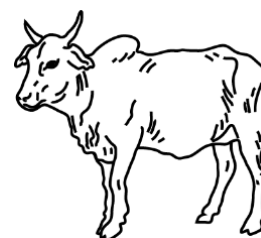
- **Shelter** is needed to protect chickens, ducks, guinea fowl and pigeons from predators such as cats, dogs, birds and other animals, including humans. Most poultry like to roost on tree branches or bars and to lay their eggs in a nest so these spaces should be designed into their shelter.
- **Diet** of insects, plants and kitchen scraps are common poultry food. Chickens and some other birds like to find their food by scratching around. Giving them some fresh food scraps from the kitchen attracts insects, which the poultry can also eat. Having a movable chicken shelter (see page 38) helps an area grow again, after chickens have been eating there a while, because their manure will enrich the soil.
- **Fresh water** is needed every day for all types of birds to stay alive. Ducks need more water to have enough to swim and bathe.
- **Health:** Diseases can be spread easily through poultry, especially if they are raised in unhealthy conditions (overcrowding, inadequate food and water). Some plants, like aloe, mixed in with food or water provide extra health protection (although be sure to give them healthy living conditions as well!). Chickens keep themselves clean in dust baths; ducks take water baths. Be sure that the species you are raising have what they need for their health.

### ***Poultry provides:***

- **Male birds and older females are food eventually**, but get the birds to do as much as possible before they go in the cooking pot!
- **Eggs are usually the reason people raise poultry.** A few chickens can provide a few eggs every day if you plan well and care for them properly. Raising different species of poultry means there is less risk of failure, or illness and can give a staggered harvest of eggs. Different species will also provide a variety of different egg colours, sizes, flavours and different nutrients.
- **Feathers can be used for warmth** and comfort (pillows, duvets etc.) and can be used creatively in decorations. Feathers add nutrients to the soil if they are composted.
- **Manure and urine adds nitrogen** to mulches or compost heaps. Design poultry houses with small gaps in the floor so it is easy to collect the manure. Build duck houses over ponds with small gaps so the manure falls straight into the water (see page 39).
- **Protection:** Poultry will eat insects and pests that might attack plants, but they can also damage small seeds and seedlings, so build simple moveable pens to keep chickens where they will help you. Your poultry can help keep the soil, plants and trees healthy. Some birds, especially geese and guinea fowl, are excellent guards; they signal when any unknown human, or other animal, (hawk, snake, dog, etc.) is in the area, by making a lot of noise to get your attention.

## **Mammals**

Mammals are animals that feed their young with milk, like cows, goats, sheep, pigs, rabbits, guinea pigs, etc.



### ***Mammals need:***

- **Shelter and protection:** Letting animals wander around, fending for themselves does not provide them with the care they need. We must protect them from predators, thieves and vehicles, and also protect ourselves from their manure and urine being in the wrong place (such as our water sources). Animals also need a bit of shade, especially in the hottest part of the day. Larger mammals (like cows, goats, sheep and pigs) need more space and do well in larger fenced areas. Smaller animals like rabbits and guinea pigs can be raised in pens and mobile tractors (page 38). They all need a comfortable, clean place for sleeping, and breeding.
- **Food and Water:** Bigger animals need more food and water than smaller animals. Goats and pigs eat just about anything. Cows and sheep prefer grasses and can be particular about which grasses. For the best milk and meat you must learn the nutrient and / or food needs for the types of animals you have.
- **Health:** Mammals are prone to disease when they are not well cared for. Pigs have very special health needs and are often stall-fed and cared for even more carefully than other mammals.

### ***Mammals provide:***

- **Meat** is a high protein food, as well as providing B vitamins, iron and fats. Before you slaughter your animals, try to get the most out of your animal by using its milk, manure, warmth and other useful qualities or products of its behaviour.
- **Milk:** All mammals produce milk. Malawians mostly use cows for milk although some people use goats' milk. Sheep and camels are milked in some other countries. Each species makes the perfect milk for its young if the mother has received the right food, water and care. When humans bottle-feed human babies with artificial milk it deprives them of important health benefits that only come from human milk. But, in some rare cases, artificial milk is the best choice. Human babies are designed to have only human breast-milk for the first 6 months of their lives. They should continue to have human milk for about 2 years, while increasing their consumption of other foods. More people are starting to understand how important their own species' milk is for young mammals, whether humans or other animals.
- **Manure** is easy to collect if moveable pens or fencing are used, or by keeping the animals tethered. After the animals are moved to a new area, crops can be grown where the manure has gathered. When the crops are harvested, the animals can go back to that area (Topic 21). Smaller animals can be kept in raised pens so the manure can fall through and be collected regularly.
- **Raw materials** like hides, bones and horns are valuable and useful. They can be made into drums, bags, clothes, shoes, jewellery, ornaments, etc. Good quality items can be sold for extra income. Lower quality materials can be returned to the soil.
- **Skills:** Milking, butchering, tanning, etc. are skills that you'll want to learn if you are to reap the most benefits from your animals.



