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Research Article

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Possible Implications of the Anthropocene on Climate Change and Soil Health

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ABSTRACT

Anthropogenic and climatic factors influence soil's physical, chemical, and biological properties, setting the stage for agriculture's sustainability. Soil is a primary carbon sink crucial for reducing greenhouse gas emissions, making soil health essential for mitigating climate change. Healthy soil enhances climate resilience by maintaining or increasing carbon content and lowering emissions. The overuse of fertilisers pollutes the environment and inadequate application damages soil fertility and microbial activity. The conversion of forests and pastures to agricultural land has resulted in significant carbon losses from the soil. Additionally, soil sealing, air pollution, and industrial contamination all contribute to climate change. Harmful practices such as heavy tillage, land neglect, monoculture cultivation, and excessive chemical use, driven by the pressure to meet growing food demand, have led to soil compaction, degradation, pollution, and nutrient imbalances. Current mismanaged crop and soil techniques deteriorate soil quality; however, by increasing carbon storage in mineral soils and removing emissions from organic soils, sustainable management can contribute to climate neutrality. Climate change can be exacerbated by the release of carbon dioxide into the atmosphere from unsustainable farming practices and poorly managed soils. The purpose of this study is to investigate the detrimental impacts of anthropogenic (Anthropocene) effects on the environment and soil health from a comprehensive perspective and to formulate potential recommendations. The European Union's Green Deal, Bioeconomy, and Farm to Fork initiatives aim to sustainably transform agriculture in response to climate challenges. These strategies aim to reduce chemical pesticide use by 50%, fertilizer use by 20%, and nutrient losses by 50% by 2030 to preserve soil fertility. These management practices include efficient fertilizer use to maintain soil health and mitigate climate change effects. Restoring degraded soils and implementing conservation measures can reduce greenhouse gas emissions and increase carbon storage capacity. Sustainable soil and crop management, including crop rotation, minimizing post-harvest ploughing, preserving vegetation cover, boosting organic matter, and using fertilizers sensibly, is urgently needed to minimize greenhouse gas emissions and store atmospheric carbon dioxide in soil.
Keywords: Soil Properties, anthropogenic and climatic factors.

INTRODUCTION

Intergovernmental Panel on Climate Change (Change, 2024) reported, "There is now new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities." Since then, over 25 years, human activities and human-created problems have changed daily life. Many scientists are trying to understand the current situation. The term "Anthropocene," popularized by scientist Paul Crutzen, denotes the current geological epoch characterized by the significant impact of human activities on Earth's systems (Crutzen, 2006). Significant environmental changes during this era highlight the impact of humans on natural processes. The interplay between climate change and soil health degradation has serious implications for global ecosystems, food security, and human health. The current scientific understanding of nature and geological history is continually evolving. While we were initially limited in knowledge, recent research and technological advancements have significantly expanded our understanding of how human activities impact both nature and geology.

The concept of the Anthropocene, introduced by Italian geologist, Antonio Stoppani in 1873, has gained considerable attention in recent years. Stoppani used the term to describe the growing influence of humans on the environment. The Anthropocene refers to the geological epoch during which human activities became the dominant force shaping climate and environmental changes. Despite increased discussions about climate change and the Anthropocene, scholars still lack a deep understanding of how human actions affect geology and climate. Historical data embedded in the Earth's geological layers—formed over 4.5 billion years—provides valuable insights into past climatic and natural events. A vertical cross-section of these layers can reveal a wealth of information, highlighting the importance of understanding the impact of post-industrial changes on the future.

When did the Anthropocene Begin?

The Anthropocene may begin around 13,000-16,000 years ago with the advent of agriculture. Although agricultural scientists are still uncovering the specifics of how and when agriculture began to affect nature, evidence from Göbekli Tepe in Southeast Anatolia provides insight into the early impact of human activities (Figure 1).

Scientist William Ruddiman postulated that the onset of farming and the emergence of sedentary populations some 8,000 years ago marked the beginning of the Anthropocene. Even though there were not many millions of people living on the planet back then, it was still comparatively unspoiled compared to the modern world. Large civilizations like the Roman Empire, the classical dynasties of China, the great kingdoms of India, the Napata/Meroitic empire in Africa and the Olmecs and Chavín cultures in the Americas began to alter the environment more than 2,000 years ago, according to historical data. Although there were often large natural barriers separating these civilizations, their activities—like mining—had a significant negative influence on the ecosystem.

