sustainability

Review

Plant Nutrition under Climate Change and Soil Carbon Sequestration

Heba Elbasiouny [1,*], Hassan El-Ramady [2], Fathy Elbehiry [3], Vishnu D. Rajput [4], Tatiana Minkina [4] and Saglara Mandzhieva [4,5]

1 Environmental and Biological Sciences Department, Home Economics Faculty, Al-Azhar University, Tanta 31723, Egypt
2 Soil and Water Department, Faculty of Agriculture, Kafrelsheikh University, Kafr Elsheikh 33516, Egypt; hassan.elramady@agr.kfs.edu.eg
3 Central Laboratory of Environmental Studies, Kafrelsheikh University, Kafr Elsheikh 33516, Egypt; Fathyelbehiry@gmail.com
4 Academy of Biology and Biotechnology, Southern Federal University, 344090 Rostov-on-Don, Russia; rajput.vishnu@gmail.com (V.D.R.); tminkina@mail.ru (T.M.); msaglara@mail.ru (S.M.)
5 Kalmyk Scientific Center of the Russian Academy of Sciences, 358000 Elista, Russia
* Correspondence: Hebaelbasiouny@azhar.edu.eg

Abstract: The climate is one of the key elements impacting several cycles connected to soil and plant systems, as well as plant production, soil quality, and environmental quality. Due to heightened human activity, the rate of CO_2 is rising in the atmosphere. Changing climatic conditions (such as temperature, CO_2, and precipitation) influence plant nutrition in a range of ways, comprising mineralization, decomposition, leaching, and losing nutrients in the soil. Soil carbon sequestration plays an essential function—not only in climate change mitigation but also in plant nutrient accessibility and soil fertility. As a result, there is a significant interest globally in soil carbon capture from atmospheric CO_2 and sequestration in the soil via plants. Adopting effective management methods and increasing soil carbon inputs over outputs will consequently play a crucial role in soil carbon sequestration (SCseq) and plant nutrition. As a result, boosting agricultural yield is necessary for food security, notoriously in developing countries. Several unanswered problems remain regarding climate change and its impacts on plant nutrition and global food output, which will be elucidated over time. This review provides several remarkable pieces of information about the influence of changing climatic variables on plant nutrients (availability and uptake). Additionally, it addresses the effect of soil carbon sequestration, as one of climate change mitigations, on plant nutrition and how relevant management practices can positively influence this.

Keywords: climate change; elevated CO_2; precipitation; plant nutrition; soil carbon sequestration

check for updates

Citation: Elbasiouny, H.; El-Ramady, H.; Elbehiry, F.; Rajput, V.D.; Minkina, T.; Mandzhieva, S. Plant Nutrition under Climate Change and Soil Carbon Sequestration. *Sustainability* **2022**, *14*, 914. https://doi.org/10.3390/su14020914

Academic Editor: Pietro Santamaria

Received: 16 December 2021
Accepted: 12 January 2022
Published: 14 January 2022

1. Introduction

Human activity elevates the atmospheric levels of greenhouse gases (GHGs), causing the warming of the planet's surface and a change in the climate [1–3]. Undoubtedly, climate change (CC) caused by global warming poses significant environmental risks [4]. Changes in CO_2 levels in the atmosphere, temperature, and precipitation have a direct effect on agroecosystems (Figure 1), however, agroecosystems also account for almost one-third of overall GHG emissions, owing mostly to N fertilizers, livestock, and rice cultivation, and tropical deforestation [1,2]. There is much discussion over how varied the significance of the CC effects will be in different places throughout the world. The least developed and developing countries in the sub-tropics and tropics are more vulnerable to the adverse effects of CC. Crop productivity in low-income countries is projected to be negatively affected as a result of CC [2].

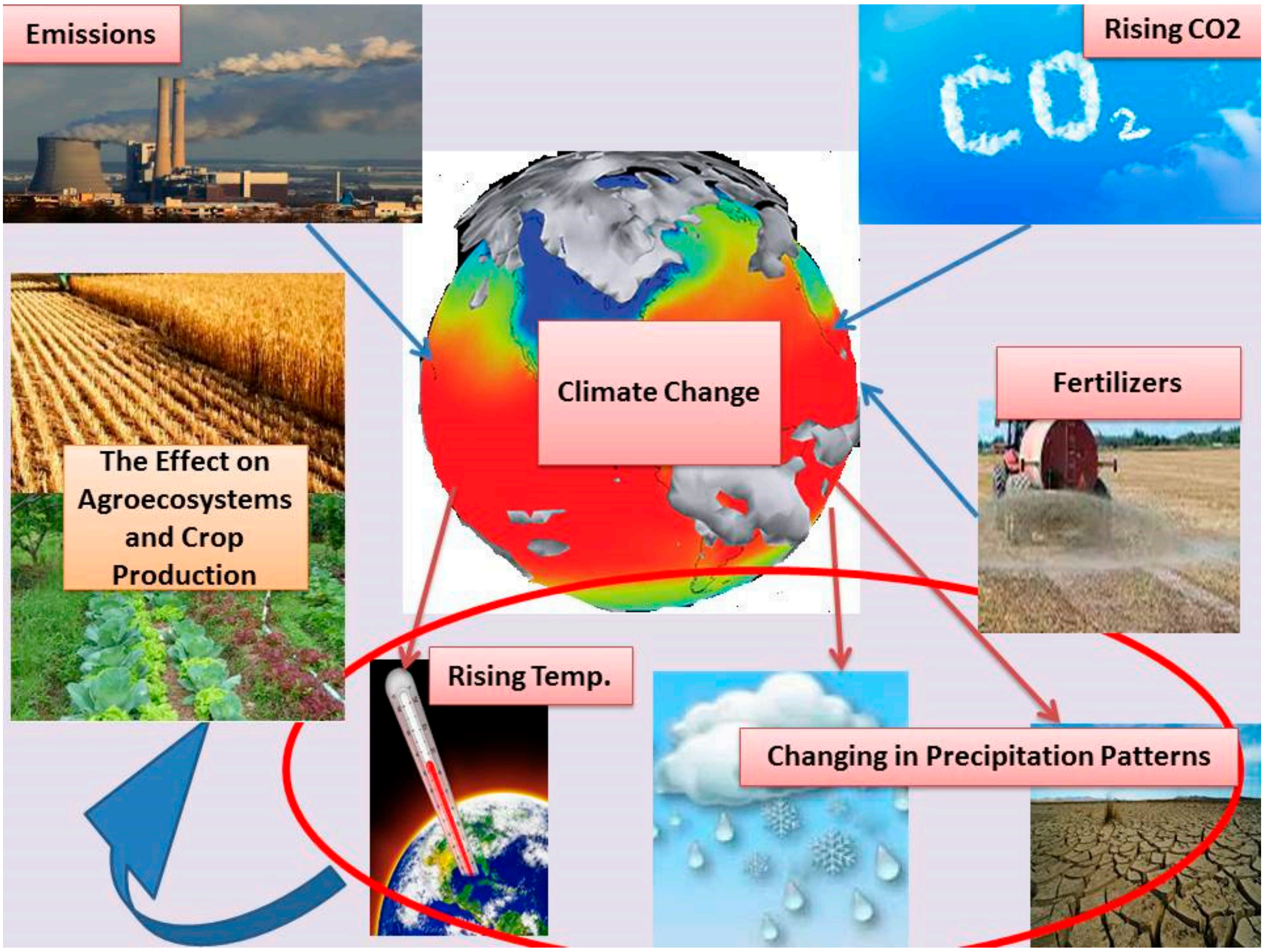

Figure 1. The effect of rising temperature and climate change on agroecosystems.

Carbon is an important element of the primary building block of all living beings for Earth's life. It may be seen in a variety of forms, the most popular of which is plant biomass. Soil contains around 75% of the total C pool on the ground. As a result, soil is critical to sustaining a balanced global C cycle. Carbon dioxide content has increased by 30% in the atmosphere during the last 150 years [5]. The rising CO_2 level of the atmosphere is a result of human activity and is linked to strong and perhaps catastrophic CC. Many solutions for dealing with soil misuse or degradation could help with CC adaptation [6]. One strategy proposed for reducing atmospheric CO_2 is to enhance C storage in soils. As a result, there is an urgent need to manage soils and boost their capacity to retain more organic C [5,7]. Preventing and minimizing soil overuse, as well as encouraging sustainable land uses, could improve the fertility of the soil, enhance C stocks in soil and biomass, and help agricultural production and food security. As a result, soil nutrients are preserved and the impacts of climate change are mitigated [6].