## **Bees**

### ***Bees need:***

- **Home:** Bees need a beehive. If the entrance to the hive faces east it helps attract bees to live there. The hive needs to be designed so that the bees can create honeycombs easily – many hives are designed with bars. Putting beeswax and herbs in the hive to also help attract them.
- **Protection:** Bees need protection from ants and other insects, from smoke, fire, water and chemicals. The hive needs to keep rain out. Hives are often tied up between two trees to keep them off the ground. Putting cooking oil or grease on the wires helps keep ants out. Keep grass and plants nearby trimmed low enough so ants do not crawl up into the hive and steal the honey. Teach others to understand how chemicals, smoke and fire threaten bees.
- **Food:** For the best honey harvest, bees need a diverse diet of different flowers and water, all year long. Keeping bees where you have ponds, gardens and orchards works well for both the bees and the plants that need the pollination.
- **Equipment:** You will need protective clothing (gloves, and a bee suit), a smoker for calming the bees when you harvest the honey, and clean buckets, strainers and storage containers. Water, hygiene and sanitation are all very important for processing.



### ***Bees provide:***

- **Honey** can usually be harvested 3 times a year. Depending on the size and health of the hive, a harvest can be up to 10 - 20 litres of honey each time.
- **Beeswax** has many uses: for candles, beauty creams, wood polish, etc.
- **Pollination** is a very important function of bees. It is important in gardens, orchards, farms and forests – everywhere in the world.
- **Manure** of bees is too small to collect but it still adds fertility to the soil in the area where you keep the hive.
- **Protection: Bees can sting!** Bee stings hurt and some people react badly to a bee sting (they are allergic to it). Putting a beehive in an area you do not want people to go to can help protect that area. Think hard and do not put your hives in areas that will bother your community. Bees are not just for the countryside but can be kept in urban areas, too, without any problem. Help your community to understand about bees and what they do for us.

## **Fish**



### ***Fishes need:***

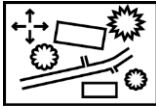
- **Pond:** All fish have to have water. Clean water in ponds must circulate or have movement and flow to get air and oxygen into the water. If ponds are stagnant (still water) most fish will start dying, although some species, like catfish, survive in very small amounts of water. Ponds over 1 metre deep and full of plant and animal life generally circulate enough on their own, just by the activity of the life in them. Smaller ponds often need a pump to move the water around.
- **Food:** Fish feed on a variety of different plants and animals. Animal manure, added to the water, helps feed the fish but too much would destroy the natural balance.
- **Equipment:** Fish can be harvested to eat with a hook and bait on a line, with nets, or by draining the pond and refilling it, depending on your situation and the kind of fish in there.

### ***Fishes provide:***

- **Food:** Fish are a very nutritious food, high in proteins, B vitamins and minerals. Most fish are low fat but a few are rich in a very healthy kind of fat.
- **Nutrient-rich pond water** is great for watering plants or for raising other animals. Bees, birds, frogs and other animals thrive in areas where there are ponds.
- **Protection:** Many fish eat insects and larvae, helping to control insect populations. Birds and frogs are also attracted to ponds to eat insects.

## **Any animal can be a useful part of your guild!**

Design your guilds well and put the right species in the right space so they can get what they need while providing for you at the same time. There are different types of guilds for different places, from highly cared for areas to very wild areas, which we will look at in the next topic on Zones.



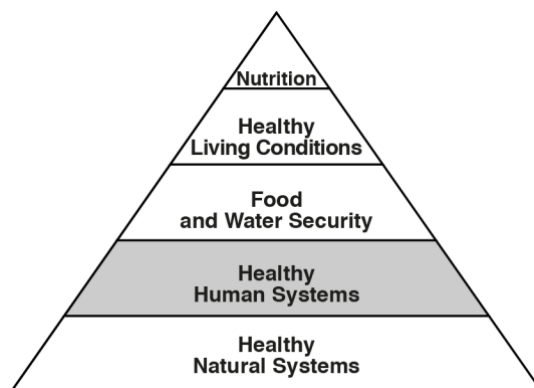
Add to your map any animal pens that already exist. If there are no pens think about where a pen for large animals (or small animals) could be sited. Where could a beehive or a pond be sited? Where could you keep goats or rabbits?

