http://humanstudies.education/trees-for-life

TREES FOR LIFE

Trees for Life

Introductory Activities: Trees

Parts of a Tree

Age of a Tree

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Schools can make a difference

PDF file for this Unit

Description of Unit

This unit explores the important part that trees play in our lives.

- We all have a favourite tree that is a joy and inspiration to us.
- Trees give a livelihood to many people.
- They provide many essential items:
    - Fruits and nuts.
    - Leaves for infusions and for wrappings.
    - Twigs and branches for sticks, walking canes and other things.
    - Wood from the trunk for making planks for doors, furniture and shelving; and boats for fishing.
- Trees provide shade for sitting, playing and meeting.
- They are also good to climb!
- The bark can be used as rope and some can be made into cloth.
- Their leaves make oxygen for us to breathe and remove carbon dioxide from the air.
- Trees play a crucial part in preventing global warming.
- Trees, woods and forest provided cover and homes for the many other species of bird, insects, amphibians and mammals that we share this Earth with.
- Trees help to maintain the balance of nature and biodiversity.

Teachers will want to combine the material in this unit with their own knowledge of the natural world, the children they teach and their particular teaching skills. Our aim is to encourage children to take an interest in trees and develop a sense of wonder about the important part they play in our lives and in our survival as a species.
We could not live without trees!

Introductory Activities: My favourite tree

Here are some baselining activities to give children an opportunity to express what they already know and feel about the trees in their lives. This is a good initial whole class activity, though some parts can be done in groups or individually.

1. Which is your favourite tree?

2. Where is it located?

3. Why is it your favourite?

    - Do you like the fruit?
    - Is it good to climb?
    - Is it a shady spot to play and sit?
    - Or do you have some other reason?

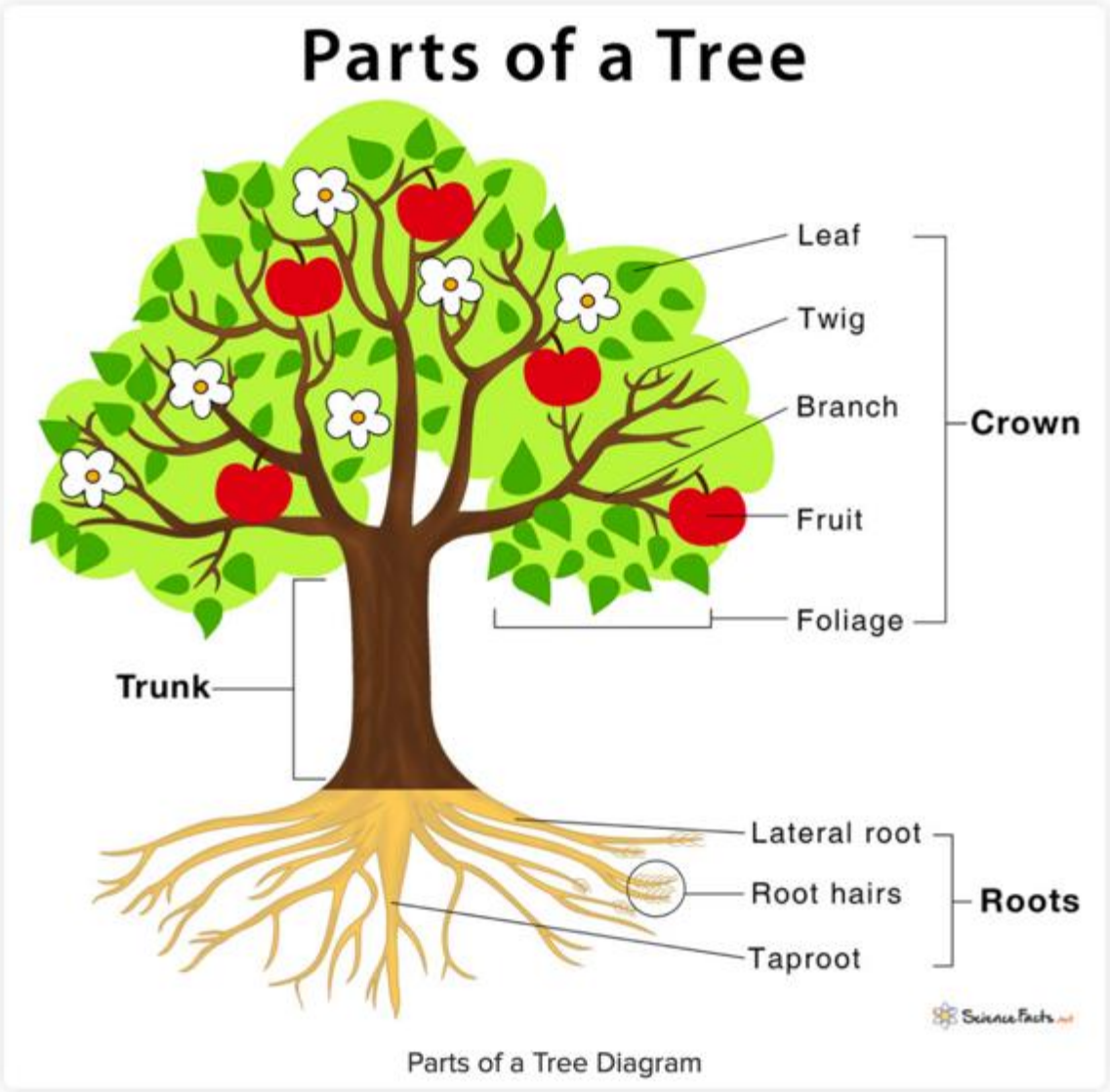
4. Name the parts of a tree?

5. Try to identify as many trees as you can by their local name English name and botanical name. You may need to get help with this. Perhaps the school can buy an identification book.

6. Talk to members of your family and local people to find out all the uses made of the different trees.

7. Write down all the uses of trees that you know
   – ask friendly adults to tell you the uses that they know.

8. Sit in front of a tree and draw it as accurately as you can.
   Below are some examples of what you could expect from children of different ages.



The picture above labels the main parts of a tree, and they are described below.

Parts of a Tree: https://www.sciencefacts.net/parts-of-a-tree.html

Teachers: *Please adapt the description of a tree to the age group of the children you are teaching.*

Roots: These grow underground and are often cover the same ground area as the crown of branches and leaves. Roots physically support the tree and root hairs take up water and nutrients from the soil to enable the tree to live and grow. In cold and dry periods, the roots act as a store for nutrients. Tree roots bind the soil together and help to prevent soil erosion and landslides.

Crown: This is the part of the tree which includes the branches, twigs, leaves and flowers, fruits and nuts. The crown provides shade for the roots, produces energy from the sun's rays and controls the release of water vapour, carbon dioxide and oxygen from the tree.

Leaves – are the food factory of a tree. They contain a green substance called chlorophyll, which enables the leaves to use energy from the sun's rays, carbon dioxide from the air and water brought from the roots to make energy in the form of glucose. This process for making glucose is called ***photosynthesis***. It is used to make new cells and enables the tree to grow. Photosynthesis removes carbon dioxide from the air. It locks up carbon in cellulose, which forms the walls of the cells of the tree. As part of this process, trees release oxygen into the air, to enable humans and animals to breathe.

Branches – support the twigs and help to spread out the leaves so they can have access to sunlight. They also bring water and nutrients to the leaves and store extra glucose.

Trunk – the trunk supports the crown of the tree and transports water and nutrients, through a network of small tubes, from the roots to the branches and leaves.

Age of a Tree

In climates that have seasons where the tree grows or stands dormant, a tree's trunk has ***growth rings***, also called ***tree rings***.

Growth rings form under the bark of the tree during every growing season. So, the newest rings are the outside ones near the bark and the oldest ring is the one formed from the first year growth of the tree and that is in the very centre of the trunk. If the growing season is good, e.g. when there is a lot of rain, the tree ring will be thick. If the year is particularly dry, then there will be less growth and the tree ring will be thin.

By counting the number of rings from the bark to the middle, you can tell how old the tree is. By looking at the thickness of the rings you can also get an idea of how much rain fell in each year. In the cross-section of the trunk shown, you can even tell from the scar that the tree was damaged by a forest fire in that year.

In **cool temperate climates**, where trees do not grow in the low temperatures of winter, a new ring of wood grows under the bark of the tree every summer.

In **tropical climates** where trees do not grow in the dry season, a new ring of wood grows every wet season.

We have to be careful on the equator. If the climate has two wet seasons (the long and short rains) and two dry seasons, then two rings may form each year. So, to get the age of a tree you have to count the rings and divide by 2 to get the tree's age.

When trees grow in a swamp or by a permanent river and have a supply of water for 12 months of the year, then, in the tropics, it will keep growing all the time and, in this case, the trunk will not show growth rings.

Dendrochronology

Dendrochronology is the science of dating wooden object by studying their tree rings. By studying first the tree rings of a particularly old tree, we can get a reference pattern for climate over hundreds of years. If we then find a fragment of wood in an old building or boat, we can compare the tree rings with the pattern in the reference tree and use this to tell us in which year the building or boat was made.

Very clear accounts of how Tree-ring dating is used in archaeology can be found in these links:

http://www.pbs.org/time-team/experience-archaeology/dendrochronology/

https://www.nationalgeographic.com/culture/archaeology/how-tree-rings-date-archaeological-site/

Activity

Find a tree that has recently been sawn down.

What can you find out about the story of the tree from its growth rings?

(a) Which is the newest ring?

(b) Which is the oldest ring?

(c) Estimate the age of the tree by counting the number of growth rings.

(d) What can you say about the weather conditions in each year from now to when the tree was a small sapling? (Remember, the wider the tree rings the better the growing season).