According to accumulated findings, atmospheric CO_2 concentrations will increase by up to 800 ppm through the end of the 21st century, and elevated CO_2 might boost the growth and photosynthesis of plants, which would increase biomass output. Furthermore, elevated CO_2 can enhance plants' water relationships by modulating stomatal closure [8]. This is beneficial for increasing water usage efficiency and mitigating drought damage to the plant. However, higher CO_2 has been demonstrated to have a negative effect on plant nutrient concentrations [8]. One of the most significant components of soil fertility or quality is the amount of soil organic carbon (SOC) [9,10]. The SOC is critical for enhancing the physical, chemical, and biological soil characteristics [7]. It has a close relationship with nutrient cycles and soil fertility in crop fields and it is a vital stock to enhance crop production and conserve agroecosystems. While enhancing SOC input may stimulate soil carbon sequestration (SCseq) and ensure long-term soil productivity, its efficacy in boosting SCseq varies between studies. Clearly, SOC dynamics in different fractions are influenced mostly by the chemical structure of organic inputs and the availability of soil nutrients, as they both play a role in controlling microbial metabolism. Thus, conserving or enhancing SOC stock in agricultural soil is a crucial part of sustainable land management for both agronomic and environmental reasons [10,11]. This review highlights the two most significant issues; (1) the influence of climate change on the availability and uptake of plant nutrients; and (2) the influence of SCseq on enhancing plant nutrition uptake.

2. Plant Nutrition under Climate Change

The plant needs some mineral nutrients for optimum growth and development. These nutrients are essential constituents of several macromolecules, which include nucleic acids, phospholipids, specific amino acids, and various co-enzymes, and they play an important role in plants' cellular metabolism. Furthermore, they aid in chlorophyll production, redox processes, plasma membrane integrity, and cellosmotic potential [12]. The climate, as a key element of global ecosystems, has had a significant effect on the cycles and processes associated with humans, plants, and animals [13]. One of the most important elements influencing plant productivity is soil nutrition. Simultaneously, the availability of soil nutrients to plants varies widely among species [14]. Nutrient availability is vulnerable to CC. However, global warming may modify overall annual and seasonal nutrient availability and cycling [15]. In particular, variations in C, N, and P availability have serious impacts for plants because they are essential nutrients for plant development.

In addition, P has a major effect on water-use efficacy, regulating plant sensitivity to drought stress. These CCs, along with the significant spatial variability of soil nutrients and processes related to changes in habitat quality, result in a complicated scenario that influences soil microbial activity and hence nutrient availability for the plant. In addition, it is becoming increasingly obvious that variations in temperature or precipitation caused by CC change nutrient cycles and, as a result, plant nutrient availability [16]. Arndal et al. [17] reported that increased CO_2, rising temperatures, and water stress are key variables that might alter future nutritional demand and availability. The growth of plants has been demonstrated to enhance and boost plant root biomass in many kinds of grassland when CO_2 levels are increased. However, it is unclear whether plants will be able to exchange extra carbon for nutrients as a result of CC. Plant nutrient uptake will be controlled by compensative modifications under high CO_2, and initiation of the mycorrhizal relationship is one of the potential mechanisms for improving nutrient uptake.

With CC, nutrient uptake will have to be preserved at current levels and also to be increased owing to the dispersion effect of more C assimilation to preserve nutrient concentrations in agricultural products. There is a functional equilibrium between shoot and root growth to improve a plant's uptake of nutrients from the soil and atmosphere. The photosynthetic efficiency × leaf weight is correlated to the nutrient uptake × the root weight. If one of the previous four parameters is changed, the balance is changed unless some other parameter is also changed. In non-woody plants, increased CO_2 in the atmosphere stimulates root and shoot development, with root growth exceeding shoot growth. Nevertheless, root growth is only encouraged if N is not a limiting factor [18]. However, the relationship between plant nutrition and climate change is extremely complicated because climatic circumstances impact all plant growth phases, including development, metabolism, physiology, and plant yields [19]. Agroecosystems capture water, light, CO_2, and nutrients and use them to make various plant products such as proteins, carbohydrates, and starch. Solar radiation drives the total plant process, which is chemically converted via the photosynthesis process [20]. Globally, CC is a severe challenge that has simulated the curiosity of the world's scientific community. The temperature rise caused by numerous human activities is the primary driving force behind CC. It has been observed that the average temperature of the surface of Earth has risen by about 0.9 °C since the late

19th century, with CO_2 that caused by human activities being the primary cause of this rise [21]. Nonetheless, the CC affects temperature, water availability, and CO_2, which affects the process of plant development and, ultimately, plants' capacity to efficiently generate the abovementioned items that people require as food [20].

According to Dotaniya et al. [13], the overall impact of CC will decrease SOC pools, releasing more CO_2 into the atmosphere, which will act as a positive feedback, increasing CC. As a result, reducing atmospheric global warming gas emissions and improving SOC is a global problem. According to Brouder and Volenec [22], CC factors including temperature, precipitation (quantityand distribution), and atmospheric CO_2 levels are expected to impact agricultural production patterns over the world. Changing precipitation patterns and greater global temperatures are projected to be connected with increased CO_2 levels, and these variables may diminish or cancel any improvements in output or perhaps lower production below the critical levels. According to Bocchiola et al. [23], the effects of CC on agriculture may include (1) CO_2 increasing in respiration, primarily for C3 plants, and (2) variations in temperature and rainfall, possibly leading to altered agricultural output over the twenty-first century.

However, according to Amouzou et al. [24], CC and variability threaten crops and food security in some areas. Production systems that are already vulnerable to soil fertility loss have become increasingly vulnerable to rainfall variability and climate change. These pressures will have the greatest effect on resource efficiency in cereal-based agricultural systems like maize (*Zea mays*) and sorghum (*Sorghum bicolor*). Brouder and Volenec [22] emphasized that any possible variations in agricultural productivity may result in related changes in the application of plant nutrients. Local possible productivity is influenced by dominant climate, surrounding CO_2 levels, and crop features; however, this productivity is nearly continually controlled by the resources of the root zone (i.e., water and nutrients) and decreased by diseases and pests. They also emphasized that existing recommendations on nutrient management depend on the recognition of crop-specific requirements to achieve expected production and soil-specific nutrient provisions.

2.1. The Effect of CO_2 Elevation

Elevated CO_2 in the atmosphere has direct and indirect impacts on soil properties and processes via forced alterations in soil water and temperature, in addition to the competing of nutrients [13]. Investigations on plant response to the elevation of CO_2 may not be representative of the conditions of actual fields in some plant species. There was a drawback in the effectiveness of the experiments of raised CO_2 and temperature for determining their impacts on photosynthesis and other processes of the ecosystem. They attributed this to incorporating short-term sudden variations in elevated CO_2 or temperature in the laboratory or field experiments. These changes rarely generated quantifiable variations in net primary productivity (NPP), C in the ecosystem, or other properties linked to long-standing responses to continuing CC [20]. Hatfield and Prueger [20] studied the influence of elevated CO_2 on native grass and cultivated ecosystems and found that understanding the link between CC and plant nutrition may be best accomplished firstly by understanding this interaction in both range and grazing areas. Nitrogen is a limiting element for plant development in certain ecosystems. Terrestrial N exists in organic forms that are unavailable to plants and so the concept of how the response of rangeland to global CC will differ depending on the N cycling rate among the organic and inorganic N molecules being tested. Plant materials or roots that fall to the soil surface are degraded by fauna and microflora in the soil and so become a component of the soil organic matter (SOM) pool. Plant-available N forms and other minerals will be produced during the SOM decomposition stage. Many environmental and plant factors influence the rate of N-release, which is then impacted by CC and CO_2 enrichment.