## Topic 29: Zones in Permaculture

Towns and cities are usually planned and arranged with different areas for different purposes. These areas are called zones or referred to as zoning. There are zones for houses, factories, leisure, shopping and so on.

Permaculture also uses zones to organise areas. Permaculture zones help you make the best use of the resources available.

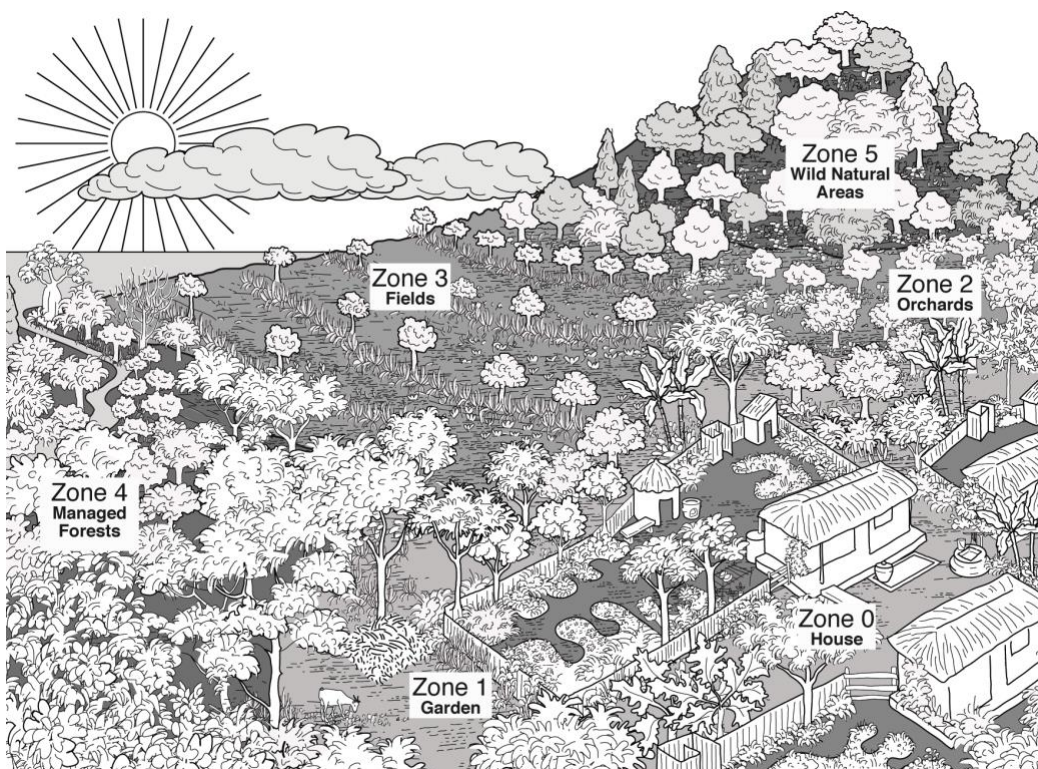
Permaculture Ethics and Principles are applied to the process of zoning so that the decisions made help care for the Earth, for the people, and promote sharing the resources fairly. It would be wonderful if town and city planners thought about these things when they are zoning!



Permaculture zones are based on natural features of the area and how often humans need to care for an area or visit it to collect resources from it. Zoning helps us to use areas efficiently and zones can evolve over time. There are 6 zones in Permaculture, which we will apply to your design for Sustainable Nutrition in Part 3 of the manual.

- **Zone 0** Buildings
- **Zone 1** Gardens
- **Zone 2** Orchards
- **Zone 3** Fields
- **Zone 4** Managed Forests
- **Zone 5** Wild Natural Areas

This image shows the edge of a small village. This community has lots of space and they are able to be near to all 6 of the Zones. Most villages in Malawi are not so lucky and they have to walk long distances to collect forest products from community-shared Zones 4 and 5. This is only one example, typical to a rural area in Malawi – Zoning can be applied to schools, offices, towns and nations and should include all infra-structure such as roads, bridges, buildings water tanks, etc.