(e) Measure the diameter of the tree.

(f) Try to estimate the ages of some trees that have been planted in recent years by measuring their diameter. Ask the owner to check whether your estimate coincides with when they were planted.

Tree Giants

Trees are the elephants of the plant family. Their long, woody trunks transport water and nutrients from the soil high up to the branches and leaves, which make up the canopy or crown of the tree.

The tallest tree in the world is a **Giant Redwood (*Sequioia*)** in Northern California in the United States. It is 115.61 metres tall.

The tallest tree in Uganda is the ***Entandrophragma excelsum***. It is a deciduous tree which grows in the montane forests of the Rwenzori and Virunga and can reach heights of 60 metres. Below is a picture looking up from the base of the tree.

Other big trees that are found in Uganda include :

The Baobab

This can grow up to 30 metres high. The Baobab tree is also called the upside-down tree, because its branches look like roots, and it appears as if the roots are pointing up to the sky. Baobabs can survive long, dry periods because they store water in their trunks. For this reason elephants and antelopes chew the bark of the baobab in the dry season when they are thirsty. Animals eat the seeds of the tree, which are very nutritious, and weaver bird like to build their nests in the trees. Baobab trees can live for over a thousand years!

Sausage Tree (*Kigelia Africana*)

The sausage tree grows up to 20 metres. It is found in tropical and wet savannah regions and often grows close to rivers, because it needs a good supply of water. The tree produces large flowers, which bloom for up to 2 months and are pollinated by bats. The sausage-shaped fruits are one of the largest fruits in the plant kingdom. They can grow up to 1 metre in length and weight 10 kgs. The leaves are eaten by elephants and antelope. The wood of the tree has been used in the past for building canoes.

Borassus Palm (*Palmyra*)

Produces a fine specimen trees of up to 30 metres in height.

The Borassus Palm is found in grassland, where the water table is high. The leaves of the Palm are used for thatching roofs, making mats, sweeping brooms, baskets and hats. The fruit can be eaten fresh or dried and cooked and fruit juice can be extracted. It is also made into palm oil and, after processing, the excess oils provide raw materials to make soap and the residue is used for manure.

In some places the sap is made into palm wine or vinegar.

Elephants like the fruit, especially after it has started to ferment!?

Mutuba (*Ficus natalensis*)

This is an evergreen or partly deciduous tree with a wide, spreading crown, that can grow up to 30 metres tall. The Mutuba tree (pictured left below) is special because part of the bark can be removed each year and it will grow again. Once removed (pictured right below) the bark is turned into bark cloth, to make the ceremonial dress of the Baganda. It is also turned into a variety of craft products and sold in the tourist industry. A single tree can be harvested for up to 40 years and yield up to 200 sq. m of cloth. Each year after harvesting the bark, the areas must be wrapped around in plantain leaves to prevent the tree from drying out.

Activity: Measuring the height of a Tree

Task for students:

Work out a method you could use to work out the height of a tall tree?

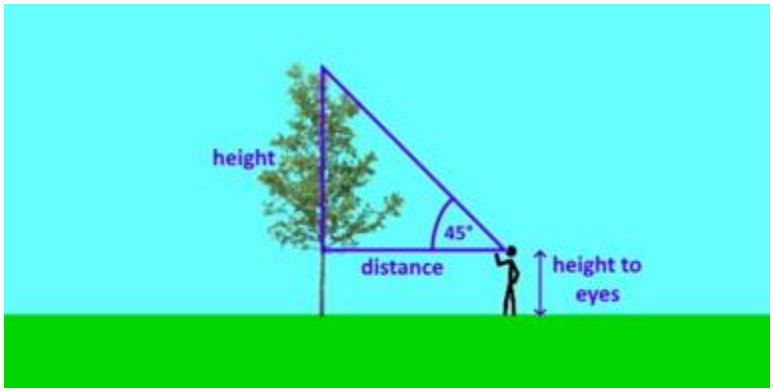
The topic of trigonometry in mathematics might give you some ideas.

Once you have worked out a method, go out and measure the height of some trees around the school.

Teacher: If your students cannot come up with a method here are two to compare:

45 Degree Angle Method

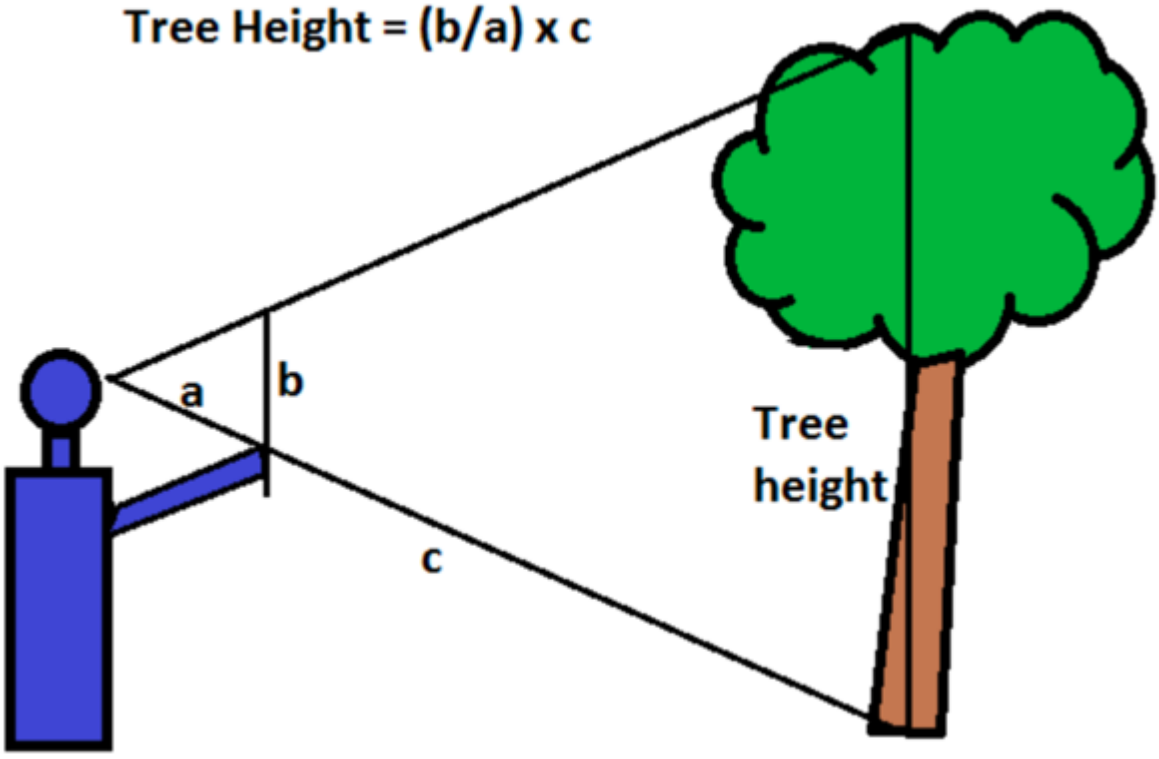
Fold a square piece of paper diagonally to form a right angle and two 45 degree angles.



Using the hypotenuse as a sight line, walk back from the tree until the sight line points to the top of the tree.

Measure the distance from where you are standing to the base of the tree, then add your height from the floor to your eye. The results will be a pretty good estimate of the height of the tree.

Pencil Method with Similar Triangles



1. Find a pencil or a short stick (measure its height, b in the diagram).

2. Hold the pencil in your outstretched arm (measure the distance from your eye to the finger of your outstretched hand, this is distance a).

3. Stand far enough back that the tree height fits the length of the pencil. The base of the pencil should be in line with the base of the tree and the top of the pencil should match the top of the tree.

4. Measure the distance from your eye to the base of the tree (this gives distance c). NOTE – if you are measuring a very tall tree, the distance will be roughly the same as the distance from your feet to the base of the tree.

5. Use the formula above to estimate the tree height.

Mango Tree

Sections

Introductory Quiz

Little Known Facts about the Mango

Meet Annet, the Mango Farmer

The Mango Tree: A Fable

Introductory Quiz

1. What do you know about mango trees?
2. In which part of the world so they originate?
3. When and how did they come to East Africa?
4. How tall can they grow?
5. How long do you think they can live?
6. What are their uses?

Little Known Facts about the Mango

The mango tree plays an important part in social and economic life in Uganda.

It provides welcome shade from the heat of day. It is a cool place for people to relax, chat and discuss important matters.

Mangoes originated in South Asia where they grow wild. They have been cultivated and harvested as a food in India since 2000 BCE. They have been in East Africa since the 10th Century. The seeds were brought by dhows on monsoon winds from India.

The tree is evergreen and requires tropical temperatures and a supply of water from regular rainfall, permanent rivers or underground water. The mango tree is in the cashew family, *Anacardiaceae*, and is known in many places as "*omuyembe*".

Mango trees grow up to 35-40 metres tall, with a radius of 10m. Leaves are between 6 x 2.5cm and 35 x 14cm in size, depending on variety and age. Over 500 varieties are grown in different parts of the world. Young leaves are orange-pink and become dark glossy red and dark green as they mature. The fruit takes 4-5 months from flowering to ripen. Fruits can be yellow, orange red or green depending on variety. They vary in size from 5-25cm, and from 140grams to 2 kg in weight.

Mango trees live much longer than people. The oldest mango tree in the world is over 300 years old.