The interplay between CO_2 and N in cultivated agroecosystems is as complex as it is in native ecosystems. The critical concentration of N for sufficient growth declined in several species when CO_2 concentration increased. Hatfield and Prueger [20] supposed that one of the essential questions in this context was whether elevating CO_2 concentrations influenced the plant nutrient concentrations. It is proposed that the required amount of N fertilizer in C_3 crops for achieving the greatest productivity under elevated CO_2 concentration would not increase because the critical concentration of N declines in C_3 species with elevating CO_2. On the other hand, in C_4 plants, the required N for achieving maximum production could increase owing to no indication of N decreasing with elevating CO_2. Although they recommended that not all these changes could be specifically attributed to elevating CO_2, CO_2 rising might have been a factor associated with this decline.

Nitrogen is an essential nutrient that influences plant development and physiology. It is also a key component of amino acids, protein, nucleic acids, and chlorophyll, helping to regulate C absorption and metabolism. It is indicated that elevated CO_2 reduces leaf N content, in general, due to the diluting effect. Moreover, the decreased transpiration rate by elevated CO_2 might cause a decrease in mass flow, reducing N absorption with the mass flow. Furthermore, the N concentration in plants may be connected to endogenous abscisic acid concentrations, which are influenced by variations in root development. Furthermore, low leaf N might enhance cytokinin levels under elevated CO_2, encouraging stomatal opening. It is noteworthy that N can impact the accumulation of endogenous abscisic acid and the responses of the stomata to endogenous abscisic acid, thereby influencing the stomatal response to the stress of drought under elevated O_2 growth conditions [8].

Seneweera and Norton [25] stated that the response of legumes to elevating CO_2 varies between plant species and may reveal variable degrees of determinacy or the effects of nutrient limitations other than those chosen because of simulated growth. They added that P and Mo have been involved in limiting elevated CO_2 responses in specific situations, though this might be counted as a typical drawback that may become worse if C and N supplies increase. Generally, elevated CO_2 in the atmosphere induced fluctuations in temperature and precipitation, which lead to alterations in the vital soil processes that expose the soils to many kinds of degradation—physio-chemical degradation, salinization, erosion, reduced available water with changes in the soil, declined soil nutrient storage, and depletion of soil biodiversity. Such unfavorable changes pose a big threat to soil productivity, water and soil quality, and production system sustainability [21].

It was reported that increased CO_2 reduced the levels of other nutrients in edible sections of crops, which were lower than N concentrations, such as Ca, K, Mg, and P. High CO_2 levels have also been demonstrated to reduce plant concentrations of Co, Fe, Mg, Mn, Ni, S, and Zn [18,26,27]. However, Wang et al. [28] reported that although increased CO_2 has a beneficial effect on agricultural productivity, warming has the capacity to negatively affect crop yield by reducing photosynthetic C absorption rates and shortening the growth period of plants. They added that it is unknown how variations in plant growth caused by CO_2 elevation and/or warming impact will make soil micro-nutrients available and accessible to plants (i.e., it is not only controlled by its soil concentration but also by climatic conditions). However, Wang et al. [28] mentioned that elevated CO_2 and warming together increased the availability of several soil micronutrients like Cu, Fe, and Zn. In addition, these climatic variables had a considerable effect on wheat's micronutrient uptake and translocation. However, an increase in the availability of soil micronutrients did not necessarily increase micronutrient uptake (which is affected by the element types and crop growth stage).

2.2. The Effect of Temperature

High temperatures result in an increase in CO_2 efflux from the soil. Global warming is lowering the SOC stock by boosting the rate of decomposition and, as a result, the residence time of C in the soil. As a result, soils are expected to be the main source of CO_2 emissions in the future [29]. The increasing temperature modifies the factor of plant nutrients and different nutrient cycles in nature [13]. The rising temperature also influences physiological processes such as photosynthesis and respiration. The net impact of CC will vary owing to specific conditions. Therefore, in areas with cold spring and summer periods, where the growing season is short, higher temperatures may improve the crop yields. However, a warmer climate will reduce yields when the temperature increases. Additionally, increasing the temperature can shorten the growth and grain filling periods of the crop. Furthermore, various crop cultivars may display diverse responses to upcoming CC because of different seasons' lengths [30]. Arndal et al. [17] stated that higher temperatures are likely to lengthen the growing season and enhance net mineralization, resulting in increased nutrient availability and perhaps increased uptake. Temperature increases caused by CC, which are both expected and observed to happen at faster rates at higher elevations, are believed to promote soil microbial activity and influence its physiology, resulting in higher levels of N mineralization and decomposing SOM at a quicker pace. This might result in releasing soil nutrients and their availability and decreased nutrient restriction. This happens more at warmer temperatures than colder ones [15,18].

The expected increases in temperature in the 21st century will likely influence the availability of nutrients in terrestrial ecosystems because biological pathways such as SOM decomposition and mineralization and N nitrification generally rise with increasing temperature [31,32]. Soils will be affected by CC through increasing the nutrient leaching rate and soil erosion [1], thus increasing nutrient depletion. Lotze-Campe [1] explained that higher temperatures affect nutrient conservation because warmer temperatures are possibly increasing the natural decomposition of SOM as a result of microbial activity stimulation. When mineralization is higher than plant uptake, the consequence will be the leaching of nutrients (Figure 2). It largely happens if plant requirements are low and nitrogen mineralization rates increase owing to rising soil temperatures. Wrage et al. [33] stated that P is an essential element for plant energy and sugar metabolism. Soil P availability is influenced by global CC. The P mineralization in litter tends to rise as temperatures rise. Temperature rises of 0.3 to 6.0 increased interest in mineralization by an average of 48%. Phosphatase exudation and plant P uptake are stimulated by higher levels of N. This might lead to higher soil P availability, which would be boosted further by enhanced P mobilization as a result of human activity. This will limit phytodiversity while promoting the spread of ruderal, fast growing plants [33].

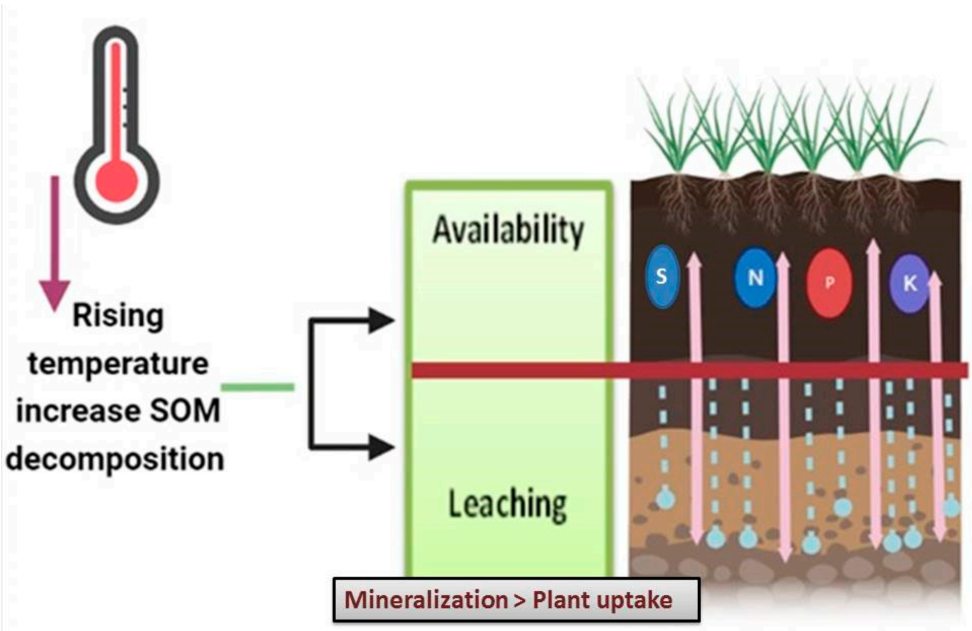

Figure 2. The effect of CC and rising temperature on SOM decomposition and thus soil nutrients.