- **Zone 0 – Buildings** in the community. The roofs of the houses overhanging on the East and West sides to protect the house from hot sun and heavy rains and are designed to guide water to where it can be used. Zone 0 could also be a borehole with a Zone 1 or Zone 2 at the end.
- **Zone 1 – Gardens** are near almost every Zone 0 with garden guilds dotted around areas where it is easy to provide daily care and watering and to harvest for daily use. The gardens are integrated with plants, trees and animals.
- **Zone 2 – Orchards** are between the homes in the village and around the edge of the village. They help provide protection from wind for the gardens and houses and areas for a medium sized animals.
- **Zone 3 – Fields** are on the lowest part of the hill, before the slope becomes too steep to farm. It is fairly easy to get to this area here so soil can be fed (with mulch and compost) all year and animals can be managed, such as a rotation of grazing to assist both the animal's nutrition and the soil's fertility. Strips of perennials are used at intervals to help prevent soil loss and to increase bio-diversity.
- **Zone 4 – Managed Forests** are encouraged and planted along the river to protect and preserve the riverbank. This zone is visited about once a month to look after the trees, bees and grazing animals that thrive there, and to collect food or other forest products. The first 20-50 metres along river banks are also ideal for zone 5 to reduce human disturbance in the area.
- **Zone 5 – Wild Natural Areas** are on the steep part of the hill because it is the hardest to get to, would take more energy to maintain than the other areas and would be likely to harm the area if it were disturbed. Zone 5 is protecting the hill and all the land below it. The natural eco-system with varied tree and plant cover and natural wildlife, helps the water soak into the soil to support life in the other zones.

## **Zone 0: Buildings**

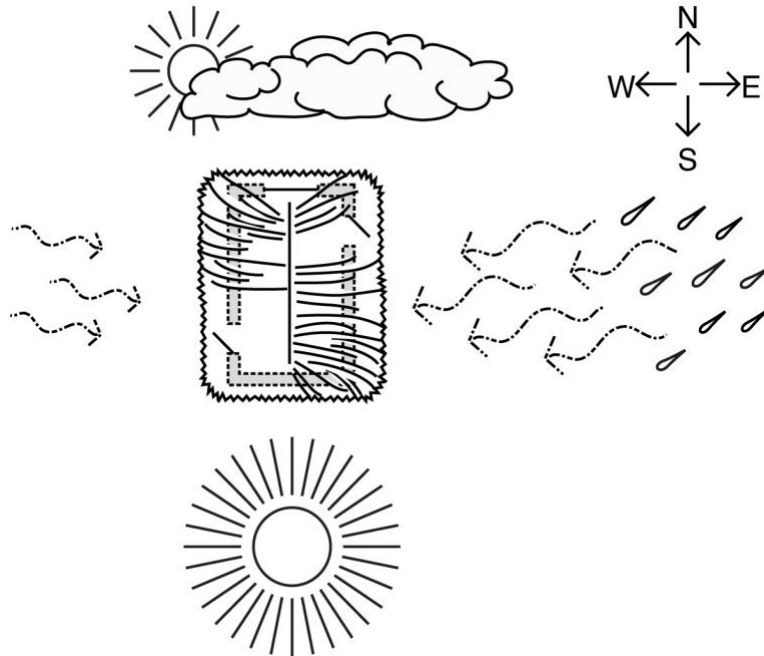
This zone includes structures that have been made by people: roads, buildings, wells, boreholes, latrines, etc. Earlier in the manual we looked at a lot of improvements that can be made in the house and kitchen. Perhaps changes have already begun to your diet, food preparation, hygiene, water purification, fuel-efficient cooking, etc. but if a new house is going to be built it is good idea to consider the following points, or you can adapt and improve your current house with these considerations:

### ***House design and location***

Everyone wants a home that is warm during cool weather and cool when it is hot outside. Can you design your buildings so that this happens? Think about these things:

- **Slopes and hills** - Would it be better to build your house up on a gentle slope, in a bit of a dip, or a flat area? Is there a lovely view if you look in a particular direction?
- **Water sources** - How can you make use of any water sources? Do you need to be near a water source or can you make better use of rainfall than you do now?
- **Paths and roads** - If you build near a busy road there will be noise from people and traffic passing by. Do you want a quiet house or one with more activity going on around? Do you want to be able sell things by the roadside near your house or do you want somewhere quiet to study and rest when the day's work is done?

