

General soil threats of the region – Africa south of the Sahara

The loss of vegetative cover and deterioration in the level of soil organic matter (SOM) are the root causes of most soil degradation since all the physical, chemical and biological problems follow a drop in SOM content.

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SUBTROP

SOIL THREAT PART 2 – LOSS OF SOIL ORGANIC MATTER

Soil organic matter (SOM) is a key component in any terrestrial ecosystem. Variation in its abundance and composition has important effects on many of the processes that occur within the system. The amount of organic matter and the size of soil carbon stock results from an equilibrium between the inputs into the system, which are mostly from biomass waste, outputs of the system and largely from decomposition and volatilisation.

These processes are driven by various parameters of natural or human origins. A decrease of organic matter in topsoil can have dramatic negative effects on the water-holding capacity of the soil on the soil structure stability and compactness, on nutrient storage and supply and on soil biological components such as mycorrhizas and nitrogen-fixing bacteria. Approximately 58% of South African soils contain <0,5% organic C, 38% contain 0,5 to 2% organic C, and 4% contain >2% organic C.

South Africa is therefore characterised by soils with very low organic matter levels. This is much less than the average of >10% for the Central African, South American and Northern

Hemisphere countries, like Russia. There are large differences in organic matter content within and between soil types, which depends on climate, vegetation, topography and soil texture. Overgrazing and the use of fire in rangeland management resulted in significant losses of soil organic matter (Fig. 1, 2).

DIRECT CAUSES OF SOM DECLINE

- Apart from climatic factors that influence carbon changes in the soil, inappropriate land uses and practices are the main causes of the decline in SOM. These causes and practices include monoculture crop production, intensive tillage, short to no fallow and reduction or absence of crop rotation systems. In subtropical fruit production, the main cause would be production without the use of organic mulches, inappropriate fertilisation practices and no ground covers between tree rows (Fig. 3).
- Due to the direct impact of human activities, the carbon balance of terrestrial ecosystems is changing across the world. Land use changes such as those related to tourism practices, like off-road driving, removes the topsoil layers (Fig. 4) and destroys the vegetation which is responsible for sub-soil compaction and surface crusting (Nortjé, 2014), and veld

burning which is responsible for anthropogenic CO₂ emissions.

SOCIO-ECONOMIC CAUSES OF SOM DECLINE

In the countries south of the Sahara, socio-economic pressures involve increasing production, income and job creation (FAO, 2001). They create incentives for farmers to encourage the reduction of the rate of fallow periods, continuous cultivation, overgrazing of fields or the removal of the majority of the above-ground biomass for fuel, animal fodder, building materials and to cut on essential inputs (e.g. fertilisation, mulching in subtropical fruit production) (Fig. 3).

EXTENT OF SOM DECLINES IN THE REGION

Land degradation leads to release of carbon to the atmosphere through oxidation of soil organic matter. Africa's current major negative role in the global carbon cycle can be attributed to the substantial releases of carbon associated with land use conversion from forest or woodlands to agriculture. In the 1990s, these releases accounted for approximately 15% of the global net flux of carbon from land use changes.

Soils often continue to lose carbon over time following land conversion, resulting to further reductions in crop yields and impoverishment of the farming population. However, the carbon stock can be replenished by using combinations of residue retention, manuring, nitrogen (N) fertilisation, along with agroforestry and conservation practices.

In most semi-arid and sub-humid areas, the majority of the grazing land is burned annually during the dry season to remove the old and coarse vegetation to encourage the growth of young and more nutritious grasses. Burning



Figure 1. Poor soil cover due to overgrazing and drought.



Figure 2. Fires causes significant losses in soil organic matter.



Figure 3. No soil cover or mulch under and between rows in a macadamia orchard

causes the loss of soil organic matter (released as CO₂) and thus impairs agricultural productivity.

It exposes the soil to the erosive forces of the wind during the dry season and water during the rainy season (Nortjé, 2014). Furthermore, the annual burn of the vegetation severely reduces the return of the organic matter to the soil. This results in the loss of the benefits of soil organic matter including fertility, structure, water retention and biodiversity. The soil becomes biologically, chemically and physically poorer (FAO, 2001; Nortjé, 2014).

Land degradation further leads to a release of carbon to the atmosphere through the oxidation of soil organic matter which results from soil disturbance and the consequent exposure of the soil surface to the weather.

In agriculture, such as the South African subtropical fruit industry, the challenge has been and is still, to produce increasing quantities of food (fruit) in an economical and institutional context where the means to improve productivity in a sustainable manner are generally not available (e.g. lack of sustainable technological packages, absence of extension, training or affordable inputs etc.).

Pressures to increase outputs in the absence of these supporting factors has led to 1) the rapid expansion of agriculture land (over 65% in the last few decades); and 2) the shortening of the fallow periods in traditional, extensive land use systems, which reduced the rehabilitation of soil fertility through natural processes.

The increased use of fire as a clearing tool has led to the further loss of nutrients in many systems. Fertiliser consumption has not increased to compensate for the loss of soil nutrients resulting from the intensification of land use (FAO, 2001). Hence, there has been widespread mining of soil organic matter and nutrients.



Figure 4. Off-road driving destroys vegetation, causes sub-soil compaction and erosion.

As a consequence of this poor land management combined with the vulnerable nature of many soils, much of SSA's cropland is now characterised by low organic matter content, often in combination with a low pH and with aluminum toxicity. On degraded soils with low organic matter, inorganic fertilisers are also easily leached which is likely to have negative long-term effects on agriculture productivity and on the quality of downstream water resources.

SOLUTIONS TO SOM DECLINE:

- Appropriate land management could reverse the trend of SOM decline and contribute to soil carbon sequestration. Several studies on SSA have shown that a synergetic effect exists between mineral fertilisers and organic amendments and that this synergy leads to both higher yields and higher SOC content.
- Barnard *et al.* (2002) emphasised the importance of establishing and maintaining an effective and intimate association between soils and growing plants. Biological measures for stabilising slopes and decreasing the rate of runoff are essential.
- There is abundant evidence that soil organic matter plays a major role in stabilising soil and in preventing its physical, chemical and biological deterioration. This has been demonstrated under South African conditions by several scientists (Barnard *et al.*, 2002).
- Because nitrogen dynamics are so important in establishing a stable C:N ratio in soil, alternative sources of natural forms of nitrogen such as suitable legumes should be included in rotations. Rhizobial and mycorrhizal associations need to be stimulated and soil organic carbon and nutrient levels need to be systematically monitored and evaluated. Other soil quality indicators relating to specific situations need to be developed and

utilised, with emphasis on earth-worm populations as an indicator of soil quality.

- Soil organic matter could be gradually built up again through carbon sequestration. Among the land use changes which could be promoted with this objective in mind are improved agricultural practices, the introduction of agroforestry and reclamation of degraded land. Organic mulch (including wood chips, leaves), and composted organic manure are essential for the cultivation of fruit tree crops in the subtropical industry.

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