Hatfield and Prueger [20] also reported that increasing temperatures accelerate the decomposition of SOM with much greater impacts in colder areas where minor elevations in temperature may have sensational influences on the decomposition of SOM plus other soil processes. On the other hand, increasing warming will interplay with soil water and increase its evaporation, which may constrain microbial activity. When the soil water becomes limiting, the interplay between temperature and soil water will grow and decomposition will be more reliant on the soil water content and less dependent on temperature. The low soil water content will decline the decomposition rates. Kirschbaum [34] reported that the temperature dependency of organic matter decomposition is significant in terms of ecophysiology, especially in light of potential CC feedback effects. It largely regulates whether or how much C will be emitted as a result of global warming, as well as the amount to which that C release constitutes a harmful positive feedback effect that results in more warming. Howden and Crimp [35] stated that climate is the main driver of cropping activities through significant impacts in the crop cycle involving soil moisture, droughts during the grain-filling period, heat damage, frost, and storm damages. Moreover, climate affects nutrient leaching, salt mobilization, and erosion risk. The CC may modify many of these impacts; for instance, the increasing temperature will lead to damage of grain numbers and quality, promoting drought stress and slashing initial soil water conditions. On the contrary, CC may also result in a decline in other hazards like dryland salinization.

2.3. The Effect of Precipitation

Global CC has already resulted in considerable variations in the volume, intensity, duration, and geography of rainfall. In addition, a large increase in the surface air temperature and seasonal patterns with similar or stronger moves are projected in the future [36]. Although rising temperatures are certain in the future, the projection of precipitation trends is still uncertain [32]. Precipitation changes and air temperature increases will substantially affect the prevailing temperature and moisture schemes of the root zone. The type and degree of the variations in both factors' characteristics involve leaf area index and ground litter stores [22].

The considerable variations in precipitation directly influences the yield, especially in semi-arid and arid climates. Soil water is an essential resource in agriculture. Nutrient absorption is connected to soil water availability, which may be affected by climate change and changing precipitation patterns [37]. Additionally, nutrient leaching will also be forced by increased precipitation. It is known that intensive rainfall increases soil erosion, which is likely to be higher under CC. An increase of 1% in precipitation is projected to result in a 1.5 to 2% increase in erosion. Intensive rain and transforming from snowing to raining will moreover increase the erosion rate. Plant cover reduces soil erosion rates by weakening rain power (in addition to stabilizing soils by root and reducing sediment transportation by crop residue). Thus, variations in plant biomass can increase those impacts of soil erosion and nutrient leaching. On the other hand, in arid and semiarid climates, dry soil is susceptible to soil erosion across wind and rain [1]. Howden and Crimp [1] stated that commonly the integrating impacts of expected higher temperatures and decreased in-crop rainfall will lead to lower yields, an increase in the variability of yields, erosion risk, and thus the need for enhanced nutrient and water management. They also added that adaptation options in this regard include several different (separate or combined) levels of response, such as changing inputs (i.e., crop diversities and nutrient management) for matching the dominant climate, altering the amount and improving the proficiency of irrigation water, and more intensive residue and canopy management.

Climatic extremes in precipitation (such as floods and droughts) also cause damage to crop farming, which results in a reduction in the overall farm yields [1,2]. Rosenblatt and Schmitz [38] mentioned that although the precipitation is not projected to vary regularly over the world as CC continues, a consistent tendency over lots of terrestrial ecosystems is increasing the frequency of droughts, which has already doubled since 1970. Low water potential remains a widespread limiting factor of soil microbial activity (and thus nutrient mineralization) and in extremely dry soils may result in total inhibition in microbial activity. For example, the drought serious effect on mineralization is very distinct at high soil temperatures compared with low ones. Soil microorganisms physiologically respond to drought in many ways, such as a decline in cell osmotic potential, then by dehydration, and ultimately the death of microorganisms. In addition, Arndal et al. [17] reported that fine roots may dehydrate throughout a drought, reducing nutrient uptake and leading to declining root activity and nutrient mobility.

Generally, the fall of microbial activity in drought circumstances looks to be related to the drying length [32]. Rosenblatt and Schmitz [38] added that carbohydrate and protein levels generally increase in drought-stressed plants when osmotic potential decreases, allowing plants to retain more water. Furthermore, when drought stress increases, the relative water content of the leaves declines. However, the impacts of drought on plant nutrition are complex and vary depending on species, development stage, tissue type, drought severity, and length. Table 1 presents some studies that address the influence of climatic conditions on plant nutrition.

Table 1. Effect of climate variables on plant availability and uptake of plant nutrients.

Climate Variable	Study Objective	The Effect on Plant	The Ecosystem	Ref.
- Air warming - Shading With fertilizing	- Investigating the simultaneous responses of biomass, N, and P in plants after five years of fertilizing, air warming, and shading	- Plants significantly responded to fertilizer by increasing N and P uptake (among other effects) - Plants responded little to warming, showing a decrease in N and P - Plants did not respond much to shading	Two plants community predominated by *Cassiope tetragona* (L.)	[39]
- Variable rainfall	- Investigating the effects of three opposing climatic scenarios on C, N, and P fractions (among other aims)	- The studied climatic scenario did not influence the nutrient contents in the litter layer - Increased rainfall-induced microbial and plant nutrient uptake and nutrient cycling - Declined rainfall resulted in nutrient accumulation in soil, which increases the nutrient loss risk (by erosion or leaching)	Mediterranean forest, shrubland, and open areas	[16]
- Elevated CO_2 - Warming - Drought	Study the root nutrient uptake under predicted climate change	- The root growth increased under the studied climatic variables - N and P uptake did not increase comparably with root growth after 5 years of treatment	Dry heathland/grassland	[17]

Table 1. *Cont.*

- CO_2 enrichment - Warming	Investigate the effect of CO_2 enrichment and warming on the availability and plant uptake of soil micronutrients	- Availability of some micronutrients (Cu, Fe, Mn, and Zn) improved after CO_2 enrichment, while the availability of Cu, Fe, and Zn improved after warming - The uptake of Mn and Zn by wheat was increased by CO_2 enrichment, while the uptake of Cu and Fe was increased by warming	- Paddy field (with rice–wheat rotation) cultivated with wheat at the time of the experiment	[28]
- Variable temperature - Snow melt - Other factors	Investigate the effect of environmental conditions on nutrient availability	- The snow melt delay did not change the seasonal soil dynamics of N and P concentrations - At the warmest site, net N mineralization was highest while P was significantly immobilized	- Sub-Arctic catchment	[15]
- CO_2 enrichment - Warming	Studying the effect of CO_2 enrichment and canopy warming on nutrient concentration and accumulation (among other aims)	- CO_2 enrichment decreased N, P, and K concentration and did not change the accumulation of N and P - The warming increased the concentrations of N, P, and K, while it decreased their accumulation	- Rice field (*Oryza sativa*)	[40]
- Predicted warming - Predicted drought With the pathogen effect	Examining the effect of climatic variables and pathogens on C, N, and P	- *Phytophthora cinnamomi* pathogen induced mortality in *Q. suber* trees - Predicted warming and drought may concurrently interact to alter biogeochemical cycles in the soil	Mediterranean forest soil	[41]
- Elevated CO_2 with N supply		- Elevated CO_2 decreased the plant N acquisition and major ionic concentrations (NO_3^-, SO_4^{2-}, PO_4^{3-} and Cl^-) in xylem sap		[42]
- Climatic factors with soil factor	- Examining the variation of plant N and P among the desert plant organs and their response to soil and climatic factors.	- Soil factors had direct effects on N and P stoichiometry among organs, while climatic factors had indirect effects	Desert soil	[43]

Table 1. *Cont.*

- Elevated atmospheric CO_2 - Elevated temperature	- Examining the individual and combined effect of elevated CO_2 and elevated temperature on tree growth, N mineralization, and N availability, among other aims	- Plant growth was strongly stimulated under elevated CO_2 but not elevated temperature - Available N significantly correlated with plant height - The N mineralization response and nutrient availability to elevated CO_2 and temperature varied with time	Eucalyptus globulus plants	[44]

3. Soil Carbon Sequestration (SCseq) and Plant Nutrition

3.1. Carbon Storage in the Soil

Soil is the largest and most important C reservoir globally. It comprises about 75% of the total C stock in terrestrial ecosystems and stores more C (1500 to 1600 Pg C) than the atmosphere (780 Pg C) and vegetation (620 Pg C) put together [45–47]. However, it is reported in [48] that soil C storage is about 2500 Pg and consists of about 1550 Pg SOC while the other amount is soil inorganic C. The SOC is the key feature of soil biogeochemistry to maintain soil ecosystem services like nutrient cycling, microbiomes, soil health, and erosion control [49]. Liang et al. [49] also reported that SOC, as the largest terrestrial C storage globally, ranges from 2376 to 2456 Pg C in the top 2 m and about 1220 to 2000 Pg C in the top 1 m. About 46 to 61% is stored deeper than the top 30 cm.