- **Wind and rain** - Do you want shelter from wind and rain? How can you avoid water erosion damaging your building's foundations? Nobody wants a building that floods in the rains or has wind blowing through in the cool season.
- **Sun and shade** - Where does the sunlight fall in different seasons? Where are there areas of shade? Can you make use of hot spots or shady areas?



This drawing shows a house situated to take advantage of the weather and the climate in its area. In much of Malawi most of the “weather” comes from the East.

**North facing walls get the sun in the cold season** (June–September). Large windows let light and heat in for warmth. Grow short plants this side so you do not shade the house too much here.

**South facing walls get the sun in the hot season** (October-May). Small windows let in some light but not too much heat. If it is really hot in your area, do not put any windows on that side. Shade windows with climbing plants or a tree. If you want the light, but not sunshine, add a window that has a small roof to shade it.

**East facing walls get the morning sun, afternoon shade** and (in many areas of the Malawi) most of the wind and rain. An over-hanging roof on the East wall can help to protect walls, windows and vents from the rain while allowing the air to flow through your home. Some areas in Malawi have such strong wind, rain and / or sun from the east that it could be better to keep those sides solid / closed.

**West facing walls get morning shade, evening sun and occasional winds and rain.** Have an over-hanging roof on this side too, to protect the building, and include open vents or windows that help air to flow through the building.

## **Zone 1: Gardens**

Zone 1 Garden is where you put things that are high maintenance and that need care and attention every day. There are often annuals, but having some perennials helps reduce maintenance and protect the area. Zone 1 is usually fenced, but doesn't have to be if animals are well managed. Any food group can fit in this area.



- You can water things with grey water and care for the area every day with mulching or compost or other soil food
- You can easily harvest foods every day
- This zone should be designed to use the other things in the area (zone 0 walls, trees, living poles, etc.)
- Zone 1 will need organic matter (kitchen scraps) from zone 0 (the house) and will use fertilizer from composting toilets, urinal and a worm farm
- Solar dryers, solar cookers and a fuel-efficient stove will save you time and money
- Small animals can provide meat, eggs, manure and other products
- The beds for growing foods can be built with curved or straight edges
- Pathways in and around zone 1 should be clearly marked so that people stay on the paths

## Zone 2: Orchards

Zone 2 Orchards have lower maintenance species and needs attention about once a week. You will probably use these resources weekly too.

The area usually relies on natural weather patterns, but some deep irrigation may be done from time to time.

The area can use run-off from boreholes, wells, roads, paths, buildings or slopes. Small animals can be integrated to help provide fertility, pest management and all the other services discussed earlier.

In the dry season the area is semi-forested, with heavy mulch and in the rainy season, the space between the trees fills up with annuals.



These pictures show zone 2 in the dry and rainy seasons.



## **Zone 3: Fields**

Zone 3 Fields are visited seasonally with maintenance once or twice a month. This area is dependent on the natural weather patterns and climate. Zone 3 could also be in a marshy area, if designed carefully so as not to harm the wetland.

Zone 3 supports mostly annuals, with perennial plants in hedgerows, swales, strips, or dotted throughout the beds. It is well mulched with permanent pathways, but as few as possible – just enough for access.

Diverse planting and integration of animals means that there will always be some foods that do well, at all times of the year. Include agroforestry species, animals, and legumes with other hardy annuals to benefit the soil. Plant windbreaks to protect the area along with heavy mulching, and make and use compost. Tether your grazing animals here, or use a moveable fence, to help keep the soil fertile without damaging what you have planted.



These pictures show Zone 3 in the dry and rainy seasons.





## **Zone 4: Managed Forests**

Zone 4 Managed forests are visited seasonally. These areas are dependant on local weather and climate. There should be very little soil disturbance here and the area is always well covered by Nature.

Riverbanks benefit if designed as zone 4 (or 5) but they should never be designed as zones 1, 2, or 3, as the soil in riverside areas should not be disturbed.

Zone 4 has mostly perennial species used for building, fuel, hardy fruits, nuts, oils and medicines. There will be some naturally reproducing (wild) annual plants too. The area is good for grazing animals and keeping bees.



These pictures show zone 4 in the dry and rainy seasons.



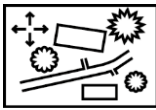
## **Zone 5: Wild Natural Areas**

Zone 5 Wild Natural Areas are usually furthest away from the home and are managed entirely by the Nature Cycle. Animals, plants and trees thrive on their own in a healthy zone 5, with very little interference from people. Hunting and gathering may be allowed, depending on the local rules and laws.