In Uganda's equatorial zone it is possible to get two harvests of mango fruits each year – usually around June and December, after the long and short rains. In wetter areas in tropical zones, one harvest is possible between November and January, following the rains. Although the harvest season is fairly short, mangoes are a welcome addition to the diet and, for some farmers, they provide a good source of income. During the harvest period, Uganda exports surplus mangoes to Sudan and Congo. For the rest of the year, additional mangoes have to be imported to meet local demand via the port of Mombasa in Kenya.

- **When do mangoes ripen in your area? Do you get 1 or 2 crops?**

Mangoes are eaten as fruit, made into drinks and in India mixed with sugar, vinegar and spices to make chutneys and pickles to each with curries. Mango leaves are dried and powdered to make a mango tea, which is thought to be good for managing diabetes.

Mangoes are very nutritious. They are rich in energy and contain over 20 different vitamins and minerals. They are a rich source of vitamin C and are rich in folate. Folate is one of the B-vitamins which is used to make red and white blood cells in the bone marrow, convert carbohydrates into energy, and produce DNA and RNA. In high growth phases of life, such as pregnancy, infancy and adolescence, it is very important to have sufficient folate.

- **Find out who consumes the largest number of mangoes where you live.**

  Are most eaten by children, young people and pregnant ladies, i.e those who most need a folate supplement?

The heartwood of the mango tree is a hardwood that is used for making doors, furniture, musical instruments, flooring and wooden vessels.

In Mexico they grow Mangoes on a commercial scale and export to the USA. Research has revealed that the average mango tree can sequester 2 to 2.5 times the carbon than is used in growing and harvesting and transporting to the US retailer. The average mango tree can absorb 7 x more carbon that releases through respiration.

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Meet Annet, the Mango Farmer

On December 22, 2018 the Daily Monitor told the story of an enterprising lady farmer, called Annet Kyinkuhaire, who has done well by specialising in the growing of mangoes.

https://www.monitor.co.ug/Magazines/Farming/Kyinkuhaire-picks-her--money-from-mangoes-/689860-4905788-3ok6n7/index.html

Annet was a subsistence farmer, growing maize and beans and other crops, in Kiruhura District, north-east of Mbarara. She attended a training course for farmers in Mbarara, where she picked up some ideas on how to identify a good cash crop to specialise in and to devote part of her land to it. With a loan, she bought 550 mango seedlings at Shs4,000 each. She chose a variety called Tommy Red because it was a firm fruit that would not be damaged by handling and transportation and it had a long shelf life. She planted the trees on 2.5-acres of land, which she weeds regularly and, when necessary, sprays to control mango hoppers. Where she lives, she can get two harvest a year, in June and December. The fruits each weight about 1kg and she sells them for Shs1,000 each. Buyers come from Kampala and Mbarara, and she supplies some supermarkets directly. Her income has grown each year. In the last two seasons she has earned about Shs3.5m (UK£760), which gives her a good living and enables her to pay school fees. Although not one of her goals, the trees, as they grow, are also acting as a carbon sink. Each year of growth they remove more CO2 from the atmosphere. So, Annet is also making her own significant contribution to reducing global warming.

- **What do you think is the secret of Annet's success?**

- **Find out about a farmer near you who is trying something new and tell the class about them.**

- **What are the challenges of specialisation? What are the rewards?**

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The Mango Tree: A Fable

Definition *– A Fable is a short story with a moral message.*

Once upon a time, there lived a big mango tree. A little boy loved to come and play around it every day.

He climbed to the treetop, ate the mangoes, took a nap under the shadow… He loved the tree and the tree loved to play with him.

Time went by… The little boy grew, and he no longer played around the tree.

One day, the boy came back to the tree with a sad look on his face.

"Come and play with me," the tree asked the boy.

"I am no longer a kid. I don't play around trees anymore." The boy replied, "I want toys. I need money to buy them."

"Sorry, I don't have money… but you can pick all my mangoes and sell them so you will have money."

The boy was so excited. He picked all the mangoes on the tree and left happily. The boy didn't come back. The tree was sad.

One day, the boy, grown into a man, returned. The tree was so excited.

"Come and play with me," the tree said.

"I don't have time to play. I have to work for my family. We need a house for shelter. Can you help me?"

"Sorry, I don't have a house, but you can chop off my branches to build your house."

So, the man cut all the branches off the tree and left happily. The tree was glad to see him happy, but the boy didn't come back afterward. The tree was again lonely and sad.

One hot summer day, the man returned, and the tree was delighted.

"Come and play with me!" The tree said.

"I am sad and getting old. I want to go sailing to relax myself. Can you give me a boat?"

"Use my trunk to build your boat. You can sail far away and be happy."

So, the man cut the tree trunk to make a boat. He went sailing and didn't come back for a long time.

Finally, the man returned after he had been gone for so many years.

"Sorry, my boy, but I don't have anything for you anymore. No more mangoes to give you." The tree said.

"I don't have teeth to bite," the man replied.

"No more trunk for you to climb on."

"I am too old for that now," the man said.

"I really can't give you anything… the only thing left is my dying roots," the tree said with sadness.

"I don't need much now, just a place to rest. I am tired after all these years," the man replied.

"Good! Old tree roots are the best place to lean on and rest. Come sit down with me and rest."

The man sat down and the tree was glad and smiled.

By Shel Silverstein

What can we learn from this fable?

Note for Teachers:

When we use trees, we need to remember how they contribute to the lives of others of all ages. If we each take what we want from a tree, we may be depriving others of what they need, and we may destroy the very thing that gives us so many useful things.

Another way to interpret the story is to think of trees as the role parents play in supporting you through your life. They are prepared to sacrifice everything for their children.

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How plants make energy

Baselining:

Ask the children to tell you what they know already about what a tree needs to survive. Do they know that trees drink and breathe?

Plants needs water, nutrients and energy if they are to survive and grow.
They obtain the water and nutrients from the soil through the root system.
They make their energy by combining the water with carbon dioxide from the air, using solar energy in the form of sunlight. What makes this possible is a green substance in plants, called ***chlorophyll***, and a process called photosynthesis.

Photosynthesis is the process that green plants use to make food and grow. The leaves absorb energy from the sun's rays (solar radiation) and use it, with the help of chlorophyll in the leaves, to convert carbon dioxide, from the air, and water, from the soil, to make a sugar, called glucose, and oxygen. The glucose is converted into cellulose to make plant cells and the oxygen is released into the air for us to breathe.

During the process of photosynthesis the tree is breathing in carbon dioxide and breathing out oxygen. This breathing, which is the exchange of gases between the plant and the atmosphere, is through small holes in the leaves, called ***stomata***.

The amount of photosynthesis that takes place depends upon:

- the total leaf area of a tree,
- the amount of solar radiation and
- the CO_2 concentration of the atmosphere.

Low air humidity, low air temperature and low soil moisture reduce photosynthesis. Below is the chemical reaction for Photosynthesis:

Photosynthesis

$6\ CO_2 + 6\ H_2O + \text{solar radiation} \Rightarrow C_6H_{12}O_6 + 6\ O_2$

CO_2

$C_6H_{12}O_6$ = glucose

CO_2 = carbon dioxide

O_2= oxygen

H_2O = water

Carbon and Life on Earth

Sections

Carbon is a very important substance. It is an important part of the composition of all living things, including human beings. Carbon is in the oceans, the air, and in rocks.

In the atmosphere, carbon is bonded to oxygen in a gas called carbon dioxide (CO_2).

Plants use carbon dioxide from the air and sunlight to make their food. The carbon becomes part of the plant. Plants that die and are buried for millions of years may turn into fossil fuels, and their carbon becomes coal and oil. When humans burn these fossil fuels, the carbon re-enters the atmosphere as carbon dioxide.

Carbon dioxide is a greenhouse gas. It traps heat in the atmosphere. Without carbon dioxide and other greenhouse gases the Earth would be a frozen world. But, if there is too much carbon dioxide in the atmosphere, the earth can become too hot to sustain life.

Venus is an example of a planet where life has become impossible. The CO_2 concentration of the atmosphere is so high that, due to the greenhouse effect, air temperatures have risen to 740°C.

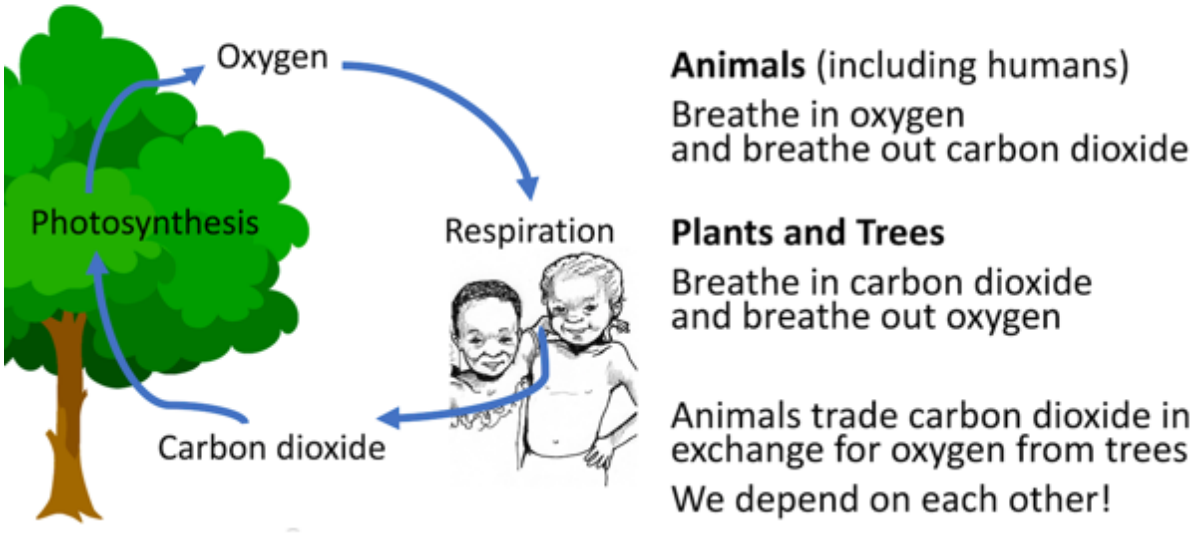
Simple Carbon Cycle

A useful reference: https://onetreeplanted.org/blogs/stories/planting-trees-reduce-carbon-footprint

Animals, including human animals, breathe in oxygen and breathe out carbon dioxide. Plants, including trees, breathe in carbon dioxide and breathe out oxygen.

