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LEARNER GUIDE

Sustainable Farming Practices

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INTRODUCTION

Welcome to Learning Unit: Sustainable Farming Practices of the Further Education and Training National Certificate in Mixed Farming Systems. This is an NQF registered qualification 48977 level 2. This qualification is for any individual who is, or wishes to be involved in the Agricultural industry and serves to support and advance the functioning of individuals in this industry – specifically for the following occupations:

- Farmers
- Farm managers

CHAPTER 1

NATURAL RESOURCES AND FARM LAYOUT

In this chapter we explore the following:

- Factors effecting farm layout
- Natural resources on the farm
- Landscape and topography
- Waste and pollution
- Energy
- Carbon

FACTORS EFFECTING FARM LAYOUT

INTRODUCTION

The layout of infrastructure on a farm is determined by:

- The natural resources available on the farm

Climate (rainfall, temperature, daylight hours, wind)

Soil (determines the growing capacity and vegetation type)

Indigenous vegetation (specifically for grazing purposes)

Landscape and topography

Decisions will be influenced by already existing resources.

- What will the farm's main income source be – the forms of production (crops, animals, etc?)

Once we know what we are going to do we have to decide and find out:

- What is needed in order to achieve the forms of production (services, inputs, storage, irrigation)
- Getting the produce or products off the site and also bringing in what is needed to achieve production (access/transport),
- Using the outputs of the farming activities appropriately (waste water).
- Ensure that farming activities are not negatively impacted by, nor have a negative impact on anyone or anything outside of the farm's borders (buffer zones, windbreaks, firebreaks).

THE NATURAL RESOURCES AVAILABLE ON THE FARM

Through understanding how delicate our world is and realising the importance of harmony and balance, we can learn to maintain all resources on earth and live in a healthy and better world. Sustainable farming practices are achieved through greater understanding, and through the implementation of good farming practices.

LOCAL NATURAL RESOURCES

Definition:

Resources - A resource is a natural or man-made element, which can be utilised to meet human needs.

Renewable resources - Renewable resources originate from sources that are constantly renewed – the wind keeps blowing, the sun keeps shining and the earth keeps heating the ground.

Non-renewable resources - Non-renewable resources are limited and thus exhaustible. Examples include fossil fuels, water, and soil.

Natural Resources - Natural resources are materials that occur naturally and are used by humans. Examples include water, air, land, forests, fish and wildlife, topsoil and minerals. Natural resources that are alive, such as plants, are called biotic resources. Natural resources that are not alive are abiotic resources and include water.

CLIMATE

Definition:

Climate is the summary of weather conditions experienced in an area over a long period of time. Weather is the climatic conditions experienced at a particular time, such as over a day or week. The data includes precipitation (rainfall, hail, and snow), temperatures, wind, daylight hours and humidity.

For example, climate statistics may indicate that the average winter daytime temperature for an area is 12ºC but today the temperature is 22ºC and yesterday it may have been 2ºC.

The layout and activities of a farm will be influenced by regional climatic conditions and micro climatic conditions found in the area. In South Africa, summer rainfall areas include the Northern, South and Western Cape, the East coast and the Highveld.

The South African west coast and interior experiences dry conditions due to the mainly cold Benguela ocean current running South/North in the Atlantic Ocean.

The South and South Eastern coastlines experience increasingly wetter conditions towards the North East due to the warm Agulhus Ocean current. Long and high mountain ranges running parallel with the coastline result in inland rain shadows and drier conditions.

Rainfall

It is important to know when it rains and how much it rains in the area. This would tell you how much water is available through the area's water cycle. It is also important to know what the flood cycles are. Farms are normally (where possible) situated along rivers due to the need for water and fertile arable land found along the banks and flood plains.

Surveyors can indicate the levels to which rivers have risen in the past. Statistics compiled by using data collected over many years have shown that there is a flood pattern. The data will also show how high the rivers have risen and how often.

It is advisable for farmers to take notice of flood warnings determined by these indicators. Structures should be built above the 50-year year flood lines.

Temperature

It is important to consider the average winter and summer temperatures as it can affect the germination requirements of seeds as well as (especially in cold areas) the impact on livestock.

Daylight hours

Certain species of crops require a certain number of daylight hours before germinating.

Wind

If the area experience severe winds, one will have to make decisions regarding windbreaks.

RECORDING OF CLIMATE DATA

To appreciate the true risks of farming, farmers need to access long-term climate records. Most farmers have at least one rainfall gauge on their property from which they record daily rainfall. To look at frost-risk, farmers need access to reliable, long-term temperature data.

Climate change has had a significant impact on sectors that create employment and sustainable livelihoods, such as agriculture. Human induced climate change will cause the temperatures to constantly rise. Modern industrial agriculture is one of the biggest

contributors to the rapid advance of human-induced climate change. The year 2005 was the warmest year on record, the last eight years were the warmest in the last century and the last century was the warmest in the last 1200 years.

What are the effects of these changes on agriculture?

In the short term:

- Soil loss due to wind, water erosion and soil moisture
- Loss of required cold units essential for fruit and vineyard production
- Erratic rainfall patterns leading to extreme droughts and rainfall events, e.g. storms and floods
- Reduction on quantity and quality of groundwater and the recharge rate

In the box below, you will find information on techniques that you can use to record the changes in climate and plan your farming practices accordingly.

FOUNDATIONAL KNOWLEDGE

TECHNIQUES TO ORGANIZE AND REPRESENT DATA

DATA TABLE

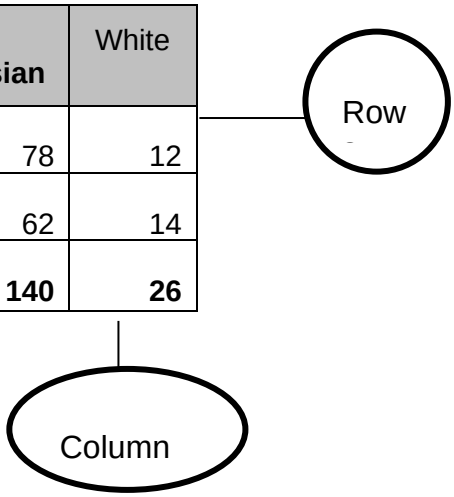
We often have to gather information to establish the trends and reality of situations. Data tables assist us to organize this information logically so that it can be applied to the purpose it was intended for.

Definition:

Data tables are similar to a register or record of events or items that give us information and the information is given to use in rows and columns. A row is any horizontal collection of data while a column is any vertical collection of data.

Example:

Number of students	African	Coloured	Asian	White
Male	56	45	78	12
Female	68	52	62	14
Total	**124**	**97**	**140**	**26**



Interpretation of Data.

The interpretation of data is very simple if you are able to work through it systematically. The most important features of data are:

- frequency
- average
- modus
- median
- range

✦ **Frequency**

Frequency is the number of times a certain value appears in a series of data.

Example: In the series of data below, the number 5 appears 6 times, therefore the frequency of 5 is 6. It is the value that appears most often in the series:

3; 5; 3; 7; 5; 6; 5; 9; 5; 2; 4; 4; 5; 5; 8

✦ **Average**

Adding together all the values and then dividing it by the number of items

calculate the average of a set of data. The average is also known as the **mean**.

Example:

We will use our previous set of data:

- 3; 5; 3; 7; 5; 6; 5; 9; 5; 2; 4; 4; 5; 5; 8

To calculate the average, we first add together all the values:

3 + 5 + 3 + 7 + 5 + 6 + 5 + 9 + 5 + 2 + 4 + 4 + 5 + 5 + 8 = 126

Then we count how many items are there, i.e. 15

- **Mode**

The mode is the **number** that occurs most frequently in the series of data. In the series of data below, the mode is **5**.

3; 5; 3; 7; 5; 6; 5; 9; 5; 2; 4; 4; 5; 5; 8

- **Median**

The median in a series of data is the number that is exactly in the middle, or halfway between two numbers in the middle.

- **Range**

The range is the difference between the highest number and the lowest number in a set of data.

The **range** in the set of data we have been using as an example will be as follows:

2; 3; 3; 4; 4; 5; 5; 5; 5; 5; 5; 6; 7; 8; 9

Range = Highest Number – Lowest Number

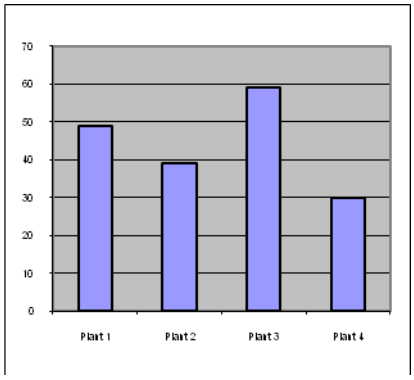
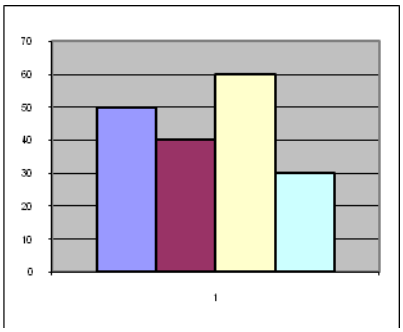
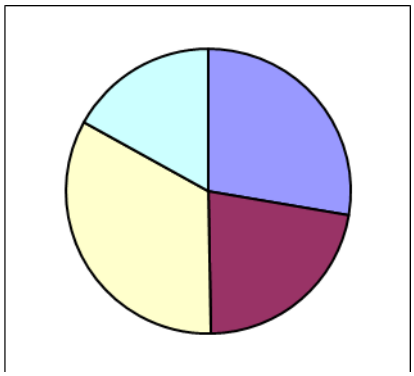
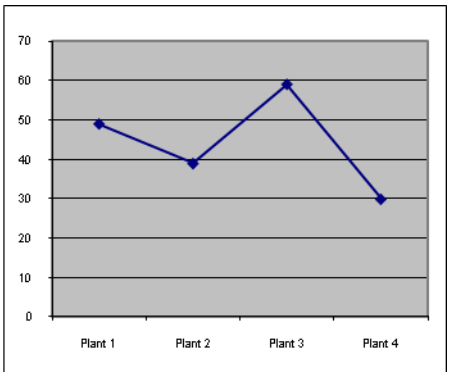
= 9 – 2

= 7

GRAPHS

Graphs are visual representations of what is written in a data table. There are many types of graphs that we can use, and it usually depends on what you need to represent and to whom the representation is made.

Examples:

BAR GRAPH	HISTOGRAM
	
PIE CHART	**Broken Line Graphs**
	

Bar graphs

Bar graphs are used when the data classes are not continuous e.g. in comparing the annual yield of carrots, tomatoes and potatoes of a vegetable farm. There is no intermediate between carrots and tomatoes. The classes are different from each other.

Histograms

Histograms are used if the data classes are continuous. For example, a farmer wants to see how many tons of carrots a certain field produced per year from 2000 to 2006. There are no spaces between the bas, because 2000 borders on 2001. Time is continuous. He could also use a line graph.

Pie graphs

Pie graphs are graphs that represent the data as segments of a circle. The various data will take up a certain angle of the total angles in a circle (360º).

Broken line graphs

When we were drawing the bar graph and histogram, we used the whole column to show our data. With a broken line graph, we will only use points, not full columns.

SOIL

Soil determines the growing capacity and vegetation type.

Soil characteristics:

Soil and parent rock has a major influence on veldt management. Different soil types determine the yield and palatability of grazing in the long run. Important soil characteristics (to remember) are described below.

- ✓ **Colour:** determined by iron content, parent rock and organic matter (e.g. red means good drainage and aeration while grey in the lower layers indicates a high-water table).

- ✓ **Texture**: Indicates the ratio of clay, sand and silt in the soil. The clay content indicates the water and nutrient holding capacity.

  Sand contains between 0 – 10 % clay, Loamy sand contains 10 – 20 % clay, Clay loam contains 20 – 55% clay and Clay contains > 55 % clay.

- ✓ **Structure:** Is determined by the soils' ability to form larger structural units. A soil with no structure would simply crumble after compaction. Soil with strong structure has a

hampering impact on the penetration ability of plant roots when searching for water and nutrients.

Soil conservation:

Soil conservation is approached contextually as the strategies that apply in small-scale intensive systems differ from those applied in broad scale systems.

General land usage practices that contribute to soil conservation include:

Soil erosion caused by wind and water can be prevented by using contours, bunds, and/or swales, or by

Using sustainable strategies to enrich the soil, such as compost, crop rotation, double digging, liquid nutrients, green manure, mulching and/or ridging.

LANDSCAPE AND TOPOGRAPHY

The layout of a farm will be determined by its topography (the direction of slopes). In general, north-facing slopes in the southern hemisphere receive full sun throughout the year. South-facing slopes, depending on their steepness, may never receive direct sunlight. This would have an impact on heat and light available to crops, and thus growth potential.

Slopes are also important when considering harvest surface run-off.

WATER HARVESTING

Surface run-off should be slowed down to allow water to sink into the ground as soon and as much as possible. This can be done using the practice of contour ploughing, and/or the establishment of contour bunds and/or swales.

Definition:

Swale - Is a long, narrow ditch dug on a contour. The excavated soil is placed on the down-slope side of the ditch to create a mound. The swale has an overflow on each end. The ditch creates a place where surface run-off can collect and sink into the ground. The soil mound is covered with either mulch or plant material and sometimes trees are planted along the bottom of swale, thus applying alley- or avenue-cropping practices.

Instead of digging a swale, a contour bund can be built using stones to achieve the same effect.

WASTE AND POLLUTION

Undisturbed ecosystems are ecological communities that together with its environment functions as a unit. In such natural environments, substances decompose and are eventually broken down which means that it decomposes and becomes part of the earth again.

Waste is the unwanted bi-products from industry and human activities.

Pollution is the unwelcome concentration of waste by-products that the environment does not have the capacity to dissipate. These substances are detrimental to people and other living organisms.

Definition:

Waste - Waste refers to the “leftovers” or unwanted products from industries and other human activities.

Pollution - Pollution is the unwelcome concentration of unnatural, harmful or poisonous substances that are beyond the environment’s capacity to handle. These substances are detrimental to people and other living things.

Farm activities generate a certain amount of waste. It is the responsibility of farm management to control and limit the amount of waste generated, but workers must be able to identify waste and control it before it pollutes the environment. In the table below, various sources of waste and pollution are described.

Target Resource	Source of Pollution	Health and Environmental Effects	Remedies
Air	Burning coal for energy	Acid rain Respiratory problems Global warming Acid rain and global warming are earth threatening environmental pollutants (see definitions below table).	Using more efficient energy sources
Air	Fumes from vehicles	Smog Respiratory problems Restricts breathing Global warming	Limiting vehicle use where possible, using more environmentally friendly fuels
Air	Land clearing	Smoke	Controlling fires when burning firebreaks
Air	Noise from traffic	Affects hearing	Limiting vehicle use where possible
Water	Organic and inorganic nutrient enrichment (fertiliser run-off)	Toxic algal blooms poison the water, causing liver disorders, cancer and other diseases in humans Kills aquatic life by inhibiting light penetration and by de-oxygenating the water	Do not over fertilise. Check run-off and use natural filters like reed marshes or sugar beet to capture surplus nutrient salts.
Water	Sewerage from	Pathogens that cause many	Using toilets with a

Target Resource	Source of Pollution	Health and Environmental Effects	Remedies
	inadequate sanitation	diseases and illnesses in humans	suitable sewage system
Water	Build-up of silt in dams	Kills aquatic life Destroys the food chain	Practicing soil maintenance and preventing erosion in daily farm activities
Water	Agrochemicals	Toxicity Interferes with breeding of animals Destroys the food chain Cause illness if water is consumed	Handling and storing agrochemicals and disposing of used containers in an eco-friendly manner. Old or used containers must not be reused, but punctured and stored safely until disposal
Land	Hazardous solid waste (radioactive, chemicals, poisons)	Threatens the health and lives of humans	Awareness of threats posed by waste products, and proper control and disposal.
Land	Non-hazardous solid waste (domestic, urban)	Unsightly Disposal uses up land space Can contaminate surface water	Limiting domestic waste, purchasing products with environmentally friendly packaging

Definition:

Acid Rain - When water in the air combines with gasses, most importantly sulphur and nitrogen, rainwater becomes more acid and is referred to as acid rain.

Global Warming - Global warming is the increase in the average temperature of the earth's lower atmosphere as a result of an increase in greenhouse gasses since the industrial revolution. Greenhouse gasses are water vapour, carbon dioxide, methane, nitrous oxide and ozone. The sustained increase in temperature causes climatic changes.

Acid rain occurs naturally where active volcanoes erupt, where there is lightning, or if there is bacterial action in the soil. Acid rain has however reached levels where the environment is no longer able to cope with it due to increased human activity that produces sulphur dioxide and nitrous oxides. The burning of fossil fuels, for example in power stations, factories and petroleum-based vehicles, contributes to this problem.

The all too frequent oil wars also cause huge amounts of sulphur and nitrogen to enter the atmosphere in a relative short time period and pose a serious environmental and climatological threat to the earth's survival systems.

If materials and equipment is used carefully and responsibly, its lifespan can be extended, and the amount of waste can be reduced. Farmers must follow regular calibration and maintenance plans, which will reduce wear on tyres and other equipment.

Global warming is the increase in the average temperature of the earth's lower atmosphere. It is believed caused by as a result of an increase in so-called greenhouse gasses (including Carbon Dioxide and Methane). The sustained increase in temperature could cause dramatic changes in climate.

Air pollution from agriculture may occur during land clearing through burning of natural veldt. The smoke generated affects the air, be sure to control fires when burning firebreaks.

Water pollution may occur when sewage enters water sources due to inadequate sanitation. The pathogens that then develop in the water cause many diseases and illness in humans. Water pollution by nutrients such as fertilisers leads to deutrofication of water sources, which could kill aquatic life and destroys the food chain. When Agrochemicals pollute water

sources, the toxic agrochemicals interfere with breeding of and life cycles of animals and plants, affecting the food chain.

REUSING WASTE

Definition:

Reuse - Reusing waste means employing certain waste items for a different purpose, for instance using empty non-chemical plastic containers for storage

Recycling - Recycling means reprocessing waste material and using the material to make new items, such as melting down old plastic containers and using the plastic to make new containers.

Reducing – Refers to the using less of a particular substance or material

Some waste, including materials and by-products, can be reused. Ideally it should be reduced and recycled where possible. Recycling or reusing waste products should be part of a farm's daily practice. The following are examples of waste and their uses as a resource:

Waste	**Resource**
Paper	Use as fuel for burning
Wood	Use as fuel for burning
Plastic Containers (Non-chemical)	Use as storage containers in workshop and field Small containers can be used to manually apply granular fertiliser
Metal	Recycle
Oil	Recycle

Waste	Resource
Tyres	Use to support soil in erosion areas, such as gullies
Organic Waste	Can be incorporated, composted or if suitable, fed to animals

ENERGY

Definition:

Energy - Energy is the ability to do work and it comes in various forms of heat and light. There are two main types of energy, being working energy and stored, or latent, energy. Stored energy becomes working energy when it is used.

We use energy every day. It is used to grow food, to warm and cool homes, make electricity, run cars, make products like clothes and toys and any other items. It is a very important part of our lives.

Most countries use stored energy for fuel. By burning fuel, the stored energy is set free in the form of heat. Fossil fuels, such as oil, gas and coal, are mostly burnt.

Fossil fuels form over time from the remains of dead animals and plants. Dead plants and animals are buried under dirt and rock, where the heat from the earth and the pressure from the soil and rocks change them into fossils and then into oil, natural gas and coal. Because it can take thousands of years to make or renew fossil fuels, they are referred to as a non-renewable resource.

More than 75% of South Africa's energy comes from coal. One half of this is used to generate electricity, a quarter is used to produce liquid fuels, and the other quarter is used as fuel to heat homes. South Africa is the country in the world that is the most dependent on coal, and therefore we need to look at generating energy from alternative sources.

ALTERNATIVE ENERGY SOURCES

The alternative energy sources that are used mostly are:

- ✓ Solar energy
- ✓ Wind energy
- ✓ Water energy
- ✓ Nuclear energy
- ✓ Bio diesel

SOLAR ENERGY

The sun is a great source of energy, which is referred to as solar energy, which can be turned into electricity or heat. Solar energy are used in many ways, for example by simply keeping the curtains open during the day, sunlight can light and warm a room.

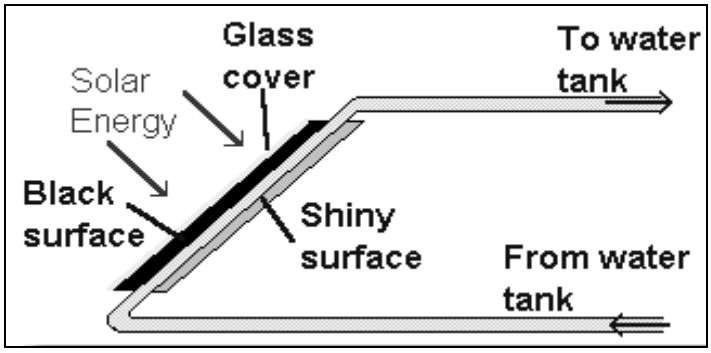
Example:

Solar Energy - Cars with dark seats are good examples of how the absorbers in a solar collector work. Have you ever sat on a dark seat after the sun's solar energy passed through the windows of a car? The seats absorb heat and feel hot. If the seats were white, the light would be reflected away from the seats and they would absorb less heat.

Technology has been developed to harness the energy of the sun, so that it can be stored and used by humans for heating or electricity generation. Solar energy systems, or solar collectors, produce energy without releasing pollution particles or chemicals into the air. Most solar collectors are boxes that have the following components:

- Clear covers to let the solar energy in.
- Dark surfaces, called absorber plates, on the inside to soak up the heat.
- Insulation material to prevent heat from escaping.

- Vents or pipes to carry the heated air or liquid from inside the collector to where it can be used.



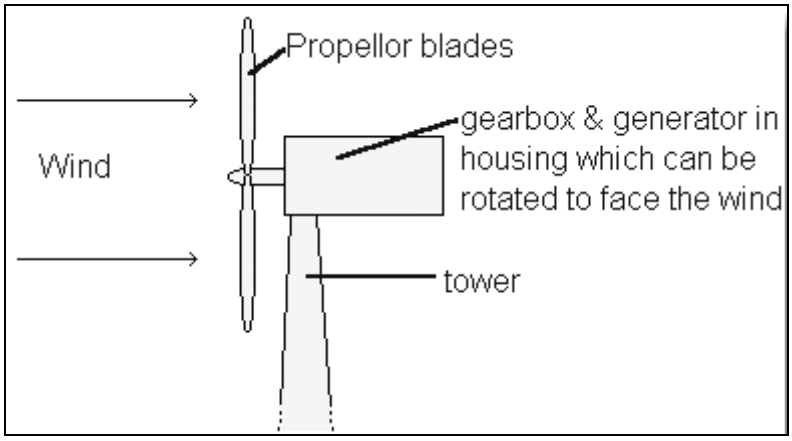
Simple Solar Water-Heating Device

Solar energy systems fall into three main categories, being:

- Photovoltaic Cells, also known as PV's, absorb sunlight and a chemical reaction occurs, turning sunlight into electricity.
- Passive solar systems use sun for lighting and heat by absorbing sunlight and slowly releasing it even after the sunsets.
- Solar Thermal Systems heat water or air by using a mechanical device to move it across surfaces that have absorbed sunlight.

WIND ENERGY

When the power of wind is used to generate electricity, it is referred to as wind energy. The wind turns large fans that power a generator to make electricity. The power of the wind to generate electricity is proportional to the wind speed. Much more electricity can therefore be generated in places with high average winds speeds, and "wind farms" are often established in such places. The windier the location, the more kilowatt-hours can be generated.



Fan Used to Generate Electricity through Wind Energy

WATER ENERGY

Water is another renewable source of energy. A watermill or a hydro-electric scheme uses the force of water to generate electricity. Water moves across impellers, rotating them and generating electricity.

NUCLEAR ENERGY

Nuclear energy is generated by using special radioactive materials. Harmful substances are not released when nuclear energy is generated. However, once the radioactive material has been used to generate energy, the waste remains radioactive and hazardous to all living organisms. The waste material must be stored safely for thousands of years to avoid contamination.

BIO DIESEL

Bio diesel is a liquid fuel than can replace regular diesel. It is made from used vegetable oil from deep fryers or freshly grown grains, such as maize. The particles released from

burning regular diesel can cause cancer, but by using bio diesel this hazard can be reduced. Bio diesel is a renewable energy source.