Currently, national or regional scales of SOC content and SCseq investigation, particularly in agricultural soils, is really interesting, partially due to its prominent role in CC and environmental quality and partially due to SOC being the greatest considerable factor determining soil fertility, soil quality, and consequently crop productivity and sustainability [13,50–55]. Agricultural management for enhancing SOC must either increase SOM inputs, decrease SOM decomposition and oxidation, or both [56]. Indeed, increasing SOM stock is valuable for soil fertility, as organic matter mineralization could provide plant nutrients. However, this requires the implementation of agricultural practices that are adapted to local situations and will enhance soil C inputs with stable or decreasing outputs, thus maximizing soil C storage [57].

The agricultural ecosystem plays one of the most active roles in the global C stock and has equivalent or larger net production (NP) than the natural ones. By 2030, agricultural ecosystems may mitigate CO_2 emissions by 5.5 to 6.0 Gt CO_2 yr^{-1}, with about 89% of this quantity being a result of SOC storage. Several activities, for example, cultivation, irrigation, and fertilization, may affect agricultural ecosystems, causing great variations in net CO_2 exchange in the ecosystem. However, soil degradation and water pollution can happen due to excessive fertilization, and this may counter the benefits of carbon sequestration [58].

The SOC represents approximately 50–60% of SOM. The SOM comprises all the organic soil components, including living biomass (intact plant, animal tissues, and microorganisms), plant residue, dead roots, dead tissue, and soil humus. SOM, along with plant and animal detritus, are essential for soil biological activity and is a key source of energy, nutrients, and habitats for most soil organisms. Soil biodiversity is directly related to SOC and SOM is closely related. Soil biodiversity refers to the mix of soil living organisms that includes bacteria, fungi, protozoa, worms, insects, various invertebrates, and vertebrates interacting with each other and with plants and small animals to create a biological activity web that conserves soil fertility [59].

3.2. Soil Carbon Sequestration

Goh [60] suggested reducing or retarding the accumulation of atmospheric GHGs by increasing SCseq and storage to mitigate CC. Goh [60] cited the description of carbon sequestration given by Eswaran et al. [61], which is "medium and long-term (15 to 50 years) C storage in terrestrial ecosystems, in underground largely as carbonates", or in the oceans. Lal et al. [62] cited the definition of sequestration as "the provision of long-term storage of carbon in the terrestrial biosphere, underground, or the oceans so that the buildup of CO_2 (the principal GHG) concentration in the atmosphere will reduce or slow". Stout et al. [63] defined SCseq as "the process of transferring CO_2 from the atmosphere into soils through crop residues". It is defined also as "the process of transferring carbon dioxide from the atmosphere into the soil through crop residue and other organic solids and in a form that is not immediately remitted" [5,64]. Sarfraz et al. [21] stated that carbon sequestration is related to accumulating C in a stable solid form.

C sequestration is controlled by many factors, such as the rate of production and decomposition of SOM, parent material, temperature, rainfall, landscape position, living organisms, and various management processes. The SOM, more than any other factor, participates in changing soil C storage and influences SCseq. In addition, there are some variations in SOM depending on the soil, release, and transport, and hence these factors affect the soil's physiochemical and biological properties and can decrease the potential SCseq [21]. Thus, the SOC content in a specific soil is the result of the long-term balance between SOC additions and losses [51,60]. Minor gradual variations in the SOC stock could lead to significant impacts on the concentration of atmospheric C. On the contrary, some practices like residue removal, intensive tillage, and improper soil nutrient management can deplete not only SOC but also N pools and interrupt their dynamics. Thus, C sequestration using improved management practices of soils and crops is necessary to enhance the productivity system and soil quality [65]. Improving SOC is connected to organic carbon (OC) inputs in agroecosystems. For example, an increase in OC inputs associated with high yields of the crop can increase the SOC content. Generally, there is a positive correlation between SOC and crop productivity. Thus, high biomass would result in more OC inputs into soils and then enhance SOC sequestration [51,66].

Increasing the stored SOC may improve soil quality because SOC contributes to many useful processes in the soil ecosystem (i.e., biological, physical, and chemical processes). When SOC is below 1%, soil health may be restricted and yield potential may not be accomplished [66,67]. On the other hand, increasing the SOC is a way to increase C sequestration as it increases the capability of agroecosystems to absorb atmospheric CO_2 and store it in the soil. Therefore, SOC management is a climate change mitigating option. Several studies have confirmed the potential of soil carbon sequestration and its significance for plant nutrition on the one hand and soil quality on the other. Some studies provide some dynamics for managing soil C, such as the following:

- Decreasing disturbing soil to maintain C in the aggregates,
- Improving the amount and quality of biomass [68],
- Improving richness and functionaries of useful microbes in the soil, and
- Preserving continual vegetation on the soil surface [69].

Some other studies have presented some management choices for restoring soil C representation, including conservation tillage [65,70], cropping systems [71], legume-based crop rotation [72,73], cover crops [54], integrated nutrient management [74,75], irrigation management [76], agroforestry systems [77,78], and grass land/pasture management [79].

Nutrient supply is one of the biological advantages of increasing SOC. It was stated in [62] that the decrease in the SOC stock would have opposing consequences on soil quality. Shi et al. [80] stated that SOC content acts as a surrogate for SOM, which is the main supplier of plant nutrients and hence soil fertility. Thus, quantifying the variations in soil C is essential to understanding the global C cycle and soil fertility. Pimentel and Burgess [81] reported that soil C correlates with SOM content. High SOM content has many benefits, including an increase in the retention of plant nutrients, among others. In addition, it also facilitates plant nutrient movement from the soil to the plants, causing better crop growth and production.

SOM modifies the physiochemical and biological soil properties. It physically improves soil particle aggregation, which results in better soil structure, allows air and water movement through the soil, and contributes to better root growth. This reduces soil erosion, retains soil nutrients, and protects water quality. It chemically increases the soil CEC (leading to higher retention of positively charged nutrient ions such as Ca, Fe, K, Mg, Zn, and many others) where cation exchange sites are very important for nutrient retention, while biologically SOC is the major source of energy for most microorganisms and fauna in the soil. Therefore, increasing the SOC enhances the soil biodiversity and the biomass, which in turn drives the soil microbial transformations and enhances the plant nutrients' availability [82,83]. The SOC quantity, together with the organic input quantity and type, has great impacts on the nutrient dynamics. The SOM itself is considered a large nutrient reservoir that is gradually released by the activity of soil, microorganisms, and fauna, which is especially important for N, P, and S plant supply [83].

It is reported in [62] that aggregation reduction may aggravate the challenges of water runoff, erosion, crusting, and compaction. Thus, increasing plant nutrient loss, either inherent or applied, and water could reduce their use efficiency as well as their productivity. They also described that the depletion of SOC is one of the most important biological process factors for increasing and extending soil degradation, in addition to physical (compaction, erosion, anaerobiosis), chemical (elemental imbalance, salinization, and acidification), and other biological (shift in soil flora and fauna activity) processes. Thus, increasing the SOC of degraded soils also increases crop yields through (1) rising the available water, (2) enhancing the nutrient supply, and (3) improving the soil structure, in addition to other physical properties, which in turn improves soil quality.