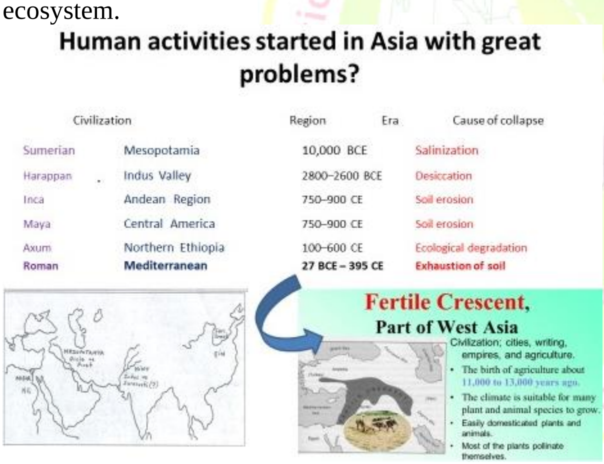

Figure 1. The first human activities began in Asia during the agricultural revolution

According to this perspective, the shift toward agricultural practices marked the beginning of human impact on the environment. The "Agricultural Revolution" led to the destruction of natural areas and forests and contributed to species extinction.

Harvard University professor Dr. David Reich notes that the transition from a hunter-gatherer society to agriculture first occurred in the Harran region of present-day Southeastern Anatolia, which is a part of the Fertile Crescent or Mesopotamia. This region is notable for its wild crops, which are precursors to many of today's staple foods. Alluvial deposits from the Tigris and Euphrates Rivers enrich the soils, making the region suitable for agriculture. As the climate stabilizes, plants and animals adapt to this environment, allowing humans to transition from nomadic to settled agricultural societies. This shift led to genetic changes in crops through artificial selection and breeding, as well as the development of metal tools and weapons, which further altered both the environment and human societies.

The idea behind the term "Anthropocene" is that humankind's significant influence on the planet, which dates back well beyond modern times, characterizes the current age. The term "Anthropocene," popularized by scientist Paul Crutzen, denotes the current geological epoch characterized by the significant impact of human activities on Earth's systems. Nobel laureate Paul Crutzen proposed that the Anthropocene officially began with the Industrial Revolution because of its profound worldwide influence on the environment. By now, a large portion of the Earth's landscape has already undergone major changes because of human activity. According to some researchers, this influence may have begun as recently as 11,700 years ago during the last significant ice age. Originating from the Greek word "anthropoid," which means "human," the phrase "Anthropocene" refers to how human activity has caused widespread extinctions of plant and animal species, contaminated oceans, and changed the atmosphere, among other long-lasting consequences.

Why did the human impact on nature increase after the Industrial Revolution?

When we examine the historical processes of the Earth, the beginning of the industrial era, and the rapidly increasing consumption of fossil fuels, which have witnessed a progressively more destructive course over the last three centuries, we can characterize the Anthropocene epoch. Human intervention in nature leads to much larger changes. Scientists have defined the Anthropocene as a new epoch in which human activities, including those of all living organisms on Earth, have led to an irreversible extinction process. The demand for food security created by a growing population, coupled with an increasing scientific understanding of nature's laws, has led to a transition from an agricultural to an industrial society. After the Industrial Revolution (IR), the world population started to increase, and recently every 50 years, the population has doubled (Figure 2). In the 1930s, the global world population was 2 billion but had grown to 8 billion by 2024. In this period, 6 billion people were added at a four-fold rate.

Extensive petroleum and charcoal usage led to higher CO_2 concentrations in the atmosphere. Experts argue that the Holocene epoch must give way to the Anthropocene starting in the mid-1900s due to factors such as significant land transformations, worldwide species extinctions, increasing sea levels, carbon dioxide emissions, and fast industrialization.

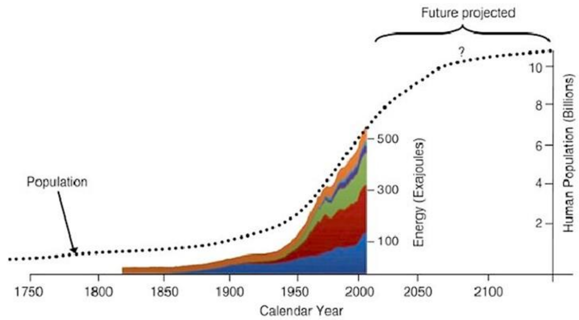

Figure 2. World and continental populations increased from 1961 to 2050 (https://www.change-climate.com/Anthropocene_Anthropogenic_Epoch/Anthropocene_Human_Epoch.htm)

Since the Industrial Revolution, human health care has changed. Human life expectations increased. The size of human agricultural mechanization and advanced technology based on fossil hydrocarbon energy sources' surface ecosystems has changed. The Agricultural Revolution and the Industrial Revolution began 200 years ago, and it further intensified human intervention in nature (Figure 3). Before the Industrial Revolution, the atmospheric CO_2 concentration was 280 ppm; today, 200 years later, they are 420 ppm. However, industrial development has led to the burning of billions of tons of fossil coal and oil, resulting in a 140 ppm increase in CO_2 greenhouse gases in the atmosphere, which is the source of many of the environmental and health problems we face today. The resulting increase in global temperatures from +1.2°C to 1.3 °C has led to significant melting of ice in the Polar Regions, as measured and determined. However, it should be noted that the current unsustainable state, which is defined as climate and ecological crises, is not the result of the civilization and societal order that emerged with the advancement of science and technology but rather the consequence of competitive neoliberal capitalist policies and their advocates, who exploit everything for profit without restraint.