THE ROLE OF CARBON

Carbon is an important element. It is not only found in minerals, such as diamonds, but also in the tissue of living organisms. Carbon atoms are the main component of all organic compounds, including sugars, starches, fats, proteins and coal.

Carbon compounds give us energy (food), keeps us warm (wood and coal), and power vehicles and industry (oil petrol and natural gases).

The Role of Carbon Dioxide

Plants absorb carbon dioxide from the atmosphere and use it with sunlight, water and soil minerals to produce energy-rich organic compounds, such as carbohydrates. This process is known as photosynthesis.

Too much carbon dioxide in the atmosphere however has a negative effect on the environment. Carbon dioxide traps heat in the earth's atmosphere, making life on earth possible, but if there is too much carbon dioxide, an imbalance is created resulting in a greenhouse effect, which leads to global warming.

The over-production of carbon dioxide that causes this imbalance is the result of the burning of fuel, such as coal. At the same time, vast tracts of vegetation are being destroyed due to deforestation, affecting the rate of photosynthesis. This means that while we are producing more and more carbon dioxide, there are less and less plants that are able to absorb and use it.

The earth is becoming warmer and the global climate is changing. In South Africa, some areas are becoming hotter and drier, while other areas experience more frequent and extreme floods.

The role of Carbon Sinkholes

Definition:

Carbon Sinkholes - Carbon sinkholes are where carbon is stored after being returned to plants and soil through photosynthesis.

Farmers are key players in creating carbon sinkholes. Grasslands are a temporary carbon sinkhole, because the carbon is lost when grass is burnt and carbon dioxide is released. Forest and fruit trees grow slowly and store organic carbon for many years.

Soil is the ultimate carbon sinkhole. About 60% of organic carbon occurs in soil. Soil enriched with organic matter is a stable carbon sinkhole, because carbon is stored for long periods of time.

Land is managed to store more carbon by:

- ❖ Minimising tilling to conserve organic matter and to stabilise the soil structure and reduce erosion.
- ❖ Adding organic matter, lime and sulphur to the soil to increase soil fertility, structure and water holding capacity.
- ❖ Restoring erosion areas on farms, thereby enhancing ecological processes and resilience of the ecosystems.
- ❖ Using renewable sources of energy. It is preferable to burn firewood grown in woodlots or plantations rather than burning coal. Avoid cutting down indigenous plants.

REMEMBER:

- Renewable natural resources are resources that nature reproduces constantly, while non-renewable natural resources are resources that cannot be reproduced or are reproduced over many years.
- Biotic natural resources are alive, such as plants and animals, while abiotic natural resources are not alive, such as water and air.
- Waste is what is left over once resources have been used to create energy.
- Pollution is the over-production of waste that the environment cannot deal with naturally.
- Acid rain and global warming are deadly consequences of pollution.
- Reusing means using a waste product for another purpose, while recycling means reprocessing waste products to produce other products.

- Energy is the ability to work and is produced from using resources. There are two forms of energy, being working and stored energy.

- Traditional energy sources use stored energy from non-renewable resources, such as the burning of fossil fuels.

- Alternative energy sources aim to use renewable resources and include solar energy, wind energy, water energy, nuclear energy and bio diesel.

- Carbon is the building block of life as most living organisms are made up mostly of carbon atoms.

- Carbon dioxide is produced through amongst others the burning of fuel and used by plants during photosynthesis.

- Higher production of carbon dioxide and reduction in plants causes an imbalance that causes a greenhouse effect and leads to global warming.

- Carbon sinkholes are where carbon is stored, mostly in organic form in plants and in soil.

CASE STUDY:

Energy-smart farming – April 2010: Story by Liza Burger

The national energy regulator, Nersa, announced in February that Eskom would be allowed to increase electricity tariffs by 24.8%, 25.8% and 25.9% over the next three years.

While this is not the original 35% hike Eskom applied for, it is still a hefty burden on milk producers, whose input costs are high to start with. Last year, Eskom increased its tariffs by 31%. That, together with the latest tariff increases, will move South Africa from its position as one of the cheapest energy suppliers in the world a few years ago, to one of the top ten most energy-expensive countries.

The effect this will have on the bottom line will be significant, as modern dairies are mechanized and often reliant on electronic measuring and monitoring technology. Cooling tanks cannot be done away with and warm water for washing milking equipment and tanks, remains a necessity.

Alternative and effective

Cutting costs means cutting on Eskom power usage by combining more efficient electricity usage and implementing alternative energy sources.

More effective electricity consumption should be the first step in exercising better control over your electricity bill. Coordinating activities that use high voltage during Eskom's off-peak periods, is a good start. This lessons the load on the national grid and is slightly cheaper than peak-time electricity.

While there are quite a number of very clever and effective ways to become independent from the main power grid, it is not always immediately practical or affordable in the South African context. Although plans are in place and exist on paper, it is not yet possible for most people with alternative energy sources, to feed their surplus power into the country's main power grid.

But future plans envisage that the power you generate, but don't use, can be sold to the utility company (in our case Eskom). This means that alternative energy does not only save you money and is better for the environment but has the potential to make money!

Switch to sun power

Locally the most affordable, practical and immediately available alternative source of energy, is sun power. Solar panels can be used to supply electricity for water pumps, charging batteries or for lighting. However, photovoltaic solar panels are expensive, have a lifespan of approximately ten years, and can be vulnerable to hail and theft. They also need to be cleaned regularly, as dust reduces efficiency.

However, solar power used for heating water is currently one of the most affordable and practical starting points when it comes to using clean and sustainable alternative energy sources.

Cobus Roux of the solar heating and energy company, Home Comfort, says the normal range of geyser capacity (100, 150, 200 and 300 litres) also apply to solar geysers and, for larger capacities; a purpose-designed system can be installed.

"Solar power is ideal for cooling and lighting applications but has a substantially higher start-

up cost per kW."

"Solar water heating, in comparison, has a substantially lower cost per kW produced, but is limited to heating applications. Solar heating is a great starting point, as any heat-producing process consumes a large volume of energy," says Roux.

Let Eskom pay you back

Many jokes have been made about Eskom, but the reality is no joke: South Africa's capacity to deliver reliable power to the national grid, is failing and will continue to do so unless some drastic steps are taken.

In a bid to lessen the stress on the power supply, Eskom is actually paying its customers rebates to find an alternative source of energy! So how does the rebate system work?

"To reduce the growing demand for electricity, Eskom has started energy efficiency and alternative energy pogrammes that promote energy savings on a large scale.

"The programme is structured around a rebate which reduces the selling price of and SABS-approved solar water heating system. The reduction in price is based primarily on the performance of the solar water heater and its associated electricity saving potential.

Only registered products complying with the Eskom DSM criteria, qualify for the rebate. Solar heating systems must include:

- A high-pressure system 100kPa and higher.
- A timer to optimize energy savings and regulate everyday usage. Alternatively, a load management device to control the usage in crisis situations.
- The system must be appropriate for the intended use and area, in terms of size, frost protection and water quality compatibility.
- It must have a comprehensive guarantee of at least five years.
- The system must have the South African Bureau of Standards (SABS) mark and comply with the South African National Standards (SANS) for thermal and mechanical performance and safety.
- The supplier of the system must be registered with Sustainable Energy Society of South Africa's (SESSA) solar water heating division.
- Installation must be done by a registered installer and the customer will only be able to claim the rebate once the facilitating auditors receive a final invoice from their supplier. "Customers who qualify receive a rebate directly from Deloitte, the

facilitating auditors of the programme." According to information supplied by Eskom Demand Side Management (DSM).

The Eskom supplied list indicates the relevant suppliers, contact details, system specifications, indicative retail price, the expected installation charge and qualifying rebate.

Look for the best

"Both SABS and Eskom approval are only an indication that a system complies with basic requirements. Best is to look for a reputable supplier with long track record, in conjunction with a long warrantee period, and relevant references," advises Roux.

Extras to be on the lookout for are an extended warrantee period of ten years (or even longer) and hail-resistant models.

Take note that terms and conditions do apply and before any installation is considered, the Eskom supplier list should be consulted. Prices for systems and tariffs for installation vary significantly.

A typical 300-litre, flat place, thermo-siphon, indirect solar water heating system can cost from as little as R20 000 (approximately R2 000 for installation) with a rebate of about R7 000, while a similar system can cost up to R30 000 (R5 000 for installation) with a rebate of around R12 000.

The cost of a solar water heater (including installation) is higher than electric or gas water heaters, but the savings on your electricity bill will compensate for this over-time. Once you have paid back your system through saving, your hot water is for free!

Log onto www.eskom.co.za/dsm for more information, e-mail solar@eskom.co.za or phone 011 800 4744 to make sure you are on the right track and that you do qualify for rebates.

Other alternatives

Wind turbines are effective in constantly windy areas, but expensive to buy, install and maintain. Back-up batteries are needed for those not-so windy days and wind turbines are not suited for all areas. Conservationists are also calling for stricter environmental impact studies, as the larger electricity wind mills seem to affect bird life adversely.

However, as an alternative source of energy for specific uses such as charging back-up batteries (incorporated into the farm's power grid) or powering water pumps, wind turbines

can be of good use on most farms. The windmill next to every dam on the South African landscape is proof that wind power has been the farmer's friend for more than 100 years.

Giant wind turbines, such as those near Klipheuwel in the Western Cape, are still being tested for proven efficacy and reliability within the South African context. Large wind farms are much more common in Europe and have been proven to be a popular and effective source of sustainable alternative energy.

Another golden oldie with a modern application, is the water wheel. It is an old concept, but combined with modern technology, this can be a real energy saver if you have fast-flowing water on your farm. However, with South Africa's notorious inconsistent weather patterns, recurrent droughts and criminal element, this option should be well-considered before spending a lot of money on it.

Clever adaptations to the stationary water wheel solve most of these problems. Mounted on floating pontoons, the revolving wheel can be moved as the level and flow of a stream or river changes. This is a great way to power water pumps.

Methane gas is used effectively, although not widely, as a source of energy in both the first and third world. Using the gas produced by digested manure and effluent, large farms (especially piggeries) elsewhere in the world can run whole farming operations from these methane plants.

A simplified version of this technology is used on some farms in rural Africa and these small-scale methane gas plants provide a steady source of cheap, gas-based energy.

However, running such a methane plant to be used on a modern commercial dairy farm, requires a large herd and effective manure management.

The farm needs a properly installed manure collection pit, a covered digester, a means to effectively harvest the methane gas, a generator that uses methane gas as energy source and the ability to turn this energy into a steady stream of electricity. It is an expensive exercise that needs strict management but will be one of the energy sources to watch on the agricultural front in the future.

Pure solar power from photovoltaic panels, enables you to harvest electricity from the sun and not just energy to heat water with. The installation and costs involved are much more comprehensive and some photovoltaic panels have a lifespan of only 5-10 years, depending on conditions.

The typical components of a solar power system are the photovoltaic module, batteries, inverters, controllers and physical structure, although exceptions to this rule do exist.

The batteries are needed to store electricity to provide energy on demand at night or on overcast days. Controllers manage the energy storage to the battery and deliver power.

To convert the DC power produced by the photovoltaic module into AC power, an inverter is required. A proper structure should be used to mount and install the PV modules for optimal sun exposure.

Interesting solar fact: The silicon from just one ton of sand, used in photovoltaic cells, could produce as much solar power as burning 500 000 tons of coal!

Additional power sources, such as a generator or the local power grid, can be connected to the system to supplement the power requirements as needed.

“Although there is still no Eskom rebate on solar power for electricity needs other than heating water, credits and funding are available for commercial systems which might apply in some cases to large dairy farms,” says Roux.

“Integrating solar power into a farm’s power grid is also possible. Although the initial capital outlay can be expected to be large, the long-term savings and independence from an Eskom-only power supply, is worth it.

“Standard application for a solar power system to supply into the same local distribution grid as Eskom, is possible and solar can be referred power source with Eskom as a back-up source.”

Budget call

Before switching to solar powered geysers or implementing alternative energy sources determine your budget to ease financial planning:

1. Install a meter that will indicate electricity use (national grid). Take measurement of typical electricity usage levels before implementing power-saving habits or installing alternative energy sources. Determine the cost per kW.
2. Determine the full cost of buying, installing and integrating the alternative energy system.
3. Calculate the amount of kW which the new energy source will “save” in monetary

value per year.

4. Determine how long it will take before the new installation will deliver “free” energy.

CHAPTER 2

SUSTAINABLE FARMING

In this chapter we explore the following concepts:

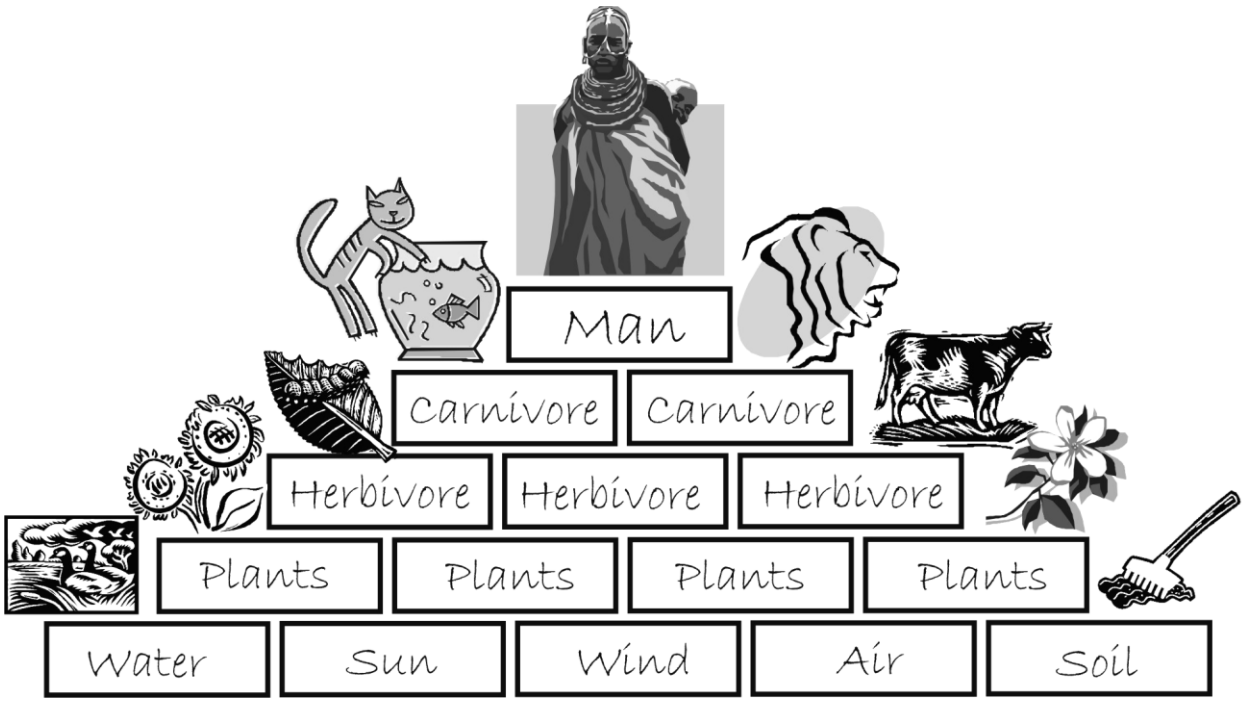
- Ecological environment
- Patterns and resources in the environment
- Fauna and flora
- Alien plants and weeds
- Eroded areas
- Fertilizers
- Pest control
- Soil conservation
- Field fires

RECOGNISE AND IDENTIFY THE BASIC FUNCTIONS OF THE ECOLOGICAL ENVIRONMENT

In order to be a successful crop grower, you must be able to recognise the patterns of the environment, such as rainfall, climate, dry cycles, original vegetation, seasons, the movement patterns of animals so that you can apply these in implementation of your agricultural enterprise.

The processes of the biophysical environment include the interactions and relationships between food webs, human activities, soil, climate, water, plants, animals and solar energy.

We all live in an environment where certain basic requirements are provided. No matter how much technology or money we have if those basic resources are not provided we cannot live. The diagram below illustrates this.



PATTERNS AND NATURAL RESOURCES IN THE ENVIRONMENT

Definition:

***Climate*:** Refers to the average temperature and rainfall patterns in an area.

***Rainfall pattern*:** Refers to the volume and incidence of rainfall over a year and it's distribution across the country.

Indigenous vegetation: Refers to the plants that occur naturally in a specific area.

***Fauna*:** Refers to the animals that occur in an area, they need not be indigenous.

***Flora*:** Refers to the plants that occur in an area, they need not be indigenous.

Natural resources: Refers to the living (e.g. plants, animals, and insects) and non-living (soil, climate and water) resources that occur in an area.

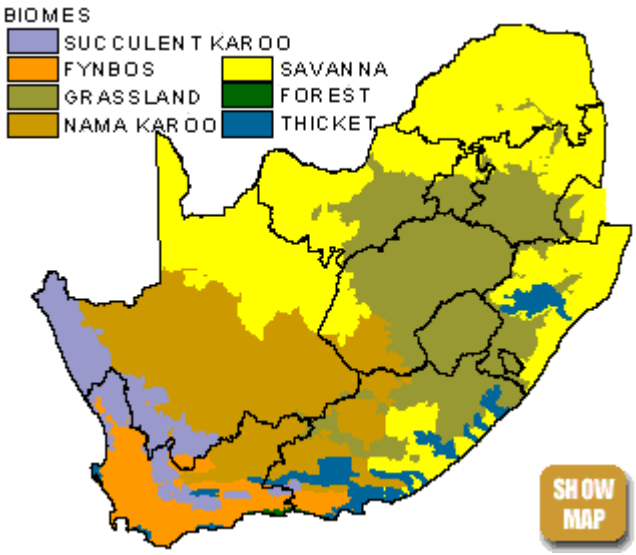
FAUNA AND FLORA OF SOUTH AFRICA

Biomes can be defined as the major communities of the world, classified according to their predominant vegetation and characterised by adaptations of organisms to that particular environment.

Ecosystems are communities of organisms that inhabit specific physical environments. Biomes are composed of several ecosystems and represent a regional community of organisms named after the dominant vegetation.

Ecosystems of South Africa:

- Succulent Karoo
- Savannas
- Fynbos
- Grasslands
- Forests
- Nama-Karoo
- Marine and Coastal Ecosystems
- Wetlands



Succulent Karoo

The succulent Karoo is restricted to the year-round and winter rainfall areas and have the greatest summer aridity. This biome occurs mostly west of the western escarpment through the western belt of the Western Cape and inland towards the Little Karoo. This is the land of many spring flowers, which for a few weeks each year, draw large numbers of tourists from all over the world.

Succulent plant species with thick, fleshy leaves are plentiful here, the diversity of which is unparalleled anywhere else in the world. This, together with many geophytes (plants that survive by means of bulbs, tubers, etc. in times of unfavorable climatic conditions) and annual plants, makes the succulent Karoo unique and of international importance in terms of conservation. Examples of animals that occur here are the bat-eared fox (*Otocyon megalotis*), suricate (*Suricata suricatta*) and the common barking gecko (*Ptenopus garrulus*).

Savannas

Savannas are the wooded grasslands of the tropics and subtropics that account for 46% of the South African landscape. They are second only to tropical forests in terms of their contribution to terrestrial primary production. They are the basis of the livestock industry and the wildlife in these areas is a key tourist drawcard.

The fact that the public are well aware of African savannas may be explained by the variety of large mammals found here. Large game species such as lion (*Panthera leo*), buffalo (*Syncerus caffer*) and elephant (*Loxodonta africana*) occur here. The large diversity of

animals is associated with the rich plant diversity. A well-known tree species found in the Northern Province is the baobab (*Adansonia digitata*). Other species found here include the mopane (*Colophospermum mopane*), monkey-thorn (*Acacia galpini*) and knob-thorn (*Acacia nigrescens*). Savannnas also include valley bushveld, the veld type containing the greatest range of rainfall seasonality in South Africa. Fire is a crucial factor in the ecology of all savannas and is therefore a regular natural feature of this environment.

Diversity of plant life

South Africa is characterised by a wide diversity of plant life and is ranked as the third most biologically diverse country in the world (mainly due to the richness of plant life). Over 18 000 species of vascular plants occur in South Africa, of which over 80% occur nowhere else. This diversity is caused by variations in climate, geology, soils and landscape forms. However, South Africa also has the highest concentration of threatened plant groups in the world. Approximately 3 435 of South African plant groups are considered to be globally threatened by extinction. A further 204 groups are estimated to be threatened at a local level.

Fynbos

Fynbos occupies 5,3 % of South Africa, occurring almost exclusively in the south-western and southern parts of the Western Cape Province. Fynbos comprises evergreen heathlands and shrublands in which fine-leafed low shrubs and leafless tufted grass like plants are typical. Trees are rare, and grasses comprise a relatively small part of the biomass.

Fire is a very important component in fynbos. Most fynbos is highly flammable due to the common presence of flammable oils. Finely wooded fynbos plants are obligate seeders, which means that the whole plant dies after fire and can only reproduce through seed. This distinguishes fynbos from the other ecosystems where fire is common. Many plant species are dependent for pollination on small mammals or birds such as the Cape sugarbird (*Promerops cafer*).

Fynbos, with its complement of at least 8 578 species of flowering plants, is now recognised as supporting one of the most diverse and distinctive floras in the world. All in all, 5 832 or 68 % of the plant species are endemic. Many of the fynbos plant species are restricted to

extremely small distribution ranges, a fact which has rendered them dangerously susceptible to extinction.

Economic utilisation of fynbos vegetation is limited to selective grazing by small stock on newly burned lowland areas and to wild-flower production. Most commonly utilised are the protea species, which are exported fresh or dried.

The floristic diversity of the fynbos is not paralleled by an equally rich fauna due to the absence of grass and berry-producing plants. Fauna includes species such as the leopard (*Panthera pardus*) and geometric tortoise (*Psammobates geometricus*).

Fynbos products such as rooibos tea, buchu, veld flowers and thatching-reed are also harvested while table and wine grapes, wheat, fruit and olives are important agricultural products. South Africa's oldest city, Cape Town, at the foot of Table Mountain, is located in the fynbos biome.

Invasive alien plants

In South Africa, invasive plants cause billions of rands of damage each year. Over 160 plant species introduced into South Africa have become invasive. If left unchecked, these species will spread at an alarming rate, doubling within 15 years. Invasive alien plants have the following impacts:

- They use about 7% of our scarce water resources.
- Their impact on agricultural resources and indigenous natural resources is significant.
- They increase the likelihood of flooding and bush fires.
- They cause erosion, siltation of dams and estuaries and adversely affect water quality.
- They lead to the extinction of indigenous plants and animals and undermine the ecological functioning of natural systems.

For more information:http://www-dwaf.pwv.gov.za/wfw/

Grasslands

The grasslands cover the high central plateau of South Africa, inland areas of Kwazulu-Natal and the mountain areas of the Eastern Cape Province. Grasslands are defined as those areas where grasses dominate the vegetation and where woody plants are absent or rare. They occupy 24,1% of the country's surface area. Most grassland occurs in high-rainfall areas, where thunderstorms and hail are common in summer and frost is common in winter.

The grassland biome is regarded as the third-richest area in terms of plant species diversity, with a total number of 3 788 species. The most noteworthy species with a wide distribution is, *Themeda triandra*, more commonly referred to as 'rooigras'. In the past the ungulate fauna (hoofed animals) of the Highveld grasslands included vast herds of blesbok (*Damaliscus dorcas phillipsi*), black wildebeest (*Connochaetes gnou*) and the springbok (*Antidorcas marsupialis*). A surprisingly rich variety of birds are found in the grasslands, including the blue crane (*Anthropoides paradiseus*), black korhaan (*Eupodotis afra*) and helmeted guineafowl (*Numida meleagris*).

Forests

The forests of South Africa include the indigenous evergreen and semi-deciduous closed forests of the coastal lowlands and escarpment slopes and cover only about 0.25% of the land area.

With a few exceptions such as the forests of the Knysna area and the KwaZulu-Natal coastal dune systems, forests are small, usually occupying less than 1 000 ha. These forests amount to little more than patches scattered through the higher rainfall areas. The total area of forests in South Africa is probably less than 2 000 km². The forest structure results in reduced light levels in the area beneath the canopy where species such as tree ferns are common. Typical mammals include the bushbuck (*Tragelaphus scriptus*), bush pig (*Potamochoerus porcus*) and blue duiker (*Philantomba monticola*). Birds found in forests include the Knysna lourie (*Tauraco corythaix*) and rameron pigeon (*Columba arquatrix*). Despite the small land surface area that they occupy, forests have relatively high species richness. Only fynbos exceeds the species richness found in forests.

