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Climate Change Impact on Soil and Water Management

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Abstract

Since the 1800s, scientists studying physics and climate have examined the effects of the atmosphere on climate, in particular the effects of carbon dioxide (CO_2) concentration and how it relates to Earth's temperature. However, agriculturalists and environmentalists were mainly ignorant of the connection between emissions from fossil fuels and atmospheric warming as industrialization quickly boosted greenhouse gas (GHG) emissions. It is becoming more and more obvious that the effects on society have been more severe and the rate of climate change has accelerated beyond what scientists had predicted.

Keywords: Climate change, Soil and water resources, hydrological Cycle, soil processes and Properties

Introduction

The world's population recently passed 8 billion people and is projected to grow throughout this century to over 10 billion people. In the past year, we witnessed severe floods and droughts on all continents of the globe, often with the same region experiencing drought followed by flood. In 2022, the United Nations Climate Change Conference (COP27) grappled with the global response to climate change, reaffirming commitment to limit global temperature rise to 1.5°C (2.7°F) above preindustrial levels and establishing a mechanism for "loss and damage" funding for vulnerable countries hit by climate disasters. While climate change impacts vary from country to country, loss and damage include degradation of soil, water, and biodiversity resources. With the pressure of an increasing human population coupled with the increasing challenges of climate change, the threats to the natural resource base, global food and water security, and the world's ecosystems have never been greater.

The previous 150-200 years have seen significant changes in the atmosphere's gas composition as a result of both natural and man-made processes, including growing energy use, industrialization, intensive agriculture, and the growth of both urban and rural areas. A spike in global temperature as well as significant regional

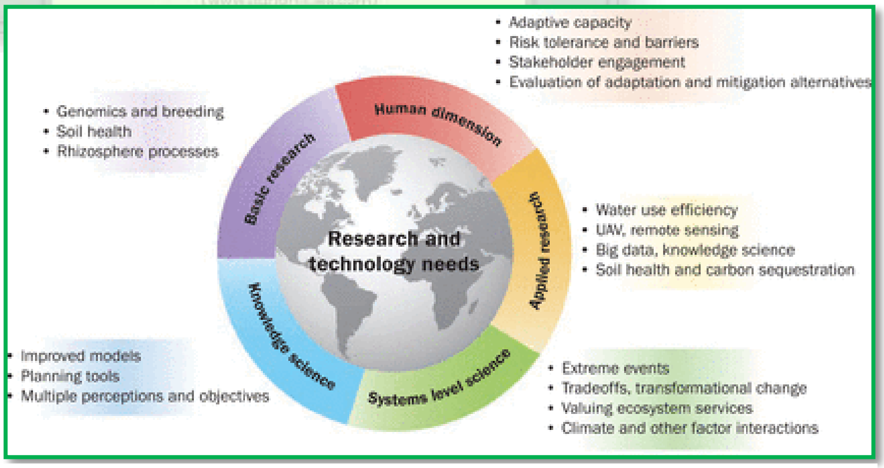

Figure 1: Complex, transdisciplinary research is needed to address basic understanding of climate change impacts on natural resources and to develop tools and methods to apply that knowledge at multiple scales

and temporal variability could result from this. The precipitation pattern would alter significantly as a result of the shifting temperature regime.

The polar ice caps, the permafrost soil zone, and a growing number of mountain glaciers will melt if temperatures rise as predicted. This would cause modifications to the dynamics of water flow, including flood waves and surface runoff, which would raise the eustatic sea level and endanger low-lying, man-protected areas, settlements, agricultural regions, and long, low-slope seashores. An additional outcome could be the continued expansion of areas impacted by salt due to direct sea level rise or the rise in the sea level-connected water table of brackish or saline groundwater.

Naturally occurring vegetation and land use practises will undergo significant changes as a result of a changing climate. The altered albedo, surface roughness, microcirculation processes, heat and energy balance of the near-surface atmosphere, temperature, and precipitation pattern all have a significant impact on the field water cycle and soil formation/degradation processes. These changes in turn have a feedback effect on the climate.