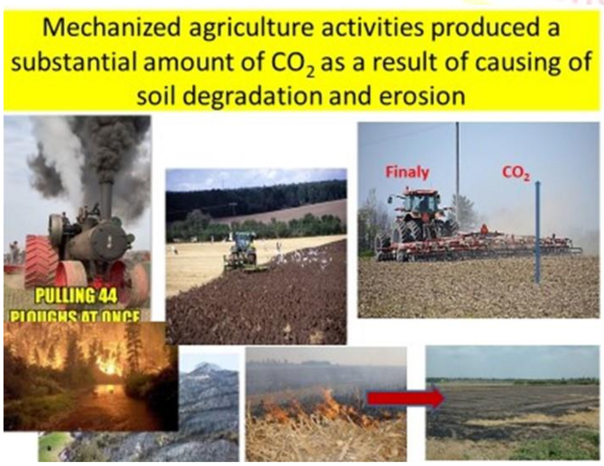

Figure 3. Effects of human activity on greenhouse gas flux to the atmosphere

Human-created differentiation in several areas increased climate change's impact on agriculture and food security. The biggest obstacles to food and water security are population growth, soil-water management, healthy production, and climate change. The two critical issues in the Anthropocene are climate change and soil health degradation. The interplay among these factors has serious implications for global ecosystems, food security, soil, and human health.

The purpose of this study is to investigate the detrimental impacts of anthropogenic (Anthropocene) effects on the environment and soil health from a comprehensive perspective and to formulate potential recommendations.

MATERIALS AND METHODS

A large literature review was conducted on WOS and Scops, and data from many long-term studies were used to determine the Anthropocene effects on soil and crop management. Several soil, plant, water, food, climate change, population growth, and other ecosystem service parameters were collected from the FAOSTAT. (FAOSTAT, 2023) and (Maslin and Lewis, 2015; Our World in Data, 2024) Websites. All data were re-evaluated.

RESULTS AND DISCUSSIONS

Impact of the Anthropocene on Natural Sources

The world has entered an era when the imprint of one species, such as humans, can threaten not only us but also the rest of the biosphere. Unfortunately, human collective activities can drastically affect climate change, biodiversity, and natural resources. Moreover, after the Industrial Revolution, especially in the 21st century, technologies offered huge benefits, were so empowering, and our globe was so interconnected that a small group of people could, by error or by evil intent, create a catastrophe that cascades globally. During the last 200 years, humans have created and/or artificially created several problems. As a result of human activities, several natural processes have been artificially escalated, such as soil erosion, land degradation, deforestation, and conversion of meadow-pasture areas into agricultural land, and water, air, and land pollution have increased. Plant, animal, and organism biodiversity, soil nutrient content, fertility and quality decreased.

Climate Change

Greenhouse Gas Emissions: Increase due to fossil fuel combustion, deforestation, and industrial processes (Figure 4). The source of human-induced climate change began with the Industrial Revolution, which began with Scottish engineer James Watt's patent for a steam engine in 1769 and began with the first fossil fuel-burning machine. As technology has made life easier for years, the average standard of living has increased, leading to more vehicles, machines, and technology, and the uncontrolled burning of fossil fuels has increased. Human activities, particularly since the Industrial Revolution, the use of hydrocarbon fossils for energy greenhouse gas (GHG) emissions have increased. GHG has amplified the natural greenhouse effect. Naturally, the greenhouse gases released into the atmosphere along with the use of fossil fuels have led to climate change, increasing the temperature of the atmosphere on a global scale.

In recent years, with the development of measurement techniques, more concrete data have been used to calculate the annual and total flows of CO_2 gas. The burning of fossil fuels for energy, deforestation, and industrial processes have raised atmospheric CO_2 levels to unprecedented levels. For instance, before the Industrial Revolution, CO_2 levels in the atmosphere were 280 ppm and reached 419 ppm in 2024, a concentration not seen in millions of years (NOAA, 2024). In a study conducted in the 1960s, it was determined that the global growth rate of atmospheric carbon dioxide increased by about 0.8±0.1 ppm per year, and in the next half century, the annual growth rate tripled, reaching 2.4 ppm per year in the 2010s (Climate, 2024) and now is around 1.8-2.0 ppm (https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide). An increase in atmospheric CO2 concentration also caused global temperature and sea level increases (Table 1)