Nama-Karoo

The Nama-Karoo covers most of the vast central plateau region of the Western and Northern Cape Provinces. The area forms an ecotone or transition between the Cape flora to the

south, and the tropical savanna in the north. Many of the plant species of the Nama-Karoo also occur in the savanna, grassland, succulent Karoo and fynbos biomes.

Species that occur in the Nama-Karoo include the sweet-thorn (*Acacia karroo*), stone plant (*Lithops ruschiorum*) and blue Karoo daisy (*Felicia australis*). The former vast migratory herds of springbok (*Antidorcas marsupialis*) have been replaced by domestic stock, particularly sheep and goats. A rich variety of rodents and reptiles, also occurs in the Nama-Karoo. The few, endemic or near-endemic bird species include the Sclaters lark (*Spizocorys sclateri*). Sheep-farming is the main agricultural activity in this region.

Marine and coastal ecosystems

The South African coastline covers a distance of over 3 000 km, more than 80% of which consists of sandy beaches and sand dunes. Other ecosystems include rocky shores, coral reefs, kelp beds and the open sea. Two hundred and seventy of the world's 325 fish families occur in South African waters.

The east coast waters are characterised by the warm waters of the southward flowing Agulhas Current, while those of the west coast are characterised by the upwelling of cold, nutrient-rich waters of the Benguela Current. Along the southwest and south coast, there is an extensive mixing of water masses. The currents influence the composition of the animal and plant communities along this coastline.

Wetlands

The term "wetlands" groups together a wide range of inland and coastal habitats – from mountain sponges and midland marshes to swamp forests and estuaries – linked by rivers and streams. These wetlands share common and important functions in river catchments by providing a regular water supply, by filtering the water naturally, by reducing the effects of floods and droughts, and by providing a vital wildlife habitat and superb recreational areas for people.

Most wetlands are characterised by a high-water table, water-carrying soil and hydrophytes (water-loving plants), but in semi-arid Southern Africa there are numerous pans that support few if any hydrophytes and that may contain shallow water only once in five or more years.

Wetlands play an important role in maintaining biodiversity since they support an extraordinary variety of plant and birdlife e.g. the red bishop (*Euplectes orix*), the South African shelduck (*Tadorna cana*), insects, mammals, reptiles, amphibians, e.g. the striped stream frog (*Strongylopus fasciatus*), fish and invertebrate species.

Wetland plants such as the bulrush (*Typha capensis*), play an important role in the healthy functioning of a wetland ecosystem by generating organic matter, the primary element for any foodweb. They also provide the soil and water with oxygen, prevent erosion and serve as a filter that purifies the water. These plants provide food, shelter and breeding sites for many birds and aquatic animals such as the hippopotamus. Attractive plant species such as the arum lily (*Zantedeschia aethiopica*) and the red-hot poker (*Kniphofia caulescens*) are common to wetlands.

Wetlands are likely to occur in the catchment of all river systems in South Africa, but their form and abundance vary considerably owing to regional differences in topography, climate, vegetation, soil, land use and hydrological conditions. South African wetlands, being at the southern tip of the continent, host a number of endemic and highly isolated bird species, e.g. the Cape shoveller (*Anas smithii*). A number of paleoarctic migrants visit Southern African wetlands during the northern hemisphere's winter, some of which come all the way from the Taimyr Peninsula in Siberia (a distance of approximately 15 000 km). South Africa extends into the tropics, providing the southern limits to a number of tropical species such as the pink-backed pelican (*Pelecanus rufescens*), the rufous-bellied heron (*Butorides rufiventris*), the dwarf bittern (*Ixobrychus sturmii*), the open-billed stork (*Anastomus lamelligerus*) and the pygmy goose (*Nettapus auritus*

ALIEN PLANT SPECIES AND NOXIOUS WEEDS

INTRODUCTION

South Africa has the third richest biodiversity in the world, which is under considerable pressure and threat. The remarkable richness of South Africa's biodiversity is a result of the mixture of tropical, subtropical and temperate climates and habitats, which gives rise to extraordinary plant variety.

Human activity has changed ecosystems in South Africa. Ecosystems have been degraded and ecological processes impaired. One of the reasons for this is the increasing growth of urbanisation and industrialisation. The South African Red Data Book reports that the following percentages of species can be considered threatened:

- Plants: 15%
- Amphibians: 18%
- Reptiles: 24%

- Birds: 14%
- Mammals: 37%
- Butterflies: 22%

Alien plant species is another factor that threatens biodiversity and indigenous plant species.

IDENTIFICATION OF ALIEN PLANT SPECIES

Definition:

Alien Plants - Alien or invasive plants refer to plants that do not originate in South Africa. They cause problems by using 10% of South Africa's annual rainfall, killing indigenous plants, causing fires and soil erosion, and endangering many animals.

Alien plants came to South Africa as garden plants, in horse feed, and with forestry plantations. Alien plant species grow well in South Africa because they have no natural enemies such as insects, animals and disease that would control them in their original countries.

Some alien plants spread less aggressively than others. The Department of Water Affairs has identified and categorised 198 invader or alien plants in South Africa. These alien plants have detrimental effects on farming areas, indigenous bush, water supply, cause fires, and increase soil erosion. For more information refer to www.dwaf.gov.za for a detailed list.

Alien plants are classified as follows:

Category 1: Invader plants that must be removed and destroyed immediately.

Category 2: Invader plants that may be grown under controlled conditions only.

Category 3: Invader plants that may no longer be planted, but that do not have to be removed.

Alien plant species grow in different regions in South Africa. For the purpose of the classification, South Africa has been divided into three sections, namely:

- **Subtropical Region**: K-Zulu Natal, Mpumalanga, Limpopo, North-West Province,

Gauteng

- **Fynbos Region**: Western and Eastern Cape
- **Arid Region**: Northern Cape, Eastern Cape, Free-State

In the tables below, the alien plants that are found most commonly in the different regions are listed together with its control measures.

Subtropical Region:

Category	Invader Plant Name	Control Measures
1	Bug weeds (Solanum mauritianum)	Cut Cut + herbicide treatment Hand-pull Bio control Herbicide
1	Sweet Prickly Pear (Opuntia ficus indica)	Bio control Herbicide
1	Triffid Weed (Chromolaena odorata)	Cut Cut + herbicide treatment Hand-pull Herbicide
1	Water hyacinth (Eichornia crassipes)	Hand-pull Bio control Herbicide
1	Lantana (Lantana camera)	Cut Cut + herbicide treatment Hand-pull Bio control Herbicide

1	Mauritius Thorn (Caesalpinia decapetala)	Bio control Herbicide
2	Black wattle (Acacia mearnsii)	Cut Cut + herbicide treatment Hand-pull Bio control Herbicide
2	Grey Poplar (Populas x canescens)	Cut Cut + herbicide treatment Hand-pull Herbicide
3	Syringa (Melia azedarach)	Cut Cut + herbicide treatment Hand-pull Herbicide

Fynbos Region:

Category	Invader Plant Name	Control Measures
1	Lantana (Lantana camera)	Cut Cut + herbicide treatment Hand-pull Bio control Herbicide
1	Silky Hakea (Hakea sericea)	Cut Cut + herbicide treatment Bio control

1	Australian Myrtle (Leptospermum laevigatum)	Cut Cut + herbicide treatment Bio control
2	Grey Poplar (Populas x canescens)	Cut Cut + herbicide treatment Hand-pull Herbicide
2	Black wattle (Acacia mearnsil)	Cut Cut + herbicide treatment Hand-pull Bio control Herbicide
2	Australian Blackwood (Acacia melanoxylon)	Cut Cut + herbicide treatment Hand-pull Bio control Herbicide
2	Rooikrans (Acacia Cyclops)	Cut Cut + herbicide treatment Hand-pull Bio control Herbicide
2	Cluster Pine (Pinus pinaster)	Cut Cut + herbicide treatment

Arid Region:

Category	Invader Plant Name	Control Measures
1	Sweet Prickly Pear (Opuntia ficus indica)	Bio control Herbicide
1	Oleander (Nerium oleander0	Cut Cut + herbicide treatment
1	Stipa Trichotoma	Hand-pull Herbicide
1	Queen of the Night (*Cereus jamacaru)*	Hand-pull Bio control Herbicide
1	Rosea Cactus (Opuntia rosea)	Bio control Herbicide
2	Sisal (Agave sisalana)	Herbicide
2	Wild Tobacco (*Nicotiana glauca*)	Cut Cut + herbicide treatment
2	Honey Mesquite (Prosopis glandulosa)	Cut Cut + herbicide treatment Herbicide

Clearing Alien Plant Species:

In the tables in the previous section, the control measures for the various alien species are stated. The following method is used for removing alien plants:

- Identify the area and extent of coverage of invader plants and weeds.
- Identify the invasive species present.
- Segment the area into manageable units.

- ❖ Remove invader plants from the first segmented area by using the measure suited for the specific plant and the growth stage and size of the plant.
- ❖ Make sure that personnel handling chemicals and equipment are trained to apply any chemical and understand the precautionary measures.
- ❖ Be careful not to remove all vegetation. Remove the invaders but retain the indigenous plants and prevent weeds from taking over.
- ❖ Once the first segment is cleared, move onto the next area.
- ❖ Remove secondary growth of the invader in the cleared area using the relevant methods
- ❖ Maintain area to ensure re-growth and seedling emergence is minimised.
- ❖ Continue with the process until no re-growth or new seedlings emerge.
- ❖ Removed plant material can be used as a compost or mulch or in the case of larger trees, as charcoal or firewood.

REMEMBER:

- Alien, or invasive, plants are plant species that are not indigenous, and were brought to South Africa as garden plants, in horse feed or when plantations were established.
- Alien plants proliferate in South Africa because they do not have any natural enemies in their environment.
- Alien plants are categorised into three categories, from plants that should be removed and destroyed wherever they are found, to plants that may not be planted, but that may be allowed to continue growing where they already are.
- Alien plants are controlled by means of sawing, hand pulling, bio-control or berbicides.

RECOGNIZE ERODED AREAS

INTRODUCTION

Farming activities have a direct impact on the environment. This may be a positive or negative one depending on how pro-active and conservation conscious the farmer is.

The following are examples of “poor farming practices” that have a negative effect on the environment:

- Over grazing of animals.
- Poor irrigation.
- Inappropriate farming techniques (i.e. deep ploughing 2 to3 times per year to produce annual crops).
- Intensive farming practices – the lack of crop rotation.
- Planting crops down the contour instead of along it.
- Destruction of tree and plant cover.

SOIL EROSION

Soil erosion is a serious problem throughout the world. South Africa is a relatively dry country compared to many other countries. Poor soil management results in soil loss from arable lands, into rivers, which eventually finds its way into the ocean.

Soil erosion is caused by water and/or wind.

Water erosion:

The main cause of soil erosion is water. When a drop of water hits soil with no plant cover, it impacts on the soil is like a bullet. This action causes the soil grains to loosen. The loose soil grains are suspended in the water and runs off with the water.

Nutritious topsoil is always first to be removed as it is the top layer of soil. Without topsoil, plants cannot grow, and the land becomes desert-like. Without plant cover, the effect of water is multiplied, and the result is in desertification, meaning that the area literally becomes a desert.

Water erosion also affects downstream areas, causing flooding and silting up dams because of the suspended soil particles.

The flow of the water causes the formation of channels, and eventually dongas and gullies. Channels occur on steep slopes because of the irregularities in the land. Water finds hollows that run into one another and slowly deepen to form miniature dongas.

Dongas usually occur near the bottom of slopes and are caused by runoff of water and soil forming a deep channel or gully. A deep channel eventually opens at the bottom end of the slope and slowly works its way from the channel, deepening and widening it, until a donga is formed.

Wind erosion:

Wind erodes the soil by blowing away loose soil particles if the soil is left bare. Wind erosion is not a big issue in citrus production, but is prevalent in arid areas, and around animal watering holes.

PREVENTING SOIL EROSION

Soil erosion can be prevented by employing the following measures:

- ✓ Arable land should not be left bare.
- ✓ Make and use contours when ploughing and planting.
- ✓ Plant windbreaks.
- ✓ Ensure the soil is rich in humus.
- ✓ Allow indigenous plants to grow along rivers and in gullies.
- ✓ Conserve wetlands, grasslands and forests.
- ✓ Perform minimum or no tillage.
- ✓ Encourage water infiltration by improving the soil structure.
- ✓ Reduce water runoff.
- ✓ Ensure there is a protective plant cover.
- ✓ Plant ground covers to stabilise soil.
- ✓ Build gabions and install shade cloth barriers in gullies to prevent soil washing away.
- ✓ Mulch soil to prevent dust particles from blowing away.

Although weeds compete with citrus trees for water and food, and is therefore controlled in an orchard, a good grass covering provides protection against excessive run-off and the resultant soil erosion. Careful management of irrigation also contributes to controlling soil

erosion.

The formation of gullies and dongas can be prevented by:

- Diverting waterways to reduce the intense water flow
- Planting grass in waterways to prevent soil erosion

Once a gully has formed, the land can be rehabilitated by shoring it up with old tree trunks, etc.

REMEMBER:

- Soil erosion is caused by water or wind.
- Gullies and dongas are formed as a result of soil erosion.
- Soil erosion can be prevented and controlled by maintaining a grass cover in orchards and controlling irrigation by managing irrigation to prevent excessive runoff.
- Dongas and gullies can be rehabilitated by diverting waterways and by shoring them up.

SUSTAINABLE FARMING PRACTICES

PREPARATION AND APPLICATION OF NATURAL FERTILISERS

Natural fertilisers: in a natural environment the only soil enrichment that occurs is through decomposition of organic material. The nutrients derived from this process are slowly released back into the soil system. Limited nutrient loss occurs as the system is constantly cycling the **nutrients**.

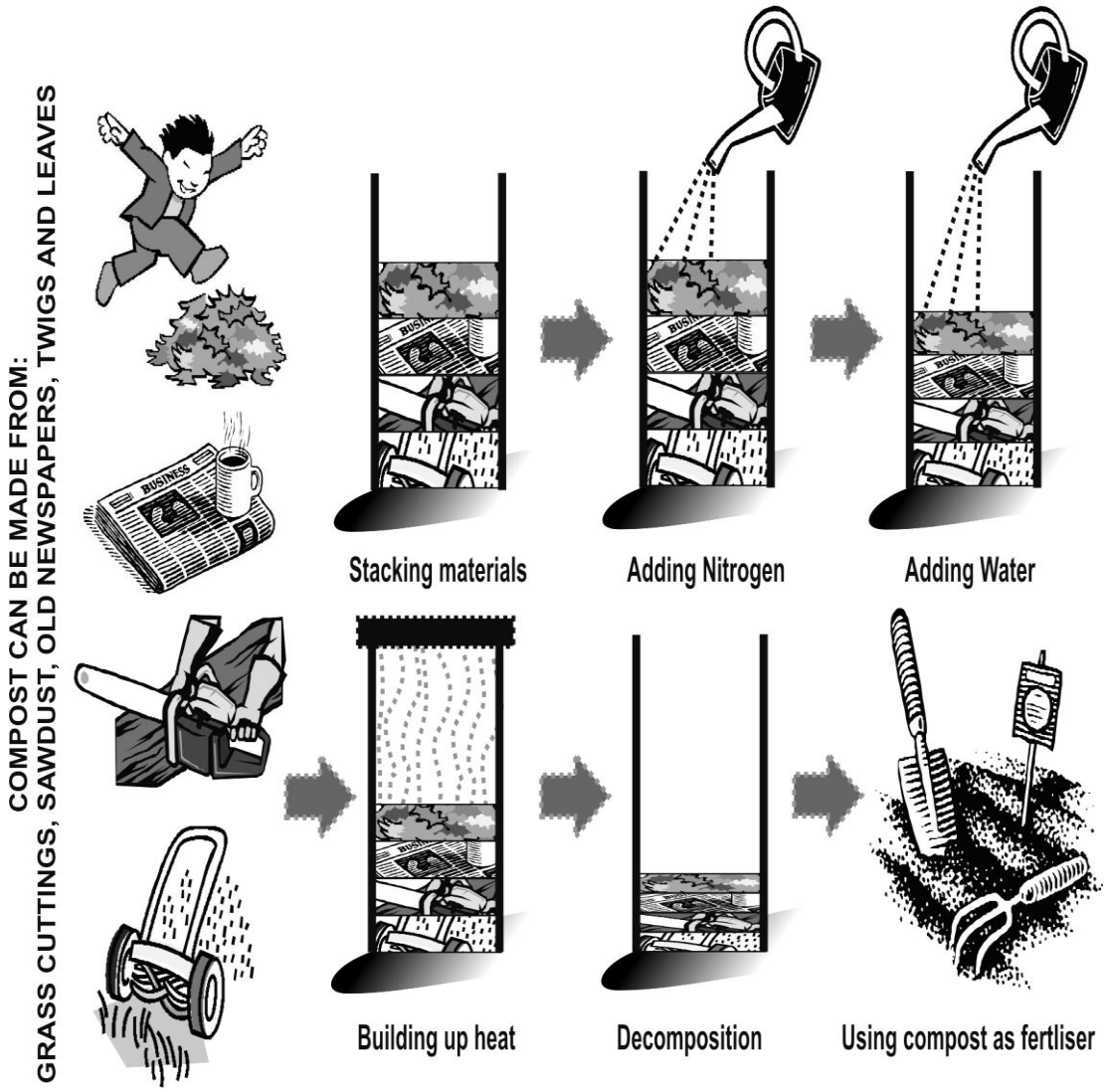
If this area were to be farmed, significant loss would occur because the crop is harvested and removed. Sustainable farming requires the farmer to replace the **nutrients** that are lost by crop production.

There are two key components in the making and use of natural fertilizers; manure and decomposing plants. Manure is available from domestic livestock and poultry. Decomposing plants are available from plant off-cuts and the discarded parts of plants.

The section below is an illustration of the process of **compost** and other natural fertilisers can be produced from constituents that would normally be treated as waste.

It is important to use these materials properly so as to avoid the transfer of diseases and to ensure that the strength of the materials produced does not harming plants during application.

How to make compost from your organic waste material:



Waste from the garden and table does not have to be disposed of. This can be condensed and reused as a fertiliser through a process called composting. To make a good compost heap you will need about five wheelbarrow loads of 'wet' materials and 'dry' materials, as

well as about two wheelbarrow loads of either compost or well-rotted manure. You will also need access to water.

INSTRUCTIONS:

Step 1:	If there is a species of grass that sends out runners, cover the compost heap area with a thick layer of cardboard to prevent the grass from growing into the heap. Otherwise the heap can be made in any sheltered position.
Step 2:	Cover the area with a 20 – 30cm layer of branches and coarse materials to allow for aeration and drainage. It should be like a thick mattress. Ask someone to hold a long straight pole upright in the middle of the heap so that the rest of the heap can be built around this; the pole will be removed later to allow for air circulation.
Step 3:	Put a 30 cm layer of wet organic (green leafy) composting material on top of the coarse materials. Green leafy materials such as comfrey, tansy, clover are good compost activators. This layer can include weeds, vegetable and kitchen scraps. Exclude diseased plants, weeds with seeds and grass such as kikuyu that grows with runners. Keep the sides as straight as possible, as if it was a bed.
Step 4:	Next, add another 30cm layer of dry material on top. This layer can include leaves, mulch, maize stalks and dry grass.
Step 5:	Put a 5 cm layer of activating material, e.g. old compost or manure, on top of this.
Step 6:	Water the two layers that have been placed so far so that it is as wet as a squeezed sponge.
Step 7:	Repeat the process from Step 3 to Step 5 until the heap is about 1.5 m high. It is important that the heap should be high enough to place enough pressure on the rest of the heap because this helps

	the heap to heat up, which in turn helps the activation process.
Step 8:	Cover the top of the heap with some material that will keep out rain and retain heat. Black plastic sheeting, soil or dry grass all work, remembering to remove the chimney pole first, and to keep the chimney open to allow air to circulate.

The heap should heat up within about two days. Hold your hand over the ventilation hole and feel whether or not it is hot. If it not heating up, remake the heap, adding more activating materials.

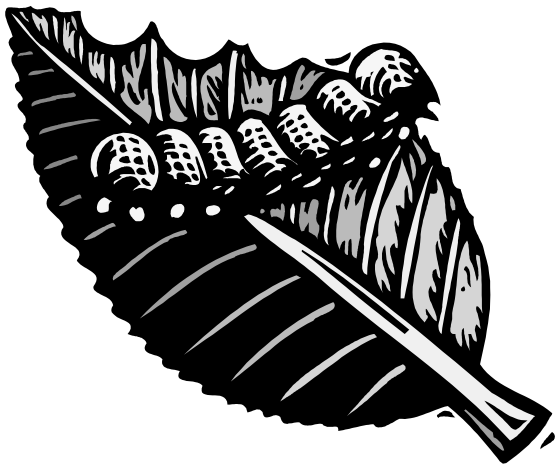
When the compost heap has cooled down – six to ten weeks later – the compost heap can either be turned inside out so that the materials that were in the middle are now on the outside and top, or a spade full of compost earthworms (the red ones) can be added to the heap. The earthworms will take about six to eight weeks to turn the heap into good compost. If the heap is turned, it should heat up again, and once it has cooled down it is ready to use. When the composting process is complete the heap should be dark brown in colour and the organic materials that were used to make the compost no longer recognisable.

BASIC METHODS OF NATURAL PEST CONTROL

The most effective way to protect a plant is to strengthen it; this can be done by adopting special cultivation methods and with management of the environment.

Companion plants. These are plants that are planted together, with the aim of one plant protecting the other against specific pest and diseases. Some plants contain and exude chemicals that are toxic to pest and diseases or repel pests. An example is planting garlic plants around the edges of a vegetable patch. The garlic will repel	**Plants that have components that are toxic to insects**. An example of this would be the pyrethrum daisy (chrysanthemum sp), **which contain Pyrethrum**. The pyrethrum can be extracted from the plant and used as a spray as well.

pests such as cutworm and thereby you prevent damage to the vegetable.	
Traps. Traps are effective if they are used early enough, these could be as basic as a light trap for nocturnal insects or more complex such as pheromone traps.	**Natural enemies.** It's important to understand that every insect has its place in the ecosystem, but it is only when man manipulates the environment and produce a crop that a certain insect becomes a pest. Natural enemies of insect must be utilised to their optimum ability. Different categories of natural enemies are found such as: **Predators.** Spiders, lady bird beetles, ground beetles and syprid flies. **Parasites**. Wasps and flies. **Pathogens**. Fungi, bacteria or viruses. **Nematodes**. Small microscopic worms found soil.
Basic soil conservation. Soil erosion destroys the most fertile part of the soil. There are several ways you can reduce soil erosion. • Work on reducing the impact of wind and water on the soil. • A large amount of soil at all times. • Improve rain infiltration. • Reduce the flow rate of water across the soil. • Plant a cover crop to protect the soil.	

Crop rotation. • Each plant type has different requirements that it sources from the soil and will therefore occupy different areas in the soil. • Rotating plants allows the soil to be built up as different plants add different characteristics to soil. Crops Rotation of also ensures that pathogens do not build up in soil. • Crop rotation also means there is diversity of crops, which builds in protection for the farmer.	

SOIL CONSERVATION

There is general agreement that there are three basic principles that are used in conservation agriculture:

- Minimal soil disturbance
- Maintain a protective cover on the soil
- Practice crop rotations

Following and understanding these principles are the basis for developing successful conservation agriculture systems, for both large-scale commercial farming operations and subsistence level systems common in many parts of Africa.

Minimum Soil Disturbance

Rather than disturbing all the soil in a field – typically down to a depth of 15cm (6 inches) as little soil as possible is disturbed. This is typically achieved by directly placing seed into a small slot formed in the soil with a no-till planter for mechanized operations, or jab planter or even a stick for small-holder farmers.

In modern day agriculture tillage operations (ploughing, disking, harrowing etc.) require a considerable amount of energy, different pieces of equipment and can have considerable negative effects on the soil structure.

Maintain Soil Cover

Soil erosion is the result of several natural and manmade factors. For the most part, things like rainfall (amount and intensity), the erodibility of the soil and the slop cannot be modified by farmers. Bare soil will erode much more than soil with crops or other plants growing on it. After crops have been harvested it is the non-harvested residue can be laid on the surface of the soil to protect it during the time when there are no crops in the field.

The one thing that farmers can do to reduce erosion is to protect it from the impact of falling raindrops. This can be done by maintaining an adequate soil cover, either with vegetation or residues from the previous crop.

Practices that remove residue after harvest (such as burning), should be avoided, or kept to a minimum.

