

Soil in Kerala's monoculture plantations less healthy, productive than natural forests: study

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- A study found that monoculture tree plantations in Kerala have reduced soil organic carbon, higher soil temperature and bulk density, all indicators of poor soil health and productivity.
- They also score poorly on biodiversity and are less drought-resistant compared to natural forests.
- The study results help understand the effect of soil respiration on climate, a parameter that needs to be included during environmental impact assessments.

If depleting groundwater resources was one of the reasons why the Madurai bench of the Madras high court passed a landmark judgement in 2014 to remove all eucalyptus and wattle from the heartlands of the Western Ghats, Goa, in 2019, decided to do away with Australian acacia from the state that was facilitating human-animal conflict, and replace it with native fruit trees. Over a period of time, studies have shown that irrespective of the type of trees — foreign or native, invasive or endemic — monoculture tree plantations have a far-reaching impact on the health of the air and the soil.

A recent study that unpacks the effect of monoculture tree plantations on the soil organic carbon (SOC) in Kerala found that SOC levels are strongly influenced by land-use systems and decrease when converted from natural vegetation to monoculture tree plantations. Soil health influenced by human activities shaping land use can aid environmental impact assessments, the researchers stress.

Soil organic carbon, which is the carbon stored in the soil, is crucial to soil health, fertility and ecosystem services, including food production. But when this carbon escapes into the atmosphere and is oxidised, it contributes to global warming.

Vijo T. Kurien who led the study as part of his Ph.D. thesis said that the authors studied four different land-use types — natural forest, teak, eucalyptus and rubber plantations. The plantations studied were 40-50 years old and were created by clearing natural forests which helped them study the change that came about with conversion.

The average SOC content in 0–10 cm soil depth in the natural forest was significantly higher (54.09 gram per kg) than in the other three land-use systems, teak (41.89 gram per kg), eucalyptus (44.07 gram per kg) and rubber (47.01 gram per kg). The higher SOC content in the forest may have been due to more litter contributions from understorey vegetation, root secretions and tree root biomass.

Teak, eucalyptus and rubber plantations were introduced in Kerala during the British era in the early 1900s. Later, large-scale rubber cultivation that saw a surge in Kerala's economy eventually changed the landscape of the southern Indian state as more and more natural forests were converted to rubber plantations. "Kerala is broadly divided into three geographic regions — Malanadu (the hills), Edanadu (the Central region) and the coastal region. Both Malanadu and Edanadu, especially Edanadu, were completely dominated by rubber from the 1940s," shared Kurien. Monoculture, though proved profitable, eventually led to soil degradation.

Researchers say soils can act as both sources and sinks of carbon, depending upon management, biomass input levels, micro-climatic conditions, and bioclimatic change. Substantially more carbon is stored in the world's soils than is present in the atmosphere. Globally, it is believed that cultivated soils have lost 50 to 70 percent of soil carbon stocks.

According to the CFAES Rattan Lal Center for Carbon Management and Sequestration, the annual rate of soil organic carbon sequestration differs among climate, landscape position, profile depth and soil properties. Strategies to enhance the health of soils include identifying site-specific soil and land-use management practices that create a positive soil/ecosystem carbon budget and increase inputs of biomass-carbon and especially that of plant roots towards bolstering soil organic carbon sequestration.

Understanding the link between soil respiration and climate change

Kurien said that he undertook this study to understand the role of soil respiration in climate change. "Like humans, even soil biota respire as a result of which carbon dioxide gets released from the soil. I wanted to know how land-use change affects soil respiration," said Kurien.

The latest report of the Intergovernmental Panel on Climate Change (IPCC) points to anthropogenic carbon emission as one of the main causes of climate change. "Being able to quantify the carbon emission during land-use change will help us find solutions. These studies are done extensively in developed countries and China but very little information is available from South Asia, Southeast Asia and Africa," he said, adding that these studies can play a major role during environmental impact assessments.