Table 1. Key Indicators of Climate Change during the Anthropocene

Indicator	Pre-Anthropocene (1700s)	Anthropocene (Current)	Trend
CO2 Concentration (ppm)	280	419	Rising
Global Temperature (°C)	Baseline	+1.1°C	Rising
Sea Level Rise (mm/year)	0.5	3.3	Rising
Ocean pH	8.2	8.1	Falling

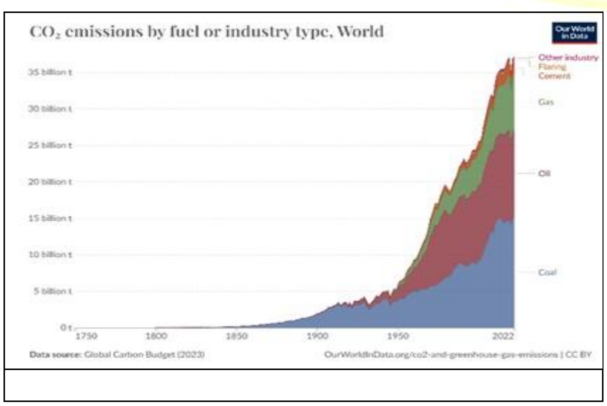

Figure 4. Global release of CO2 (NOAA, 2023)

Global Warming: Accelerated temperature rise leads to extreme weather events. The increasing GHG concentration in the atmosphere also increased the temperature (Figure 5). The consequences of increasing temperature are visible in rising global temperatures, melting polar ice, more frequent extreme weather events, and shifting climate zones.

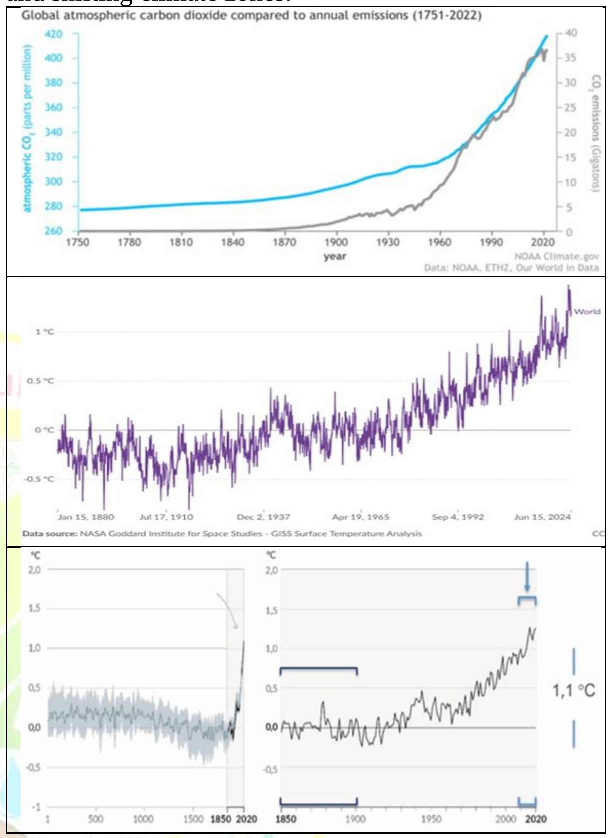

Figure 5. IPCC (2021), "Climate Change Widespread, Rapid, and Intensifying" (https://www.ipcc.ch/2021/08/09/ar6-wg1-20210809-pr)

Per Capita, CO_2 emissions are nearly 20 tons for the USA, 13 tons for China, and the world's mean amount is around 5 tons. It is clear that per capita CO_2 emissions depend on the development population and energy use. Recently, Europe has taken serious measures to reduce CO_2 emissions.

The fundamental principle of an ecosystem, similar to the law of conservation of energy and matter, is that "nothing can be created out of nothing, and what exists cannot be destroyed." However, we can contribute to the preservation and enhancement of nature by learning from it. Moreover, understanding the laws of nature requires living in harmony with it; for example, the practices we propose to combat climate change will also directly contribute to the preservation of nature. (Steffen *et al.*, 2015).

As a result of 200 years of human activities;
Sea-Level Rise: Melting ice caps and thermal expansion contribute to rising sea levels (Table 2).
Precipitation and distribution
Water availability,
Drought conditions,
Runoff,
Potential evapotranspiration,
Changes in soil moisture are affected by global temperature and rainfall.
These factors affect agricultural production and food security. (Ortas, 2022).