The following **cost-saving structures** are all used as small structures in catchment areas of less than 5 km^2. The structures are established at less productive times when labour employed for extensive farming can be utilized better. The structure should not be built on very steep slopes. However, the soil type will determine what constitutes a safe slope. The structures should be regarded as part of a pasture rehabilitation program aimed at long-term benefits. The purpose is to conserve moisture and to establish a seed-bed.

The structures should be established in a strategic spot. This is usually where a few small gullies converge, or where the slope is slighter than in the rest of the donga, or where a reef has been exposed clearly in the right position with regard to the slope of the donga.

If the flow of the water is diverted by the small structure, the water must be left on a safe, hard stratum, or in the original bed where there is no chance of erosion.

Gutter Structures

The **gutter structure** is used to move water from a more elevated part of the donga bed to a lower-lying terrace. The structure can be built from concrete, bricks or stone masonry.

An upstream **cut-off wall** of about half a meter below the floor, and a downstream cut-off wall extending all the way to the reef, is very important. The floor against a slope must be

cast on a firm base. The water must be returned to the existing donga. The structures can be erected without great expense by using materials occurring in the vicinity, for example sand and building/concrete stone.

Tyre Structures

Structures made from old **car tyres** must be attached very firmly to iron poles driven into the ground in each stack of tyres that is piled up. The tyres must be tied together, and they must be filled with stones. A layer of shade-cloth must also be attached to the upstream surface of the tyres. This must extend from ground level to the top of the tyres. The tyres must be inserted into the sides of the dongas where they are used, in such a way as to prevent water from flowing between the tyres and the walls. Where excavations are made in the sides of the walls, soil must be thoroughly compacted against the tyres after the piles had been stacked. The iron poles around which the piles are stacked must be anchored to one central pole upstream from the stacks. The upstream iron pole must be driven into the ground as deep as possible.

These **structures** are not recommended unless great care is taken to stack them properly. Fast flowing water can cause any number of problems.

Small Concrete Structures

Small **concrete structures**, brickwork or stone masonry can be used in small gullies where the reefs are clearly exposed. The spill-over part of these small structures is not built higher than half a meter. The structures can be built in any shape. The shape must be simple and practical. If structures are built higher than half a meter they have to be designed, and correctly spaced buttresses must be added on the downstream side.

These structures are built to **conserve moisture** and to establish a seed-bed on a bare reef. The reef must be cleaned very thoroughly to enable the concrete to bind. All loose material must be removed. If the reef is brittle, it cannot be used. The structures must be well-recessed into the sides of the donga. If the recesses are dug neatly, the brick or stone-work, or the concrete can be put in place without shuttering. Shuttering can be used where necessary. It is very important that the structures should have a floor on the downstream side to prevent erosion of the stone and damage to the structure. The object of this work is not to form dams.

Once the work has been **overgrown** or silted over the idea is that is should blend in with the environment. To keep transport costs down as far as possible, the structures should

preferably be built with materials found in the vicinity. No brittle stones should be used for building, since this would weaken the structure. Use stones of 150-200 mm in diameter for stone-work.

Bare Spots (brackish spots)

Branches can be used to cover bare spots to prevent them from drying out so soon after rain. It is advisable to break up the spots with an implement to form holes in which water can collect.

Loosening of the soil also breaks the upper crust and brings some of the subsoil to the surface. To this end the spade plough or ripper can be used.

Stone Stacks (with or without wire baskets)

Stone stacks can be used almost everywhere with great success. The stones must be stacked correctly to enable them to absorb the force of the water. Where steep slopes occur, it is preferable to stack stones in wire baskets. The stones must be stacked together tightly to prevent the water from readily washing away loose stones. It is very important that the direction of flow of the water should not be altered. The water must keep flowing in the donga and must merely flow over the structure. The slides of the stone stack must be higher than the part over which the water is supposed to flow.

The stone stacks are used to establish **plant growth** which would increase the carrying capacity of the area. They retard the run-off rate of the water, which results in increased infiltration of the soil. In the long term this can benefit the underground sources of water. The paddocks, in which the structures occur, must be continuously monitored to ensure that the vegetation being established around the structures is not damaged by grazing stock. If seeds are sown to accelerate rehabilitation, only seeds that belong in the immediate vicinity must be used. Avoid all strange or alien seeds, which could result in problems with alien vegetation.

In areas where more than 500 mm of rain occurs annually, rehabilitation work can be done with grass sods. The sods can be placed in strategic spots where water is available, to cover the ground and prevent further erosion.

Crop Rotations

Farmers have long known the value of crop rotations for keeping their soils productive and crops healthy.

Crop rotations include growing crops from different plant families, and leguminous and non-leguminous plants in successive growing seasons. This helps to reduce the buildup of soil pests and diseases that might accumulate between seasons when growing the same crop.

Here you do not plant the same crop in the same place year after year, but you make sure that a different crop is planted in each space. This is a good idea because:

- ✓ It prevents or stops the accumulation of insects and diseases. If the same crop is planted some insects and diseases will become more every year!
- ✓ Different crops use different nutrients or plant food stored in the soil. In this way you do not overuse some of the plant food while not using others.
- ✓ The soil can be covered all year round.
- ✓ Some crop adds nutrients or nitrogen to the soil. Examples are beans, peas, broad beans, soya beans, peanuts, cowpeas, Lucerne and clover.
- ✓ It prevents the soil from building up bad or negative reactions to specific plants. An example here is nematodes on tomatoes and swiss chard. Nematodes are very small worms, that we cannot see with our eyes. They live in the soil and feed on the roots of your plants.
- ✓ There is no build up of specific weeds.

In the first season after applying compost and or manure heavy feeders or nitrogen consumers are planted. In the second season the light feeders are planted and in the third season legumes are planted. This is followed by another application of compost or manure and the cycle is repeated.

In trench beds, where the organic matter is decaying slowly in the soil, you may want to start with legumes, move on to heavy feeders or nitrogen consumers and then move on to light feeders. This is because during the decaying process plant nutrients will take a while to become available for use by plants. The legumes can fix most of their own nitrogen and are thus a better starting point.

Prepare the land or bed well. Put a lot of compost or manure in your bed (4 full spades/square meter). Then, start by planting a fruiting crop. Leaf crops need less and can follow fruit crops. Then root crops can follow leaf crops without much addition of plant food. Root crops like fertile soil, but do not like fresh manure or compost. It has to be well rotted. Then, nitrogen fixers can follow, with addition of little or no plant food. Then you need to prepare the land well again. Start once more with fruiting crops.

Preparing the land or bed:

This would mean trenching or double digging or addition of a lot of compost/manure forked into the top 30 cm. You will need at least 4 full spades for every square metre.

A general recommendation is to place 30 tons of compost or manure to a hectare of land. This comes to about one half of a wheel barrow load for every square metre. This is about the same as 4 full spades!

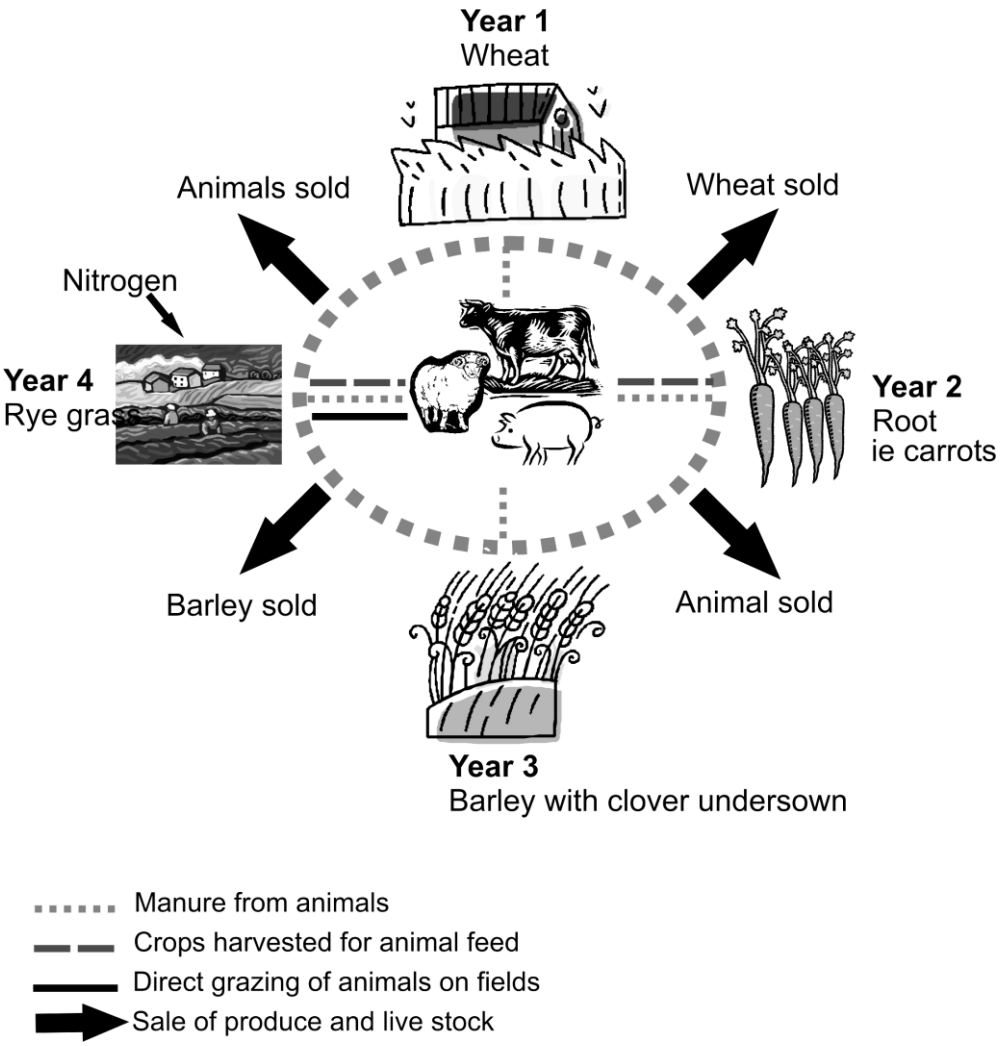
Advantages and disadvantages of crop rotation

ADVANTAGES of crop rotation	DISADVANTAGES of crop rotation
• No build up of pests and diseases • Soil nutrients are used effectively • Soil moisture is used effectively • A healthy living soil can be built up over time	• Without a plan, either drawn or written on paper, it is difficult to remember which crop is to follow. • It can be tricky to decide which rotation to follow when inter-planting is also used.

NORFOLK FOUR-COURSE ROTATION

This section illustrates the Norfolk four-course rotation system, which allows sustainability that increases in productivity from these farmlands.

Year 1	Fields are sown to wheat, which is harvested and sold.
Year 2	Root crops are grown on the fields, which are fed to animals. The animals are then sold and the animal manure is used to fertilise the fields.
Year 3	Barley is sown as green manure.
Year 4	Ryegrass is sown, fixing valuable nitrogen into the soil and providing direct grazing for the animals.



PREVENT THE SPREAD OF FIELD FIRES

INTRODUCTION

Fire poses a huge risk to any commercial farming operation. Citrus orchard that has taken a long time to become established and productive can be seriously damaged or destroyed in a short space of time. Procedures must therefore be in place to prevent fires from spreading.

A firebreak, also referred to as a fireguard, is a strip of land that has been cleared of trees, bushes, and any other combustible material in order to prevent a fire from spreading.

The firebreak forms a boundary around orchards that is able to hinder a runaway fire. However, a firebreak cannot stop every veld fire and it is possible that a fire can jump a firebreak under very windy and dry conditions. A firebreak is however useful to stop most fires, to provide a line from which to combat a fire by back burning, and to protect property. Roads between orchards form natural firebreaks.

BUILDING FIREBREAKS

All landowners are required to prepare firebreaks on their side of a boundary between two farms, and it is good practice to have firebreaks anywhere on a farm where orchards neighbours natural vegetation.

There are general guidelines that must be followed when preparing firebreaks, being:

- The firebreak must be wide and long enough to have a reasonable chance of stopping a veld fire.
- The firebreak must not cause soil erosion.
- The firebreak should be reasonably free of inflammable material.
- It is advisable for farmers to remove protected plants from the path of a firebreak before undertaking the building of a firebreak. These plants must be transplanted where possible.
- The method used to prepare a firebreak depends on the conditions around the orchards, and on the equipment that is available. Grading and burning are the most common methods used.

Burning

Burning is most often used in combination with slashing. The vegetation is slashed and kept short to keep the flammable material to a minimum. As winter approaches, and the threat of veld fires increases, farmers may then burn this area to further reduce the flammable material. In some cases, herbicide is sprayed on the slashed vegetation before it is burnt.

Tall, uncut vegetation is not often burnt on a farm, as this can cause a runaway fire in itself. The vegetation must be reduced to a minimum through slashing and using herbicides before it is burnt.

If the firebreak is to be burnt on a border with a neighbouring farm, it is good practice to contact the neighbour to agree to burn on mutually acceptable dates. Inform the Fire Protection Association of the agreed upon dates. Never burn a firebreak on a windy day.

It is essential that any material that might burn is removed. Any paper, rubber, grass, dead plant material, and flammable chemicals must be removed from the area to prevent the spread of fires.

Grading

Grading is generally used to make dirt roads on farms and can also be used successfully to level and compact the soil around orchards to form firebreaks.

It takes longer to make a firebreak through grading than through burning, but it is safer to use this method especially where the firebreak is between an orchard and natural vegetation.

REMEMBER:

- Fire poses a great threat to all farming operations.
- A firebreak, or fireguard, is a strip of land that has been cleared of trees, bushes, and any other combustible material in order to prevent a fire from spreading.
- Grading and burning most commonly make firebreaks.

CHAPTER 3

CONSTRUCTING AND PLACING INFRASTRUCTURE FOR SUSTAINABLE LAND-USE

In this chapter we explore the following:

- Erecting infrastructure
- Building a contour
- Milking a cow
- Good working order of tools, implements and machinery
- Maintain and store tools, implements and machinery
- Safety measures

ERECT INFRASTRUCTURE TO ENSURE SUSTAINABLE FARMING PRACTICES

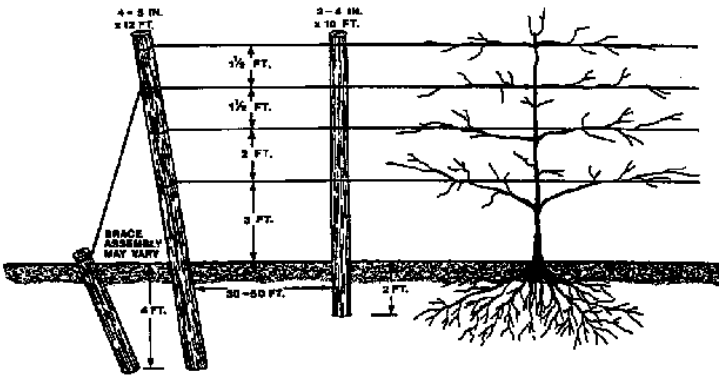
ERECTING A FENCE

Tools and equipment for erecting a fence

➢ **Fences and trellis systems**

During the erection of fences and trellis systems we might use the following tools:

- Spirit-level
- Pickaxe
- Mattocks
- Spade
- Shovel
- Pliers
- Rake
- Wire cutters
- Fence strainer and saw.



Most modern agricultural fences are constructed from different types and sizes of steel wire in combination with wooden posts etc.

Reasons for using the following equipment:

Spirit level: Use a spirit level to ensure that all posts and fences are at a 90 degree angle in relation to the surface area. This will ensure that once the fence is erected it will not fall over to one side due to its own weight.

Rake: Use a rake to remove leaves and branches and for leveling the earth around posts after they have been erected.

Pickaxe: When erecting posts as part of a fence, hard sediments and underground rocks are found when digging the holes for the posts. A Pickaxe can be used to loosen rock and break up sediments. The earth can then be removed with a shovel.

Mattocks: When an area is selected for erecting the fence and it's covered with shrubs and underground roots a mattock can be used to clear the obstacles.

Jemmy/ Koevoet: This is a heavy, thick, hard steel shaft used to deepen a hole for breaking up rock and is very useful especially when holes are deep and a pickaxe cannot reach the bottom.

Spade: When erecting a fence, one must dig holes for the posts to be planted. Spades are used to dig theses holes. Workers must take care not to damage spades when digging in hard areas and must first loosen up the earth using a pickaxe.

Shovel: Shovels are used to remove earth from holes where posts are being planted

Saw: A saw is used to make shallow notches in the posts at the correct height to keep wires from slipping down the post after the fence has been erected. The wire is winded at least twice around the post in the notch and then fastened.

Pliers: These are used for gripping and fastening wires to posts and connecting steel, wooden or rubber droppers/spars vertical to the wires to give strength and stability to the fence. The shape of the pliers depends on their use. When connecting steel or galvanized wire to a post use pliers with a square front that can properly grip the wire.

Fence-strainer: There are different types of wire strainers found in the market today. This tool is used to tighten wires within a wire fence by using lever action. Operators must take necessary precaution and ensure that all fellow workers are at a safe distance because if a strained wire snaps it can cause serious injury or death.

Wire cutters: When erecting a fence, one often uses a wire cutter to cut off access end of wire. Most pliers used for fastening wires can also be used for cutting wires. Take care not to use wire cutters for cutting hard steel as this will cause damage to the cutting edge.

Combination of tools used for erecting a fence

- Pickaxe, Jemmy / Koevoet, shovel, spade, mattock and rake

The above combination of equipment is used for digging a hole when a fence is erected. The pickaxe, mattock and jemmy/koevoet are used to loosen obstacles like roots, rocks and hard sediments. The shovel and spade are used for deepening the hole and removing loose earth out of the hole. Rakes are used for clearing the site where posts must be planted and for leveling the area around the posts after the posts have been planted.

- Pliers, Fence-Strainers, Saws and Wire cutters

When all the posts in a section of fence have been planted the process of straining must begin. The notches in posts are made with a saw to keep wires from slipping down the posts and ensuring the correct spacing in-between wires. Wire pliers are used to fasten wires around posts after the fence-strainer has tightened the wire to the correct tension. Wire cutters are used to cut away access wire. Pliers are also used to attach droppers to the tightened wires using thinner more pliable types of wire.

Agricultural fencing

- In agriculture, fences are used to keep animals in or out of an area.

Fences used to divide paddocks

- Timber agricultural fence. (*Photo taken in 1938)*

- Barbed wire.

BUILDING A CONTOUR

TOOLS, EQUIPMENT AND MACHINERY USED FOR BUILDING A CONTOUR

- **Tractors**

- **Ploughs**

- **Graders**

A **grader**, also commonly referred to as a **blade**, is an engineering vehicle with a large blade used to create a flat surface. Typical models have three axles, with the engine and cab

situated above the rear axles at one end of the vehicle and a third axle at the front end of the vehicle, with the blade in between.

- **Bulldozers**

- **Dumpy levels**

A **dumpy level**, **Builders auto level**, **leveling instrument** or **automatic level** is an instrument used in surveying and building to transfer, measure, or set horizontal levels.

It is an instrument that is set up on a tripod and, depending on the type, either roughly or accurately set to a leveled condition. One operator looks through the sight while the other holds a tape measure or graduated staff at the position to be measured.

They are used to gather and/or transfer elevations (or levels) during site surveys or building construction. They generally start from a reference point known as a benchmark, this may be a value from a known survey point, or an arbitrary point used as a *once off.*

Dumpy level in use on a construction site

THE PROCESS OF BUILDING A CONTOUR

Contours are imaginary lines on a slope connecting areas on the same level. In agriculture contours refer to terraces or plough furrows that are created when ploughing in the same direction as the imaginary contour.

Depending on the size of the operation and the characteristics of the site different machinery is then used to create the contours by ploughing, grading or bulldozing the earth to form ridges and lines.

In agriculture, a **terrace** is a leveled section of a hilly cultivated area, designed as a method of soil conservation to slow or prevent the rapid surface runoff of irrigation water. Often such land is formed into multiple terraces, giving a stepped appearance

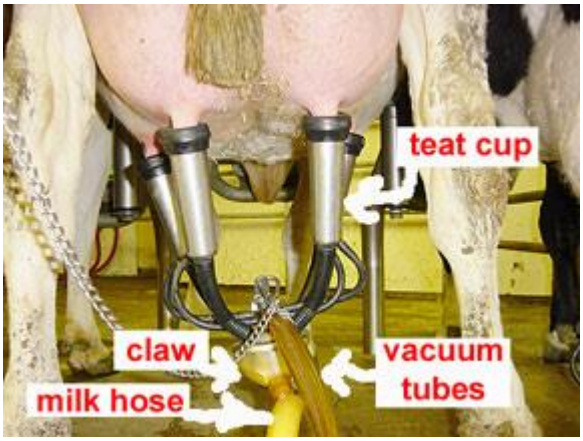
This form of land use is prevalent in many countries and is used for crops requiring a lot of water, such as rice. Terraces are also easier for both mechanical and manual sowing and harvesting than a steep slope would be.

MILKING A COW

TOOLS, EQUIPMENT AND MACHINERY USED FOR MILKING A COW

Milking machine: The milking machine is a system consisting out of varies parts that work in combination with each other to milk a number of cows at the same time. The following parts form the basic framework of the milking machine:

- Claw;
- Teatcups;
- Milk tubes (many different shapes and sizes);
- Pulsator;
- Bulk tank



Milking machines are used to extract milk from cows when the herd is larger than about 4 cows. The milking unit is the portion of a milking machine for removing milk from an udder. It is made up of a claw, four teatcups, long milk tube, long pulsator tube, and pulsator.

The claw is manifold which connects the short pulse tubes and short milk tubes from the teatcups to the long pulse tubes and long milk tubes. Claws are commonly made of stainless steel or plastic. Teatcups are composed of a rigid outer shell (stainless steel or plastic), which holds a soft inner liner or inflation. Transparent sections in the shell may allow viewing of liner

collapse and milk flow. The annular space between the shell and liner is referred to as the pulsation chamber

Milking machines work in a way that is different from hand milking or calf suckling. Continuous vacuum is applied inside the soft liner to withdraw milk from the teat by creating a pressure difference across the teat canal (or opening at the end of the teat). Vacuum also helps keep the machine attached to the cow. The vacuum applied to the teat causes congestion of teat tissues (accumulation of blood and other fluids). Atmospheric air is admitted into the pulsation chamber about once per second (the pulsation rate), to allow the liner to collapse around the end of teat and relieve congestion in the teat tissue. The ratio of the time that the liner is open (milking) and closed (massaging or resting) is called the pulsation ratio.

The four streams of milk from the teatcups are usually combined in the claw and transported to the milk line or collection bucket (usually sized to the output of one cow) in a single milk hose. Milk is then transported (manually in buckets) or with a mechanical pump to a central storage vat or bulk tank. Milk is refrigerated on the farm in most countries either by passing through a heat-exchanger or in the bulk tank.





In the photo above is of a bucket milking system with the stainless-steel bucket visible on the far side of the cow. The two rigid, stainless steel teatcup shells applied to the front two quarters of the cow are visible. The top of the flexible liner is visible at the top of the shells as are the short milk tubes and short pulsation tubes extending from the bottom of the shells to the claw. The bottom of the claw is transparent to allow visualization of milk flow. When milking is completed the vacuum to the milking unit is shut off and the teatcups are removed.

Milking machines keep the milk enclosed and safe from external contamination. The interior 'milk contact' surfaces of the machine are kept clean by a manual or automated washing procedure implemented after milking is completed twice or three times per day.

Milk contact surfaces must comply with regulations ensuring that they are food grade materials (typically stainless steel and special plastics and rubber compounds) and are easily cleaned.

Most milking machines are powered by electricity but, in case of electrical failure, there can be an alternative means of motive power, often an internal combustion engine, for the vacuum and milk pumps because milking cows cannot tolerate delays in their scheduled milking without suffering serious milk production reductions.

MONITOR THE GOOD WORKING ORDER OF TOOLS, IMPLEMENTS AND MACHINERY

THE MALFUNCTION OF TOOL, IMPLEMENTS AND MACHINERY ARE RECOGNISED

Recognition of a malfunction in a machine by the operator using his senses

- **Touch:** When a machine or tool works at a higher temperature than normal and heat is felt by the operator he may assume a malfunction.

- **Smell:** The smell of burning rubber or oil is normally one of the first signs of a defective machine.

- **Hearing:** Operators are normally very aware of the noise the equipment he/she is working with makes. Loose bolts and screws may cause rattles that is audible and can help with the identification of a defective implement etc.

- **Sight:** Operators doing prescribed maintenance checks on their equipment may spot loose screws or leaks well before any damage may occur and may rectify the problem immediately. While operating a machine like a tractor the driver often see smoke or flames from under the bonnet and can switch off the machine instantly.