There could be various reasons why the SOC in plantations wasn't as healthy as in natural forests. The oblong conical canopy, exhibited by the eucalyptus and rubber plantations, was more exposed to environmental factors that increased the acidity of soils, the study observed. The strong understorey vegetation found in the forest which is missing in the plantations studied could be another reason. In teak plantations specifically, poor quality of teak litter nutrients could also have accelerated the loss of organic carbon from the soil.

"Teak leaves have phytotoxic substances giving the teak litter allelopathic properties," said Kurien. While this property helps in managing the weed in agroforestry, it depletes the organic soil carbon content.

Natural forests tick all boxes on better soil health

The study also found that the mean soil temperature was the lowest in a natural forest while the soil moisture was the highest compared to the plantations. In the plantations studied, the soil in the rubber plantations exhibited the most temperature followed by eucalyptus and teak. Soil moisture influences the distribution and cycling of nutrients in the natural soil systems. The moisture content of the soil in the areas studied varied from 21.2 to 42.1 percent with the highest mean moisture content recorded in forest soils followed by teak and rubber and lowest in eucalyptus plantation.

Soil bulk density is another parameter studied which is an indicator of soil compaction and health. The lower the bulk density, the better it is since it can influence many things from available water capacity to plant nutrient availability and soil microorganism activity, all of which determine the health of the soil and its productivity.

The study found that the soil in teak plantations had the highest bulk density followed by rubber, eucalyptus and forest, which indicates that the soils in plantations were degraded unlike that in the natural forests.

Local climatic conditions like rainfall and sunlight determine soil moisture content, explained Kurien. Soil moisture can be increased by increasing soil porosity which is in turn influenced by the presence of soil biota. "If the rains fall directly and with force on the soil, the soil porosity will be lost. In the forests, the canopy stops the rain from falling directly on soil whereas the plantation canopy is not wide enough to do that," he said. One way to solve this problem is to have plant vegetation like legumes on the ground which will protect the soil. Mulching helps too, he suggested.



Rubber plantation in Kerala. Photo by Vaikooverly/Wikimedia Commons.

Loss of biodiversity, carbon sequestration potential

In a separate 2019 [study](#), done to understand the carbon sequestration potential of forest systems in the Western Ghats, researchers found that the evergreen forest has declined in the biodiversity hotspot by five percent due to expansion in agriculture, plantations and built-up area. The annual

incremental carbon in the Western Ghats is found to be about 37.5 million tons which underscores the role of forests in lowering carbon at the regional level.

Researcher Anand Osuri of Nature Conservation Foundation who has extensively studied the effect of monoculture plantations on the environment says that replacing natural forests composed of multiple native species with single species that might not even be native to the region can not only harm biodiversity but also reduce carbon sequestration and affect sustenance and livelihoods of forest-dependent communities. “Another major threat is monoculture plantations replacing natural grasslands, which are unique and important ecosystems. Besides harming biodiversity and local livelihoods, planting trees in these grasslands can increase the release of soil carbon dioxide to the atmosphere, and reduce water availability,” he says.

T.V. Ramachandra of Centre for Ecological Sciences, IISc, who has co-authored the [paper](#) *Hydrological importance of sacred forest fragments in central Western Ghats of India* said that native forests have more pollinators due to the presence of diverse species of plants and trees and have better underground water retention capacity as well. Leaves of plantations like acacia, eucalyptus, or rubber take a longer time to degrade after falling on the ground which makes it difficult for water to percolate underground during rains, he shared.

Osuri said that irrespective of the type, all forests experience a loss of productivity during drought. “Our research shows that biodiverse natural forests experience a relatively smaller loss of productivity compared to monocultures during drought; i.e., the natural forest is more “resistant” to drought than monocultures,” he said. As a result, the productivity of natural forests, and thus their ability to capture carbon from the atmosphere, is more stable over time. One possible reason for this is the portfolio effect of biodiversity—having a variety of species can make an ecosystem more stable in its functioning, just as investing in a diversity of schemes can make one’s financial portfolio more stable, Osuri concluded.

Source: <https://india.mongabay.com/2021/09/soil-in-keralas-monoculture-plantations-less-healthy-productive-than-natural-forests-study/>