Soil Health during the Anthropocene
Relationship between Soil Health and Climate Change
Climate change's global influence on sustainable agriculture depends on efficient management of land use and freshwater resources.
As a result of population expansion and rising settlement demand, agriculturally viable land has been sealed off. Unexpected rural-urban migration has resulted in major issues related to food, water, and settlement. Agricultural land is used for settlements and other purposes due to unintentional land use. In addition, fewer people are employed in agriculture due to the use of technology and rising production costs, which has led to people migrating to urban suburbs. In developed nations, the percentage of the population employed in agriculture is approximately 5%, whereas in underdeveloped nations, it is closer to 50%. This situation triggers the use of agricultural land in urban areas as settlements other than agriculture. This situation negatively affects agricultural production and land assets.
Human actions such as soil and organic matter degradation, erosion, and loss of plant and microorganism biodiversity all have a direct impact on soil health. The Anthropocene over the last year has had significant negative effects. Since humans used heavy tillage with heavy machines on one side, the soil was turned over, and on the other hand, the soil was compacted under the machine wheels. Soil health, the foundation of terrestrial ecosystems, is closely linked to climate change. Healthy soils store carbon, regulate water, and support biodiversity. However, human activities such as industrial agriculture, deforestation, and urbanization have led to soil degradation worldwide.
Soil Degradation: Resulting from intensive agriculture, deforestation, and urban sprawl. In many regions, soil degradation size is enlarged. As a result, soil degradation increases annually in many areas after heavy rains (Figure 6).
Erosion: Loss of topsoil due to unsustainable farming practices and deforestation. As a result of the loss of organic matter, agricultural soil is eroded (Lal, 2015).
Loss of Biodiversity: Reduction in soil organism and plant species diversity, affecting soil degradation and fertility.

Table 2. Soil Health Indicators Affected by Human Activities

Soil Health Indicators	Pre-Anthropocene State	Anthropocene State	Trend
Soil Organic Carbon (%)	3-6	0.5-2	Declining
Erosion Rate (tons/ha/year)	0.1-1.0	10-40	Rising
Soil Fertility (NPK content)	Balanced	Imbalanced	Declining
Soil Biodiversity	High	Decreasing	Declining

Figure 6. Global soil degradation during the Anthropocene (In the near past, human-caused several diseases were happening in Turkey)
Soil Degradation and Organic Matter Decrease
All over the world, >50% of the organic matter in the soil has oxidized over the past 100 years, releasing carbon dioxide into the atmosphere. Strong pressure must be applied to reduce soil degradation, particularly heavy soil tillage, to create a crop management and soil sustainability system (Table 2).
Soil Erosion: Intensive farming practices, deforestation, and overgrazing have accelerated soil erosion. In some regions, soil is lost 10 to 40 times faster than it is replenished.
Nutrient Depletion: The overuse of chemical fertilizers disrupts soil nutrient cycles, leading to reduced soil fertility and crop yields. An example is the decline in soil

organic matter in agricultural lands, which has decreased by up to 60% in some areas.

Desertification: In arid and semi-arid regions, human-induced factors like overgrazing and improper irrigation have intensified desertification. This process affects over 2 billion people worldwide and threatens food and water security.

Ocean Acidification: Increased CO_2 not only contributes to warming but leads to ocean acidification. In the South Pole, increasing temperatures in the poles have caused glaciers to melt (Figure 7). Sea water's pH has been measured in several areas where acidity is increasing and water temperature is increasing. This reduces the ocean's ability to function as a carbon sink, thereby exacerbating climate change.

Figure 7. Increasing temperatures in the poles have caused glaciers to melt.

Deforestation: The conversion of forests to agricultural land contributes to 11% of global greenhouse gas emissions. The loss of forests will reduce the Earth's capacity to absorb CO_2, thus accelerating global warming.

Overgrazing and reducing grasslands

The process of desertification, which occurs when productive land becomes arid due to overgrazing, makes overgrazing a major threat to ecosystems. The following outcomes result from livestock consuming vegetation more quickly than it can regenerate:

Depletion of Vegetation: Overgrazing disturbs habitats and increases soil erosion by removing plant cover (Figure 8).

Lack of Vegetation: The land's capacity to hold water is diminished, and groundwater replenishment is decreased. The lack of plant roots to stabilize soil makes it more vulnerable to wind and water erosion, which reduces the richness of topsoil.

Figure 8. Overgrazing and its devastating impact on desertification (Sources)
AnuMeena Care Foundation

Decreased vegetation leads to biodiversity loss and ecosystem disruption, as well as local agriculture. About 40% of the planet's land is at risk due to desertification, which affects over 2 billion people globally. About 70% of drylands are used for extensive livestock grazing, which is a major contributing factor to this problem and is estimated to cause an annual economic loss of $50 billion or more. Rotational grazing to allow pasture recovery, controlled grazing with livestock limits, and restoration initiatives like replanting are some of the solutions.

Agricultural Lands Are Used for Settlements and Other Structures Due to Unintentional Land Use

As a result of population expansion and rising settlement demand, agriculturally viable land has been sealed off. This situation has triggered the use of agricultural lands in urban areas as settlements other than agriculture. This situation negatively affects agricultural production and land assets. Çukurova plane is fertile and rich in plant diversity. In the last 40 years, most of the citrus plantations in the Mediterranean region have been converted into tourism, and plantations have been removed (Figure 9). In the long term, the occupation of agricultural land causes food insecurity (Imran *et al.*, 2023).

