

Review Paper:

Effects of deforestation on soil functions and how reforestation can reverse them

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nsakadzo87@gmail.com**Abstract**

Deforestation has become so rapid the world all over due to demand for agricultural land, food and fuel supplies. This has led to destruction of a number of forests which has adversely affected soil functions, the environment and surrounding ecosystems. The increase in human population has caused people to clear forest in order for them to create space for creation of settlements and different industrial purposes. This clearing of land for economic and social purposes has resulted in land degradation which is also affecting different soil functions that include loss of nutrients.⁸

There has been an adverse effect on soil properties that include carbon and nitrogen content, a decrease in the soil microbial activities. The soil micro-organisms provide enzymes required for different soil processes or functions like nutrient mineralisation, nutrient cycling, decomposition and organic matter formation.

Keywords: Deforestation, Soil, Reversal, Reforestation.

Introduction

Chenga¹³ has shown that forestry covering the size of Harare is being lost due to deforestation every year. There is a sharp increase in the number of smallholder tobacco farmers resulting in high demand for wood fuel. Wood fuel is seen

as a cheaper and readily available source of fuel compared to coal and electricity especially for small holder farmers who cannot afford other alternative sources of fuel that can be used to cure tobacco. Deforestation is defined as the permanent unnecessary destruction of forests in order to make the land available for other uses without replacing the cut down trees.¹¹ The removal of trees without reforestation has resulted in significant damage to soil functionality leading to imbalance of the ecosystem. Soil plays a critical role in delivering ecosystem services. Soil function is defined as the processes necessary to maintain the ecosystem services humans rely upon.¹⁷

Sound soils give nutrient cycling, water maintenance, air and water filtration, organic environment and physical solidness. Studies have shown that deforestation alters the physical and chemical properties of soil, therefore deterring its functionality. In Zimbabwe, the Forestry Commission has embarked on a drive to address deforestation where the first Saturday of every December was declared the National Tree planting day¹³. This was done in order to ensure that there is repopulation of forests around the country to reverse the adverse effects of deforestation on soil functions.

There is need not to affect disruption of soil and its function as there are different roles played by the soil. Figure 1 clearly illustrates how soil is of great importance to people and their environment. Soil performs five key functions in the ecosystem. Figure 1 beneath demonstrates the five functions of soil.

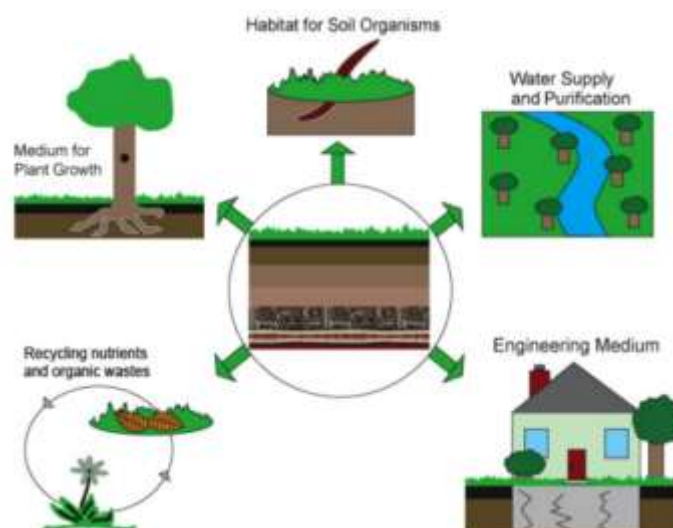


Figure 1: Five functions of soil provided by healthy soil.

Source: The Cooperative Soil Survey <http://www.soilsurvey.org/index.asp>

- 1) **Medium for plant growth:** People and animals require food in order to live and one of the key and most important functions of soil is to serve as a plant root anchor, moisture holding tank and stores plant nutrients.
- 2) **Regulator of Water Supplies:** It is the role of the soil to absorb and ensure moisture retention for subsequent use by plants and other life forms of soil which have to enjoy accessible water.
- 3) **Recycler of raw materials:** The decomposition of organic and biochemical material by bacteria transforms them into simpler nutrients that will be used in generating new living tissues and soil humus by other living plants, animals and microorganisms. These bacteria require a favourable environment to live in so as to perform the function of recycling of raw materials.
- 4) **Habitat for soil organisms:** The development of wide range of microorganisms is provided for by the soil which is very prevalent in rainforest areas as litter from tree leaves provides the ideal habitat for the soil microorganisms. These microorganisms are essential decomposers of old, dead materials.
- 5) **Landscaping and engineering medium:** Soil serves as a foundation to support structures, from plants to buildings.