The only human activities should be to preserve, protect and restore these areas where needed to prevent erosion, to restore indigenous wildlife and to promote biodiversity through education and advocacy. These areas are often managed jointly as opposed to by one individual.



Look around the area where you live. What zones are clear already? What areas could be changed?



Look at your map and see where you might put your different zones. Do not draw anything new yet; just be thinking about which zones might go where in your area.

## **Congratulations! On to Part 3!**

Now you have learned about your bodies and what they need, and you have learned about the environment and what it needs. The next part of the manual is about designing your plan for Sustainable Nutrition. This means taking everything you have learned and using it to re-design your area so that life improves for you, for your family and everyone in your community.

## Glossary for Part 2

### **Absorption**

To take in liquid and nutrients. Plants absorb water and nutrients through their roots. Humans and other animals absorb nutrients through their intestines. Soil absorbs water when it soaks in, 56

### **A-Frame**

A simple device that helps mark level contour lines on a slope, 73

### **Agroforestry**

The use of trees to benefit agricultural systems., 123

### **Air-layering**

A method of propagation in which damp soil is tied around a branch of a plant or tree with a cloth or bag until the roots begin to grow, 108

### **Animal pens**

Moveable cages or fences that manage animals and allow easy use of manure, 38

### **Annual**

A plant that lives for only one season or one year, 106

### **Arbor loo**

A composting toilet where a tree is planted in a toilet pit that has been filled, and a new pit is dug to use the manure, 51

### **Artesian well**

A hole drilled deeply that reaches water naturally under pressure which rises to the top, 85

### **Bed**

An area of ground that is prepared for growing plants in, 78

### **Black water**

Dirty water from toilets and sewers containing human manure, 70

### **Broadcasting**

Scattering seeds on the ground where you want them to grow, 107

### **Budding**

Taking a bud from a mature tree and getting it to grow on a young tree, 109

### **By-product**

something that is made as part of the process of making something else, 32

### **Calcium**

A soil nutrient that is important in joining a plant's cells together. It works in the human body to make bones and teeth strong, 30

### **Carbon dioxide**

A poisonous gas that is believed to be the cause of climate warming, 6

### **Climate Change**

Changes to weather systems around the world as a result of global warming, 7

### **Climbers**

Any plant that can be used in a guild to climb vertically and maximize production, 91

### **Compost**

Food for the Soil made from diverse organic materials, rotted down, 43

### **Contour lines**

Level lines going across a slope or around a hillside used for planting along to conserve soil. Contour lines are also used to describe hills and slopes on map, 30

### **Contour planting**

Planting in lines across a slope or around the hillside to prevent and repair soil erosion, 26

### **Cover-cropping**

A crop that is planted to protect the soil from erosion and to improve soil structure and fertility, 35

**Crop rotation**

System of planting where different crops are grown one after another in the same space. Leaf or grain, then fruit, then root, then legume, is a good system to follow, 34

**Cutting**

A short length of stem that is cut from a mature plant or tree and used to propagate another plant or tree, 108

**Decay**

The process by which dead organic matter rots down and decomposes so the nutrients return into the soil, 3

**Diggers**

Any plant, animal, or insect that can be used in a guild to dig into the soil and open up pathways for air and water to penetrate deep down, 91

**Drought**

Times when there is not enough water, or when the rains don't come, 20

**Erosion**

When soil and soil nutrients are carried away by water, wind, sweeping etc., 25

**Extinct**

When no living specimens of a particular species exist any longer (because they have all died or been killed) that species is extinct, 87

**Fallow**

Letting an area of land rest for a season or more, without growing crops there, 44

**Fertile**

Containing sufficient nutrients for reproduction, 16

**Filtration**

The process of removing dirt from water by pouring slowly through rocks and soil removing the impurities, 56

**Fish ponds**

Ponds work well in permaculture system, especially if the right animals are around too, like ducks, frogs, rabbits etc., 39

**Flooding**

When there is too much water in the wrong place, like a river with burst banks, 20

**Fossa alterna**

A composting toilet system that uses two shallow pits alternately, 51

**Genes**

These are the instructions for the cells in living organisms that decide what that living thing is going to be like, 102

**Genetically Modified Organisms**

Plants and animals that have had their genes changed by humans to give certain characteristics. A GMO is completely new type of organism produced by changing the organism's basic genetic structure, 102

**Germinate**

This is when a seed begins to grow and sprout, 106

**Global warming**

Increase in the temperature of the earth's atmosphere due to increased levels of carbon dioxide, and other pollutants in the atmosphere, 7