“When a **tree** breathes, it inhales **carbon dioxide** and exhales oxygen - the exact opposite of **humans**. As a **tree** matures, it can consume 22kg of **carbon dioxide** per year and releases enough oxygen for a human to breathe for two years!”

Simple Carbon Cycle



Trees and green plants are essential to the survival of humans and other animals!

They maintain a healthy balance between the concentration of oxygen and CO_2 in the atmosphere.

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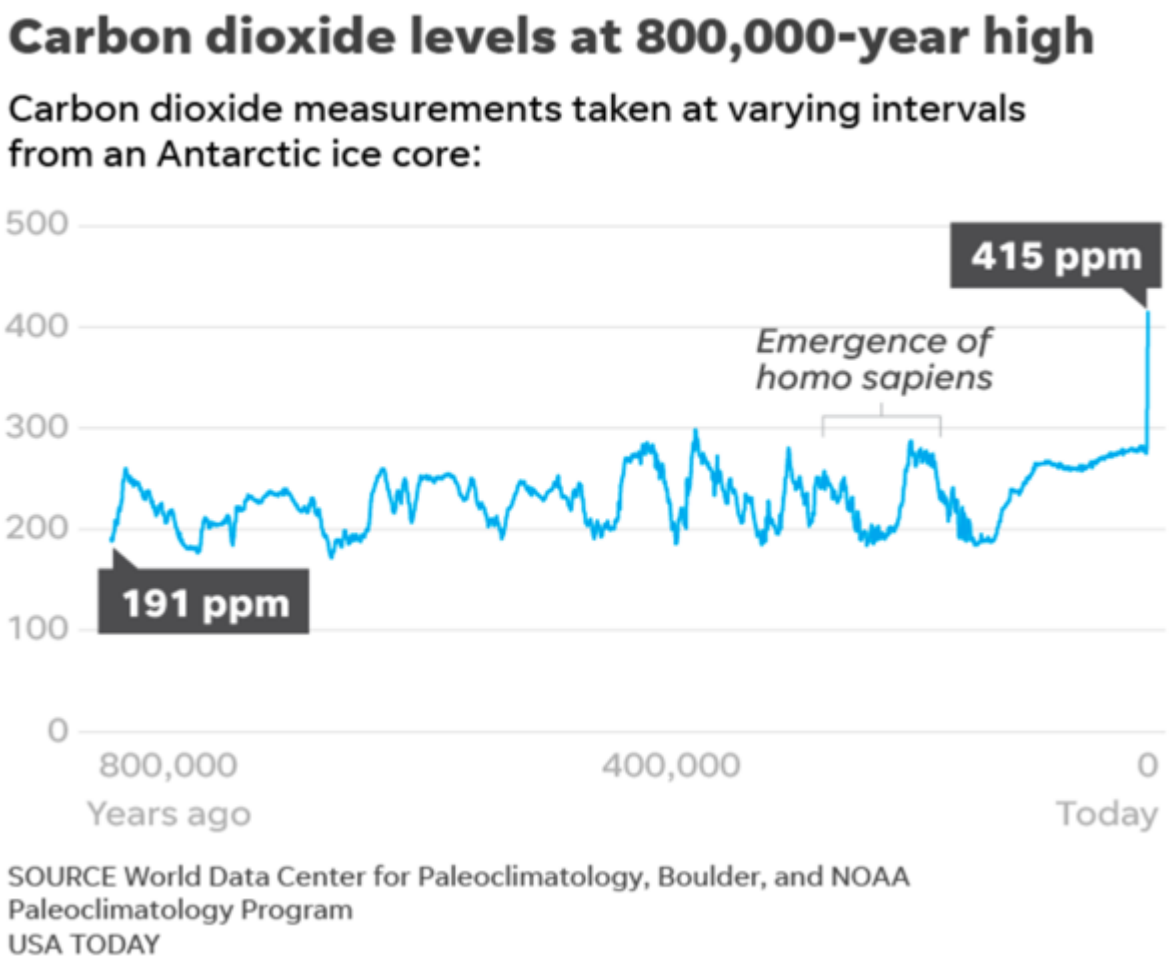
CO_2 balance is being disturbed

Atmospheric carbon dioxide fluctuated between 190 and 290 parts per million (PPM) over the past 800,000 years. We can tell this be looking at CO_2 trapped in Antarctic ice, which has been formed over thousands of years.

However, since the middle of the 19th century (1850) there has been a steep rise in the amount of carbon dioxide in the atmosphere. Today it is as high as 415 ppm, 75% higher than it has been for the past 800,000 years!



Clearly something has been going wrong and human beings are the ones to blame.

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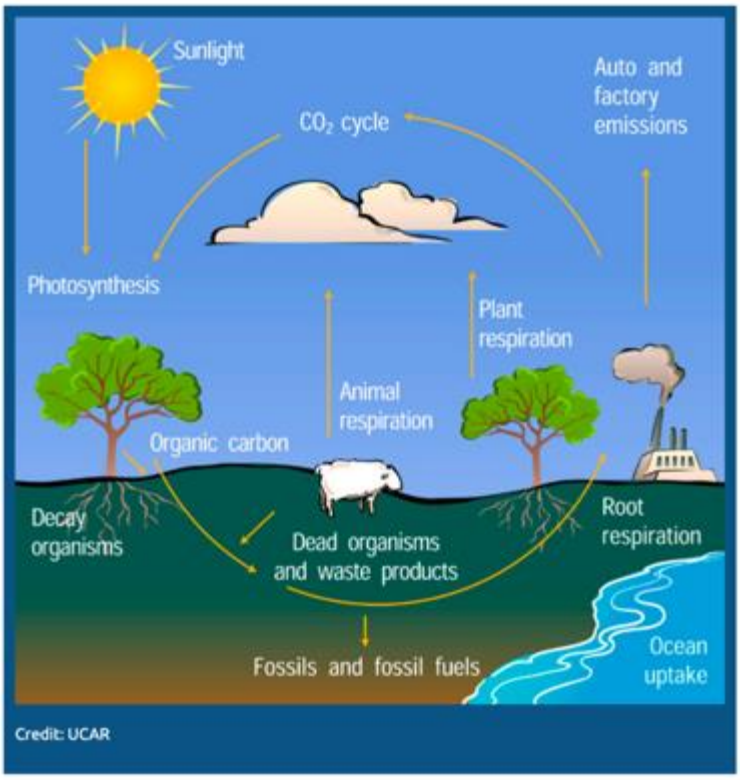
Carbon Cycle and Human Activity



Source: UCAR Center for Science Education https://scied.ucar.edu/carbon-cycle

Actions by the growing numbers of human beings are upsetting the carbon balance.

1. **Burning fossil fuels.**
   There has been a huge growth in industry across the world. Industrialisation uses huge amounts of energy. Most of this extra energy has been obtained by extracting carbon locked away in underground deposits of fossil fuels. When coal and oil is burned, carbon dioxide is released into the atmosphere.

2. **Cement Manufacture**
   Cement is an important building material in the modern world. To make cement, limestone has to be heated to high temperatures using fossil fuels. In the process, huge amounts of CO_2 are released into the atmosphere. The initial stage of cement making involves using coal or oil to heat Calcium Carbonate to temperatures over 825°C. This calcination process produces Calcium Oxide, also called quicklime, and releases huge amounts of Carbon Dioxide.

$$CaCO_3 \rightarrow \text{plus heat} \rightarrow CaO + CO_2$$

3. **Deforestation.**
   a. The chopping down of trees for wood and charcoal burning releases carbon into the atmosphere.

b. Burning forests to clear land for farming adds carbon to the air.
c. Chopping down trees for timber for making furniture and other things, does not release carbon directly (the carbon is still locked in the wood), but it reduces the number of trees and forests for photosynthesis. This means that there are fewer trees to remove excess CO_2 from the atmosphere.

4. **Rising population.**
   For every 1 person in the world in 1800, there are now 7.5 people. This is a huge increase in world population, which is now 7.5 billion people. People compete with other animals and plants for space and resources. We put pressure on the natural environment, cause pollution and upset the carbon balance of the atmosphere.