Effects of deforestation to soil functions

Deforestation has adverse effects on soils and biodiversity which has economic implications.⁵ When land is cleared for agricultural purposes, it affects soil organic matter content and the structural stability of soils. According to Six et al.,⁸ if land is cultivated there will be reduction in the carbon content and the stability of soil aggregates. If land is left bare, the soil is left exposed to agents of soil erosion as the soil aggregates must have been disrupted. The rate of runoff increases in deforested lands as there will not be any roots to bind the soils together.²

This will also increase the rate of soil erosion which in some cases where the slope is steep can lead to landslides. The rate of infiltration is very low for areas where there are no trees to hold the water during runoff. Deforestation increases sedimentation as there would be no vegetative cover and also soil particles must have been detached.

The soil structure is destroyed after land is cleared for agricultural purposes. This is done by the tillage process and this will also increase pore space. During heavy rains, rain drops cause splash erosion in areas where land must have been cleared. This will obviously affect the physical properties of soil. During growth of plants, roots decompose which help to stabilise the soil aggregates.³ However, if the trees are cut down, this will reduce the organic matter content affecting stabilisation of soil aggregates.

Deforestation according to Rasmussen⁶ causes leaching of nitrogen from the soil. The rate of soil enzyme activity in the soil is decreased as there will not be enough organic inputs as trees must have been removed during deforestation. The

soil micro-organisms provide enzymes required for different soil processes or functions like nutrient mineralisation, nutrient cycling, decomposition and organic matter formation.

Different types of soil erosion are common in areas where deforestation is rampant. These forms of soil erosion first affect the top soil which support the majority of field crops which makes the soil to become poor for any agricultural purposes. This in other words deforestation results in reducing the quality of soils. In the long run, there will be desertification which makes the soil unable to support any plant growth and also animals. Thus forests protect the soil and the absence of trees or plants leads to development of gulleys and siltation of rivers.

The continuous decrease of the forest, the soil's ability to preserve water is greatly reduced which leads to a drier climate. Different water resources are affected by deforestation that include drinking water, fisheries, waterways and dams. Trees helps to improve soil fertility and even during soil erosion, the sediments and contaminants in the soil reduce the quality of drinking water.¹⁶ This will make the filtering and treating of water expensive and forests can reduce the costs of treating water for consumption. Deforestation impacts soil function by disrupting the everyday cycling of nutrient in a number of ways.²² Figure 2 illustrates the effects of deforestation on nutrient cycling.

Although the impacts of deforestation on soil function are devastating, they can be mitigated by reforestation (replanting of trees) which requires commitment and persistence. Although a massive effort to replant would help reverse the deforestation effects, it would not solve all the problems at once.¹⁷

How reforestation reverses the adverse effects of deforestation

The process is shown in figure 3 in more detail:

- **Litter:** Leaves, twigs and branches die and fall as litter to the ground during a tree's lifetime. When soil is covered with litter, it has the effect of reducing erosion to minimum levels. Another feature of litter is that it contributes to the soil's organic material content after it breaks down. Soil rich in organic matter can better absorb and hold water and is therefore also more resistant to erosion.
- **Nitrogen fixation:** The earth's atmosphere is about 78% nitrogen. For plants to use the nutrient, it must first be reduced to ammonium, a procedure conducted by special bacteria called nitrogen fixing bacteria found in leguminous plants. The fixation of nitrogen has been proven and found to be a significant factor in soil fertility. Nitrogen can be fixed if there are nitrogen fixing plants like Acacia that can be planted specifically for such a purpose.

- **Atmospheric nutrients:** The presence of a tree reduces wind speed and creates good conditions for the deposition of dust. Atmospheric nutrients are transmitted to the soil when dissolved in rain or settled with dust. Rain water that drips from the leaves and flows along the branches carries nutrients to the ground

along with those released from the tree itself and associated plants that grow on it.

- **Erosion Control:** By maintaining coat of living plants and litter on the ground, soil erosion can be controlled. A cover of litter on the soil reduces the impact of rain drops that causes soil erosion. Therefore, trees play an important role in erosion control.