- **Input vs. output:** When machines and equipment do not run cost effectively e.g. when fuel or oil consumption increases but production rate stays the same one may assume the equipment is malfunctioning.

THE CAUSE OF THE MALFUNTION IS CORRECTLY IDENTIFIED

Definition:

Malfunction – A fault in the way a machine or equipment operates.

The farm Tractor

The reasons why tractors malfunction are the following:

- **Operators**: In most cases the cause of malfunction in tractors is negligence or mistakes made by the driver or operator, (human error). Insufficient maintenance or no maintenance is probably the most common cause of malfunction. Often a driver or operator is in charge of a tractor without being properly trained for this task and this may lead to mistakes causing malfunction. If a tractor is not used for its intended purpose by its operator it may lead to misuse and cause malfunction.

- **Faulty Machinery**: On very few occasions the cause of malfunction is faulty machinery. Normally such a malfunction will be apparent in the first period after purchase and will be covered by the supplier's warranty.

APPROPRIATE ACTION TO PREVENT FURTHER DAMAGE

The following procedure will help operators to prevent further damage to their machinery in the case of a malfunction.

- **Stop:** Make sure you come to a standstill and then switch off the motor of your machine/ equipment.

- **Assess:** Do an inspection of your machine to ascertain the cause of the malfunction.
- **Get help:** If you are unsure regarding the cause of the malfunction, get a technician or your direct manager to help you.
- **Report:** Make sure you report the incident to the person responsible for maintenance and see to it that your report is recorded.
- **Repair:** Make sure the problem is repaired fully before using the tractor etc. again.

APPROPRIATE ACTIONS TO RESTORE GOOD WORKING ORDER

The best ways to ensure good working order is to ensure routine maintenance, repair malfunction equipment and to use the correct operating procedures. The most important aspect to take note of is that activities on a farm are an ongoing process and therefore maintenance and repair must also be seen from this point of view.

All the different kinds of infrastructure found on a farm require routine maintenance to ensure that the farming activities that they service can continue without hold ups. For example, a drip irrigation system is designed to supply water to each individual vine in a vineyard. If one of the drippers become blocked, the result is that the vine being fed water by that dripper will become stressed and potentially die. Therefore, one of the routine maintenance checks on a drip irrigation system would be to check that all drippers are working.

MAINTAIN AND STORE TOOLS, IMPLEMENTS, EQUIPMENT AND MACHINERY

OVERVIEW

A modern farm must function as a business unit with an intergrated plan for maintenance and servicing of all equipment nessscary for operation. This plan needs to be established as part of a total management plan and intergrated from top level management down to the operator's level.

The importance of an effective maintenance plan:

Planning and **control** is vital if an effective maintenance plan is to be implemented. The management must, in conjunction with the person who will be responsible for the maintenance procedure, establish from the outset a plan that is practical and functional (It is

important that this person be in a senior position). This plan must allow for unforeseen deviations, but only under extreme conditions.

At this point it is important to establish a plan for the storage of equipment; this storage will determine the value that management places on the maintenance level of the equipment. It must include a demarcated area that is specific to the cleaning of equipment. This area must conform to the farms conservation and environmental policy and plan that would take into account the use of strong cleaning materials that will be most detrimental to the environment.

Once the five-year production plan for the farm is established, then planning for maintenance of equipment and machinery within the production plan can begin.

The routine maintenance and scheduling plan needs to be broken into two major sections and that is detailing the scheduled times that coincide with non-production peaks for major maintenance and the frequent inspections, either daily / weekly / monthly checks that are carried out on the equipment.

A **farm maintenance budget** needs to be practical and consists of two sections:

- **Frequent routine maintenance costs**- these costs are budgeted for in general but not planned for. For example, a tractor might get a puncture and this would come out of this cost centre.

- **Major maintenance work**- in the plan it would be budgeted that after one year the tractor would require a major service and after five years the engine would require a total overhaul.

Frequent inspections would identify the need to replace or repair faulty items. Major maintenance work involves complete rework of equipment or an engine that has had considerable service time. This sort of maintenance is planned and budgeted for and would be scheduled to occur during a non-productive period on the farm.

In the planning stage the managers would have to decide if they are going to have the infrastructure available to do major maintenance work on engines and equipment or are they going to outsource this work. If they decide to keep the work in-house they must plan to have all the tools and equipment available to carry out major repair work. The costs involved in the maintenance of a tractor are substantial. For example, over the lifetime of a normal tractor, a

farmer will spend the value again on keeping the tractor running in a condition that is compliant with the Occupational Health and Safety Act.

Often all major maintenance is carried out by specialists as it works out to be more economical in the long run.

The farm store would normally have a list of the suppliers of all equipment operating on the farm and if a new part is required to carry out work identified during a frequent inspection then the stores can order the part if they do not carry it as a stock item.

Part of the planning process would be to identify how much capital would be invested in stock items for maintenance and what would be acceptable down time if the maintenance team has to wait for the supplier to deliver. A balance needs to be planned for, as it is very costly to keep stock in the store and it can be costly to production not to have it immediately available.

For every type of equipment operating on the farm there must be the necessary specific or generic equipment available to carry out maintenance on the machines or equipment. Most engine sprayers or brush cutters come with a set of spanners that is specific to that machine. It is best for the workshop to have a set and for the operator to have a set to take into the field.

No machine must be operated on unless the correct equipment is available. Using improvised tools on specific equipment can be costly and dangerous in the long run. A chain saw, brush cutter and sprayer usually have a specific sparkplug spanner and it is important to use the correct one.

On a farm the equipment is designed for hard and rugged use but it is important that on a daily basis that the machines be cleaned and stored appropriately.

During this cleaning process it is important for the operator to check for stress fractures. Dirt often conceals these fractures and damage occurs before the fracture is identified if daily maintenance is not carried out on the machine.

On a monthly basis the equipment needs to go into the workshop to be serviced and minor repairs made.

The table below provides an example of a preventative maintenance plan for internal infrastructure.

Infrastructure Preventative Maintenance		
Infrastructure Item	Preventive Maintenance	Recommended Action in case of Deterioration
Access Roads	• Storm water-drains are clear and sufficient. •Potholes and other faults in the roads are repaired. • Cracks in paving are marked and repaired	Report faults and deterioration to local road authority
Farm Roads	• Storm waterways are clear and sufficient. • Potholes and other faults in the roads are repaired.	• Clear storm water ways • Repair faults and cracks as soon as possible before the condition of the road deteriorates more.
Irrigation and Water Supply	See Irrigation System Maintenance Plan	
Electricity Supply	• Annually: get a competent person to inspect distribution boxes. • Periodically: test earth-leakage and circuit-breakers. • Periodically: inspect lightning conductors.	• Repair all possible problems and faulty equipment. • Lightning conductors and earth spikes are prone to theft, replace as necessary.
Communication Systems.	• Test communication lines. • Test batteries, power packs, etc. • Inspect lightning conductors.	• Report broken or poor lines. • Replace battery and power packs with a short standby time.
Boundary Fencing	• Visually inspect fence for broken lines, slack wires and unwanted plant growth. • Test electrical fences for proper voltage on wires and the correct working of power suppliers.	• Repair the fence as needed. • In the case of electric fences, the cause of voltage drop must be investigated and rectified. • Look out for slacked wires and vegetation that can cause the fence to make a short.

Buildings and Housing	Annually inspect: • Roof sheeting for leaks • Gutters for blockage • Plumbing for leaks • Interior / exterior surfaces for cracks and peeling paint • Doors and windows to lock and close properly	Repair all problems as necessary. Make use of a competent plumber to repair plumbing.
Vehicles	Follow detailed service plan as recommended by the manufacturer, including aspects such as servicing intervals and preventative maintenance.	Repairs in line with the manufacturers recommendations.
Equipment	Follow detailed service plan as recommended by the manufacturer, including aspects such as servicing intervals and preventative maintenance.	Repairs in line with the manufacturers recommendations.

Some infrastructural items are made up of a number of components and require a specific maintenance plan. Below is an example of a maintenance plan for irrigation systems.

Maintenance plan:

Frequency	Task	Action
Daily	Check block pressures	Determine if within prescribed limits, if not determine cause and correct
	Check emitter operation	Look for clogged, broken or misplaced emitters. Repair, replace, unclog or
	Check for leaks and water wastage	Repair if found
	Flush primary filter	Flush filters as prescribed
	Check fertigation application	Repair if not be within specifications
Weekly	Flushing of laterals	Flush lines as prescribed
	Flushing of secondary filters	Flush filters as prescribed
	Check the system pressure and flow	Repair if not as per design
	Check the pump operation parameters	Repair if not within prescribed parameters
	Check block pressures for automated valves	Repair if not as prescribed
	Check pump oil levels	Correct if out of limits
	Inspect fertigation plant	Look for damage and / or vandalism
Monthly	Visually inspect valves, water meters, and gauges	Look for damage and / or vandalism
	Open and inspect filters	Implement prescribed actions
	Check for leaks at pump pipe work	Check for leaks loosing water and for leaks through which the pump can suck air
	Grease pump motor	Follow actions as prescribed
	Perform CU tests	Follow actions as prescribed
Annually	Service valves and physically check correct operation	Follow actions as prescribed
	Thoroughly clean filters and replace sand in sand filters	Follow actions as prescribed

Agricultural equipment such as tractors and implements are incredibly expensive. It is cost effective to plan and build sheds to house tractors and equipment for the following reasons:

- The equipment is kept together and can be accounted for.
- The condition of the equipment can be checked and compared
- Equipment is accessible for inspection.
- Protected from the environment and theft.
- A policy of total quality management requires that all equipment is maintained and stored in a manner that complements this management strategy.

EXPLAIN AND APPLY NECESSARY SAFETY MEASURES

THE APPROPRIATE PROTECTIVE CLOTHING TO USE AND WEAR

Protective clothing for general hand tools

Hand tools are often used without any protective clothing. Spades and forks do not normally require protective clothing. A common exception is when working in muddy conditions when rubber boots must be worn. When using picks or hammers on material like rock, protective eyewear is recommended as rocks splinters can damage eyes. When working with cement or rough material like rocks or barbed wire leather gloves must be worn.

When using power tools like angle grinders, eye protection should be mandatory. Welding equipment has its specialised headgear to protect eyes from the very intense light during the operation. A leather apron must also be worn during welding. The farm manager should be aware of the safety needs of his/her workers and respond to that before it develops into a problem.

PROTECTIVE EQUIPMENT THAT MUST BE AVAILABLE:

These include:

- Overalls.
- Face shields.
- Rubber boots.
- Rubber gloves or leather gloves.
- Goggles.

THE SAFE USE OF MACHINERY

The Occupational Health and Safety Act determines the following regulations with regards to the safe use of machinery:

Safeguarding of machinery

1. Every employer or user of machinery shall:

- Ensure that all machinery used by him, is suitable for the purpose for which it is used, and that it is installed, operated and maintained in such a manner as to prevent the exposure of persons to hazardous or potentially hazardous conditions or circumstances

- In particular cause every exposed and dangerous part of machinery which is within the normal reach of a person to be effectively safeguarded by means of insulation, fencing, screening or guarding, except where an inspector has granted written permission for the omission of such safeguarding

- Ensure that all safety equipment is kept in good working condition and is properly used

- ✦ Ensure that the quality of material used in, and the construction, of the machinery or safety equipment is suitable for the purpose for which it was intended.

2. Where machinery constitutes a danger to persons, the employer or user of machinery concerned shall cause the premises in question to be enclosed, and where such premises are unattended the designated entrances to such premises shall be kept closed and locked.

3. Unless he has been authorised thereto by the employer or user of machinery, no person shall remove any safety equipment which relates to the machinery in question.

Operation of machinery

1. An employer or user of machinery shall ensure that every person authorised to operate machinery is fully aware of the dangers attached thereto and is conversant with the precautionary measures to be taken or observed to obviate such dangers.

2. If a person operates any machinery which requires constant attention in order to avoid accidents, he shall under no circumstances leave his post while such machinery is in operation, unless he is relieved by a person who is authorised and competent to operate such machinery.

3. An employer or user of machinery shall ensure that any machinery which requires constant attention in order to avoid accidents is under the supervision of a shifts man, who shall at all times be present on the premises while such machinery is in operation and no person shall attend or operate such machinery, except under the general supervision of a shifts man.

4. No person supervising machinery and no person operating machinery shall, without the permission of his superior, authorise any person to do his work.

5. If machinery threatens or is likely to threaten the safety of persons when it is unexpectedly set in motion or made electrically alive, the employer or user of machinery concerned shall take all reasonable

precautionary measures in order to ensure that such machinery cannot be set in motion or made electrically alive, and any person intending to set such machinery in motion or make it electrically alive shall take reasonably precautionary measures to ensure that the safety of a person is not threatened or likely to be threatened.

6. If machinery in operation threatens or is likely to threaten the safety of persons, the person supervising or operating such machinery or the employer or user of machinery concerned shall stop such machinery or cause it to be stopped.

Reporting of incidents in connection with machinery

Each incident in which –

- the fracture or failure of any part of machinery resulted in a falling or flying object,
- machinery ran out of control as a result of the failure of a control or safety equipment and could have caused an injury to a person who had been conveyed on or in such machinery or had been in the vicinity thereof; or
- the fracture or failure of any part of machinery in which gas is under pressure resulted in the sudden release of such gas,

shall be reported forthwith to an inspector by the employer or user of machinery concerned.

CHAPTER 4

MONITOR WATER QUALITY

In this chapter we explore the following:

- Understanding water quality management
- Monitor and perform basic water tests and analyses
- Understanding of maintenance tasks
- Managing chemical and physical requisites
- Reporting on maintenance of water quality control systems

UNDERSTANDING WATER QUALITY MANAGEMENT

INTRODUCTION

In its purest form, water contains only water molecules with the chemical formula of H_2O, meaning each molecule consists of two hydrogen (H) atoms and one oxygen (O) atom. Water is however an excellent medium for many other materials, such as salts, to dissolve in. Water is also host to a variety of organisms, and furthermore often carries insoluble and suspended material.

Definition:

Salts: Salts not only refer to table salt (sodium chloride), but any compound of acids and bases, such as calcium sulphate, potassium nitrate, magnesium chloride, etc. In these salts, calcium, potassium and magnesium are bases, and the salts are formed when acids like sulphuric acid, nitric acid and/or hydrochloric acid are added.

Saline: Water with a high salt concentration, also referred to as high total dissolved salts (TDS), is referred to as ***saline***.

These properties of water cause its quality to be variable and are why it is polluted so easily. All the non-water components dissolved, living or suspended in water are regarded as foreign materials. These foreign materials are responsible for the chemical, physical and biological quality factors of water.

The type and concentration of foreign materials determine the quality of the water.

Managing water quality therefore concerns six critical control points, namely:

- Determining the quality of the water received on the farm;
- Identifying the causes of the said quality;
- Being aware of the quality standards of water for crop production;
- Improving the quality of received water where possible;
- Identifying water quality factors that cannot be improved and need to be managed; and
- Managing the quality of the water leaving the farm.

In most cases, the water quality manager has little say in the quality of the water received on the farm. The manager has to make the best of what water is available to produce crops profitably. However, the manager can influence the quality of the water leaving the farm, and must take this responsibility seriously.

By maintaining the water delivery infrastructure such as pumps, pipes, dams and boreholes, you are better able to maintain and monitor a consistent level of water quality and quantity.

Water is used in crop production to irrigate fields or trees, and to apply nutrients and pesticides to the crop leaves through foliar sprays and soil. Profitable production of permanent crops is not possible in Southern Africa without irrigation, through which an adequate supply of good quality water must be provided to ensure economic yields, the required fruit size and quality.

Orchards are usually irrigated using one of the following methods:

- Micro-sprayer irrigation.
- Drip irrigation.
- Basin irrigation.
- Flood irrigation.
- Under-tree-sprinklers.

Field crops are usually irrigated using one of the following methods:

- Sprinkler irrigation, quick coupling type or permanent.
- Drip irrigation for row crops.
- Furrow and short furrow irrigation.
- Basin irrigation.
- Flood irrigation.
- Centre Pivot irrigation.

PHYSICAL WATER QUALITY FACTORS

Physical water quality factors (PWQF) are influenced by all the foreign materials that do not dissolve in the water, and that can usually be seen with the naked eye. These materials pose problems primarily to the irrigation system.

Micro-sprayers and drippers have very narrow openings (0.25mm to 2.50mm diameter) and are blocked by any material that is too large to pass through, or that accumulates in this narrow pathway. When partly or totally blocked, the micro-sprayer or dripper cannot deliver the required volume of water to the trees.

The following materials influence the physical quality factors and are often responsible in clogging the drippers or micro-sprayers:

- ✓ Inorganic materials, such as clay, silt and sand;
- ✓ Organic debris, such as remnants of plants, seeds, animals, aquatic fauna and flora;
- ✓ Living aquatic plants and animals, such as algae and snails;
- ✓ Plastic cuttings from the irrigation pipes and equipment; and
- ✓ Lubricant residues.

While the first three contaminants can usually not be controlled and must be managed, the last two contaminants can be controlled by taking the necessary steps to prevent contamination by plastic cuttings and lubricant residues.

Sprinklers do not block as easy as micro sprayers but also do block causing uneven distribution of water.

CHEMICAL WATER QUALITY FACTORS

The chemical water quality factors (CWQF) refer to the non-visible components in water. Instruments are used to determine their presence and concentration. CWQF are very important, because they determine the short- and long-term potential and sustainability of the entire plant production system. Chemical quality factors affect:

- Crop production;

- Sustainability of the productivity of the soil; and
- The effective operation of the irrigation system.

The most important CWQF and their impact on each of these areas are shown in the table below, with the following classifications:

- **Y** = This factor **has** an impact.
- **Y/N** = This factor **may** have an impact depending on other factors.
- **N** = This factor **seldom** has an impact.

CWQF	***Crop Production***	***Soil Productivity***	***Irrigation System Efficacy***
Total soluble salts	Y	Y	Y
pH	Y	Y	Y
Calcium	Y	Y	Y/N
Magnesium	Y	Y/N	Y/N
Sodium	Y	Y	N
Chloride	Y	Y/N	N
Bicarbonate	Y	Y/N	Y/N
Boron	Y	Y/N	N
Iron, manganese and sulphides	N	N	Y

Definition:

pH: pH indicates the **acidity** or **alkalinity** of any substance, in this case water, on a scale of 1 to 14. pH can range from 1 (extremely acidic) to 14 (extremely alkaline). A pH value of 7 is **neutral**. Plant sap has a pH of 5.8 and the pH of human blood is almost 7. Water with a low pH is referred to as ***acidic***. Water with a high pH is referred to as ***alkaline***.

WATER QUALITY MANAGEMENT (WQM)

Water quality management (WQM) is the evaluation of:

- The impact of the incoming water on the soil, the crop and the efficiency of the irrigation system;
- Steps that can be taken to remove or neutralise negative factors; and
- Steps that can be taken to manage economically those factors that cannot be altered.

In short, WQM has to do with managing foreign material in the water, and not with the water itself.

REMEMBER:

- Irrigation is used in crop production to supply plants with the water they need in addition to rainfall.
- Water quality factors that are important depend on the type of irrigation system used. Micro-sprayer irrigation is the most commonly used in South Africa and drip irrigation the second most common.
- Water dissolves many substances, such as salts, and is a carrier for a lot of suspended material, which influences the water quality, and which is why it is polluted to easily.
- Water quality management (WQM) has to do with managing foreign material in the water, and not with the water itself.
- Water quality management concerns six critical control points, being:
- Determining the quality of the water received on the farm;
- Identifying the causes of the said quality;
- Being aware of the quality standards of water for crop production;
- Improving the quality of received water where possible;
- Identifying water quality factors that cannot be improved and need to be managed; and

- Managing the quality of the water leaving the farm.
- PWQF is determined by the foreign material that does not dissolve in the water. These materials can clog emitters and pipes.
- CWQF refer to the non-visible qualities of water, and affects crop production, the sustainability of the soil productivity and the effectiveness of the irrigation system.

WATER QUALITY IN AGRICULTURE

THE IMPORTANCE OF WATER QUALITY

The final evaluation of water quality is its effect on sustainable crop production. In fruit production, it is measured by the yield of quality fruit according to the demands of local and export markets. Water quality has a direct and indirect influence on fruit production.

Direct effects

The direct effects of water quality include:

The concentration of salts dissolved in the water has a direct effect on the water available to the tree or any other crop. The higher the salt content, the more energy is required by the crop to utilise the water. Remember that dissolved fertilisers add to the salt content of the water.

- ✓ Magnesium (Mg) is a plant nutrient but can cause imbalances at high concentrations. A high concentration of magnesium interferes with the utilisation of potassium (K).
- ✓ The high pH of water is caused by the bicarbonates. In water with low total dissolved solids, a little bicarbonate can cause a high pH. Too high pH reduces the availability of nutrients, especially the micro-nutrient elements.
- ✓ High concentrations of chlorides in water used for foliar sprays can cause scorching of the leaves.

- ✓ Although boron (B) is an essential nutrient element for plants, it is required in low concentration and can easily be over-supplied by water containing more than 1mg boron per litre.

Indirect effects

The indirect effects of water quality include those factors that have a detrimental effect on soil properties, the efficacy of foliar sprays and blocking of the emitters (micro-sprayers and drippers).

- Sodium adsorption ratio (SAR) is a measurement of the potential hazard posed by the sodium in the water to the soil. Water with high sodium content will gradually reduce the stability of the soil structure. A stable structure of the soil is required to promote water penetration and root development.

- The efficiency of foliar sprays to supplement nutrients depends on the pH and buffer capacity of the water used to mix the chemical. The optimal pH for the uptake of nutrients from foliar sprays is 5 to 6.

- The half-life of some insecticides and pesticides depend on the pH of the water used in the spray solution.

- Blocked emitters will discharge less water than intended or none at all. The distribution of the water will also not be optimal. Therefore, some trees will receive too little water and production will be reduced.

Definition:

Half-Life: The half-life of a chemical is the time taken for it to lose half their strength, or the period of time that must elapse for an agro-chemical to lose half of its original toxicity.

IMPROVING WATER QUALITY

To improve the physical water quality factors (PWQF) of huge volumes of water used for irrigation is quite easy and cheap compared to the processes required to improve the chemical quality factors (CWQF).

A high salt concentration or total dissolved salts (TDS) of irrigation water is the most important chemical quality factor. The TDS in water has a direct effect on most of the other water quality factors. Reducing the concentration of salts in irrigation water involves huge inputs of energy and is not an economical option for agriculture in South Africa. Processes that result in desalting (desalinisation) of the water involve reverse osmosis (RO), distillation, and de-ionisation or demineralisation.

Definition:

Reverse Osmosis: A water treatment process whereby dissolved salts, such as sodium, chloride, calcium carbonate, and calcium sulphate may be separated from water by forcing the water through a semi-permeable membrane under high pressure.

Distillation: The purification of salt or brackish water by removing the dissolved salts though allowing the water to evaporate and then condensate against a smooth surface, such as glass, from where it is collected again.

Deionisation: Removal of ions from water by exchange with other ions associated with fixed charges on a resin.

The quality of irrigation water can however be improved by focusing on specific factors that can be improved economically.

IMPROVING PHYSICAL WATER QUALITY FACTORS

Improving the physical quality factors of irrigation water involves processes such as:

- **Sedimentation:** Sedimentation is a process whereby the flow of water is reduced, and the suspended material is allowed to settle to the bottom. This is done by letting the water into a storage dam from where it is pumped to the orchards. During the time the water is in the storage dam, the flow is reduced to zero and solid particles settle. This process is effective at removing solids such as clay, silt, sand, cuttings and some organic debris. However, when the water has a high SAR, the clay settles slowly and in severe cases, the clay remains in suspension.

- ❖ **Filtration:** Filtration is the process where water is passed through a structure with very small openings which allow the water to pass through but trap insoluble suspended particles. **Filtration does not remove dissolved salts.** The small openings are created by a container filled with sand (a sand filter), with a series of plastic discs containing narrow spleens on their flat surfaces that are fitted together (a disc filter), or with a series of steel plates with small holes in or mesh wire (screen filter).

IMPROVING CHEMICAL WATER QUALITY FACTORS

Chemical water quality factors can either be improved or dealt with under certain conditions, as follows:

- ✓ **Correcting the pH** – It is not always economically viable to correct the pH, because large volumes of water are required for irrigation. However, when applying pesticides, adjusting the pH is always justifiable due to the cost of the pesticide, the small volumes of water required, and the potential lost in exportable yield if the pesticide is less effective. The volume of acid needed for the correction of the pH of water can be determined by titration, using a pilot plant (see practical below) or based on the carbonate plus bicarbonate content of the water.