- Weather patterns are being upset by climate change, which results in extreme weather events, erratic water availability, increased water scarcity, and contaminated water sources. These effects can have a significant impact on the amount and quality of water that children require to survive.
- These days, changes in water are the main way that a change in climate is perceived. There are millions of kids in danger.
- Access to clean drinking water is becoming increasingly challenging, particularly for the most vulnerable children, due to extreme weather events and modifications in water cycle patterns.
- Between 2001 and 2018, water-related natural catastrophes, such as floods and droughts, accounted for over 74% of all incidents. With climate change, it is only expected that these catastrophes will occur more frequently and with greater intensity.
- Approximately 450 million children reside in regions with a high or very high risk of flooding. This indicates that they do not have access to enough water for their daily needs.
- It is possible for entire water sources to be destroyed or contaminated by disasters, which raises the danger of diseases like cholera and typhoid, to which children are especially susceptible.
- Warming temperatures have the potential to introduce lethal viruses into freshwater supplies, posing a risk to human health.
- The lives of youngsters are seriously threatened by contaminated water. One of the main causes of death for children under the age of five is diseases connected to water and sanitation.
- More than a thousand children under five pass away every day from illnesses brought on by a lack of access to clean water, sanitary conditions, and good hygiene.
- Water stress, or regions with severely restricted water supplies, is made worse by climate change, which increases competition for water and can even spark conflict.
- Nearly one in four youngsters will reside in places with extremely significant water stress by 2040.
- Millions of people depend on freshwater resources, which are being jeopardised by rising sea levels.

Researchers are already observing how climate change is affecting soil throughout the world. For instance, since the 1950s, soil moisture has greatly decreased in the Mediterranean region and increased in some areas of northern Europe, according to the EEA's most recent study on climate change impacts. Similar consequences are predicted for the ensuing decades as average temperatures continue to climb and rainfall patterns shift, according to the papers.

Sustained reductions in soil moisture levels may result in a greater requirement for irrigation in farming, lower yields, and even desertification, all of which might have a significant effect on food production. Lower yields can also arise from changes in the yearly cycles of plants and animals brought about by variations in seasonal temperatures. For instance, trees may flower before their pollinators have hatched and spring may arrive sooner. The world's food output must rise rather than fall in order to accommodate the anticipated population expansion. This mostly depends on keeping the soil healthy and managing agricultural lands in a sustainable manner. The urgent need to replace fossil fuels and stop greenhouse gas emissions is driving up demand for biofuels and other plant-based goods at the same time.

Other effects of climate change on soil are also highlighted on impacts and vulnerability. One such effect is erosion, which can be amplified by extreme weather events such severe rain, drought, heat waves, and storms. Rising sea levels may not only result in the loss of land, but they may also alter the soil in coastal regions and introduce pollutants from the ocean, such as salt. Climate change has the potential to both open up new opportunities further north and render some agricultural areas, primarily in the south, unsuitable or less productive. In the field of forestry, the value of forest area could decrease by 14–50% by 2100 due to the loss in commercially viable tree species. According to a recent research on agriculture and climate change adaptation, the overall effects of climate change could result in a major loss for the agricultural industry by 2050, with large regional differences. This loss could be as high as 16% of farm income.

Permafrost melts when global temperatures rise. The organic matter that has been held in the frozen soil begins to break down as a result of this thawing, which has the potential to unleash vast amounts of greenhouse gases into the atmosphere and accelerate global warming beyond human control.

Using soil to combat the climate problem

To allow nature to absorb and store carbon dioxide from the atmosphere, a group of very powerful scientists and campaigners demanded in April 2019 that "forests, peatlands, mangroves, salt marshes, natural seabeds, and other crucial ecosystems" be "defended, restored, and re-established." Along with promoting biodiversity, the restoration of ecosystems will provide a host of ecosystem services, such as purifying the air and water and offering pleasant places for people to relax.

In spite of the uncertainties, enhancing soil quality and restoring ecosystems may prove to be highly cost-effective measures towards mitigating climate change with a threefold benefit. First, as they grow, plants absorb carbon dioxide from the air. The FAO estimates that repairing the degraded soils we presently have might remove as much as 63 billion tonnes of carbon, offsetting a modest but significant portion of the world's greenhouse gas emissions. Second, carbon is kept underground by good soils. Third, a large number of natural and semi-natural regions serve as effective barriers against the effects of global warming.

There are numerous examples of advantages. Riparian zones areas adjacent to rivers and urban green spaces, for instance, can provide as reasonably priced buffers against heat waves and flooding. Floods can be prevented by healthy land and soil, which can absorb and store surplus water. Because of the water in their soil, parks and other natural places in cities can also aid in cooling down during heat waves. The harshest effects of droughts can be lessened by healthy ecosystems gradually releasing the water they have stored underground during dry seasons.