**Grafting**

To attach a growing shoot to another plant or tree through a small incision or cut, 109

**Green manure**

Nutritious, green, plant material is allowed to grow for a while then cut and left to decompose into the soil, adding nutrients and improving soil fertility, 34

**Grey water**

Water that has been used once, for washing or cleaning jobs, but can still be used for watering plants and trees, 63

**Ground layered**

Propagation technique where a stem from a growing plant starts new roots and becomes an independent plant, 109

**Guano**

Bat or bird manure, which is very nutritious for the soil, 41

**Guild**

A group of plants, animals and / or structures working together and helping each other to thrive, 90

**Guild functions**

The six things plants can assist with in guilds are human needs, soil food, soil cover, diggers, climbers, supporters and protectors, 90

**Habitat**

The environment an animal or plant lives in, 87

**Heirloom varieties**

Native and indigenous plants, well adapted to their habitats by developing over generations. Seeds are open-pollinated and will continue to adapt naturally), 102

**Humus**

The organic matter that is in the top layer of soil, that provides many nutrients for the soil and plants, 44

**Hybrid**

Plants that have been cross-bred by humans in a way that wouldn't happen naturally. The offspring that results from the breeding of two different varieties of plants or animals is a hybrid, 102

**Hybrid vigour**

Cross-bred plants or animals have qualities that don't get passed on to their offspring. The first generation of a hybrid (plant or animal) grows

stronger than the parent but this strength does not continue with further generation, 103

**Income Generating Products**

Things you can do or make to earn extra money, 12

**Inputs**

Something put into a system to achieve a result or output, may be purchased or free. Money and effort are inputs, so is time and the weather, 3

**Inter-planting**

Growing a variety of plants and / or trees together that support, or complement, each other, 34

**Irrigate**

To supply water to plants or animals, 77

**Legumes**

Any pod-bearing plant or tree that is capable of fixing nitrogen (beans, peas etc.), 34

**Loveable loo**

A simple composting toilet system, using not much more than a bucket and a compost heap, 49

**Magnesium**

A soil nutrient that is important in making the pigment chlorophyll that makes plants green in colour, 30

**Mammals**

Animals that feed their young with milk, 114

**Marking contour lines**

Working out where to put swales on a slope to effectively repair and prevent soil erosion, 73

**Micro-climates**

Small areas within a larger area that have different climates to the area in general, 91

**Micro-organisms**

Living things so small they can only be seen with a microscope, 3

**Mineral salts**

Concentration of minerals near the top of the soil instead of distributed underground, 80

**Mulch**

A protective layer of organic matter or small stones that is laid on the ground and around plants to help protect the soil, feed the soil, and conserve water, 19

**Nitrogen-fixing**

The ability of leguminous plants and trees to take nitrogen from the air and convert it to a form that is usable in the soil for plant and tree growth, 31

**Nutrient accumulators**

Plants that collect many nutrients in their leaves and stems, that can be used to feed the soil when they are cut and allowed to rot down, 35

**Open-Pollinated Varieties**

Seeds that can breed naturally with their own species and with varieties of that species, 102

**Organic**

Derived from living organisms (made of plant or animal matter). It also means products that have no chemical additives. Organic farming does not use artificial fertilizer, or pesticides, 3

**Output**

Anything produced by a system, as a result of putting inputs in to the system. Outputs can be many things, from useful products to harmful pollution, 11

**Perennials**

Plants that keep growing year after years, like trees, shrubs and some vines, 26

**Permaculture**

A combination of the words 'permanent' and 'culture', a process of developing sustainable systems for all human needs', 9

**Permaculture Ethics**

Caring for the Earth, caring for its people and sharing resources fairly for everyone, 9

**Permaculture Principles**

Guides for living sustainably, 9

**Permaculture zones**

A way of organising different areas in a landscape according to how much humans work there, how often they use that area and what they use it for, 118

**Pests**

An animal or insect that is out of balance and causing a problem, 91

Planting stations

Sites prepared for planting single seedlings or trees, 78

**Plarn**

Plastic yarn, is made from 'waste' plastic bags being re-used as a fibre for knitting, weaving or crochet, 13

**Pollinate**

The process by which the seeds of a plant are fertilised. Often this is done by insects, birds or animals, 86

**Pollination**

To transfer pollen from a plant or flower in the process of reproduction, 116

**Potassium**

A soil nutrient that is important in a plant's fruit development and in increasing pest and disease resistance, 30