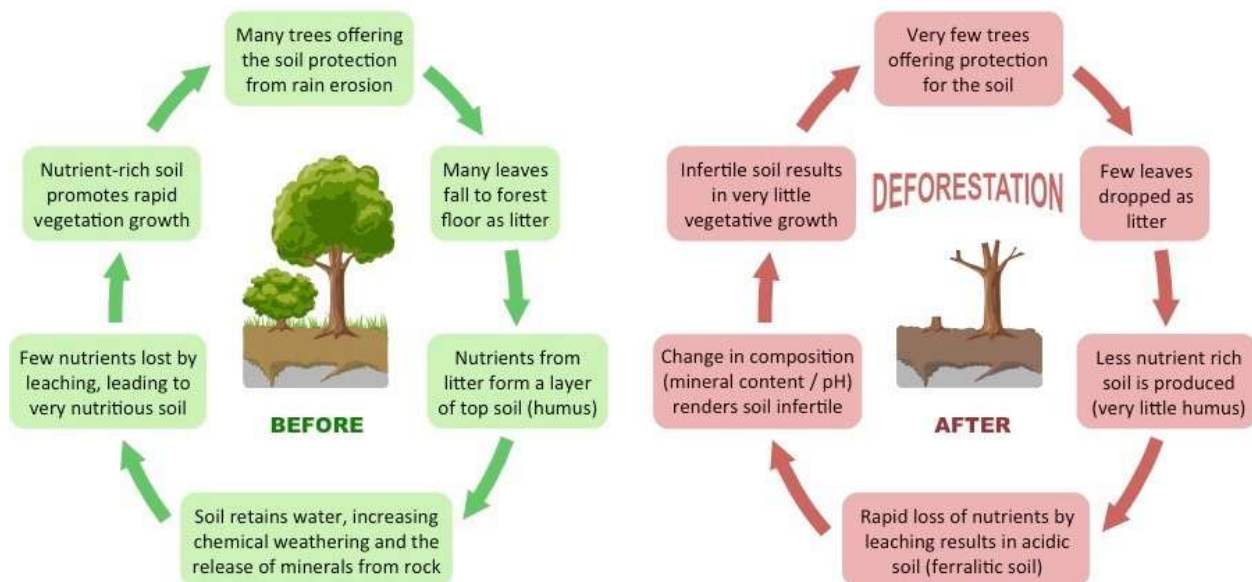


Figure 2: The Effect of Deforestation on Nutrient Cycling

Source: Natural Disturbance <http://ib.bioninja.com.au/options/option-c-ecology-and-conser/c2-communities-and-ecosyste/ecological-disturbance.html>

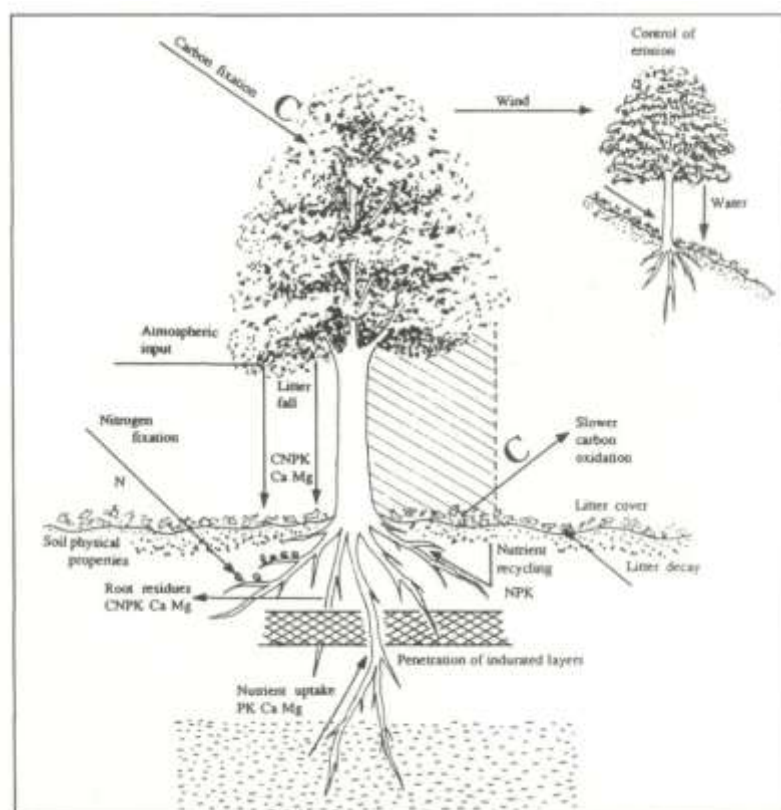


Figure 3: Processes by which trees maintains or improve soil.