Plants' impact on SOM is twofold. Firstly, plants, as autotrophic organisms, are the key SOC source throughout their development (i.e., shoot and roots) through root exudates, which are a result of passive and active mechanisms, and symbiotic (i.e., N-fixing and mycorrhizal) relations. Secondly, plants participate in SOM stabilization processes by creating inadequately degradable composites and stimulating the creation of stable aggregates. Additionally, by controlling erosion plants contribute to SOM conservation [57]. Grovera et al. [84] stated that plants rhizodeposit around 40% of the photosynthetically fixed C to the soil. Organic composites generated by roots act as nutrients for soil biota, encouraging increased rhizosphere microbial activity. Rhizodeposit compositions can eclectically govern the microbial communities in the soil rhizosphere, enabling protective and useful relationships and warranting the availability of important nutrients, which affects the physiochemical properties of the soil. The C absorption in microbial biomass and roots increases the soil C pool (i.e., C sink), while microbial and root respiration, as well as SOM decomposition by soil biota, results in C effluxes (i.e., C sources). Organic amendments are greatly recommended as an alternative to mineral fertilizers for several essential plant nutrients and are considered good practice for sustaining crop production, improving soil fertility, and enhancing carbon sequestration. It has been shown that organic amendments can improve soil carbon sequestration across its direct input of OC into soils and can significantly influence the nature and creation of soil aggregates, subsequently controlling the decomposition and transformation of SOC [66]. Liang et al. [49] and Gorova et al. [84] stated also that SOC storage primarily relies on the balance of OC inputs (i.e., plant residues, roots, and rhizo-depositions) and outputs (i.e., organic matter (OM) losses through respiration and decomposition). Moreover, SOC storage changes due to fertilization in the surface and subsurface soils. Long-term fertilization normally increases organic C input via the roots, crop residues, and manure, while SOC decomposition is likely enhanced as a result of the initial effect forced by microbial utilization of C exudated by plant roots [49]. However, the nutrient imbalance may result in an initial effect that stimulates the microbial deterioration of recalcitrant SOM into nutrients and converts soil C sinks into soil C sources. As a result of this initial effect, elevated CO_2 also considerably enhances plant biomass in unfertilized experiments. Although the availability of soil N initially increases while the reservoir of soil C decreases, the entire plant–soil system eventually gains a net C due to the inputs of rhizo-deposits and root biomass.

Conversely, the initial effect is affected by N availability [84].

3.3. Relationship of Soil Organic Carbon Sequestration with Other Soil Essential Elements

The outcomes of Grovera et al. [84] imply that soil C input is the primary driver of SCseq throughout plant development, which is affected by N availability and nutrients required for supporting N_2 fixation. Artificial fertilizers do not add OM, but they do carry a C charge and have an effect on soil health. As a result, boosting the combination of biological N_2 fixers and nutrient solubilizers/mobilizers can be a sustainable and cost-effective technique to enhance SCseqin agroecosystems [84]. One of the available approaches to increase soil C, thus improving the quality of the soil and the output of the crops, is to include green manure crops in the conventional cropping system through a rotation (different crops in different years in the same area) and multiple crops (different crops in different seasons in the same area within the same year). Crop rotation and multiple crops have long been known as an effective way to improve soil's physical properties owing to a reduction in soil erosion, an improvement in soil structure, and enhanced permeability. This practice also enhances soil fertility because of increasing soil microbial activity and SOM content. The green manure crops in the rotations will be useful in different approaches to the soil. The most popular species of green manure crops are legumes, owing to their unique capability for fixing atmospheric N_2 via their root nodules. The legume crop in a specific cropping system can (1) enhance biodiversity, (2) supply net additions of soil C and N, and (3) maintain soil fertility in many regions of the world [85,86].

SOC and N play important roles in the dynamics of plant nutrients and the performance of crop yield in different soils [87]. Therefore, their soil dynamics are linked. Similar general trends of total C and OC accumulation, degradation, and subsurface transport exist because of the unique link between them. Therefore, they always have similar patterns [88–90]. In the 1950s, most agricultural soils had limited N. Careful N fertilizer application can enhance the quality and amount of crop production that can be utilized to compensate for increased atmospheric CO_2 emissions and return assimilated CO_2 to the SOC stock throughout the production and turnover of belowground biomass. However, inefficient and excessive use of N fertilizer is not only not cost-effective but also causes contamination of surface and groundwater, soil acidification, and increased GHG emissions [58]. Adding chemical nitrogen reduces the C:N ratio and promotes the growth of non-N2-fixing bacteria with labile C. Thus, this low ratio of C:N enhances plant growth, which increases carbon sequestration via plant biomass and rhizodeposition, though non-availability of nutrients other than N may become a restraint over time. Additionally, chemical N does not provide further OM and its production carries a C cost [84]. Singh et al. [91] reported that soils and attempts at turnover are interlinked and that this is motivated by microbial biomass. The C:N ratio of crop residues/SOM regulates the soil processes. The average C:N ratio of stable forms of SOC, humus, and soil microbial biomass (MB) are about 10 to 12, 10, and 7, respectively. C and nutrients in the MB are always recycled in the soil and associate with long-term continual variations in SOC. The total SOC at any specific time is the net product of the turnover of MB, rate of respiration, and attempts at mineralization. These processes are strongly linked to the microbial metabolism in soil.

Lal et al. [62] stated that soil carbon sequestration requires other nutrients since SOM is built from plant and microorganism residues and these require many elements. On the basis of weight, the C:N ratio of SOM is 12:1, C:P was 50:1, and C:S was 70:1. Thus, to sequester one compendium of C, 83, 20, and 14 kg of N, P, and S, respectively, are required [62,92]. Richardson et al. [93] also proposed that inorganic nutrients (N), phosphorus (P), and sulphur (S) management is an important perspective for strategies of building soil C from C-rich crop residues. Additionally, Dignac et al. [57] emphasized that when considering practices from the standpoint of C cycling and increased soil C storage, the significance of its interplays with other nutrient cycles in SOM (i.e., N, P, S, etc.) must not be neglected. In crop residues, there is a very widespread stoichiometric ratio of nutrients:C compared to SOM, which has important implications for the efficiency at which C is transformed from crop residues to soil C. For example, wheat stubbles contain approximately 17, 2, and 3 parts of N, P, and S per 1000 units of C, as compared to about 90, 19, and 14 parts per 1000 units in the soil humus (i.e., fine fraction of SOM). This strong coupling of nutrients in SOM is a characteristic of soils worldwide regardless of soil type, management history, or geographical location. The stoichiometry of C, N, P, and y in SOM is similar (compared to crop residues) to the nutrient ratios in soil microorganisms (i.e., 250, 49, 26, and 103, 11, 9 parts N, P, and S per 1000 units of C in bacteria and fungi, respectively). This appears to be strongly controlled and relatively constant in different soils and ecosystems. Bio-sequestration of C via microbial deposition has also been stated to be a driving technique for long-term C storage in marine and sediment systems [93].

3.4. Soil C Accumulation or Depletion

Carbon losses are increased owing to decreased plant inputs and increased decomposition and erosion associated with agriculture [94]. As mentioned above, the most important factor that determines SOC level is the dynamic balancing between C inputs via the processes of photosynthesis and deposition, in addition to losing C through respiration, leaching, and erosion [49]. De Oca [95] attributed the depletion of SOC in agroecosystems compared to natural ones to smaller organic inputs, greater decomposition rates, alterations in soil moisture and temperature regimes, and SOC depletion by leaching and soil erosion. In addition, tillage has increased soil carbon losses from 28 to 77% based on climate and soil type [96]. The disintegration of macro-aggregates by tillage into nutrient-poor micro-aggregates and thus release of plant-available nutrients may be one of the interpretations for lower OM contents and declined nutrient-supplying efficiencies in cultivated soils [97]. Since most organic C in agricultural soils has been previously depleted, increasing organic C stocks in these soils has been proposed as an important measure to sequester atmospheric CO_2. It has been estimated that global agricultural soils can sequester about 0.4 to 0.9 Pg C year^{-1} [98]. In other words, agricultural soils have the dual long-term effects of emitting and sequestering [99]. A slight modification of the fragile equilibrium between C input and losses may offset the biological terrestrial carbon sink. However, such small changes are difficult to detect because of the high spatial variation in SOC stocks [100]. On the other hand, the most important processes involved in N loss are leaching [101], volatilization [102], uptake, erosion, and denitrification [101].

Maintaining higher soil C stock is becoming more and more significant due to its contribution to agriculture and environment. Naturally, soil has higher C compared to the terrestrial vegetation and atmospheric C together; however, the human disturbances of soil hastened the C loss from agricultural soils [52]. It has been assessed that cultivated world crop soils have lost 41 to 55 Pg C in the past. It has been stated that converting forest lands to agricultural lands reduces the SOC stocks, quickly in the early years and then at a slower rate afterward, reaching a new equilibrium 30 to 50 years later [45]. Over time, two contradictory postulations have appeared on the surface in terms of soil C dynamics in primary agricultural soils. One study proposed that soil C can be enhanced through returning additional biomass to the soil due to intensifying cropping systems. Furthermore, this could accelerate C loss owing to exploitive cultivation [52].