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Global Warming

Sections

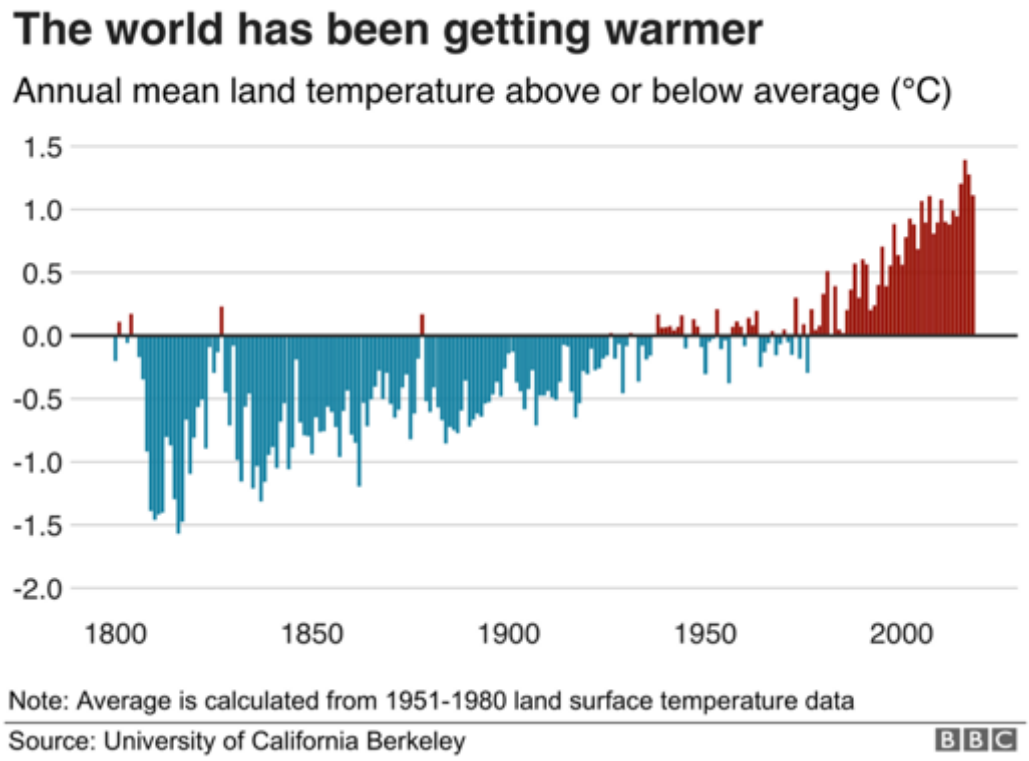
What are Greenhouse Gases?

Why is global warming harmful?

Greta Thunberg “Our House is on Fire!”

Actions on global warming.

The effect of human activities has been to bring about a huge increase in the amount of the greenhouse gases, including carbon dioxide, in the atmosphere. As a consequence, more of the sun’s incoming heat is being trapped in the atmosphere. This is resulting in a, never before seen, rise in average global temperatures.



What are Greenhouse Gases?

A greenhouse gas is one that traps heat in the atmosphere and prevents the earth from cooling to maintain a balance between incoming and outgoing energy. By retaining heat in the atmosphere, the gases cause global temperatures to rise. The main greenhouse gases are:

Water vapour – H_2O – this is water in gas form, when it condenses it forms clouds, that also reflect heat back to the atmosphere and keep the earth cool.

Carbon dioxide **-** CO_2 – this gets into the atmosphere from the respiration of animals, from decaying vegetable matter and from the burning of wood, charcoal and fossil fuels.

Methane – CH_4 – this gas is released from swamps, from rice paddies, from animals, from natural gas and coal.

Ozone – O_3 – this is found in the upper atmosphere and helps to block out harmful radiation from the sun.

Nitrous Oxide – N2O – this is released by bacteria in the soil and the oceans and also by motor vehicles.

Chlorofluorocarbons – these complex compounds of carbon, hydrogen, chlorine and fluorine. They are made in industrial processes and are used in refrigeration systems and in spray cans. They damage the protective ozone layer.

In the last 150 years, increases in carbon dioxide, methane, nitrous oxide and chlorofluorocarbons, and the decrease in the amount of ozone have caused the atmosphere to get warmer.

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Why is global warming harmful?

A useful source is the North American Space Agency: https://climate.nasa.gov/effects/

Rising global temperatures arise when more heat energy is trapped in the atmosphere. In geological time there have always been fluctuations in global temperatures. What is worrying people now, is that the rise in global air temperatures is faster than has ever been observed before and many scientists believe that the effects could be catastrophic for the future of life on earth. Average global temperatures have risen by more than 1 degree C in past 100 years – 2 degrees in Europe. 16 of the 17 warmest year on record have occurred since 2001.Here is a summary of the effects of global warming:

- Global warming means a big increase in the amount of energy in the atmosphere.
- As the ground gets warmer – heat rises in stronger convection currents.
- Rising air causes the formation of bigger clouds and more thunder cells.
- Wind speeds rise and the warm air causes more turbulence.
- Rainstorms become heavier.
- There is more flooding and landslides (especially in areas where trees have been removed).
- Weather patterns become more variable.
- There are more heatwaves and droughts. Away from the equator, summers are hotter.
- Equatorial areas are experiencing marked dry seasons.
- Deserts are growing in some regions.
- There are more extreme weather events. Hurricanes and tornadoes are becoming more powerful.
- Mountain glaciers and polar ice sheets are melting and having an adverse effect on polar bears and penguins.
- Sea level is rising 3mm a year and may rise a metre by 2100 - flooding many coastal towns and cities.
- Oceans are acidifying as they absorb CO_2 - coral reefs are dying.
- Many birds, insects and other animals and plants are having their habitats reduced. Bird migration is changing.
- Large areas of forest are lost through wildfires.
- There are water shortages in large areas and dangers of growing conflict between countries over access to major rivers, such as the River Nile.
- Some species do well e.g. mosquitoes, ticks and crop and tree pests are extending their ranges.
- Crops fail due to drought or are damaged by heavy rains or plant pest and diseases.

Further information can be found here: Intergovernmental Panel on Climate Change (IPCC) Special Report "*Global Warming of 1.5℃*" https://www.ipcc.ch/sr15/

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Greta Thunberg "Our House is on Fire!"

Reversing the build-up of greenhouse gases in the atmosphere will take a lot of effort by everyone in every country on planet Earth. The process of releasing them has gone on for many decades, and global temperatures are set to rise by more than the 2-degree ceiling agreed by world governments in the Paris accord. We cannot delay any longer!

The young Swedish school, Greta Thunberg, born on 3 January 2003, felt so strongly about the issue that she organised a school climate strike in her country. This quickly spread around the world and Greta has become the leader of a global climate protest movement.

She has spoken at large demonstrations and meetings of world leaders, including the 2018 United Nations Climate Change Conference and the 2019 UN Climate Action Summit. In 2019 there were protests in major cities around the world with some bringing over a million people onto the streets in protest. Greta has worked hard to get the following message across to world leaders.

- Our house (The Earth) is on fire and nobody is taking action.
- Business and political leaders are ignoring the threat.
- Young people and future generations are being left to cope with problems caused by current and past generations.
- The industrial countries of the world have caused the carbon emissions and the global warming, but poorer countries will be the ones to suffer through damage to crops and food supplies.

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Actions being taken on global warming?

The world is waking up to the threat of climate change. These are some of the measures being taken:

1. *Action on the use of fossil fuels*: Coal-burning power stations are being closed down, though many oil and gas burning power stations remain.

2. *Action on wood and charcoal burning*: more and more farmers are growing trees to provide a sustainable source of firewood to avoid having to cut down native forests. More efficient wood-burning stoves are being used by schools and households.

3. *Forest protection*: governments are placing protection orders on remaining woodlands and forests, making it illegal to destroy them.

4. *Forest renewal*: many countries are undertaking major tree planting programmes to restore the forested areas so they can act as carbon sinks and nature reserves.

5. *Renewable energy*: governments and companies are making greater use of renewable energy for power generation, including hydro-electric power, wind turbines, solar panels, and ground-source heat pumps.

6. *Cleaner transport*: the use of petrol and diesel engines for cars and lorries will be banned throughout Europe and in other parts of the world by 2030. Vehicle manufacturers and consumers will have to switch to making and using vehicles powered by electricity or clean fuels such as hydrogen.

7. *Energy conservation*: we can all help the planet by using less energy. In colder climates with long dark winters people are reducing heat loss from their homes by installing wall and roof insulation, triple glazing, switching to more efficient LED lights. There is also progress on making machines more energy efficient including vehicles, heating and refrigeration systems, computers and TVs. Using less water reduces the energy used in pumping water. Reusing and recycling materials can also save energy.

Governments, companies and households are beginning to act. Let us hope it is not too little, too late!

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More on The Greenhouse Effect

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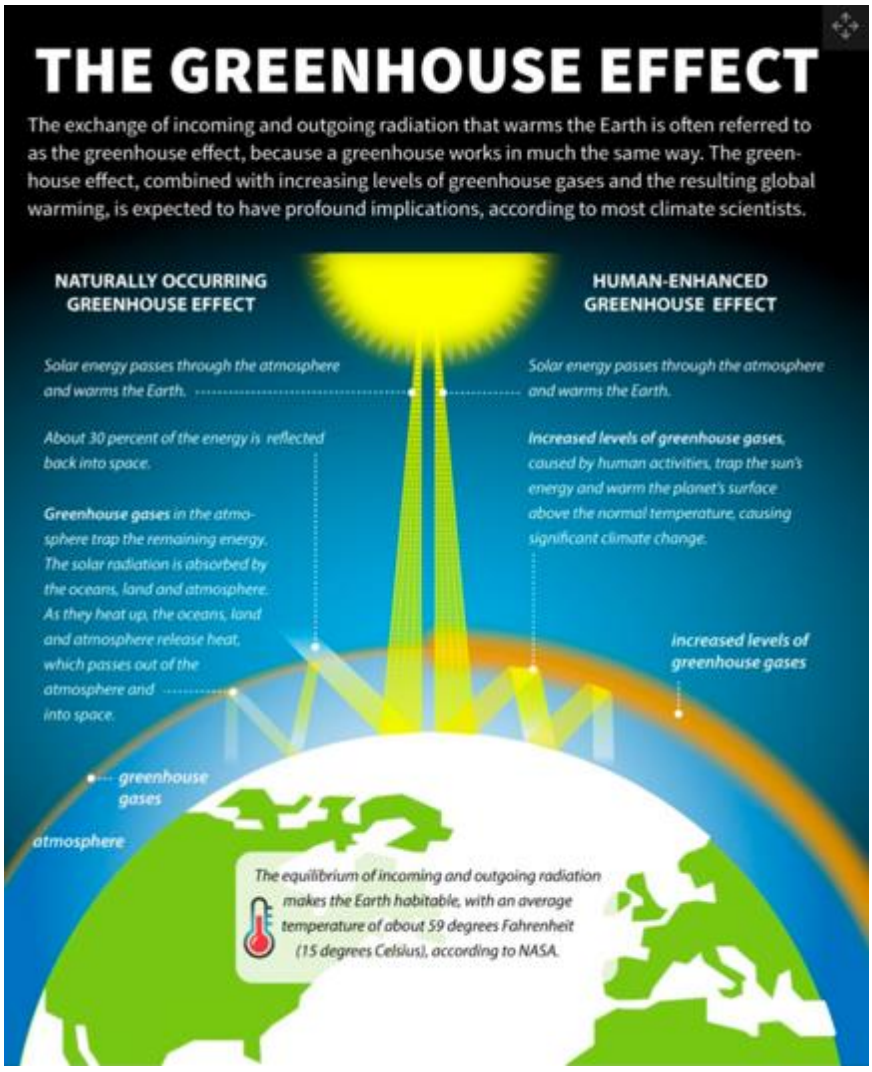
Global Carbon Dioxide emissions