Anthropocene-caused Forest and Stubble Burning Influences on Soil Degradation

The number of fires has been increasing at an increasing rate between 1988 and 2023, and in the meantime, large areas are increasing (Table 3). In the meantime, when the average biomass is analyzed from the data, a significant amount of biomass is burned and reflected in the atmosphere as a greenhouse gas. As can be seen in the table, as the number of forest fires in Turkey has increased over the years, soil organisms and other biodiversity are being lost. In particular, the fires from the Mediterranean to the Aegean region in 2021 are remarkable in terms of both the amount of burned area and biomass. The destruction of a forest ecosystem that cannot be filled with any input from an ecological perspective by such a wide fire is a complete disaster and natural budget collapse.

Table 3. Number of fires and burned areas in Turkey between 1980 and 2023.

Year	Burned Area (ha)	Number of Fires	Estimated Amount of Biomass Burned (tons)
1980	13,000	1,190	1,500,000
1985	16,500	1,870	2,000,000
1988	18 210	1 372	2,145,000
1990	13 742	1 750	2,200,000
1995	7 676	1 770	2,100,000
2000	26 353	2 353	2,000,000
2005	2 821	1 530	2,800,000
2010	3 317	1 861	1,900,000
2015	3 219	2 150	3,000,000
2020	20 971	3 399	2,600,000
2021	139 503	2 793	17,000,000
2022	12 799	2 160	1,800,000
2023	15 520	2 579	2,800,000

Interconnection between Climate Change and Soil Health

Climate change and soil health are interdependent. Degraded soil releases stored carbon, contributing to global warming, and climate change exacerbates soil degradation through extreme weather events.

Increasing population growth creates a serious demand for land-based food production. In addition to combating climate change, agricultural practices are essential for feeding the world's population. Soil is the foundation of all life on Earth. According to the FAO, the terrestrial environment (manly soil) provides more than 99.7% of human food (calories, protein). Not only humans but also other living animals and microorganisms' food is mainly supplied by photosynthesis. An integral component of a solution is the condition of our soil or its lack thereof. In addition to supporting more plant and animal life above and below ground and storing a large amount of carbon taken from the atmosphere through photosynthesis, healthy soils also enable the production of healthier, more nutrient-dense food. Plants require healthy soil for photosynthesis.

In addition to being essential for the production of safe food, soil is also necessary for the well-being of humans and healthy ecosystems. (Ortaş, 2023). The global population has quadrupled over the past century, which has necessitated a major shift in agricultural and soil management practices to produce more food. This has been the primary driver of anthropogenic intervention.

Figure 9. Cost of Mediterranean part of Turkey-Mersin (Anonymous, 2024).

Poor management of farming practices significantly contributes to soil degradation. Degraded soils are more susceptible to wind and water erosion, loss of nutrient-rich topsoil, increased pollution, and sedimentation in waterways. They also lack vital organic matter (OM) and soil microorganisms (Table 4).

When soil health deteriorates, the structure of the climate also deteriorates. The integrity of climate and soil structures affects each other positively and negatively. Factors that damage soil occur as a result of climate change.

In 1965, approximately 46.3 million metric tons of fertilizers were used. The amount rose to 195.38 million tons by 2021 (Figure 10). During that same year, phosphate and potash fertilizers held shares of 24% and 20%, respectively, while nitrogen fertilizers accounted for about 56% of the world's overall use (Steffen *et al.*, 2015). The majority of fertilizer is used in East and South Asia. It has been reported that roughly 23 million metric tons of nitrogenous fertilizers, 12 million tons of phosphate fertilizers, and more than nine million tons of potash are consumed in China alone (Steffen *et al.*, 2015).

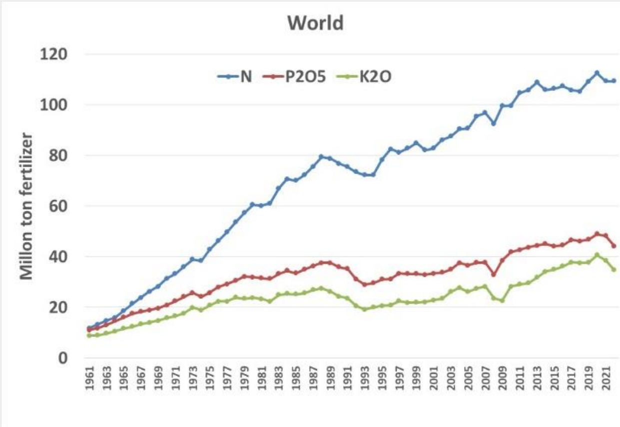

Figure 10. The world's total nitrogen, P_2O_5 and K_2O total fertilizer use (IFASTAT, 2024)