The SOC level rests on its distribution into different labile stocks variable in their residence time. Labile (active) SOC is susceptible to soil management and significantly affects soil nutrient cycles to maintain the quality and output of the soil. 'Recalcitrant organic C (passive pool) resides in the soil system for a longer period, resulting in long-term carbon sequestration [103]. Hence, a good balance between labile and recalcitrant organic C stocks offers friendly circumstances for soil sustainability and better crop production on a long time scale [67,103]. Dotaniya et al. [13] emphasized that appropriate SOC management is important to sustain soil productivity and protect it from degradation. Thus, organic and inorganic nutrient sources can improve C accumulation ability in agricultural soils. Moreover, the mixture of organic and inorganic materials provides available plant nutrients through the growing period, preserving a good soil environment (physically, chemically, and biologically) and generating favorable functions in the ecosystem [103].

Shahid et al. [67] stated that active fractions (i.e., microbial biomass C and N, particulate OC and N, potentially mineralizable C and N, which respond quickly to the change in management practices) can better reflect the variations in both soil quality and productivity through altering the nutrients dynamic owing to immobilization mineralization processes. The particulate organic carbon (POC) and particulate organic nitrogen (PON) that contain OM coarse fractions are intermediate between active and slow fractions of SOC and TN that change quickly because of management practices. These fractions are possibly more sensitive to these practices than the SOC and TN and are good indications of soil quality, thus influencing soil functions in particular pathways (such as immobilization mineralization). Therefore, these fractions of soil may act as markers of upcoming variations in SOC and total N that are presently untraceable. The stock size of a labile fraction attempts to offer a vision into the results of management procedures that would not be acquired from total SOC studies or total N studies alone. On the other hand, more resistant SOC fractions (humified) in general have slower turnover periods and therefore long-standing potential of SCseq [67,90]. It has also been found that balanced inorganic fertilizer application with or without organic manure application can enhance SOC storage and support soil productivity. Furthermore, fertilizer addition regularly increases soil microbial biomass and changes soil dynamics [67].

Soil C is depleted if C output is higher than C input, while soil sequesters C when C input is higher than C output. Through the photosynthesis process, plants assimilate C, returning some into the atmosphere via respiration. The remaining C that forms plant tissues is either consumed by animals or added to the soil after plants die and decompose. SOM is the principal way in which C is stored in the soil. Carbon sequestration can be recognized by many management practices that differ in their capacity to promote soil C storage and provide a major sink of atmospheric CO_2. An increase in the SOM stock by 1 t C ha^{-1} can raise food production by a further 30 to 40 Mt annually in developing nations [5,64]. Srinivasarao et al. [104] mentioned that the loss of C in the past 1000 years, as a result of soil degradation, represents 16 to 20% of the current global soil C stock of 1200 to 1500 Pg to 1 m depth. Additionally, agriculture mechanization has depleted soil C stock by 78 $\pm$ 12 Tg since the middle of the 18th century, and the conversion of forests into agricultural land has depleted the soil C stock by approximately 22%. Therefore, plans for the sustainable management of natural resources should recognize the decline in soil quality that negatively affects both food security and environmental quality [48,104,105].

Thus, the SOC storage in agricultural soils can be increased directly by increasing OC return to soils through changing classical tillage into conservation agriculture, organic and inorganic mulch usage to diminish the loss of nutrients through leaching and volatilization, cover crops, balanced use of macro-and micro-nutrients, compost application, plant growth-promoting rhizobacteria, biofertilizers, and the variation and diversification of crop systems [106–109]. Additionally, crop residues can be incorporated and degraded arable land can be restored [29,98]. Dotaniya et al. [13] stated that in India, long-term fertilizer trials showed that the incorporation of nutrient balancing led to the enrichment of the SOC concentration. Moreover, cereal-based crop systems had lower C content than legume-based crop systems. They added that it is clear from these results that SOC storage and dynamics may be affected by land use and management. Conversely, Choudhury et al. [103] stated that the long-standing incorporation of organic and inorganic fertilizers simplifies carbon sequestration in the soil; however, the degree can differ relying on the type and character of the organic fertilizers.

4. Conclusions

Climatic variables affect the accessibility and uptake of soil nutrients by plants. Variables such as rising temperatures may influence the length of the growing season, which in turn alters the annual and seasonal accessibility of nutrients. Elevated CO_2 may adversely or positively affect plant availability and uptake. As soil is the largest carbon pool on Earth, it plays an essential role in global C and nutrient cycling. Enhancing soil carbon storage and sequestration is necessary to improve soil quality and plant nutrition reservoirs and increase productivity, notably under the ongoing and upcoming climate change impacts. Soil carbon sequestration also contributes to mitigating the effects of adverse and extreme climatic factors such as rising surface and soil temperature, elevating CO_2 levels, and increasing or decreasing precipitation. Good management practices are the best-expected method to enhance soil organic carbon accumulation and sequestration through increasing soil carbon inputs (such as plant residues) that outputs (such as decomposition and leaching). Additionally, balanced and integrated fertilizing (organic and inorganic) is linked with enhancing soil carbon sequestration, preserving plant nutrients, and increasing productivity.

Future insights:

- Since most studies focused only on the climatic variables, a better understanding of the combination of effects on the availability and uptake of plant nutrients is critically needed.
- In addition, studies on specific site conditions and the combined effects of soil properties with climatic factors are needed in the future.
- The effects of climatic factors on the biofortification of some important elements in plants that are needed to treat deficiencies in humans should be considered future studies.
- Moreover, studies on the relationship between plant nutrient availability and food security under sever climatic conditions should be undertaken.

Author Contributions: Conceptualization, H.E.; preparing the outline, writing, and reviewing, H.E.-R.; writing and reviewing, S.M.; reviewing, F.E., V.D.R., T.M. and S.M. The published version of the work has been reviewed and approved by all authors. All authors have read and agreed to the published version of the manuscript.

Funding: Not applicable.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: All data in this review are available upon reasonable request.

Conflicts of Interest: The authors state that they have no conflict of interest.

References

1. Lotze-Campe, H. Climate Change, Population Growth, and Crop Production: An Overview. In *Crop Adaptation to Climate Change*, 1st ed.; Yadav, S.S., Redden, R.J., Hatfield, J.L., Lotze-Campen, H., Hall, A.E., Eds.; John Wiley & Sons, Ltd.: Hoboken, NJ, USA, 2011.
2. Hossain, M.S.; Arshad, M.; Qian, L.; Zhao, M.; Mehmood, Y.; Kächele, H. Economic impact of climate change on crop farming in Bangladesh: An application of Ricardian method. *Ecol. Econ.* **2019**, *164*, 106354. [CrossRef]
3. Elbasiouny, H.; Elbanna, B.A.; Al-Najoli, E.; Alsherief, A.; Negm, S.; El-Nour, E.A.; Nofal, A.; Sharabash, S. Agricultural Waste Management for Climate Change Mitigation: Some Implications to Egypt. In *Waste Management in MENA Regions, Springer Water Book Series*; Negm, A.M., Shareef, N., Eds.; Springer: Cham, Switzerland, 2020. [CrossRef]
4. Elbehiry, F.; Mahmoud, M.A.; Negm, A. Land Use in Egypt's Coastal Lakes: Opportunities and Challenges. In *Egyptian Coastal Lakes and Wetlands: Part I—Characteristics and Hydrodynamics*; Negm, A.M., Bek, M.A., Abdel-Fattah, S., Eds.; Springer International Publishing AG: Cham, Switzerland, 2018. [CrossRef]
5. Shukla, S.K.; Shee, S.; Maity, S.K.; Solomon, S.; Awasthi, S.K.; Gaur, A.; Pathak, A.D.; Jaiswal, V.P. Soil Carbon Sequestration and Crop Yields in Rice–Wheat and Sugarcane–Ratoon–Wheat Cropping Systems Through Crop Residue Management and Inoculation of Trichoderma viride in Subtropical India. *Sugar Tech* **2016**, *19*, 347–358. [CrossRef]