Government Failure and Private Progress

An excellent introduction to the Greenhouse Effect for children can be found on the North American Space Agency website: https://climatekids.nasa.gov/greenhouse-effect/

The following excellent graphic can also be found, with additional material, on the website: https://www.livescience.com/37743-greenhouse-effect.html

THE SUNS RAYS (INSOLATION, short-wave radiation) pass through the atmosphere and turns into heat energy when the light rays hit the ground. The ground is warmed and some of the heat radiates upwards into the atmosphere as heat energy (infra-red, long wave radiation). Some of this heat leaves the earth's atmosphere but some of it is absorbed by greenhouse gases such as carbon dioxide, methane, nitrous oxide and also by water vapour.



Of the incoming radiation from the sun:

- 26% is reflected back to space by the atmosphere and clouds.
- 19% is absorbed by the atmosphere and clouds.
- 55% reaches the earth's surface where much is absorbed as heat.

Clouds, and areas of snow and ice, have a high *albedo*, which means they reflect back much incoming radiation. The reflected heat is absorbed by greenhouse gases. Their molecules start to vibrate and are warmed. This holds escaping heat in the atmosphere, where much is radiated back to ground or absorbed by other greenhouse gas molecules before, finally, escaping to space.

Carbon Dioxide is made of one atom of carbon and two of oxygen. CO_2 molecules make up a small fraction of the atmosphere but have a large effect on climate. At the start of the 19th Century the carbon dioxide content of the atmosphere was 270 ppm. Today it is above 400 ppm. This causes a huge increase in the heat retaining properties of the atmosphere.

Methane has one carbon and 4 hydrogen atoms. It is a bigger molecule and can absorb even more heat than CO_2. Although there are low concentrations in the atmosphere it has a big impact on warming.

Carbon dioxide has increased with the burning of fossil fuels, such as coal and oil. Methane is emitted from the digestive systems of farm animals, such as cows, goats and sheep, which release the gas which is produced during the digestion of grass and other plant matter. When cement is made from limestone, a huge amount of CO_2 is released.

Higher concentrations of greenhouse gases keep more heat in the atmosphere and cause air and ground temperatures to rise.

The contribution of each gas to the greenhouse effect is:

- Water vapour 36-70%
- Carbon dioxide 9-26%
- Methane 4-9%
- Ozone 3-7%

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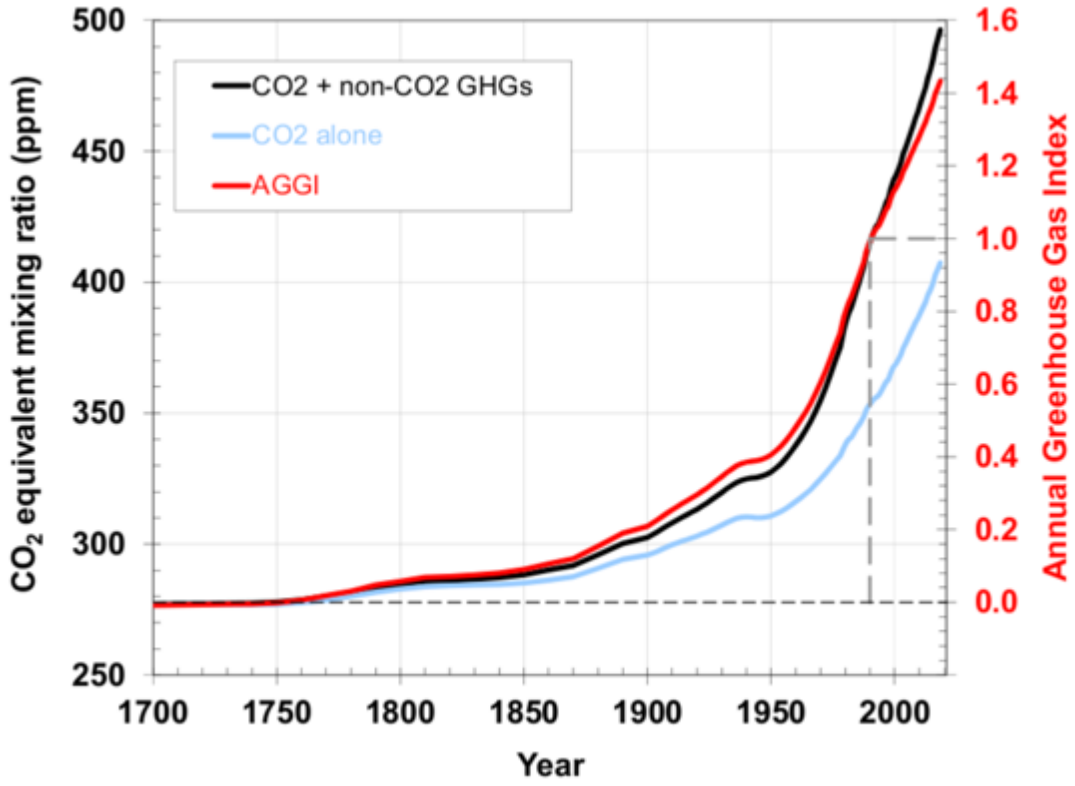
Global Carbon Dioxide and Greenhouse Gas emissions

The graph below shows the huge rise in carbon dioxide and greenhouse gas concentrations in the atmosphere since 1700.



Source: https://www.esrl.noaa.gov/gmd/aggi/aggi.html

Record Emissions

- CO_2 concentrations are at their highest ever levels of 400ppm.
- Global emissions of CO_2 from human activities are over 36 billion tonnes per year and rising.
- The contribution of other greenhouse gases, such as methane, has also grown rapidly.
- There is a 100-fold difference in per capita emissions between the most polluting and the least polluting countries.
- The largest annual emitters of CO_2 at the present time are: China 25%, USA 15%, EU 10%, India 7% and Russia 5%.
- The countries which have contributed most CO_2 to the atmosphere since the industrial revolution began are: USA 25%, EU 22%, China 13%, Russia 6%, Japan 4%.

- The world is not on track to meet its agreed target of limiting warming to 2 degrees C. Under current policies, the earth's atmosphere is on track to heat by well-over 3 degrees (3.1-3.7 degrees).

Much of China's emissions are made producing goods for consumers in other countries. By getting goods produced in China countries are exporting carbon-based manufacture.

Government Failure and Private Progress

Failed Paris Agreement of 2015

To prevent another 1.5 degrees of warming the world needs to reduce carbon emissions by 7.6% every year until 2030. Every year we delay the greater the cutbacks have to be in future. At the Paris Agreement of 2015 of the UN Climate Change Convention governments would only agree to try to limit warming to 2 degrees – yet many scientists believe that countries will fail in even this modest goal and it will have devastating consequences for the Earth's climate and ecology:

- A 1.5°C rise will cause 70% of coral reefs in the oceans to die, but a 2-degree rise will wipe out most of the coral, which is a home and breeding ground for much ocean life.
- There will be a dramatic decline in the insects that are vital for pollinating crops and plants.
- The Arctic Sea ice will melt and disappear in the summers.
- A rise in sea levels and the flooding of coastal cities – which could affect up to 10 million people.
- A rise in temperature of 2 rather than 1.5°C will cause sea level to rise an extra metre.
- Extreme weather events will increase everywhere – more powerful storms, more torrential rain, more floods and, in between, longer periods of drought.
- Crop failure will cause serious food shortages and famine in some areas.

Progress by Private Citizens

People across the world have become frustrated by the lack of progress by their governments and they are taking action themselves to reduce their carbon footprints. They are moving away from using carbon-based fuels, getting energy from renewable sources and reducing the total energy they consume:

- Families are moving away from carbon-based energy sources by:

    - fitting solar photo-voltaic (PV) panels on their homes to generate clean electricity and selling any surplus they generate to their national electricity companies. (e.g. 800,000 homes in the UK)
    - Others are fitting solar thermal panels which generate hot water directly from the sun. (e.g. 250,000 homes in the UK)
    - Homes are drawing hot water for warming their homes from ground source heat pumps.