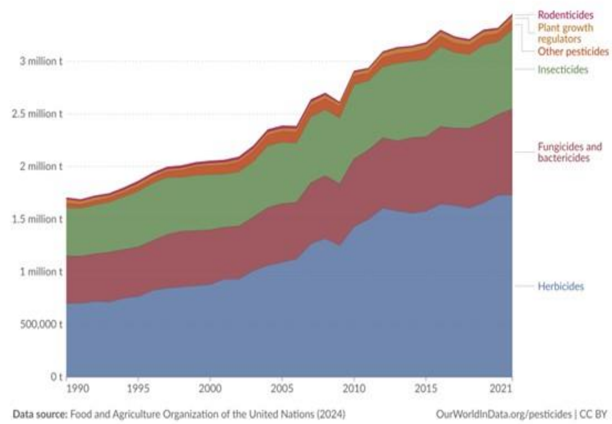

Figure 11. World Pesticide and Herbicide Use over the Last 30 Years

Table 4. Human activities affected agricultural properties before and after Green Revaluation (1960 to 2021)

Indicator	Before Green Revaluation	After Green Revaluation	Trend
Irrigation			Limited
Fertilizer use NPK (kg/ha/year)	20 (46,3)	120 (195,4)	Rising
Insecticide and Pesticide (content)	>1	3	Declining
Agriculture Mechanization			Increased
Wheat production (kg ha per year)	75	325	Rising
Humans (%) can cause wildfires.	0.005	0,035	Increases
Depletion of mineral nutrients			Declining
Water quality-purification			Declining
Changes in soil water			Declining
Changes in plant species			Declining

Pesticide Use is Increasing

All over the world, pesticide breakdown by type is increasing (Figure 11). From 1990 to 2021, the increase was rapid (Our World in Data, 2024). The biodiversity of plants and animals has decreased due to the growing use of agricultural pesticides, which has weakened the biological quality of the soil. Plant growth and human health are among the many adverse effects of the decline in biological productivity and diversity. It is well known that the use of DDT led to the extinction of numerous species living in soil habitats.

What exactly did the Anthropocene marker mean?

Soil and geological horizons, which have characteristics that can endure for years or millennia and retain information about the history of climate and geochemistry, are good candidates. It is now accepted that human activity is the sixth factor in soil creation. It directly affects soil development through processes such as levelling land, trenching, creating embankments, enriching or depleting soil with organic matter, and compaction. Moreover, it indirectly affects soil development through the drift of pollutants or eroded materials.

The World Reference Base for Soil Resources classifies anthropogenic soils as either anthrosols or technosols. Anthropogenic soils include those that have been significantly modified by ploughing, fertilization, pollution, sealing, or enrichment with artefacts. These soils are robust archives of data attesting to the pervasive influence of human activity, so they are trustworthy indicators of the Anthropocene. Certain anthropogenic soils are even referred to by geologists as the "golden spikes" because of their stratigraphic successions, which demonstrate the global influence of human activity like the emergence of unique fossils that identify previous geological epochs. Where will it end? Remains an unanswered mystery. It appears that an international agreement on anthropogenic limits is necessary to stop continued harm. The natural food production limits and the full phase-out of fossil fuels should be the main topics of discussion in this regard. Accelerating the switch to renewable energy in homes, businesses, and transportation should be the focus of efforts rather than restricting the use of fossil fuels.

Possible future effects of the Anthropocene

At the beginning of the 20th century, the use of agricultural chemicals (fertilizers and chemicals for diseases and pests, pesticides, herbicides, and insecticides) was very low. However, since the 1950s, with the modernization and mechanization of agriculture to increase efficiency, the use of chemical fertilizers and pesticides has rapidly increased. (FAO, 2024). In the 1930s, the global world population was 2 billion but had grown to 8 billion by 2024. In this period, 6 billion people have been added fourfold increase at this rapid pace. The growing global population has increased the demand for land for housing and other purposes.

Every area of life and human activity is political. Every political phenomenon is political. In addition, its solution is political. In this context, policymakers should build strong infrastructures to shape the world we live in, in history, ecology, and the future, in agriculture, technology, and life. In terms of climate change, policymakers should first eliminate administrative waste. Waste management should be provided; it is necessary to adopt rules that include reducing spending on war machines, increasing spending on public education, and supporting sustainable social policies that overlap with other cultures. It is important to develop sustainable policies for the future and to provide funds to close links in the technology chain to compensate for lost time. In this context, politicians should support projects and approaches that protect peace and nature.

The Role of Policy and Global Action

Human activities, especially after the Industrial Revolution, have developed differently, and countries that have produced technology over time based on scientific knowledge have developed and created income differences. While Western Europe and North America, in particular, have problems with access to food with per capita income and production structures, approximately 1 billion people in Sub-Saharan Africa and South Asia have problems with access to food and clean water (Ortaş, 2024).