6. Egli, M.; Bösiger, M.; Lamorski, K.; Sławiński, C.; Plötze, M.; Wiesenberg, G.L.; Tikhomirov, D.; Musso, A.; Hsu, S.-Y.; Raimondi, S. Pedogenesis and carbon sequestration in transformed agricultural soils of Sicily. *Geoderma* **2021**, *402*, 115355. [CrossRef]
7. Elbasiouny, H.; Elbehiry, F. Soil Carbon Sequestration for Climate Change Mitigation: Some Implications to Egypt. In *Climate Change Impacts on Agriculture and Food Security in Egypt*; Springer: Cham, Switzerland, 2020; pp. 151–181. [CrossRef]
8. Rajput, V.D.; Chen, Y.; Ayup, M. Effects of high salinity on physiological and anatomical indices in the early stages of Populus euphratica growth. *Russ. J. Plant Physiol.* **2015**, *62*, 229–236. [CrossRef]
9. Elbasiouny, H.; Elbehiry, F. Rice Production in Egypt: The Challenges of Climate Change and Water Deficiency. In *Climate Change Impacts on Agriculture and Food Security in Egypt*; Springer: Cham, Switzerland, 2020; pp. 295–319. [CrossRef]
10. Huang, Y.; Ren, W.; Grove, J.; Poffenbarger, H.; Jacobsen, K.; Tao, B.; Zhu, X.; McNear, D. Assessing synergistic effects of no-tillage and cover crops on soil carbon dynamics in a long-term maize cropping system under climate change. *Agric. For. Meteorol.* **2020**, *291*, 108090. [CrossRef]
11. Li, X.; Zhu, W.; Xu, F.; Du, J.; Tian, X.; Shi, J.; Wei, G. Organic amendments affect soil organic carbon sequestration and fractions in fields with long-term contrasting nitrogen applications. *Agric. Ecosyst. Environ.* **2021**, *322*, 107643. [CrossRef]
12. Soares, J.C.; Santos, C.S.; Carvalho, S.M.P.; Pintado, M.M.; Vasconcelos, M.W. Preserving the nutritional quality of crop plants under a changing climate: Importance and strategies. *Plant Soil* **2019**, *443*, 1–26. [CrossRef]
13. Dotaniya, M.L.; Rajendiran, S.; Meena, B.P.; Meena, A.L.; Dotaniya, C.K.; Jat, R.L.; Saha, J.K. Elevated Carbon Dioxide (CO_2) and Temperature vis-a-vis Carbon Sequestration Potential of Global Terrestrial Ecosystem. In *Conservation Agriculture*; Bisht, J.K., Ed.; Springer: Singapore, 2016. [CrossRef]
14. Gong, H.; Gao, J. Soil and climatic drivers of plant SLA (specific leaf area). *Glob. Ecol. Conserv.* **2019**, *20*, e00696. [CrossRef]
15. Koller, E.K.; Phoenix, G.K. Seasonal dynamics of soil and plant nutrients at three environmentally contrasting sites along a sub-Arctic catchment sequence. *Polar Biol.* **2017**, *40*, 1821–1834. [CrossRef]
16. Matias, L.; Castro, J.; Zamora, R. Soil-nutrient availability under a global-change scenario in a Mediterranean mountain ecosystem. *Glob. Chang. Biol.* **2010**, *17*, 1646–1657. [CrossRef]
17. Arndal, M.F.; Merrild, M.P.; Michelsen, A.; Schmidt, I.K.; Mikkelsen, T.N.; Beier, C. Net root growth and nutrient acquisition in response to predicted climate change in two contrasting heathland species. *Plant Soil* **2013**, *369*, 615–629. [CrossRef]
18. Pilbeam, D.J. Breeding crops for improved mineral nutrition under climate change conditions. *J. Exp. Bot.* **2015**, *66*, 3511–3521. [CrossRef]
19. Alshaal, T.; El-Ramady, H.; Al-Saeedi, A.H.; Shalaby, T.; Elsakhawy, T.; Omara, A.E.-D.; Gad, A.; Hamad, E.; El-Ghamry, A.; Mosa, A.; et al. The Rhizosphere and Plant Nutrition Under Climate Change. In *Essential Plant Nutrients*; Naeem, M., Ed.; Springer: Cham, Switzerland, 2017. [CrossRef]
20. Hatfield, J.L.; Prueger, J.H. Agroecology: Implications for Plant Response to Climate Change. In *Crop Adaptation to Climate Change*, 1st ed.; Yadav, S.S., Redden, R.J., Hatfield, J.L., Lotze-Campen, H., Hall, A.E., Eds.; John Wiley & Sons, Ltd.: Hoboken, NJ, USA, 2011.
21. Sarfraz, R.; Hussain, A.; Sabir, A.; Fekih, I.B.; Ditta, A.; Xing, S. Role of biochar and plant growth promoting rhizobacteria to enhance soil carbon sequestration—A review. *Environ. Monit. Assess.* **2019**, *191*, 251. [CrossRef] [PubMed]
22. Brouder, S.M.; Volenec, J.J. Impact of climate change on crop nutrient and water use efficiencies. *Physiol. Plant.* **2008**, *133*, 705–724. [CrossRef]
23. Bocchiola, D.; Brunetti, L.; Soncini, A.; Polinelli, F.; Gianinetto, M. Impact of climate change on agricultural productivity and food security in the Himalayas: A case study in Nepal. *Agric. Syst.* **2019**, *171*, 113–125. [CrossRef]
24. Amouzou, K.A.; Lamers, J.P.; Naab, J.B.; Borgemeister, C.; Vlek, P.L.; Becker, M. Climate change impact on water- and nitrogen-use efficiencies and yields of maize and sorghum in the northern Benin dry savanna, West Africa. *Field Crop. Res.* **2019**, *235*, 104–117. [CrossRef]
25. Seneweera, S.; Norton, R.M. Plant Responses to Increased Carbon Dioxide. In *Crop Adaptation to Climate Change*, 1st ed.; Yadav, S.S., Redden, R.J., Hatfield, J.L., Lotze-Campen, H., Hall, A.E., Eds.; John Wiley & Sons, Ltd.: Hoboken, NJ, USA, 2011.
26. Taub, D.R.; Wang, X. Why are nitrogen concentrations in plant tissues lower under elevated CO_2? A critical examination of the hypotheses. *J. Integr. Plant Biol.* **2008**, *50*, 1365–1374. [CrossRef] [PubMed]
27. McGrath, J.M.; Lobell, D.B. Reduction of transpiration and altered nutrient allocation contribute to nutrient decline of crops grown in elevated CO_2 concentrations. *Plant Cell Environ.* **2013**, *36*, 697–705. [CrossRef] [PubMed]
28. Wang, J.; Zhang, X.; Li, L.; Cheng, K.; Zheng, J.; Zheng, J.; Shen, M.; Liu, X.; Pan, G. Changes in micronutrient availability and plant uptake under simulated climate change in winter wheat field. *J. Soils Sediments* **2016**, *16*, 2666–2675. [CrossRef]
29. Shahzad, K.; Sintim, H.; Ahmad, F.; Abid, M.; Nasim, W. Importance of Carbon Sequestration in the Context of Climate Change. In *Building Climate Resilience in Agriculture*; Jatoi, W.N., Mubeen, M., Ahmad, A., Cheema, M.A., Lin, Z., Hashmi, M.Z., Eds.; Springer: Cham, Switzerland, 2022. [CrossRef]
30. Adavi, Z.; Moradi, R.; Saeidnejad, A.H.; Tadayon, M.R.; Mansouri, H. Assessment of potato response to climate change and adaptation strategies. *Sci. Hortic.* **2018**, *228*, 91–102. [CrossRef]
31. Cookson, W.; Osman, M.; Marschner, P.; Abaye, D.; Clark, I.; Murphy, D.; Stockdale, E.; Watson, C. Controls on soil nitrogen cycling and microbial community composition across land use and incubation temperature. *Soil Biol. Biochem.* **2007**, *39*, 744–756. [CrossRef]
32. Rennenberg, H.; Dannenmann, M.; Gessler, A.; Kreuzwieser, J.; Simon, J.; Papen, H. Nitrogen balance in forest soils: Nutritional limitation of plants under climate change stresses. *Plant Biol.* **2009**, *11* (Suppl. 1), 4–23. [CrossRef] [PubMed]
33. Wrage, N.; Chapuis-Lardy, L.; Isselstein, J. