Gardening and soil fertility

Are our gardens less fertile than before the mine came to Lihir?

The reason for this booklet is that there has been some misunderstanding about the effects of the mine on the gardens of Lihir. This booklet explains all the factors that affect soil fertility and the success of crops. Read on to find out how to keep the gardens on Lihir strong. >>
Gardening and soil fertility

To understand whether gardens on Lihir are less fertile because of the effects from the mine we need to learn about:

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1 What makes crops grow well?

To understand what is happening with gardening on Lihir, we first need to know what it is that makes crops grow well, and why it is that yams and other crops grow better in fertile soil.

All plants need four things in order to grow well:
1 sunshine
2 water
3 carbon dioxide (0.038% of the air)
4 nutrients (plant food).

People on Lihir know these four things but talk about them differently.
1 We don’t make a garden where the sun is blocked.
2 We know that if there is not enough rain plants will die or not grow well.
3 We weed around yams so they get enough air around their leaves, and water and nutrients through their roots, to produce new growth.
4 We know that some soils have more ‘food’ (gris, matiok) than others, and that ash from burning off provides food for yams and other crops.

Nutrients and soil fertility

Soil needs certain levels, or concentrations (see Leaflet 2) of particular nutrients for plants to grow well. The most important nutrients are nitrogen (N), phosphorous (P), potassium (K), and calcium (Ca). These nutrients are absorbed by the roots of the plant and combined with carbon dioxide and water to create new tissue in the plant.

After a while, growing plants remove most of the nutrients from the soil through this process, and as a result the fertility of the soil decreases. That is why after two years of growing food on a piece of land, the nutrients are mostly used up, and the soil is no good for growing food any more.

(see diagrams on pages 4-6 and read more)
2 Factors that reduce soil fertility

Crops
Most of the crops that we grow on Lihir to produce food (yams, bananas, cassava, kaukau, aibika) or other products to sell (cocoa, vanilla) need nutrients, which they absorb from the soil through their roots. Once these nutrients have been absorbed into the plants they need to be replaced to make the soil fertile again. If we try to grow the same crop in the same piece of land for more than one year, it produces smaller tubers or fruits in the second and third years because there are not enough nutrients left in the soil to give a good crop of that plant. So we plant different crops the next year—crop rotation.

Land degradation
Land becomes degraded when nutrients are not replaced after cropping and the soil becomes infertile and overgrown with kunai grass or malo ferns. When this happens it is hard to dig the ground to plant food crops, and hard for trees to regrow. The grass or ferns often catch fire. The fire does not kill the grass or the ferns because they both have thick rhizomes (underground roots) that can grow a new plant again after the fire. But any trees trying to grow will be killed by a fire. This land is difficult to make gardens on, and because trees cannot grow, it cannot be improved by the bush fallow cycle.

See page 12 > >
The fallow cycle

The main method for growing food in the Pacific is a 5–10 year cycle system of farming which involves cutting down a small area of bush, burning it, growing food crops for one or two years, and then letting the bush grow back again afterwards. This is called the fallow cycle. After two years of growing crops the land is left fallow for a few years so that the nutrients can build up in the soil, making it fertile again and ready for another food crop.

**Year 1** Root crops like yams, kaukau and cassava are grown in the top half a metre of the soil. After the first harvest there are still plenty of nutrients in the deeper layers of the soil.

**Year 2** In the second year bananas grow well as their roots reach down deeper to where there are still nutrients in the soil, and kaukau thrive as they do not need nutrient rich soil.

Traditional use of the fallow cycle

In the Pacific islands one of the traditional ways to maintain the fertility of the soil after land has been used for gardens is by letting the bush grow back for around 10 years after the garden has been harvested. This is called the fallow cycle, and the period of time that the bush is growing before it is cut down again is known as the fallow period.

If the fallow period has been long enough (10 years or more) then the fertility of the soil is increased as a result. see next page >>

**Mulch and fertilizer**

In the Pacific we use kaukau vines and yam peelings as mulch, and burn off after a fallow period to replace nutrients in the soil.
Hibiscus tiliaceus, called Ol in the Lihir language, is one of the main nutrient pump fallow species. It is commonly used as a yam stake, because it keeps growing after the yams have been harvested and produces a good-sized bush fallow in a relatively short time, returning nutrients to the surface layers for another yam crop after the fallow period.

Year 3 onwards People let the bush grow back. When trees such as ol (Hibiscus tiliaceus) grow in old garden land, their roots penetrate deeper into the soil, where they access nutrients that were not used up by any of the food crops. These nutrients are then drawn into the leaves and branches of the ol trees. When the leaves fall they slowly decay, releasing the nutrients back into the surface layers of the soil. After several years of fallow, the top soil becomes fertile again.