- Households are choosing to buy electricity from companies that generate power from renewable, clean sources of energy, including
    - Hydro-Electric Power (HEP). Uganda generates most of its power by harnessing the force of water in the River Nile to produce electricity from turbines.
    - Wind Power. In windy parts of the world wind turbines are becoming important as a source of renewable energy. In the UK, for example, over 20% of electricity is generated from wind and the percentage is rising rapidly.
    - Bio-mass Power Stations – these are thermal stations that burn wood or animal dung to make electricity, but the wood comes from renewable sources, so the new growth removes all the carbon that is created by the thermal power station.

- Industry and power stations are exploring the use of carbon capture, where carbon dioxide from combustion is pumped into underground storage sites, such as geological structures (anticlines) that once held petroleum.

- More families and firms are buying electric cars and there is a plan in Europe to phase out all diesel and petrol cars and lorries between 2030 and 2040.

- People are switching to energy-saving lights. Lights based on Light Emitting Diodes (LED) use 75% less energy and last 20 times as long.

- More people are cutting the distances and times they travel by car, bus or by air and there is more car sharing by those making regular journeys.

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Forests lock up carbon

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Most countries have realised that it has been a mistake to cut down their forests and that the amount of CO_2 in the atmosphere by planting many more trees. Uganda has lost much of its forest in recent years, but some impressive forests still remain and strong efforts are being made to preserve them.

Mabira Forest

The whole of the land from Kampala to Jinja, in Central Region, was dense equatorial forest as recently as the 1970s. In the years since, forest has been cleared for farming, industrial sites and to extend the sugar and tea plantations around Lugazi. Mabira Forest is what remains of a huge forested area. Mabira Forest is the the east of Lugazi on the Jinja Road. While many of the very big trees have been illegally felled, the forest that remains is impressive. It over 300 sq. km. and a large part of it is a nature reserve. The forest has 312 species of trees, 315 species of birds, 218 Butterfly species and is home to 23 species of mammals, including primates.

The trees in Mabira locked up 8.5 million tonnes Carbon in 2018 and each year the forest absorbs an additional 150,000 tonnes of Carbon per year. So it is a very important carbon sink, which releases huge quantities of oxygen into the atmosphere.

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Semuliki Forest

Semuliki is another very important forest, which forms one of the important “lungs” of Uganda – absorbing huge amounts of carbon and emitting live-giving oxygen. The Forest is in Bwamba County in Bundibugyo District. It straddles the Semuliki River, which forms the boundary between Uganda and the Congo. Semuliki became a National Park in October, 1993, so it is one of the newest parks in Uganda.

It covers an area of 220 sq km and is one of the richest areas of flora and fauna diversity in Africa, as it is the meeting point of several climatic and ecological zones, including being part of the Congo basin. The dominant tree species is Uganda ironwood, which can grow up to 46 meters and the larger trees have hollow boles and buttress roots (see picture above). As well as a varied flora, Semuliki has a rich diversity of fauna. There are over 400 bird species and 60 mammals including buffalo, elephant, leopard, hippopotamus, 8 primate species, bush babies, flying squirrels and 460 species of butterfly.
As well as acting as important carbon sinks, the biodiversity of Mabira and Semuliki Forests make them important sites of scientific interest across the world. Both forests attract many

tourists, whose spending provides jobs and income. There is huge potential to expand the income from tourism so long as the forest habitat is conserved.

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Big, Old Trees

Research by William Morris at the University of Melbourne, Australia has shown that big, old trees are important:

- Large, older trees add more growth in new branches and leaves and absorb carbon dioxide more rapidly than younger, smaller trees.
- Research published in the journal *Nature* shows that in 97% of tropical and temperate tree species, growth rate increases with size. This suggests that older trees play a vital role in absorbing carbon dioxide from the atmosphere.

David Lindenmayer, a professor of environment at the Australian National University, described findings of the study as being of global significance. "*It highlights why it is really important that we grow as many areas of forest through to being old growth forests as possible*," he said.

"*The more carbon we can store in forests, the more chance we have of reducing the effects that are going to arise from massive climate change. Storing large amounts of carbon in forests is absolutely critical and the way you do that is to have big, old trees.*"

Lindenmayer said that the study highlights flaws in current forest management policy, where big, old trees are often cleared first to provide pulp and timber. "*The value of native forests for carbon storage and for maintaining biodiversity, significantly outweighs their value for pulp and timber*." he said.

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Trees Improve Air Quality

Source: http://urbanforestrynetwork.org/benefits/air quality.htm

It is now widely recognised that healthy forests are essential for improving our air quality.

On average, one acre of new forest can sequester about 2.5 tons of carbon annually. Young trees absorb CO_2 at a rate of 13 pounds per tree each year. Trees reach their most productive stage of carbon storage at about 10 years at which point they are estimated to absorb 22 kg of CO_2 per year. They release enough oxygen back into the atmosphere to support two human beings. Planting 100 million trees could reduce an estimated 18 million tonnes of carbon per year.

The combination of CO_2 removal from the atmosphere and carbon storage in wood makes trees extremely efficient tools in fighting the greenhouse effect. Planting trees remains one of the most cost-effective means of drawing excess CO_2 from the atmosphere. If every family planted one tree, the amount of CO_2 in the atmosphere would be reduced by 10 million tonnes annually.

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Tree Arithmetic

- Annual global CO_2 emissions are 36 billion tonnes.
- World population is 7.6 billion.
- Average emissions of CO_2 are 4.7 tonnes per person.
- Removal of 1 tonne of CO_2 from the atmosphere requires 15 trees.
- So, we need 71 mature trees per person to balance the emissions.
- To cover the emissions of the whole world population the Earth needs to have 450 billion mature trees.
- The most recent estimate of the number of mature trees in the world is 400 billion.
- So, we need an extra 50 billion trees to be planted and cared for to maturity.

This implies that if every person in the world planted 7 trees and cared for them to maturity, we could eliminate the surplus carbon in the atmosphere. This is quite an ambitious target. However, if we take the other carbon reducing measures described above and governments also organise large-scale tree planting, then even small amounts of tree planting by individuals can make a big difference..

Reference: UN Food and Agriculture Study of the Uses of Forest Resources in Africa: http://www.fao.org/3/t9450e/t9450e03.htm#TopOfPage

Tree Planting Initiatives

Government Tree Planting

Many governments are waking up to the problem of global warming and are making plans to plant new forests. The United Nations has announced a ***Decade of Ecosystem Restoration*** and is aiming by 2030 to restore trees to 350m hectares of and across the world (an area bigger than India). These are just a few of the tree planting pledges made by individual member governments of the U.N.:

- India is currently planting 13m hectares of forest.
- Latin American governments will plant 20m hectares.
- African countries aim to plant 100m hectares.
- China is planning major reforestation.
- The UK government will plant 30 million additional trees.

Private Tree Planting

Many people across the world are so convinced that we need to have many more trees that they are taking action on a community and individual basis. Below are some examples of exciting schemes that together can turn the tide on global warming.

Kenya

Local farmers and women's groups are planting trees to restore the forest around Mount Kenya. According to Anastacia Njoki, a member of a tree-planting group close to Mount Kenya, she and her fellow agro-foresters share experiences, as well as singing together.

Source: The Guardian newspaper 19, June 2019
https://www.theguardian.com/world/2019/jun/19/planting-billions-trees-save-planet

Uganda

Case Study 1: Tree Planting for the Climate and to Prevent Landslides

There are a number of large initiatives to restore tree cover in Uganda. Between 1990 and 2010 Uganda lost almost one-third of its tree cover, and trees are still being felled and not being replaced.

The slopes of Mount Elgon near Mbale became badly deforested and with no tree roots to hold the soil together, heavy rains have caused major landslides. There are similar problems on the slopes of the Ruwenzoris, e.g. around Bundibugyo, where lives have been lost through landslides after tree felling for charcoal.

It has now become urgent to replant trees to stabilise the soil, prevent landslides, shade crops and to take up carbon to slow down global warming.

Anet Nabumati is one of a group of farmers in the Mbale area who is being paid, with money from the government of Wales, to operate tree nurseries. Anet has been successfully raising saplings and the group have recently planted their 10 millionth tree. Anet is now diversifying her business to grow other trees and flowers, coffee plants to sell to local farmers. This new venture is providing a good living to her family and enabling her to pay school fees for her children.

Source: World Economic Forum, October 2019
https://www.weforum.org/agenda/2019/10/wales-uganda-plant-trees-deforestation-climate-change/

Case Study 2: Rainforest-Alliance Project
Source: https://www.rainforest-alliance.org/pictures/uganda-trees-for-local-benefit

An International Non-Government Organisation (NGO) has been working with **The Environmental Conservation Trust of Uganda (ECOTRUST)** and local farmers in the Bushenyi area to replant millions of trees to restore a habitat for wildlife and to absorb the carbon that causes climate change. The 138 farmers participating in the scheme are growing a large variety of small saplings from seed and planting them in areas where forest trees had been cleared in earlier decades.

Schools can make a difference

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Schools in Armuria District

Kasese Humanist Schools Tree Initiatives

Activity: School Tree Project

Schools in Armuria District
Source: International Tree Foundation
https://internationaltreefoundation.org/amuria-schools-tree-planting-project/

In Armuria District in Eastern Uganda 10 schools are working with the NGOs International Tree Foundation and Save a Seed for the Future (SAFE). Teachers and students have created the Armuria Schools Tree Planting Project (ASTREPP) to give students skills in tree cultivation, planting and care.