  The pH of water can also be reduced by adding commercially available buffers. These buffers are usually mixtures of inorganic and/or organic acids. Application directions are supplied with each product.

  Some pesticides are more active at pH values higher than 6.50. Although this is not required often, special formulations of buffer solutions are available to increase the pH to the desired level. Increasing the pH of irrigation water is seldom required, but if high water acidity causes too much damage to the irrigation system, in the form of corrosion, a specialised investigation is called for.

Example:

Correcting the pH of Water

Information supplied:

- 7.5ml acid is required to decrease the pH of 20 litres water to 5.5
- The spray machine has a capacity of 2,000 litres

Calculation:

- Requirement per litre: 7.5 / 20 = 0.375ml per litre

- Requirement for 2,000 litres: 0.375 x 2,000 = 750ml per 2,000 litres required to reduce pH to 5.5

- ✓ **Oxidation** – When water gets in contact with air, dissolved metals like iron and manganese are oxidised to their insoluble form and settles to the bottom of the water. Oxidation can be accelerated through spraying the water through the air into a storage dam.

- ✓ **Dealing with Sodium Absorption Ratio (SAR)** – The SAR of water influences the soil. An SAR value of more than one indicates a possible sodium hazard. It is dealt with as part of the soil maintenance program.

- ✓ **Dealing with Chlorides** – Too high concentrations of chlorides can be dealt with, to some extent, by supplying to the tree more or all nitrogen in the form of nitrates and supplying the tree with more calcium. This is best done with **fertigation** and a drip irrigation system.

Definition:

Fertigation: Fertigation refers to the practice of applying fertilisers through the irrigation system. Drip irrigation systems are most suited to fertigation.

IMPROVING QUALITY OF WATER LEAVING THE FARM

A very important aspect of water quality management is to improve the quality of the water leaving the farm, thereby improving the downstream quality. If the upstream users prevent or

reduce contamination, downstream users will have fewer problems. Prevention involves the following processes:

- **Preventing Nitrogen Leaching** – Nitrate nitrogen is easily leached from the soil and will end up in underground or surface waters. Optimising the application of nitrogen and water will reduce leaching of nitrates.

- **Preventing Excessive Application of Chlorides** – Like nitrates, chloride also leaches easily and will end up in the subsoil, underground- or surface water. The application of chlorides should therefore also be controlled carefully.

- **Preventing Excessive Runoff** – When water is applied at rates in excess of the infiltration rate of the soil, runoff occurs. Runoff water carries nutrients and soil particles, and adds to the problem of suspended solids, unwanted nitrates and phosphates, and increasing the electrical conductivity of water. Runoff water also causes soil erosion.

Definition:

Electrical Conductivity (EC): The electrical conductivity of water refers to its ability to conduct an electrical current. The more salts dissolved in the water, the higher the ability to conduct current, hence an increase in the EC value.

- **Preventing Dumping** – Dumping of any chemicals or materials that can causes pollution or contamination of water sources is strictly prohibited. However, even approved dumping sites can add to the deterioration of the quality of water. Even French drains and other approved methods of getting rid of refuse can cause pollution problems. Regulations regarding the safe disposal of chemicals and other harmful materials must be strictly adhered to at all times.

SAMPLING AND MONITORING WATER QUALITY

Water quality is monitored on a regular basis, including the quality of:

- Water received on the farm, whether it be water received from a river or underground water received through boreholes;
- Water contained in storage dams; and
- Water leaving the farm.

To monitor the quality of the water, samples are taken at the water source, tested and analysed.

Sampling is the process where the body of water to be sampled is reduced in volume so that it can be transported to a laboratory. Although this sounds strange, it is important to understand that a proper sample is not just a piece of the body of water, but a very small but true reflection or representation of the entire body. The volume of a water sample is usually 500ml, but this 500ml can represent millions of litres water. Always keep this in mind when taking a water samples.

Ensure that the 500ml taken is **exactly the same** as the millions of liters of water in the dam or river, in all aspects that are to be measured and tested.

MONITOR AND PERFORM BASIC WATER QUALITY TESTS AND ANALYSIS

PREPARING SAMPLES FOR ANALYSES

Considerations

Care must be taken when sampling to ensure that the sample is not contaminated while or after it is taken.

Containers: The most appropriate container for water samples is a plastic bottle with a screw cap. In practise, 500ml mineral water or cold drink bottles made from polycarbonate is very suitable for this purpose. Special bottles for water sampling are also available on the market.

Cleaning of containers: Wash all containers that are being reused properly with warm water, but do not use a detergent. Take care that the cap is also washed properly. Do not use caps with cardboard or absorbing seals. Before taking a sample in a properly washed reused or new container, rinse it three times with the water to be sampled. Also rinse the caps.

Labeling: Never write directly on the bottle, because the lettering could be rubbed off during transportation. Stick a label onto the container or tie it to the neck of the bottle. Write all relevant information on the label with a waterproof pen. The minimum information on the label includes:

- The name of the farm/farmer;
- The identification number or name of the water source;
- If only one water sample is submitted, also write the contact information of the farm or farmer on the label. Where more than one sample is submitted from the same farm or farmer, at least one label should contain all the relevant information and the rest only the farm or farmer name and the name or number of the water source.

Water Sample Label

First sample	Second sample
Sunshine Farming **LARGE DAM** P O Box 6115 Hoedspruit 1380 Tel: (015) 766-9999 Fax: (015) 766-9988	**Sunshine Farming** **SMALL DAM**

Sampling procedure

The standard procedure for sampling water is as follows:

- Rinse the container and cap three times with the water to be sampled;
- Fill the bottle to capacity and screw the cap on, leaving **no** air space at the top;
- Label the bottle; and
- Put aside in the shade and dispatch as soon as possible to the laboratory.

Although this standard procedure remains the same on principle, special procedures are followed when sampling water from various water sources.

- **Canals** – Sample the water at in the middle of a running canal.
- **Boreholes** – Let the pump run for at least one hour or for as long as it takes to fill all piping with fresh water. Never sample the water standing in the pipes.
- **Storage Dams** – Take the sample away from the sides or wall of the dam and 50cm below the surface.
- **Rivers** – Take the sample in the flow of the river. Standing water accumulates suspended material and has a higher concentration of salts.
- **Water from Irrigation Pipes** – If the purpose of the sampling is to measure the quality of the irrigation water, remove a micro-sprayer or open the end of a lateral line. Let the water run to flush the pipes, and then fill the bottle. If the purpose is to measure the type and mass of the deposits, open the end of two or three laterals into a suitable container with a capacity of about 50 liters. Then take the sample from this container while stirring the water.

PERFORMING SIMPLE CHEMICAL WATER QUALITY TESTS

Water quality tests that need to be done on a continuous basis are pH tests and electrical conductivity (EC) tests. These two tests are relatively simple, and do not require a lot of expensive equipment.

pH Testing

The following equipment and instrumentation is required:

- ✓ A pH meter, which can be a handheld or desktop instrument;
- ✓ Alternatively, special pH sensitive paper strips, but **not** Litmus paper;
- ✓ Glass or plastic beakers;
- ✓ Washing bottle containing demineralised water;
- ✓ Reagents; and
- ✓ pH buffer solution for pH 7 and 4 or any other two whose range will include the pH of the water to be tested.

Definition:

Demineralised Water: Demineralised water refers to water from which the dissolved salts (minerals) have been removed. Car battery water is for example demineralised. In chemical laboratories, all water that is used, even for washing the equipment, is demineralised.

The following procedure is followed when a pH meter is used:

- Switch the pH meter on and let it warm-up according to the instructions of the manufacturer;
- Rinse the electrode with demineralised water;
- Mark two beakers pH 4 and pH 7, and pour the appropriate pH buffer into each beaker;

- Insert the electrode into buffer solution pH 4. Set the pH meter to read pH 4;
- Remove the electrode from the buffer and rinse with demineralised water in a separate beaker;
- Insert the electrode into buffer solution pH 7. Set the pH meter to read pH 7;
- Remove the electrode from the buffer and rinse with demineralised water in a separate beaker;
- Repeat the process with buffer solutions until the instrument reads 4 and 7 when inserted into the buffer solutions;
- Rinse the electrode well with demineralised water;
- Insert the electrode into the water sample. Let the reading stabilise before it is noted on the report (reading A);
- Rinse the electrode and take a reading of one of the pH buffer solutions. Note the reading (reading B).

pH sensitive paper strips change colour when coming into contact with a substance that is not pH neutral. The following procedure is followed when pH sensitive paper strips are used:

- ✦ Pour either the pH buffer solution of pH 4 or pH 7 into a marked beaker;
- ✦ Insert a strip into the beaker and keep it there for the required period, according to the product instructions;
- ✦ Verify the colour of the paper strip with the colour chart. This compares to reading B in the previous procedure;
- ✦ Insert a strip into the water sample and keep it there for the required period;
- ✦ Compare the colour of the paper strip with the pH colour chart. Note the pH according to colour. This compares to reading A in the previous procedure.

Electrical Conductivity (EC) Testing

The following equipment and instrumentation is required:

- An appropriate EC meter, which can be a handheld or desktop version;
- Washing bottle with demineralised water;
- Glass or plastic beakers;
- Reagents;
- Standard solution of for instance 1,000g potassium chloride per litre water

The following procedure is followed:

- Standardise the instrument according to the instructions of the manufacturer using the standard potassium chloride solution;
- Rinse the electrode of the EC meter in demineralised water;
- Insert it into the water sample;
- Note the reading (reading C);
- Rinse the electrode of the EC meter in demineralised water;
- Insert it into the standard solution;
- Note the reading (reading D).

REPORTING ON WATER QUALITY TESTS

Reporting on water quality involves three steps, namely:

- Ensuring that the value of the reference standard is acceptable;
- Ensuring that the units are correct; and

- Comparing the results with reported results from previous tests at the same source.

If this sequence is followed, the accuracy and quality of the test is guaranteed.

Reference standard

In the methods described above, reference standards are used for pH and EC to calibrate the instruments. The same solutions are used to verify the results by using it as an unknown sample together with the water sample. A water sample cannot be used as a reference, since the composition will change over time. Use one of the calibration standards, which are chemically stable as a reference.

Example:

pH Testing - Let us assume that buffer pH 7 was used as an unknown and was read at the end of the procedure. The reading is recorded as “Reading B”, with the value of 7.03. Compared to what it should read, namely 7.00, one can conclude that the deviation is acceptable and that the reading on the water can also be accepted as correct. Therefore “Reading A” is accepted and reported. Deviations of less than 5% are acceptable. A deviation of 0.03 from the expected 7.00 represents a deviation of 0.03 / 7.00 x 100 = 0.43% which is acceptable.

Example:

EC Testing - The same procedure is followed for verifying the EC reading. At 25°C, 1,000mg potassium chloride per litre water has an EC of 185mSm^{-1}. Let us assume that the reading of the potassium chloride solution at the end of the procedure was 150mSm^{-1} (Reading D). This deviation is not acceptable, and the value noted for the water cannot be accepted. Therefore, the procedure needs to be repeated, ensuring that the EC meter is correctly calibrated. A deviation of 35 from the expected 185mSm^{-1} represents a deviation of 35 / 185 x 100 = 18.92%, which is not acceptable.

Units

The pH value has no unit. It is only a value referring to the pH scale which runs from 0 (acid) to 14 (alkaline).

The international standard for EC is milli-Siemens per meter (mSm^{-1}). There is however other units that are used, which may create confusion. In the table below, the relationship between the internationally accepted mSm^{-1} and other measurements are shown for reference purposes.

Information

Relationship between EC Units

One Siemen = One mho

$mScm^{-1}$ = $mmhocm^{-1}$

1 $mScm^{-1}$ x 100 = 1 mSm^{-1}

1 mSm^{-1} = 1 mmho m^{-1} = 0.01 mmho cm^{-1} = 10 micro mho cm^{-1}

"mho" is a unit of electrical conductance, with the symbol Ω^{-1}. This unit has been renamed the siemens. Conductance in mho being the reciprocal of resistance in ohms, mho is ohm spelled backwards.

Comparisons

Once the reference standards and units are verified, the results can be compared with previous result from the same source. Please keep in mind that these comparisons need to be done on a seasonal basis. Do not compare values of samples taken in spring with those of samples taken during summer or autumn. Compare results from water samples taken in spring with those of samples previously taken in spring.

PERFORM MAINTENANCE TASKS ON CERTAIN SYSTEMS RELATED TO WATER QUALITY

MAINTAINING WATER QUALITY CONTROL SYSTEMS

Physical technical water quality control systems are not used as such in crop production, as water quality is not monitored and corrected constantly. Regular testing is done, and corrective action is taken when required. The water quality control system (WQCS) that is discussed in this chapter refers to the system that is put in place to ensure that such testing and corrective testing is done correctly and timeously.

The basic water quality control system (WQCS) involves the monitoring of received water and water leaving the farm. Monitoring must be done at regular intervals, with the frequency depending on the magnitude of fluctuations in the quality over time. The water quality of the

input water should however be measured at least twice per annum, once at the beginning of the rain season and once after the rain season. Without these measurements, no improvement or maintenance program is possible.

Another important component of a WQCS is measuring the quality of the water leaving the farm. This is not only done where natural rivers and streams are used to remove excess or drainage water from the farm or orchards, but also includes drainage furrows and water-lanes. Monitoring and measuring of this nature includes analyses of subsoil-water to monitor leaching of nitrates and chlorides.

Maintaining WQCS involves the following:

- Main water source or sources.
- Effluents from rinsing the irrigation pipes.
- Effluents from backwashing the filters.
- Other signs of water contamination.
- Composition of the water leaving the farm.

Main water source or sources

- Sample all water sources utilised on the farm for irrigation of the trees or for applying foliar sprays at least twice per annum;
- Record all analytical data on a chart or graph.

Effluents from rinsing the irrigation pipes

This information is important to identify the causes of blockages, and for evaluating the possibility of them occurring. Blockages are caused by:

- ✓ Salts that dissolve in diluted acid;
- ✓ Material that will not dissolve in diluted acid, including sand from the filters, silt and clay, organic debris, and plastic from cutting the pipes during repairs;
- ✓ Slime and filamentous material of biological origin.

It is not easy to measure these factors accurately and the quality manager has to rely on subjective observations. Nevertheless, these observations supply useful information.

The most appropriate method is to collect the material, let it dry out to form a paste and then proceed as follows:

- Drop diluted hydrochloric acid on some of the paste. If it dissolves, the paste consists of salts. If it fizzes, the paste contains carbonates. **Do not handle the paste after hydrochloric acid has been added to it**;
- Examine the deposit for pieces of plastic, seeds, etc.;
- Feel the paste between the fingers. A silky feeling indicates clay and silt, while a slippery, slimy feeling indicates microbial deposits.

Effluents from backwashing the filters

Inspection of these materials will help to identify a change in the quality of the water. An increase in the concentration of clay and silt will indicate that the water source carries more solids. This can be related to the season or current climate but indicates the need for more frequent backwashing.

To inspect the backwash from filters, collect the backwash water in a 50-litre drum. Let all the insoluble material settle, decant the water carefully and inspect the deposits visually and by touch.

Other signs of water contamination

Contamination is not easily detected except through specific testing as described above. Monitoring fauna and flora, and activities upstream will assist in detecting possible contamination.

Composition of the water leaving the farm

The Department of Water Affairs (DWAF) requires that the quality of water leaving the farm is similar to the quality of water received on the farm. This means that farm management is responsible to maintain the quality of the water passed onto the next user.

MANAGING CHEMICAL AND PHYSICAL REQUISITES RELATED TO WATER QUALITY CONTROL SYSTEMS

REQUIREMENTS TO MAINTAIN OPTIMAL PHYSICAL WATER QUALITY FACTORS

Materials required for maintaining optimal physical water quality factors depend on the method of irrigation employed on the farm. It will however always include replacement parts for the filter system and spare emitters. Although this forms part of the maintenance program for filters and the irrigation system, which will be dealt with in the guide for Irrigation, the reasons for blockages of emitters and filters must be logged to assist in water quality management.

Example:

Logging Water Quality

ORCHARD NUMBER 15		
Irrigation Type:	Drippers	XYZ-dripper 2.3 litre per hour
Total Number:	2064	

Replacements

Date	***No. Replaced***	***Reasons***	***Actions/Remarks***
25/08/04	13	Salt deposits, soluble in acid	Note for acid wash, check pH of incoming water
16/10/04	21	Salt deposits, soluble in acid	Organise acid rinse scheduled for 25/10/04
30/10/04	0	-	Acid rinse successful

REQUIREMENTS TO MAINTAIN OPTIMAL CHEMICAL WATER QUALITY FACTORS

The requirements for maintaining optimal chemical water quality factors depend on the quality of the water and the extent to which the composition of the water needs to be adjusted. Before this can be attempted, the quality of the water and the volumes required per month must be known.

Chemicals that will be required include the following:

- Acids such as nitric acid, phosphoric acid or sulphuric acid to acidify the water;
- Sterilising agents like sodium hypo chloride or hydrogen peroxide;
- Additives to lower and/or buffer the pH of the water when applying pest control chemicals.

A list should be available of the volumes of each of these chemicals required per month and the stocks must be ordered in time.

REPORTING ON THE MAINTENANCE OF A WATER QUALITY CONTROL SYSTEM

Water quality varies throughout the year. When reporting on the WQCS, it is important to first of all decide when a deviation in water quality is large enough to be alarming, and then to determine whether deviations are due to natural variation, or to contamination.

To do this, one needs a set of standards for irrigation water used on the specific crop and historical data to set standards for the particular water source. This means that a WQCS is required for every water source utilised, especially for those sources that are only being used when the usual or main source is depleted.

Detecting deviations should prompt actions to contain or address the deviations in order to minimise their effect on crop production.

Water quality standards for crop protection

Water quality standards are only of value to indicate limitations, because one seldom has a choice between water sources. Where more than one source is available, mixtures of good

and moderate quality water must be used to increase the volume of acceptable quality water.

- The optimal water quality for crops in general is water that:
- Contains little or no chloride and sodium;
- Has an EC of less than 50mSm-1; and
- A neutral pH of 7.

Water like this is however scarce and therefore care should be taken to obtain data for each specific crop's sensitivity and requirements with regards to water quality. The following table is an extract from the Irrigation Design Manual and gives general guidelines for allowable levels of salts and minerals commonly found in water.

The Department of Water Affairs and Forestry developed the South African water quality directives to provide water quality information to water users. Volume 4 of the directives specifically deals with irrigation water and contains criteria for the evaluation of water by indicating the acceptable levels for specific elements and other parameters in four classes. The document is available from the Department.

A summary of the directives is included in the Table below.

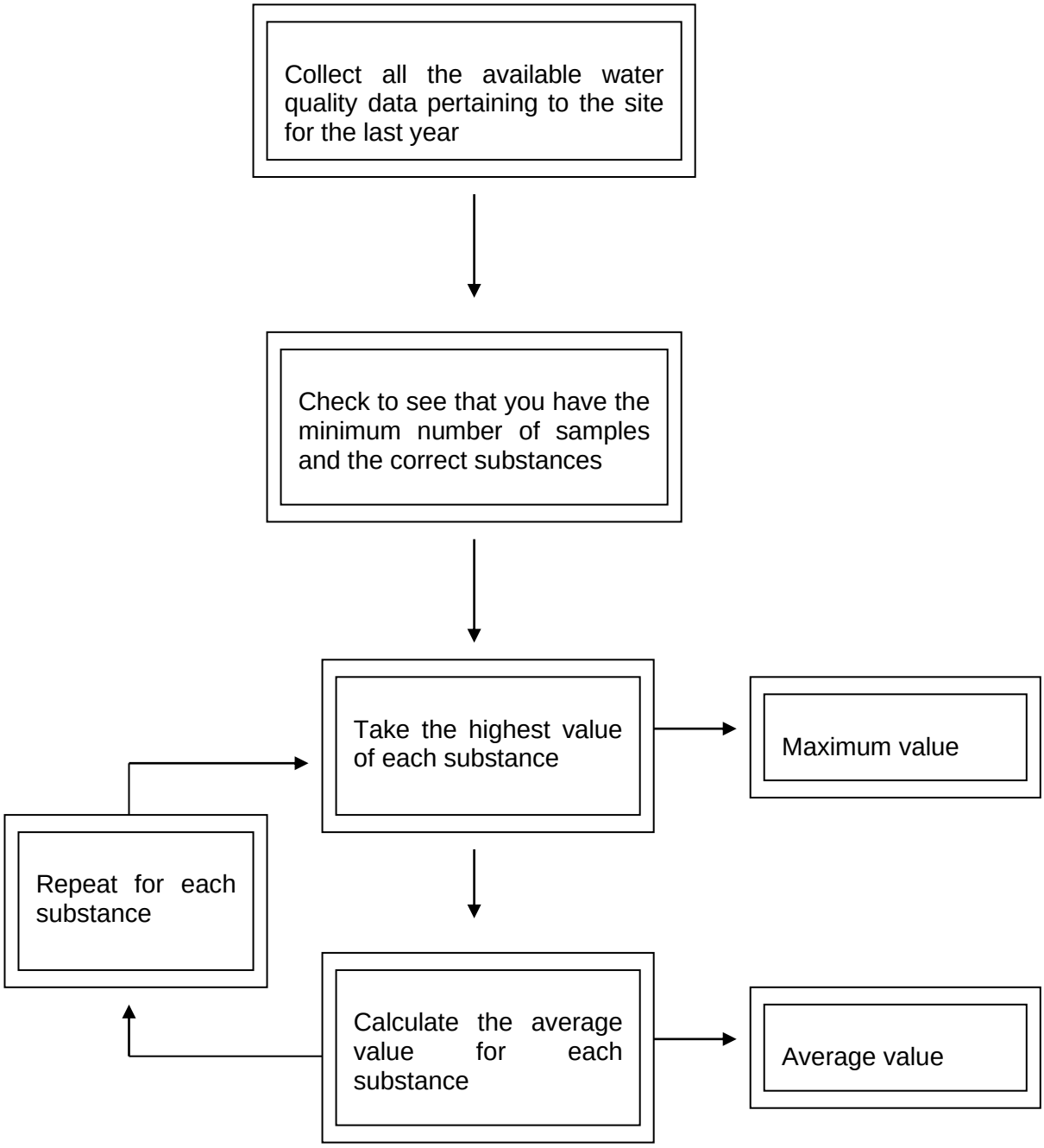
Water quality constituent	Fitness for use for irrigation water			
	Good	Fair	Marginal	Unacceptable
	Salinity and sodicity			
Electrical conductivity (EC, mS/m)	0 – 40	40 - 90	90 - 270	270 - 540
Sodium adsorption ratio (SAR, mmol/$\ell^{0,5}$)	0 - 1,5	1,5 - 3,0	3,0 - 5,0	5,0 - 10,0
	Potentially toxic ions			
Boron (B, mg/ℓ)	0 - 0,2	0,2 - 0,9	0,9 - 1,5	1,5 - 3,0
Chloride (Cl, mg/ℓ)	0 – 105	105 - 140	140 - 350	>350
(mmol/ℓ)	0 – 3	3 - 4	4 - 10	>10
Sodium (SAR,(mmol/ℓ)^{0,5})	0 – 3 0 - 3 mmol/ℓ Na (0 - 70 mg/ℓ Na)	3 - 5	5 - 7	7 - 9
	Trace elements (mg/ℓ)			
Aluminium (Al)	0 - 5,0	0 - 5,0	5,0 - 10,0	10,0 - 20,0
Arsenic (As)	0 - 0,1	0 - 0,1	0,1 - 1,0	1,0 - 2,0
Beryllium (Be)	0 - 1,0	0 - 0,1	0,1 - 0,25	0,25 - 0,5
Cadmium (Cd)	0 - 0,01	0 - 0,01	0,01 - 0,025	0,025 - 0,05
Chromium (Cr)	0 - 0,1	0 - 0,1	0,1 - 0,5	0,5 - 1,0
Cobalt (Co)	0 - 0,05	0 - 0,05	0,05 - 2,5	2,5 - 5,0
Copper (Cu)	0 - 0,2	0 - 0,2	0,2 - 2,5	2,5 - 5,0
Fluoride (F)	0 - 2,0	0 - 2,0	2,0 - 7,5	7,5 - 15,0
Iron (Fe)	0 - 5,0	0 - 5,0	5,0 - 10,0	10,0 -20,0
Lead (Pb)	0 - 0,2	0 - 0,2	0,2 - 1,0	1,0 - 2,0
Lithium (Li)	0 - 2,5	0 - 2,5	-	-
Manganese (Mn)	0 - 0,2	0 - 0,2	0,2 - 5,0	5,0 - 10,0
Molybdenum(Mo)	0 - 0,01	0 - 0,01	0,01 - 0,025	0,025 - 0,05
Nickel (Ni)	0 - 0,2	0 - 0,2	0,2 - 1,0	1,0 - 2,0
Selenium (Se)	0 - 0,02	0 - 0,02	0,02 - 0,025	0,025 - 0,05
Uranium (U)	0 - 0,1	0 - 0,01	0,01 - 0,05	0,05 - 0,1
Vanadium (V)	0 - 0,1	0 - 0,1	0,1 - 0,5	0,05 - 0,1
Zinc (Zn)	0 - 1,0	0 - 1,0	1,0 - 2,5	2,5 - 5,0

Table: *Various limits for specific problems with irrigation water*

Historical data for received water

Historical data of the composition of received water is the most important. This information determines the actions required to optimise water quality. Information on the effluent when rinsing the pipes, backwashing, contamination, and output water is also informative for managing the complete water system. Using this information, seasonal and long-term variations can be studied.