Food production and daily consumption of potatoes, rice, maize, wheat, and other plant yields are not equal between nations. An unbalanced yield and production quantity situation. Rich countries can access fertilizers and other agricultural inputs; however, poor countries are not able. This is directly related to nations' development, richness, and production potential.

During the pandemic, when a two-week lockdown was implemented globally, greenhouse gas emissions decreased, the environment became less polluted, and birds and other wildlife returned to urban areas. This short-lived experience showed us what we needed to do! In addition, it was revealed that not every nation receives sufficient food, and there is a huge food security problem.

Human activity in nature continues to reduce the ecological budget. The transformation of pasture and meadow areas into agricultural areas continues. The soil structure continues to deteriorate as a result of heavy soil cultivation. The decrease in soil nutrients continues with monoculture farming, and on the other hand, the nutrient content of the soil continues to deteriorate due to excessive nitrogen and phosphorus fertilization. The loss of tropical forests and woodlands is still significant, and greenhouse gas concentrations continue to rise quickly, endangering the stability of the climate system. The global economy is still striving for growth, but little accountability has been taken for the effects this has had on the Earth's system. There is still no planetary stewardship.

However, innovative practices and policies aimed at reducing climate impacts and restoring soil health are urgently needed. Measures to ensure both human and ecological well-being require a new framework that will sustain these efforts, provide robust universal support, and monitor developments. The EU's Green Deal and its civil green and environmental initiatives are significant and have the potential to create new and viable resilient systems. The emergence of coherent and proactive management bodies is crucial for effectively addressing these emerging and future challenges.

International agreements such as the Kyoto Protocol, Paris Agreement, UN Sustainable Development Goals (SDGs) and other peaceful suggestions. There is an urgent need to promote sustainable land use and protect natural ecosystems to stabilize the world. In the 2000s, with the global transition toward sustainable agricultural approaches, there have been efforts to limit chemical use in some regions. The less developed African and Asian nations are not able to use sufficient fertilizers. In Turkey: A similar increase was observed. Since the 1950s, the use of chemical pesticides has become widespread to increase agricultural production, and a significant increase in this use has been noted since the 1980s. Approximately 4 million hectares of agricultural land in Turkey have been diverted from their intended use. With the rapid degradation of approximately 10.25 million hectares, Turkey has found itself on the global desertification map. This phenomenon, which affects 13.88% of Turkish soil, underscores the increasing importance of food security.

Mitigation and Adaptation Strategies

To reduce the effects of climate change on soil health, fertility, and productivity, several integrated approaches and challenge strategies are needed. Possible novel strategies:

Carbon Farming: To increase soil organic matter, carbon budget C sequestration, and carbon mitigation are important. To enhance carbon sinks and reduce soil erosion, land surface restoration is necessary. Practices like agroforestry, cover cropping, and reduced tillage can enhance soil carbon storage.

Sustainable Agriculture: Practices like crop rotation, cover cropping, and reduced tillage to maintain soil health. Adopting organic farming, precision agriculture, and permaculture can reduce the environmental impact of farming and improve soil health.

Soil Reforestation and Afforestation: Initiatives to reclaim degraded lands and restore soil health by restoring forests, regenerative agriculture, and ecological farming practices can help carbon sequestration to improve soil health and combat desertification.

Climate-Resilient Crops: Developing and planting crops that are resilient to changing climate conditions and adaptable to changing climate can ensure food security while protecting soil health.

CONCLUSION

The future impacts of the Anthropocene on climate change and, consequently, soil quality, health, and food security are profound and multifaceted. As environmental effects shaped by human activities increasingly deteriorate, the ultimate challenge for humanity will be to balance development with sustainability. Climate change is likely to worsen soil degradation, reduce agricultural productivity, and further disrupt ecosystem balance.

The Anthropocene was a defining period in Earth's history marked by significant human-induced changes in climate and soil health. The challenges posed by these changes are immense, but by understanding their interconnectedness and implementing sustainable practices, we can mitigate their impacts. Protecting soil health is crucial not only for food security but also for combating climate change. As we move forward in the Anthropocene, a balanced approach that respects both our natural environment and the needs of humanity will be key to a sustainable future.

In conclusion, human activities initiated to understand natural processes and the integrity of ecosystems have caused much more damage to nature than expected. In the last few centuries, the Industrial Revolution and the Information Age have intensified human intervention in nature, leading to the current state of crisis. As stated, "the end of nature is near." If the current situation is not the result of a natural cycle, then we are now in an irreversible process with little time left. We must find new mechanisms and methods that are compatible with nature's carbon cycle. The solution lies in transitioning from fossil fuels to renewable energy sources, drastically reducing activities that harm nature and the climate, especially those that emit carbon dioxide into the atmosphere.

CONFLICT OF INTEREST

The author here declares that there is no conflict of interest in the publication of this article.

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