Source: World Agroforestry Centre.

Reforestation is beneficial in areas where it has been well embraced as it benefits on precipitation storage and erosion control. The process of reforestation can reverse all the adverse effects of deforestation. The process of reforestation is known to promote and restore environmental functions and the ecosystems. Forests protect the soil by binding with their roots from agents of soil erosion that include wind and precipitation.

In areas where there are thick forests, there is a high level of microbial activities in the soil coupled with high rainfall and high levels of well decomposed organic matter falling leaves. This on its own helps in improving the soil structure and texture which in a way supports plant growth. Forests created through reforestation supply water through transpiration which at the end results in high rainfall.³ Surface runoff on bare ground is faster than that on areas with vegetative cover. The soil in forest or where there are trees is binded together avoiding soil loss. Moreover, excessive soil loss results in depletion of carbon and nutrients which can eventually lead to landslides in areas with steep slopes. Soil loss is very low in forest as litter and humus covering the forest will be protecting the soil.

Carbon sequestration in soil is made possible through reforestation.¹ Reforestation enables the capturing of carbon and also increases the infiltration rate in soils in a way creating a healthy soil with an improved soil microbial environment. The soil microbial activities allow the cycling of nutrients as there is decomposition and also it is in soil where carbon is stored through production and aggregation of primary soil organic matter constituencies necessitated by microbial derived compounds.⁷ This obviously means that such aforementioned process can occur in an area with vegetation cover done as a result of reforestation.

Reforestation reduces biodiversity loss and can mitigate climate change. It is through reforestation where soil structures are improved due to high soil aggregation in forest soils as leaves from trees form litter that eventually decompose. There is reduced soil disturbance and less compacted soil with a lower bulk density and also the soil is porous when compared to soils which is bare and used for agricultural purposes.⁴

However, decrease in bulk density as a result of reforestation occurs over a long period of time and due to reforestation, the soils will have more assemblages with diverse microbes. According to Wardle,⁹ soil microbes recycle nutrients derived from organic matter. There is richness of soil species and there will be heterogeneity of soil resources.

Trees play a pivotal role in the resource redistribution when they take up nutrients from the soil to all parts of the tree. The planting of different tree species helps to increase the heterogeneity of soil microbes. In terms of nutrient recycling, reforestation helps in playing a key role in the nitrogen cycle when nitrogen fixing trees like Acacia are

planted. Moreover, reforestation helps to stabilize soil carbon due to changes in the physical and molecular form in the soil.⁷

Conclusion

The benefits derived from the process of reforestation ensure that all those losses and adverse effects of deforestation are reversed. Deforestation has caused changes to the environment because the soil cannot maintain the ecosystem services that humans rely upon. If major steps towards deforestation are not taken, the consequences could be dire and irreversible. Reforestation is seen as one of many effective solutions to reverse the effects of deforestation on soil; people must step forward and participate in planting trees during the tree planting season or any other season in order to recover the forest that has been lost. It requires a great commitment from the people and their communities to have the necessary knowledge in terms of how to preserve their forests by not cutting down trees unnecessarily. This is because a lot of benefits are derived from trees and forests that range from social, environmental and economical. There is need to make use of alternative sources of energy as this will minimise cutting down of trees especially in communal areas of developing countries.

Due to deforestation, the world has been experiencing dire consequences that include droughts and natural disasters as a result of climate change. Trees are a part of the water cycle, therefore if they are cut down, it affects the rainfall patterns which can cause droughts affecting the flora and fauna. There has been siltation of rivers reducing the size of water bodies as a result of deforestation. All the adverse effects caused by deforestation can be reversed by reforestation. This is because through reforestation, there are meaningful benefits that have been realized the world over. Governments have to come up with policies, rules and regulations that guard against wanton cutting down of trees.

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(Received 15th May 2020, accepted 20th July 2020)