Follow the process below as a guideline to collect your data.


Collect all the available water quality data pertaining to the site for the last year
Check to see that you have the minimum number of samples and the correct substances
Take the highest value of each substance
Maximum value
Repeat for each substance
Calculate the average value for each substance
Average value

Example:

Historical Water Quality Data

Date	*pH*	*EC*	*SAR*	*Cl*	*HCO_3*
Optimal	**<8.50**	**<125**	**<1.00**	**<2.00**	**<1.50**
26/07/00	7.24	74	0.52	1.62	1.67
24/03/01	6.35	45	0.49	0.51	0.62
27/07/01	7.18	82	0.72	1.83	1.58
25/03/02	6.55	51	0.41	0.45	0.55
24/07/02*	7.55	99	0.92	1.93	1.85
26/03/03	7.05	71	0.55	0.62	0.78
24/07/03	7.67	110	0.99	1.95	2.01
25/03/04	7.07	82	1.10	0.82	0.93

* Below long term average rainfall

Rainfall has a marked influence on the quality of most water sources, and therefore the record should include some sort of reference to the rainfall for the ensuing period or season.

Also note the two dates chosen for sampling. This farm is in the summer rainfall area. Sampling in July is done before the summer rain starts and will reflect the worse condition of water quality. The sampling in March is after the summer rains and should reflect the best quality available.

The major conclusions that can be drawn from the example data are the following:

- The quality of the water fluctuates significantly between summer and winter.
- The quality of the water source is deteriorating.

CHAPTER 5

FOOD SAFETY AND QUALITY MANAGEMENT

In this chapter we explore the following;

- Food safety and Quality management
- Personal hygiene practices
- Food contamination
- Warning sins
- Non-conformances and deviations in food safety
- Basic health and social issues
- Risk factors in food safety
- Record keeping

INTRODUCTION TO FOOD SAFETY AND QUALITY MANAGEMENT

Any farm that is going to be producing a crop that will be utilised in big food chains in South Africa or exported needs to have all of its staff trained and able to help in the process of food safety. To control and monitor a food safety process is beyond the ability of management alone. In this process, management will need the assistances of the staff at every level of the operation.

This will entail the following:

- High standard of training for staff in the importance of traceability.
- Full training in all the technical aspects carried out by the person.
- Full understanding of the OHSA.
- Personnel hygiene.
- Social issues

To get a product to an overseas market usually requires many steps. At each step there will be an assessment and sampling of quality and food safety. Before your product will be accepted by an export agent there will be an audit conducted to establish compliance to Good Agricultural Practices.

The overseas standards are important because if you want to export you will have to meet these standards. As the overseas standards raise so the South African standards have to change to meet these standards.

APPLY BASIC FOOD SAFETY PRACTICES

THE CONCEPTS OF FOOD SAFETY

Definition:

Food safety:	To produce, store and handle food in such a way that it is not hazardous to humans, animals and the environment
Chemical hazards:	Chemical hazards include substances such as cleaning solutions and sanitizers.

Physical hazards: Physical hazards are foreign particles, like glass or metal.

Biological hazards: Biological hazards come mainly from micro-organisms.

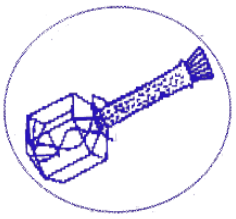
HOW DOES FOOD BECOME HAZARDOUS?

Food becomes hazardous by contamination. Contamination is the unintended presence of harmful substances or micro-organisms in food. Food can become contaminated from chemical, physical or biological sources.

Why are micro-organisms important?

Micro-organisms are everywhere. You may not see, taste, or smell them, but they hide on your body, in the air, on kitchen counters and utensils, and in food. The main micro-organisms are:

1. Viruses
2. Parasites
3. Fungi
4. Bacteria.



Viruses are the tiniest, and probably the simplest, form of life. They are not able to reproduce outside a living cell. Once they enter a cell, they force it to make more viruses.

Some viruses are extremely resistant to heat and cold. They don't need potentially hazardous food to survive, and once in the food, they don't multiply. The food is mainly a transportation device to get from one host to another.

Once in the human, viruses reproduce quickly and may cause disease.

Parasites need to live on or in a host to survive. Examples of parasites that may contaminate food are Trichinella spiralis (trichinosis) that affects pork, and Anisakis roundworm, that affects fish.

Fungi can be microscopic or as big as a giant mushroom. Fungi are found in the air, soil, plants, animals, water, and some food. Moulds and yeast are fungi.

Bacteria can cause food borne illness in the food people eats such as diarrhoea, vomiting, an upset stomach, fever, or cramps.

THE MARKET NEEDS AND DEMANDS FOR FOOD SAFETY

Food safety has always been important to consumers, but recent high-profile events around the world, including outbreaks of mad cow disease in Europe, and concerns about bio-terrorism have raised their awareness and expectations. In addition, in areas other than safety, consumers are increasingly knowledgeable and discerning in their food purchases and are demanding greater choice.

To maintain their markets, suppliers of food and agricultural products are developing and implementing systems that demonstrate to both existing and potential consumers that they can deliver products within the demanded safety and quality specifications. At the same time, suppliers are taking advantage of these changing consumer dynamics to gain new markets and develop niche markets with potential price premiums.

FOOD SAFETY PRACTICES AND PERSONAL HYGIENE

Many fresh fruits and vegetables are eaten with little or no cooking - they are "ready to eat". Because they are not cooked, raw fruits and vegetables can be a source of disease-causing bacteria, viruses or parasites (pathogens). Grains and lupines are cooked, which has a sterilising effect.

Humans and animals are the major source of pathogens in our food supply.

Harvesting can be a labour-intensive operation involving direct human contact with fresh produce.

"Personal hygiene" includes practices that promote health and cleanliness.

Good worker hygiene practices during production and harvest can help to minimize microbial contamination.

Therefore, it is important to make worker health and hygiene a priority:

- ✓ Frequent and effective hand washing is important.
- ✓ To make this possible, toilet facilities must be available, clean, and well maintained.

- ✓ If you or any of the other workers are ill, then report it immediately and your supervisor or team leader should address it without delay.

- ✓ Infected employees – those with infectious diseases or open lesions/wounds - could increase the risk of transmitting food borne illnesses. All open wounds and infected areas should be covered hygienically with dressings and with additional pairs of gloves. If there is any risk of contamination, then the worker CANNOT continue working.

- ✓ Workers with symptoms of nausea, vomiting or diarrhoea should not handle the fruits or vegetables.

- ✓ Prevention practices and knowledge is the key to the safety of the fruits and vegetables that you harvest.

FOOD SAFETY AND CONSERVATION

Definition:

Conservation: Refers to the protection, restoration or sustainability of natural resources.

When toxic contaminants - such as pesticides, mercury pollution and diesel exhaust - are released into the environment, their effect on human health can be profound.

It has been found that if ecological habitats and food chains are not conserved then some of the organisms and life forms might become extinct. As soon as one organism becomes extinct, another might become over-active and multiply to such an extent that it causes the plants and food produce in that ecosystem to become toxic or poisonous for human consumption.

FOOD SAFETY AND WASTE

Definition:

Waste: Refers to the “left-overs” or unwanted products from industry and human activities.

Pollution: Is the unwelcome concentration of substances that are beyond the environment’s capacity to handle. These substances are detrimental to people and other living things.

Farm activities will always result in a certain amount of waste. Farm management must control and limit the amount of waste but workers must be able to identify waste and control it before it pollutes the environment.

FOOD SAFETY AND POLLUTANTS

The use of pesticides in food production results in residues on foods. Research has examined the Rand value consumers might place on reducing the human health risks induced by dietary intake of pesticides.

Some consumers have tried to reduce dietary intake of pesticides by purchasing organic food. Together, the premium for organic food and consumers' willingness to pay to reduce well-known risks suggest that most consumers are willing to buy organic food for health benefits alone.

APPLICATION OF GOOD PERSONAL HYGIENE PRACTICES

Follow these steps to promote food safety in the workplace:

Step 1	Uniforms should be worn as per farm and pack house regulations and should be clean and tidy at all times.
Step 2	Wear only closed protective shoes or boots.
Step 3	Hair must be neat and trim or pulled back to avoid falling onto face. Facial hair is not recommended, although it should be kept neat and tidy if it is allowed within your place of work. It should be covered at all times in the food prep areas.
Step 4	Nail polish is not allowed. Nails should be short and clean.
Step 5	If you have body piercing, you are not allowed to wear the studs that are associated with it in your place of work.
Step 6	Staff is not allowed to wear lots of jewellery. Rings, except wedding bands, are unacceptable.
Step 7	Staff must wash their hands after touching their face and hair.
Step 8	Staff should wash their hands thoroughly with a sanitizer after visiting the toilet.
Step 9	Staff should wash their hands regularly with soap and warm water
Step 10	Staff should shower, use deodorant and change underwear everyday
Step 11	Wear a clean work uniform everyday
Step 12	Clean teeth everyday
Step 13	Have neat and clean fingernails
Step 14	Wash hair regularly

PREVENTATIVE MEASURES AGAINST FOOD CONTAMINATION

Many people get sick each year from the food they eat. They may have diarrhoea, vomiting, an upset stomach, fever, or cramps. They often think they have the flu, but the real problem is food borne illness caused by bacteria in the food they ate a few hours or several days ago.

- ✓ ***Bacteria is the greatest threat to food safety***

  Of all the micro-organisms, bacteria are the greatest threat to food safety. Bacteria are single-celled, living organisms that can grow quickly at favourable temperatures. Some bacteria are useful. We use them to make foods like

cheese, buttermilk, sauerkraut, pickles, and yoghurt. Other bacteria are infectious disease-causing agents called pathogens that use the nutrients found in potentially hazardous foods to multiply.

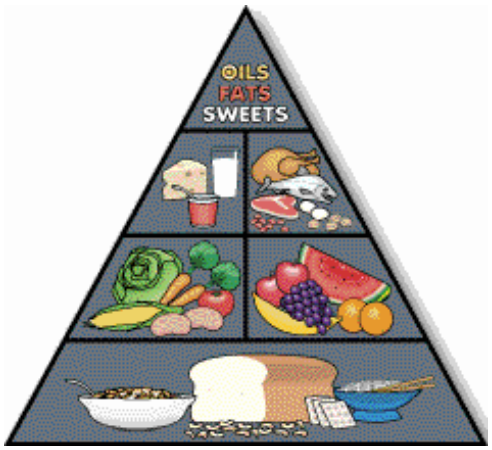
Some bacteria are not infectious on their own, but when they multiply in potentially hazardous food, they eject toxins that poison humans when the food is eaten.

Food handling practices are risky when they allow harmful bacteria to contaminate and grow in food. If you touch a potentially hazardous food during preparation, you may transfer several thousand bacteria to its surface.

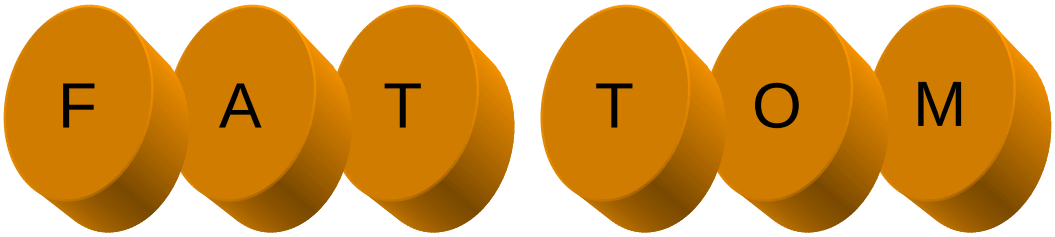
Under the right conditions, bacteria can double every 10 to 30 minutes. A single bacterium will double with each division - two become four, four become eight, and so on. A single cell can become billions in 10 to 12 hours.

- ✓ ***We need to understand FAT TOM!***

What can we do to ensure that the environment in which our produce grows, is packed and handled and has optimum food safety standards?



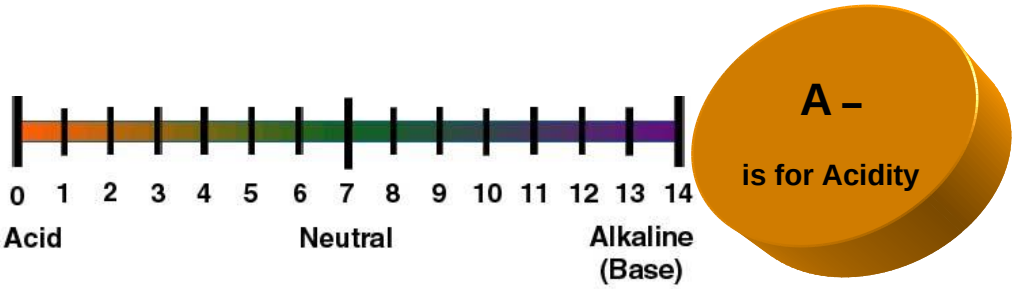
Who is FAT TOM?



F - is for Food

Nutrients available in food often determine which micro organisms will grow in it. While some micro organisms have simple nutrient requirements, some pathogens require a complex diet, including vitamins and minerals found in the foods we eat.

Moist protein-rich foods, such as meat, milk, eggs and fish, are potentially hazardous. That is, they are most likely to cause food borne illness because they are vehicles of transmission of pathogenic bacteria and can support growth of these bacteria.

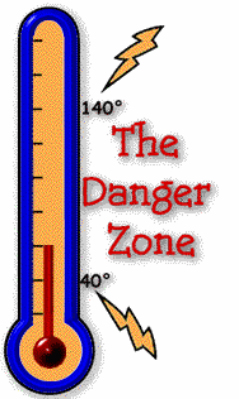


pH is the symbol for the degree of acidity or alkalinity (base) of a substance. Bacteria grow best in an environment that is neutral or slightly acidic. Most bacterial growth is inhibited in very acidic conditions. That is why acidic foods, like vinegar and fresh fruits, seldom provide a favourable climate for pathogenic bacteria.

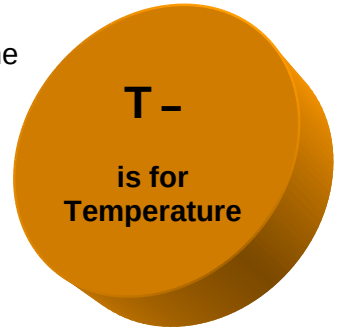
pH is measured on a scale from 0 to 14. An environment with a pH of 7.0 is exactly neutral--neither acid nor alkaline. Pure water has a pH of 7. Foods with a pH below 7.0 are acidic; pH above 7.0 is alkaline. The lower the pH, the higher the acidity; the higher the pH, the lower the acidity. Most bacteria will not grow at pH levels below 4.6. Micro-organisms thrive in a pH range between 6.6 and 7.5.

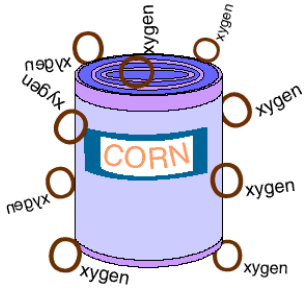
Pathogenic micro-organisms reproduce by cell division. One becomes two. Two become four. When small numbers of pathogens are present in food, they pose a very low risk to consumers. However, when low acid food (food with a neutral or alkaline pH) is abused by placing it in the **DANGER ZONE** (40° to 140°F or 5° to 60°C) longer than **two hours**, pathogens multiply rapidly. Restricting the time that low acid foods stay in the **DANGER ZONE** to **two hours or less** prevents growth of large numbers of pathogens.

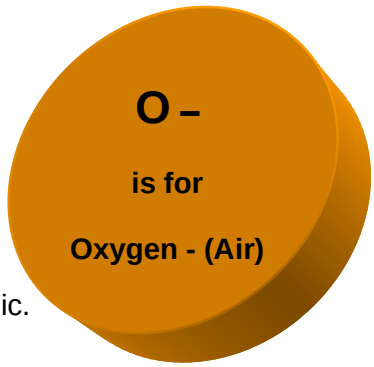
Micro organisms grow fast between the temperatures of (5° to 60°C). During the two-hour period in the DANGER ZONE, only minimal growth and reproduction can occur.



One important rule of food safety is to stay out of the DANGER ZONE, where potentially hazardous foods support the growth of pathogenic micro organisms. In general, it is advisable to cool fruit as soon as possible after harvesting.



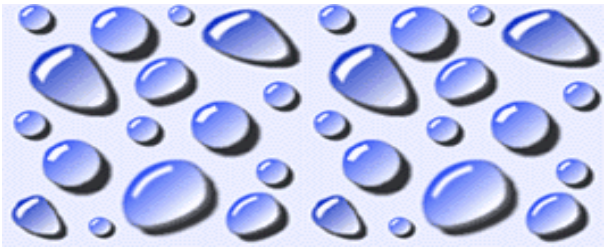




Some micro organisms need oxygen (air) to grow, that is, they are aerobic.

When foods such as meat, fruit or vegetables are canned, oxygen is excluded from the environment. Therefore, growth of aerobic organisms is controlled, and the food is preserved. Such foods are shelf stable and do not require refrigeration.

Some micro-organisms will grow only in anaerobic conditions (in the absence of oxygen). Botulism, a rare type of food borne illness, is caused by a specific type of organism that grows only in anaerobic conditions (in the absence of oxygen). Improperly preserved home canned foods are usually the source of botulism.



All micro-organisms must have an abundant supply of water to grow. Consequently, perishability of a food is related not only to moisture content, but also to water activity.

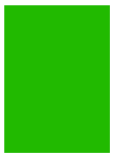
Moisture content is the amount of water in food and is expressed as a percentage. Water activity (a_w) is the amount of water available for deterioration reactions and is measured on a scale of 0 to 1.0. Bacteria, yeast, and mould multiply rapidly at a high water activity--above 0.86. Meat, produce and soft cheeses have a_w in this range (between 0.86 and 1.0).

Pathogenic bacteria have difficulty growing in foods such as jams and jellies, dry noodles, flours, candies and crackers, where a_w is below 0.85. Foods preserved with salt or sugar, such as jams have a lower a_w because salt and sugar deprive micro organisms of water and inhibit their reproduction. These products are shelf-stable (i.e. they do not need refrigeration).

WARNING SIGNS

TYPES OF WARNING SIGNS

There are four basic categories of safety sign. The categories, their usage, colour and shape are as shown:

	What it means		What it means
	**SAFE CONDITION** COLOUR AND SHAPE: green background, white symbol, square or oblong. USE: provides information about safe conditions. EXAMPLE: First Aid Equipment.		**WARNING** COLOUR AND SHAPE: yellow triangle with a black border. USE: gives a warning of risk of danger. EXAMPLE: Dangerous Substance.
	**PROHIBITION** COLOUR AND SHAPE: white, circular sign, red border and a red crossbar running from top left to bottom right. USE: states that you can't do something EXAMPLE: No Smoking		**MANDATORY** COLOUR AND SHAPE: blue background, white symbol, circular. USE: states that you must do something. EXAMPLE: Wear Ear Protection

Sign	What it means
	**Corrosive** The chemical or substance could cause injury to the person handling it and / or may cause damage to the packaging material surrounding the chemicals, fertiliser or fruit product, rendering it unsafe.
	**Dangerous to the environment** The disposal of certain agro-chemicals, fertilisers, herbicides, pesticides and materials could be harmful for the ecological system and environment, causing the fruit produced to be rendered unsafe.
	**Chemicals that will contaminate food stuffs** If certain materials, substances and agro-chemicals come into contact with a crop due for human consumption, the food safety will become compromised and thus poisonous.

Sign	What it means
	**Poisonous** Any poisonous substances would automatically render crops unsafe for consumption (Remember about harvest intervals!)
	**Poisonous Gas** Any poisonous substances would automatically render crops unsafe for consumption (Remember about harvest intervals!)
	**Biological Hazard** The material might cause microbial or organic changes in the food crop causing food safety to be unsafe.
	**Radioactive** No food crop that has been in contact with radioactive material would be considered safe.
	**Dangerous when wet** Some substances react badly to contact with water and can cause fires or explosions, or poisonous materials to be released. Any food crop that has come into contact with such a substance would immediately be considered unsafe.
	**Flammable** Any food crop that comes into contact with flammable liquid or materials would automatically be rendered unsafe.

	**Irritant or Harmful substance** Any food crop that comes into contact with chemicals or fertilisers that are irritants or harmful to human or animal consumption would immediately be rendered unsafe.

GROUP ACTIVITY: ROLE PLAY

In groups of four, play the roles of 4 different types of farm workers and explain to each other how your "type" of personal hygiene personality, might compromise food safety. Write down keynotes for yourself.

Type 1 – A farm worker with an old, dirty uniform.

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Type 2 – A farm worker with dirty hair and has a runny nose.

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Type 3 – A farm worker who has not had a bath for the past 2 weeks.

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Type 4 – A farm worker who does not wash his/her hands after going to the toilet.

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INDIVIDUAL ACTIVITY

Walk around on the farm and make a list of at least 10 different types of waste that might potentially cause food safety to become compromised. Explain why, for each item on the list.

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GROUP ACTIVITY

Hold a class discussion and write a paragraph on the decision made.

1. What is the use of placing warning signs around the farm?

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2. What types of warning signs are most important and what do they mean?

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3. Why it is important for workers to adhere to safety and warning signs?

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NON-CONFORMANCES AND DEVIATIONS IN FOOD SAFETY

DEFINING THE CONCEPTS

Definition:

Deviations: *D*escribe the difference between an observed value and the expected value.

Non-conformance: Include failures, deficiencies, defects and malfunctions in a product or behaviour that causes the deviation.

The grower, packer, shipper, and handler of fresh consumed horticultural products are often faced with a hundred different decisions and responses to weather, pests, market value and trends, labour, and customer requests. Each decision may alter microbial food safety risks. The potential risk may be reduced or increased by seemingly minor deviations in timing, source of production input, degree of handling, method of cooling, or any dozens of different interacting factors.




THE TYPES OF PROBLEMS THE ENTERPRISE CAN HAVE IF PLANS TO DEAL WITH DEVIATIONS ARE NOT IN PLACE

Animal manure is often contaminated with human pathogens. This waste management issue is believed to be a key contributor to an intimately related potential source of produce contamination, water. It has long been known that the improper use of manure can transfer pathogens onto crops, resulting in human disease. Raw manure should not be applied to crops. In addition to the hazard of pathogen transmission, it is well recognized that salt injury to sensitive vegetable crops and transfer of viable weed seed may result unless the manure is subjected, at least, to a period of unmanaged (no thorough mixing or pile inversion) composting.

The following inputs to the enterprise will become contaminated:

- **Water** – quality might become poor, with high salinity or toxicity for the crop produced, causing the crop to fail or become unsafe for human consumption.

- **Soil** – soil might become ineffective, with unbalanced nutrient profiles, causing the crop to fail or the crop to become unsafe for human consumption

- **The actual crop prior to harvesting** – the crop might become poisoned or toxic or generally unsafe for human consumption, due to exposure from microbial, physical, chemical, viral hazards.