The nutrient pump

This system is sometimes referred to as a nutrient pump, because the ol trees are ‘pumping’ the nutrients from deep in the soil back to the shallow layers where they can be used again by food crops. This is why a fallow period is important and why a longer fallow period (10 years) gives more nutrients back to a garden than a short fallow period (2–4 years).
When people make gardens on many islands in Melanesia they usually plant yams (Dioscorea alata [wih] and Dioscorea esculenta [mami]) in the first year, because these species need very fertile soil full of nutrients in order to grow well.

In the second year, people plant kaukau (sweet potato Ipomea batatas), cassava (Manihot esculenta [taipiok]) and bananas (Musa sp.) because these crops can be productive with less nutrients in the soil. In fact, if kaukau is planted in nutrient rich soil in the first year it produces too much vine, and not enough edible tubers, because the concentration of nutrients is too high. This is why people plant kaukau in old gardens.
Glossary for gardening and soil fertility

**burning off** a way of clearing the bush to make way for a new garden, and fertilising the ground at the same time, as the ash from the burnt trees is rich in nutrients.

**crop rotation** planting different crops in successive years.

**decomposition** the breaking down or rotting of plant material which releases nutrients.

**dense** closely compacted together; thick; crowded together.

**fallow** land that is left unattended for several years after being used for farming. In Melanesia this usually results in the growth of trees. After several years of being in fallow the soil is usually more fertile again (see nutrient pump).

**fertile** having nutrients capable of supporting abundant growth of plants.

**manure** animal droppings.

**mulching** the practice of putting piles of leaves and other plant material around the bases of crop plants to decay and provide nutrients.

**nematode** a group of roundworms in which many species are parasitic on other organisms, both plants and animals. There is a very large number of species of nematodes, most are microscopic.

**nutrients** substances that improve growth in plants. The main plant nutrients are nitrogen (N), phosphorus (P) and potassium (K). These nutrients are absorbed from the soil by the roots of plants and transported to other parts of the plants such as the leaves where they are needed. There are many other nutrients beside these, such as magnesium (Mg) that are required in smaller concentrations.

**nutrient pump** the process in which deep-rooted plants such as *Hibiscus tiliaceus* (Ol, Mangas) draw up nutrients from deep in the soil and deposit them, in the form of fallen leaves which decay on the surface of the soil, where they can be used by food crops.

**rhizomes** part of a plant that grows sideways just under the surface of the soil, and is able to produce many shoots that grow into new plants. Most of the grasses and ferns that grow on degraded soil have underground rhizomes that make it hard to dig the soil.

**transpiration** a process where water is released through the leaves of plants.
In most parts of Papua New Guinea, people grow the food that they eat on land owned by their family, clan or tribe. The more land a family owns, the longer they are able to leave each garden under fallow after it has been farmed, and the more fertile the soil can become as nutrients are replaced by the fallow process (see pages 4–6).

As the population increases, whether through natural growth or immigration as an effect of the mining, there is pressure to replant food crops quickly because each family has less land per person. So the amount of time that each garden can be left under fallow, before it must be cleared again, becomes shorter. This means that there is less time for the fertility of the soil to increase after the food has been harvested from a garden. So, as the human population increases, the fertility of the soil tends to decrease.

Declining soil fertility also increases the risk of the problem of land degradation (see page 12). Chiefs and clan leaders need to think carefully about managing the number of people in their community so that there is always enough land to ensure high soil fertility under the Bush Fallow system.

On Lihir the number of people has more than doubled since the mine started operating, and the soil is now less fertile in many places because of this increase in population.

The longer a piece of land has had bush growing on it, the more fertile it usually is.

As the population on Lihir increases because of mining, and the land is left fallow for a shorter amount of time, then the fertility of the soil decreases.
In traditional farming systems in Melanesia, people burn off the bush after they cut it for two main reasons:

- to kill off all the weeds and their seeds so that they don’t compete with the food for space and nutrients.
- to make some of the nutrients in the bush that has been cut down more available by converting the sticks and leaves and vines into ash. The ash is very rich in some nutrients, which are easily absorbed by the food crop that is planted in the new garden.