Planting a tree is one thing but, unless it is watered and cared for it will quickly wither and die. Each school has established a tree nursery and formed "***Green Clubs***" to mobilise the students. The project, which started in May 2017 has already planted, and is caring for, 25,000 trees around each of the schools. The two most popular species of tree are the Nile Tulip tree (*Markhamia lutea*) and the Umbrella tree (*Maesopsis eminii*). Both are fast growing native species which provide timber, fuels and fodder and provide shade for more tender shrubs, like coffee. The trees also have medicinal properties. M.Lutea is used to treat skin-related problems. The leaves of M. eminii can be boiled and used as a purgative and diuretic agent.

In the group of schools involved in the project, Green Clubs have become a popular co-curricular activity, which provides prospects of earning a living for some students after leaving school.

Kasese Humanist Schools Tree Initiatives

Contributed by Robert Bwambale the schools Director

Kasese Humanist School is built on the foundation of Science and embraces Humanist values. The school has three sites in and around Kasese Town at Rukoki, Muhokya (Bizoha) and Kahendero on Lake George

In addition to teaching the curriculum, the schools have also invested heavily in tree planting initiatives, with the aim of giving the schools a greener look while enjoying the many other benefits that come from growing trees.

Trees provide many benefits to the schools, including:

- Very welcome shade from the mid-day sun

- Essential vitamins and mineral nutrients from the fruits
- Renewable energy in the form of firewood for cooking food
- Income from the sale of poles, timber and firewood
- Soil binding and protection from soil erosion
- Serving as demonstration grounds for gardening lessons
- Provide a habitat for animals, birds, and insects
- Trees help to buffer noise pollution
- They add beauty to our schools
- They provide us with oxygen and improve air quality
- Trees contribute to the water and carbon cycles and combat climate change
- Tree reduce water run-off and help to prevent water pollution
- They help us mark the seasons by the changes in their appearance over the year.

Types of trees grown at our schools

We have chosen trees purposely to serve specific needs:

- **Fruits Trees:**

These provide fruits for our children and staff and, as the yield increases, we will sell to local markets to generate extra income to support the school economically. On our Rukoki & Bizoha campuses the main fruits we grow are: mangoes, guavas, oranges, avocados, papaya, jack fruits and sour sop.

- **Medicinal trees**

We have planted some trees to provide herbal remedies to some ailments. These include:

Neem (right) – extracts from the seeds have many traditional uses. Neem is known for its pesticidal and insecticidal properties. It can be used as a mosquito repellent. It is also used in hair washing to repel ticks and fleas.

Moringa – also called the miracle tree, has been used for centuries for its medicinal properties. It is thought to have antifungal, antiviral, antidepressant and anti-inflammatory properties. The seeds contain many useful vitamins and minerals, including: vitamins, A, B and C, folate, calcium, potassium, iron, magnesium, phosphorus and zinc. They are very low in fat and contain no cholesterol.

Castor Oil Plant – This is a source of castor oil. Although the husk contains small quantities of the deadly poison ricin, castor oil extracted from the seeds has been used as a medicine for centuries. It is commonly used as a powerful laxative and has been used to start pregnancy. The oil is added to skin care products. It is a natural moisturiser. It promotes healing of wounds, is an anti-inflammatory and fights fungal infections.

These are all in demand from local people.

- **Commercial trees**

We have planted bamboo trees, Gluveria, Eucalyptus trees and Acacia trees on a large scale to ensure our schools invest in some way for the future.Some of these trees take years to mature but we are committed to establishing forests which will provide a steady income for our schools in the future.

Bamboos will be much needed in building the cottages which are common in safari lodges in the tourism sector. The Kasese Schools are close to Queen Elizabeth National Park. Eucalyptus forests provide building poles, timber for building and making school furniture. Acacia trees to provide firewood much needed in kitchens.

- **Edible Forests**

We have created edible forest initiatives where we have invested in planting banana farms at the schools to provide extra food to the school kitchen. This food has been consumed by the children and staff and has reduced on expenditures.
We also grow vegetables under the shade of the trees. This allows us to supplement the schools diet with: tomatoes, onions, egg plants, sukuma wiki, dodo, cabbages, green pepper etc..

We have also planted staple food crops like beans, cassava, sweet potatoes, maize, sim sim and chia seed.

Creation of hedges at the Schools

We have invested in planting hedges to beautify our schools at the same time adding a greener and environmentally friendly look. These hedges provide manure from the cuttings, fresh air and help improve security.

Creation of Nursery Beds and Green Houses

In order to keep the tree planting costs low, Kasese Humanist Schools have invested heavily in creating our own nursery beds and green houses such that it becomes easy to grow as many trees without the worry of needing to find funds to buy more seedlings.

Mango World Ecological park

Several years back we procured a large piece of wetland with a thriving eucalyptus trees. We reduced the number of eucalyptus trees and added fruit trees instead. We now have hundreds of trees growing up on this land, including: palm, eucalyptus, mangoes, reeds, bamboo, avocadoes and we also grow some vegetables.

Bizoha Farmland

Although this land is principally for growing crops, we also have some fruit trees such as: mangoes, jackfruit and guavas. In future we intend to reserve some acres for a tree project as well.

Kahendero School Acacia Tree Forest

The Kahendero School has a tree project that helps to ensure that the school looks green. This school is on the boundary of Queen Elizabeth National Park and we are trying our best to make it as green as possible. We planted a forest of acacia trees outside the school several years back and now we have embarked on a programme of planting trees inside the school fence.

Activity: School Tree Project

Form a tree planting project in your school. If you already have a Gardening Club or a Humanist Club, it could be an activity that they undertake. Otherwise, you could set up a School Tree Project. Some things you will need to think about?

Where will you plant the trees, and how many?

Will the trees be planted on school land or is there some other public land, in villages or along roads, where trees could be planted? You could organise a campaign to persuade local farmers to let you plant trees on their land. You will need to consult when choosing the variety of tree you are going to plant for them.

Set a target for how many trees you think you will be able to plant?

What varieties of trees will you grow?

There are a number of things you need to consider when choosing what varieties of trees to grow.

- Certain trees grow best in certain areas so planters should bear this in mind. A water source, nature of soils, altitude and location are important. It is better to plant trees in places that favour their growth.
- Are you going to grow trees for shade, commercial trees for poles, firewood or for wood; fruit or medicinal trees, or hedging to make the school more private and attractive?

Obtaining and preparing tree seed.

The first thing you will need to decide is where you will get your seed. If you have money you could buy seed from a tree seed merchant. The advantage of this is that the seed is likely to be a good quality.

If you have no money to buy seed, then you will need to collect your own seed. To be successful, you need to find healthy trees that are producing a large crop of healthy fruits and seeds and collect the fallen fruit and seeds from different trees, because this will ensure you have a genetic diversity, and some will germinate better than others. Check the seed carefully to ensure there is not sign of disease or mould growth, and make sure it has been thoroughly dried.

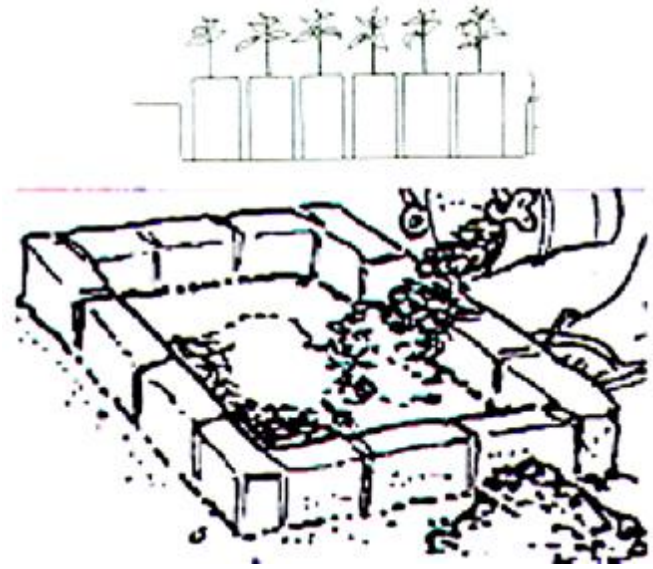
Seed Treatment: Most tree seeds need some pre-treatment if they are to germinate. The treatments include:

- Soaking the seed in hot water until the seeds look swollen. This is essential, for example, with acacia.
- Boil water and pour it over the seeds in a container. Allow to cool and leave the seed in the water until the seeds look swollen.
- Soaking seed in cold/cool water. This is recommended for seed that have soft outer coats. The soaking tie is between 12 and 48 hours. Throw away all floating seeds.
- Seeds with hard coats need to be cracked before sowing. This allows water penetration. Cracking is done with a knife or a stone.

Seed Sowing: Fine seed can be mixed with sand or fine soil and broadcast evenly over the seedbed.
Larger seeds should be planted in individual holes (preferably in pots or containers, at a depth of 1-5cm. Sowing too deep will prolong germination and the seeds may rot. Water the pots twice a day – in the morning before 9am and evening after 4pm. The evening watering is the more important as there is little evaporation, so more water is available to the seed.

Seed bed preparation: Nursery beds can be arranged in different ways. Potted seedlings can be raised on a flat bed, or can be set into a sunken bed, which is a basin like excavation of about 1 m by 1 m and about 10 cm deep.

Figure 2. An example of a sunken bed, filling a raised bed made form bricks with a mix of soil and manure



Such a structure holds seedlings together and helps to conserve water in dry areas. Raised beds are used for establishing bare- rooted seedlings; as the sides of the bed can be broken down to reveal the roots of plants, ready for transplanting.

Staking slats of wood into the ground in a square or rectangle with sides of about 1m and then filling this structure with soil (mixed with sand if possible) makes a raised bed. Alternatively, the sides can be made from bricks or the like.

For further detailed instruction on how to manage a tree nursery, please read the following pdf document produced by the U.N. Food and Agriculture Organisation: Establishing a Tree Nursery in Kenya.