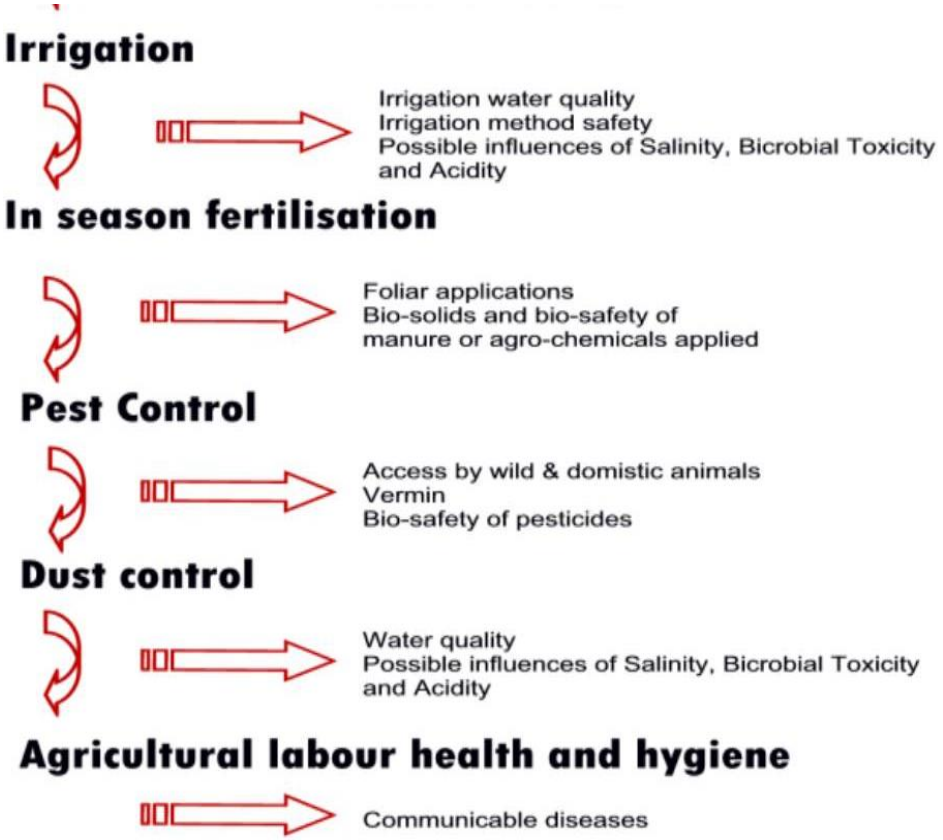
WHY IT IS NECESSARY FOR WORKERS TO BE TRAINED WITH REGARDS TO DETECTING PROBLEMS IN THE SYSTEM AND BEING ABLE TO TRACE IT TO THE SOURCE

If the workers are trained in, and really understand the principles of food safety, then they will:

- Contribute to the supply of a healthy and safe crop.
- Automatically report any deviances and problems that might lead to compromised food safety.
- Become the custodians of a Good Agricultural Food Safety Monitoring system such as HACCP.

Here is a visual representation of:

- ✓ Examples of deviations from pre-harvest norms and Critical control points for monitoring and detection.
- ✓ The way non-conformances and deviations in the food safety and quality will be detected
- ✓ The way this problem will be traced to a pre-harvest environment.



INDIVIDUAL ACTIVITY: WALK AROUND ON THE FARM AND DISCOVER

Make a list of at least 10 possible points where the Occupational Health and Safety and / or Food Safety policy of the farm is being deviated from or is not complied with. For each one write next to it, why you think the deviation took place and what can be done to rectify the problem.

Deviation / Non-compliance:	Reasons for it:	What can be done to remedy this:
1.		
2.		
3.		
4.		
5.		
6.		

7.		
8.		
9.		
10.		

BASIC HEALTH AND SOCIAL ISSUES

WHAT DOES BASIC HEALTH AND SOCIAL ISSUES INCLUDE

Definition:

Social Issues: Are questions concerning how events may affect society as a whole and individuals in society.

Health Issues: Is the absence of disease or injury along with physical, mental, and social well-being. Health also implies good prospects for continued survival.

THE OCCUPATIONAL HEALTH AND SAFETY ACT (OHSA)

What does the South African law say in the Occupational Health and Safety Act (OHSA) in terms of the worker and the working environment? The act establishes five key action areas for health promotion practice. These are:

- To promote safe environments for people to live and work in. Many of the health problems facing South African communities are caused or made worse by living and working in poor conditions. For example, having poor water and sanitation facilities or working in dangerous conditions without any safety measures.

- To develop healthy public policy. This is legislation and policy that protects health. For example, this can range from tobacco control legislation through to ensuring that housing policy protects the health of people by ensuring that, for example, it provides for adequate ventilation or sanitation facilities.

- ❖ To promote community action. Health problems are often best tackled through community action. This could include community clean-up campaigns or setting up an HIV/AIDS support group in a community

- ❖ Develop personal skills. It is essential that each person is equipped with the information and skills to promote their health. For example, in South Africa everyone needs to know about AIDS, and young people need to learn how to negotiate safe sex or how to say no to sex.

- ❖ Re-orient the health service. Often the health service does not act in the best interest of people's health. Clinics are often not open in the early evening when it may be easier for working people to get to them and environmental health officers may over emphasize the role of inspections and law enforcement rather than education for food traders.

THE IMPORTANCE OF GOOD HEALTH CARE PRACTICES AS RELATED TO FOOD SAFETY

HIV/AIDS

Persons with Acquired Immunodeficiency Syndrome (AIDS) are susceptible to many types of infection including illness from food borne pathogens. They are at higher risk than are otherwise healthy individuals for severe illness or death. Affected persons must be especially vigilant when handling and cooking foods. The recommendations provided here are designed to help prevent bacterial food borne illness.

- ➢ **Why do bacteria endanger people with AIDS?**

  When the AIDS virus damages or destroys the body's immune system, the person becomes more vulnerable to infection by food borne bacteria and other pathogens. For example, the common pneumonia, which is caused by a bacterial infection of the lungs, can occur in any individual but occurs much more frequently in persons with AIDS. In addition, when pneumonia strikes a person with AIDS, it causes a more severe illness and is thus more dangerous.

- **How can persons with AIDS prevent food borne illness?**

  Food must be handled safely at every stage from purchase through consumption. Critical points are transporting perishable foods home from the store immediately; prompt, safe storage; thorough cooking to destroy bacteria and other pathogens; and prompt refrigeration of leftovers.

- **Can people who are infected with HIV and AIDS cause fresh food products to become unsafe for consumption?**

  Essentially the answer is “NO”, unless the person’s body fluids are somehow injected into the fresh food product. Even then the likeliness of the HIV virus surviving long enough to be ingested and cause HIV infection is nearly impossible. Luckily the HIV virus is very weak and cannot survive in the face of Acidic conditions or exposure to air.

  It is still a good idea for any people who work with fresh fruit products to take extra care with handling according to the following guidelines (for their own sake of not becoming infected as well as for the peace of mind of others.):

  - Clean -- Wash hands and surfaces often.
  - Separate -- Don't cross-contaminate.
  - Cook -- Cook to proper temperatures.
  - Chill -- Refrigerate promptly.

COMMUNICABLE DISEASE

Food borne illness often presents itself as flu-like symptoms such as nausea, vomiting, diarrhoea, or fever, so many people may not recognize the illness is caused by bacteria or other pathogens in food. Thousands of types of bacteria are naturally present in our environment. Not all bacteria cause disease in humans. For example, some bacteria are used beneficially in making cheese and yoghurt.

Bacteria that causes disease are called pathogens. When certain pathogens enter the food supply, they can cause food borne illness. Millions of cases of food borne illness occur each

year. Most cases of food borne illness can be prevented. Proper cooking or processing of food destroys bacteria.

Age and physical condition place some persons at higher risk than others, no matter what type of bacteria is implicated. Very young children, pregnant women, the elderly and people with compromised immune systems are at greatest risk from any pathogen. Some persons may become ill after ingesting only a few harmful bacteria; others may remain symptom free after ingesting thousands.

- ✓ **How bacteria get in food:** Bacteria may be present on products when you purchase them. Plastic-wrapped boneless chicken breasts and ground meat, for example, were once part of live chickens or cattle. Raw meat, poultry, seafood, and eggs are not sterile. Neither is fresh produce such as lettuce, tomatoes, sprouts, and melons.

- ✓ **How are communicable diseases and food borne illnesses linked?** Before we examine this point, we need to define what Communicable Disease might include:

Definition:

Communicable disease: Any disease that is easily spread through direct/indirect contact. An infectious disease that can be spread from person to person or animals to humans.

The only communicable diseases that can really have an influence on the food safety of fresh product, such as fruit, is bird flu and mad cow disease. These are passed on indirectly through fertilisation, and the impact is as yet, unknown. Food borne illnesses - the incidence of food borne diseases is minor compared to the more serious diseases related to environmental health. We can therefore conclude that communicable diseases are only dangerous in pre-harvest crops in as far it concerns worker health and safety and fertilisation or water sources.

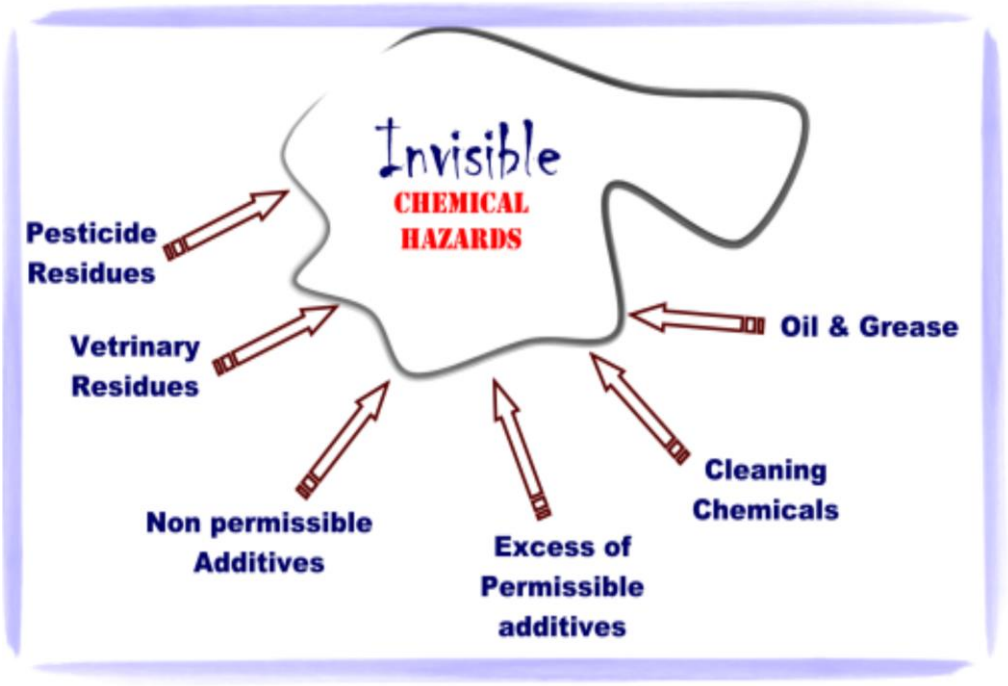
RISK FACTORS IN FOOD SAFETY AND QUALITY

Definition:

Food Safety and Quality: With reference to agricultural enterprise refers to protecting the food supply from microbial, chemical (i.e. rancidity, browning) and physical (i.e. drying out, infestation) hazards or contamination that may occur during all stages of food production and handling-growing, harvesting, processing, transporting, preparing, distributing and storing. The goal of food safety monitoring is to keep food wholesome.

DIFFERENT TYPES OF RISK FACTORS IN FOOD SAFETY

CHEMICAL HAZARDS:



Residue monitoring and evaluation programs identify animals containing harmful residues and remove them from the food chain. These residues include toxins from natural sources, from pesticides, from feeds, or from antibiotics administered to animals too soon before slaughter.

Number of agricultural chemicals (pesticides, herbicides, and fertilizers) may leave potentially hazardous residues in foods, and chemical contamination during manufacture is also possible. Where compounds that might enter the food chain, are known or believed to

be hazardous, there are limits on the maximum amount that may be present in foods. This acceptable daily intake is set by determining the highest lifetime level of intake that causes no detectable effect and dividing it by a safety factor of 100.

Pesticides

- All crop protection products must be approved for their intended use. They should only be used in accordance with the manufacturer's instructions and any relevant codes of good practice should be observed. Compliance with 'harvest intervals' should be ensured.

- Pesticides (including herbicides, fungicides and wood preservatives) should be stored in an appropriate well ventilated and secure area. This area should be constructed in such a manner as to contain spillages in the case of accidents. They should be kept in the original container and not transferred to e.g. unmarked containers such as drink bottles.

- Appropriate protective clothing and masks should be worn when handling, mixing or using these products, as indicated on the label of the product.

Other Farm Chemicals

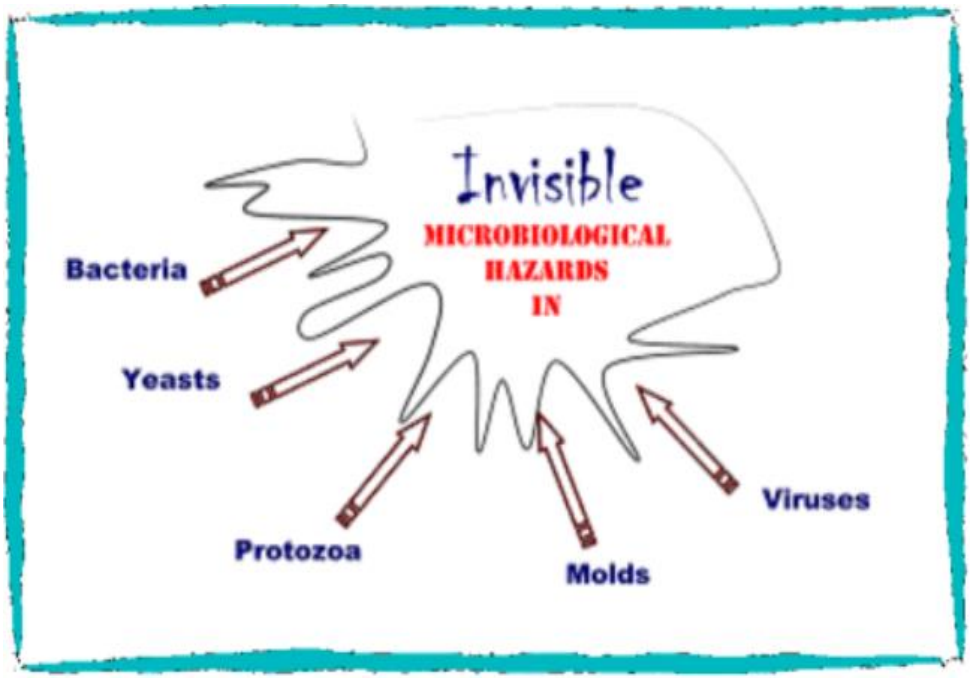
- These include detergents, sterilisers/cleaning agents, disinfectants, feed additives, fertilisers, fuel oils, lubricants etc.

- As with pesticides, all other chemicals must be handled, stored, used and disposed of in a manner that minimises the risk of contamination of primary food produce or animal feed as well as the risk of accidental ingestion/uptake by animals/crops.

PHYSICAL HAZARDS:

Apart from the physical hazards given above, dust must also be considered. After packing and during transporting dust must be prevented to contaminate food products.

MICRO-BIOLOGICAL HAZARDS:



Bacteria and fungi (yeasts and moulds) are the principal types of micro-organisms that cause food spoilage and food-borne illnesses. Foods may be contaminated by micro organisms at any time during harvest, storage, processing, distribution, handling, or preparation. The primary sources of microbial contamination are soil, air, animal feed, animal hides and intestines, plant surfaces, sewage, and food processing machinery or utensils.

MONITORING THE RISKS AND AVOIDANCE OF CONTAMINATION

There are various internationally recognised monitoring systems available to help farmers to monitor any and all risk areas related to food safety.

The most well known of these systems is called:

HACCP

Definition:

Food Safety and Quality Hazard Analysis Critical Control Point: An internationally recognized and recommended approach to food safety that anticipates and prevents hazards associated with ingredients.

THE PRINCIPLES OF HACCP:

HACCP offers continuous and systematic approaches to assure food safety.

Principle 1	**Hazard Analysis:** Hazards (biological, chemical, and physical) are conditions, which may pose an unacceptable health risk to the consumer. A flow diagram of the complete process is important in conducting the hazard analysis. The significant hazards associated with each specific step of the manufacturing process are listed. Preventive measures (temperature, pH, moisture level, etc.) to control the hazards are also listed.

Principle 2	**Identify Critical Control Points:** Critical Control Points (CCP) are steps at which control can be applied and a food safety hazard can be prevented, eliminated or reduced to acceptable levels.
Principle 3	**Establish Critical Limits:** All CCP's must have preventive measures, which are measurable! Critical limits are the operational boundaries of the CCPs which control the food safety hazard(s). The criteria for the critical limits are determined ahead of time in consultation with competent authorities. If the critical limit criteria are not met, the process is "out of control", thus the food safety hazard(s) are not being prevented, eliminated, or reduced to acceptable levels.
Principle 4	**Monitor the CCP's:** Monitoring is a planned sequence of measurements or observations to ensure the product or process is in control (critical limits are being met). It allows processors to assess trends before a loss of control occurs. Adjustments can be made while continuing the process. The monitoring interval must be adequate to ensure reliable control of the process.
Principle 5	**Establish Corrective Action:** HACCP is intended to prevent product or process deviations. However, should loss of control occur, there must be definite steps in place for disposition of the product and for correction of the process. These must be pre-planned and written.
Principle 6	**Record keeping:** The HACCP system requires the preparation and maintenance of a written HACCP plan together with other documentation. This must include all records generated during the monitoring of each CCP and notations of corrective actions taken. Usually, the simplest record keeping system possible to ensure effectiveness is the most desirable.
Principle 7	**Verification:** Has several steps. The scientific or technical validity of the hazard analysis and the adequacy of the CCP's should be documented. Verification of the effectiveness of the HACCP plan is also necessary. The system should be subject to periodic revalidation using independent audits or other verification procedures.

THE ROLE OF WORKER HEALTH AND WELFARE ON FOOD SAFETY AND QUALITY

If the workers are trained in, and really understand the principles of food safety, then they will:

- Contribute to the supply of a healthy and safe crop.
- Automatically report any deviances and problems that might lead to compromised food safety.
- Become the custodians of a Good Agricultural Food Safety Monitoring system such as HACCP.

RECORD KEEPING ACTIVITIES ON THE FARM

THE DIFFERENT RECORDS REQUIRED TO ASSIST THE OPERATION IN ENSURING OPTIMUM FOOD, SAFETY AND QUALITY

Management of health and safety can make a significant contribution to the performance of the crop and for enhancing food safety by reducing injuries and ill health and helping minimize losses and liabilities.

It is however very important to ensure that records of all actions are kept. The main reason for these records is “traceability”.

Definition:

Traceability: Refers to the completeness of the information about every step in a process chain.

EU Food Law 178/2002:

The EU Regulation with regards to the traceability applies to everyone involved in the production, processing, distribution or sale of any item intended for human consumption, including food service and catering companies.

The law lays down a number of principles that, by their nature, affect anyone exporting foodstuffs into Europe and it clearly states that all food businesses must have a traceability system in place.

- Responsibility for the safe production of food lies with the producer
- Food that is in any way unfit or unsafe for consumption cannot be marketed
- The entire food chain, from farm to fork, is included
- The Traceability and Recall Articles require that a food traceability system must be in place that enables everyone within that chain to know who supplied the ingredients that make up the final product that goes to the market. This is known as the one up/one down principle
- This information must be available to any competent authority on demand

This means that every partner in a supply chain will have to know who supplied goods to them and, in turn, who they supplied the resultant goods to.

HACCP versus te EU Food Law:

These two are totally separate issues. An effective food safety management system requires a proactive hazard management system (HACCP) as well as a traceability and recall system.

Safety records are the responsibility of dedicated team leaders, foremen, the health and safety committee, and specific individuals such a spray pump operator. It is important to keep the records in an organised and centralised point, under control of one person who will be able to access the information at a moment's notice.

Records can be kept manually (by filling in the forms and records in by hand) or by utilising electronic systems where the information is fed in via computer. Electronic systems have the benefit of also processing the data fed into the program and additional information can then be extracted from these programs. Electronic programs can, for example, deliver graphs and comparisons about the progress of the producer in terms of the quality of his produce or financial statements can be expressed by extracting data from different records. Electronic data can often be used when comparisons are drawn over a period of time. Although manual data can supply the same information, it is a lot more complicated to extract the required information without the assistance of electronic equipment and software.

The records subscribed by the various quality management systems and PPECB (Perishable Products Export Control Board) require that the documents be filled in correctly. The nature of these documents will serve as evidence of compliance with traceability

recommendations because specific information with dates and signatures of responsible parties will be found on these documents if they have been filled in correctly.

It is thus important that all relevant staff and workers be trained in:

- ✓ Hoe to complete the different forms and checklists correctly
- ✓ How, where, when and for how long, to report on and/or file these forms and checklists
- ✓ The consequences of accountability and responsibility in terms of traceability and the law related to the completion of (or failure to complete) these forms and checklists

Evidence of records need to be kept for a specific period in a central place and under the authority of a specific person.

The records should meet standard criteria of tracking and tracing, in other words:

It should be accessible in a systematic and chronological way, by date, batch number geographical reference point, delivery and dispatch reference.

TYPES OF RECORDS

The following types of Health and safety records are important for traceability in terms of food safety:

- Employee health records I.e. Food handler tests, sick notes, sick leave records, etc.
- Incident and Accident Reports.
- Agro-chemical application details.
- Agro-chemical annual programmes.
- Agro-chemical stock control and consumption records.
- Training records of staff for health and safety.
- Environmental control records.

Below is an example of what such a record form would look like:

PESTICIDE FIELD RECORD

ASCS Farm/Field #:		Acres:			
Location/Legal Description:					
Crop:		Planting Date:			
Soil Test Information	N:	kg		pH:	
	P2O5:	kg		OM:	
	K2O:	kg			
Fertilizer Applied:		Method:			

PESTICIDE INVENTORY

CHEMICAL	ACTIVE INGREDIENTS	EPA REG. #	REI

PESTICIDE INFORMATION

Application Date/Time		
Restricted Entry Interval		
Product Name & EPA Reg. No.		
Target Pest		
Active Ingredients		
Rate of Formulation/Acre		
Method/Equipment		
Total Amount Applied		
Applicator's Cert. no.		

Bibliography/Reading List

References and Resources

Books:

1. South African Water Quality Guidelines: 1996, Vol. 4, Department of Water Affairs and Forestry, Pretoria

2. Koegelenberg F.H. and Van Niekerk R.: Treatment of Low Quality Water for Drip Irrigation Systems, ARC Institute for Agricultural Engineering, Telephone (012) 842-4000

3. Water Analyses: An Interpretation Manual: 2002, published by the Central Analytical Laboratories, Telephone (012) 305-5003

4. Irrigation Design Manual: 2003, published by the Agricultural Research Council, Telephone (012) 842-4000

5. Encyclopaedia Brittanica – South African Version

6. Wikepedia – International Version

7. Advances in Microbial Foods Safety by Vijay Juneja, John P. Cherry, and Michael H. Tunick Salmonella Infections : Clinical, Immunological and Molecular Aspects (Advances in Molecular and Cellular Microbiology) by Pietro Mastroeni

8. Food Safety Control in the Poultry Industry by G. Mead

9. Aflatoxin and Food Safety by Hamed K. Abbas Marcel Dekker

10. Practical Guide To Food Safety Regulation H.L. Goodwin

11. Training and Education for Food Safety S. Mortimore, C. A. Wallace, and R. Smith

12. Preharvest and Postharvest Food Safety: Contemporary Issues and Future Directions by Ross C. Beier, Suresh D. Pillai, Timothy D. Phillips, and Richard L. Ziprin

13. Gray, D.E, 2004. *Doing research in the real world*. Sage London.
14. 'Life skills' by Edna Rooth
15. Stream and Pond Life, ShareNet, Wildlife & Environment Society of SA
16. People Farming Workbook – Environmental and Development Agency Trust
17. The Violence of Green Revolution: Third World Agriculture, Ecology and Politics by Vandana Shiva
18. Conservation and Agriculture by J.G. Hawkes

World Wide Web:

1. rdnet.princeton.edu/perl/webwn
1. www.en.wikipedia.org/wiki
2. http://www.extension.iastate.edu/foodsafety
3. http://www.hst.org.za/publications/381
4. http://ppceb.co.za
5. http://en.wikipedia.org
6. holmgren.com
7. www.polity.org.za/html/govdocs/green_papers/enviro2.html
8. safrica.info
9. environment.gov.za/
10. recyclezone.org
11. permaculture.co.uk
12. solarcooking.org
13. eltaenviro.org.za
14. sadc-reep.org.za
15. sustainablesettlement.co.za
16. southafrica.co.za

17. general.rau.ac.za
18. pubs.rsc.org
19. housing.gov.za
20. garden-resq.co.za
21. darvill.clara.net
22. arc.agric.za