Some kinds of plants might be a better source of nutrients to the food crop if they are not burned, because they can rot slowly and release nutrients over a longer period of time. The practice of putting piles of leaves around the bases of food plants for this purpose is called mulching. Mulching usually increases the productivity of the crop, but it requires some extra work from the gardener or farmer. Often people prefer to burn and clear the ground instead of mulching because burning makes sure there are no seeds lying around that will become weeds once the garden starts to grow.
Other more complicated processes can take place when the land is under fallow. Sometimes plant parasites, such as nematodes (tiny worms), start to increase in numbers while the crops are growing, reducing the yield of the food crop over time. During the fallow period, when the food crops are replaced with bush, these parasites no longer have anything to feed on and so they die off. When that land is cleared for a new garden several years later, there are few or no parasites left in the soil and the crops can grow better as a result.

Using cuttings from kaukau vines as mulch.

This garden has pigwire around it (bought at subsidised prices from DPI) and shows ash — an acknowledged source of nutrients — around the tree stumps.
Factors that increase soil fertility

Fallow

Farmers around the world use the process of fallow and crop rotation cycles to maintain the fertility of the soil after land has been used for crops. The fallow period is when no crops are planted to allow time for trees to replace the nutrients in the soil. This is explained on pages 4–6.

Manure

Animal manure is a very rich source of nutrients, particularly nitrogen and phosphorous, and most plants grow very well when a small amount of manure is added to the soil or sprinkled around the base of the plant. It is important not to put too much manure, as it can ‘burn’ the plants if it comes into direct contact with the stems.

Fertilizer

Artificial fertilizers are another way of adding nutrients to the soil, but they can cause problems if not used correctly. Disadvantages of fertilizers are that nutrients from them can be washed away quickly in heavy rain, and they are expensive.

Mulching

This is a simple process where dead plant matter, such as kaukau vines or yam peelings, is placed around the base of plants. Mulching maintains moisture in the soil by minimising evaporation (see Booklets 1 & 2), and as it rots it releases nutrients into the soil to improve the growth of the food crop.

Composting

It can take six months before nutrients are released from rotting mulch, so some gardeners speed up the process by heaping the plant mulch in a small open-bottom box and leaving it to decompose (or break down) before applying it to the crop. This is called composting.

Decomposition and micro-organisms

The process of decomposition is very important as it releases nutrients from dead plant material, which can then be used to improve the growth of food crops, like yams and kaukau. There are two main groups of micro-organisms involved in the decomposition of plant material. One group is fungi (the singular is fungus), which feed on rotting vegetation, and produce root-like branches that grow throughout the rotting material. Fungi reproduce or multiply by releasing millions of microscopic spores, which can each germinate into a new fungus. The other group is bacteria. There are many species of bacteria involved in decomposition. Bacteria are all microscopic and impossible to see with the naked eye.
9 Land degradation

When the **fallow period** is reduced to less than five years because increased population causes land shortages, trees are less able to grow back after the food crop has been harvested. Kunai grass, or even malo ferns, grow back instead. Once these species become established, it becomes very hard to plant food or trees on that land. Trees have trouble growing after kunai grass and ferns have been burned in fires, because both the kunai and malo survive the fires. This is because they have thick **rhizomes** that form a dense network between plants below the ground, making it very hard to dig the ground to plant food crops. These rhizomes are also able to sprout new shoots after a fire, whereas any baby trees growing among the grass or ferns are likely to be killed in a fire. In this way plants with rhizomes prevent anything else from growing once they are established on the land. Kunai grass and malo ferns are usually a sign of soil with very low fertility. This can occur naturally (where soils have always been very infertile) or as a result of poor land management.

Malo ferns and kunai grass grow where the soil no longer has enough nutrients to support food crops.

This grass-dominated country, which also typically feature pandanus trees, has soils which are very **depleted in nutrients**. Called Bap in the Lihir language, it is prone to regular fires, which prevents the regrowth of trees that would eventually restore nutrients if they were able to get established. Malo ferns and kunai grass grow on severely degraded soils and are very hard to get rid of once they are established. It is almost impossible to make a garden here because of the thick underground **rhizomes** that the ferns produce, from which they regenerate if they are burned in a fire.
10  Time to check how much you’ve learnt

Answer the questions below to see how well you understand what makes our gardens fertile.

1 Name four things plants need to grow well.
2 What happens to the soil when food crops are grown on the same piece of land for several years in a row?
3 Describe how the fallow cycle replaces soil nutrients.
4 Which crops can grow well in soil that is low in nutrients?
5 What happens to the fallow cycle when the human population increases?
6 Name a common type of plant parasite.
7 Why is burning the bush before planting a garden beneficial?
8 Name four things that increase soil fertility.
9 Describe how land becomes degraded as a result of over-cropping in Papua New Guinea.

Now, answer the question asked on the front of this booklet:

Are our gardens less fertile than before the mine came to Lihir?