**Predators**

An animal or organism that lives by killing and eating others, 91

**Propagation**

The various different ways that new young plants and trees can be made from mature plants and trees, including seeds, cuttings, budding, grafting, etc., 106

**Protectors**

Any part of a guild (plant, animal, insect, structure, etc.) that helps to protect the other parts, 91

**Rainwater calculations**

A simple sum to work out how much rain falls on a certain area, so you can plan water conservation make the most of it, 64

**Resource**

Anything that can be used productively. Raw materials are resources and may be sustainable or non sustainable. Food, water and air are resources. So are energy, time and creativity, 5

**Root division**

Dividing a large single plant and its roots to make several smaller plants, 108

**Rope and washer pump**

A pump to raise water, made of washers, attached to a rope, pulled through a water pipe, 83

**Run-off**

Any water that should be absorbed by the soil but is not, instead traveling across the surface, generally taking soil and nutrients with it, 65

**San-plat**

Sanitation Platform covering a pit latrine, 51

**Selective breeding**

Choosing which plants or animals you breed from to promote particular qualities in the offspring, 102

**Silt**

Grains of sand, clay, and soil that are a result of soil erosion, which settle on the bottoms of oceans, lakes, streams, etc., 19

**Sky loo**

A composting toilet system that is built above ground, not dug into it, 51

**Soil**

The layer of the Earth's surface that plants and trees grow in, made from minerals, organic matter and micro-organisms, 16

**Solar pump**

A device made to harness sunlight and convert it into electricity for pumping water, 84

**Species**

A group of living things similar to each other that can breed together, 86

**Stacking**

Growing plants and trees at different heights, as in the natural world, 94

**Staggered harvests**

When crops can be harvested one after another, not all at the same time, 24

**Staggered planting**

Sowing seeds in batches every few days or weeks (depending on the species) so you can have repeat harvests, 106

**Suckers**

Young shoots growing from the stem of a parent plant that can be transplanted, 108

**Sulphur**

A soil nutrient that works with magnesium to make chlorophyll and protein in plants, 30

**Supporters**

Any plant, tree or structure that can be used in a guild to support other plants such as climbers, 91

Sustainable systems

These are cycles that can keep going for ever, 2

**Swale**

A permanent trench and ridge going across or around a slope following the contour. It is planted with perennial plants to protect soil from erosion and to improve water management , 62

**Terraces**

Flat ledges that are made along the contour of a hill to prevent soil erosion and water run-off, 26

**The Nature Cycle**

The cycle of living and dying that sustains all life, 2

**Thinning**

Removing some live plants or shoots to improve the growth and production of the others', 110

**Three bin System**

A way to organise and use the compost produced by a composting toilet, 50

**Transpiration**

Water moving from inside the leaves of trees and plants into the air and the sky. This is an important part of the Water Cycle, 56

**Transplant**

To gently uproot a plant or tree to re-plant it in a different area, 107

**Treadle pump**

Simple mechanical pump for raising water, powered by humans working the pump with their legs, 84

**Trimming**

To remove small pieces of plants by cutting, clipping or pruning, 20

**Truncheon**

A branch cut from a mature tree or plant and used to propagate another tree or plant, 108

**Tuber**

The thick underground root of a plant (such as a potato), sometimes edible and often a good source of carbohydrates, 91

**Vegetative**

Relating to plants or plant growth, 108

**Vegetative propagation**

Making new young plants from the mature plants, 108

**Water**

The liquid of rivers, oceans, rain and our blood. Water is a vital nutrient, 54

**Water Cycle**

The constant return of water to the atmosphere through evaporation and transpiration and then back to the soil as rain. This is how the Natural World recycles all water, endlessly and for ever, 55

**Water divining**

Finding water stored underground by various means, 82

**Water table**

The highest level of saturated (wet) soil in the ground, 59

**Weed**

A good plant in the wrong place, or a plant with benefits that you don't know yet. All weeds are very useful plants if you know what to do with them!, 93

**Wilting**

Drooping leaves often from dehydration (lack of water), illness, dying or heat, 76

**Wind pump**

A pump to harness the power of the wind which can be turned into electricity or used to raise water, 84

**Windbreak**

A hedge, living fence, or row of trees used to slow down the wind, to protect plants and land from wind erosion and damage, 27

**Worm farm**

A container that provides ideal conditions for worms to turn organic matter into rich soil and liquid manure, 40

**Zones**

Ways of organising areas of land according to their purpose. See Permaculture Zones, 118









# 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.

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