Removing carbon from the atmosphere

Moreover, there are several techniques to enhance the ability of land to absorb carbon dioxide from the atmosphere. The fastest way to increase the quantity of carbon in soil is through the conversion of arable land to grassland. Increasing soil carbon stocks on arable land was best achieved by using cover crops, which are plants like clover that are cultivated between harvest and the following crop, primarily to prevent erosion and promote soil fertility.

On the other hand, choices about the alternative uses of land can also alter regions, turning them into sources of emissions. The releasing of previously stored carbon through the draining of peatlands, the burning of bog peat for heating, and the ploughing of grasslands and crops are notable examples of this. The dynamics are the same, but the timescale is different for forests. Similar to soil, forests are both carbon sinks and stocks that is, they take in and store carbon from the atmosphere. Although removing ancient forests reduces the carbon stock from the forest, fresh, growing forests often capture carbon more quickly than older forests. The carbon in the wood may be released sooner or later, depending on how it is used. For example, when burning the wood for warmth, the carbon may be released sooner rather than later.

More carbon dioxide from the atmosphere may be taken up and stored by healthier soils and land ecosystems than they do now. Natural areas and green spaces may also aid in nature's and people's adaptation to the unavoidable changes in our climate. Although soil cannot stop climate change on its own, it must be considered and may even prove to be a useful ally in our endeavours.

Water solutions that are scalable, inexpensive, and sustainable include:

Making carbon storage better: The carbon stored in peatlands is at least double that of the entire Earth's forest cover. Up to three or four times as much carbon can be sequestered by mangrove soils as by terrestrial soils. Encouraging and safeguarding these kinds of habitats can have a significant effect on climate change.

Safeguarding organic buffers: Because the vegetation in coastal mangroves and wetlands links the soil in flood plains, river banks, and coasts and helps control water flow, they are affordable and efficient natural barriers against flooding, extreme weather, and erosion.

Collecting rainfall: In areas where rainfall is distributed unevenly, rainwater collection is especially helpful in enhancing shock resistance and securing supplies during dry spells. Rooftop capture for small-scale use and surface dams to restrict run-off to lessen soil erosion and boost aquifer recharge are two examples of techniques.

Implementing climate-smart farming: Decreasing post-harvest losses and food waste; drip irrigation; improving organic matter through conservation strategies to promote soil moisture retention; and turning trash into a source of nutrients or biofuels/biogas.

Wastewater reuse: Unconventional water resources can be used for agriculture, industry, and municipal applications. One example of this is controlled treated wastewater. An economical and sustainable supply of

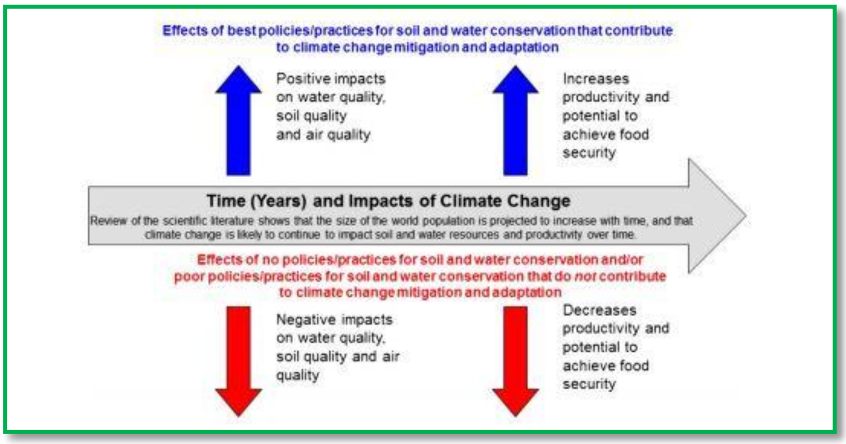

Figure 2 There is a close relationship between climate change, limited global water and soil resources, population growth and food security as climate change impacts the world's soil and water resources

water, energy, nutrients, and other recoverable materials is wastewater that is properly managed.

Using subsurface water: Groundwater is overused and contaminated in many locations; its exact amount is uncertain in others. In order to satisfy the demands of an expanding population and adapt to climate change, groundwater exploration, protection, and sustainable use are essential.

Conclusion

Climate change is primarily a water crisis. We feel its impacts through worsening floods, rising sea levels, shrinking ice fields, wildfires and droughts. However, water can fight climate change. Sustainable water management is central to building the resilience of societies and ecosystems and to reducing carbon emissions. Everyone has a role to play – actions at the individual and household levels are vital.

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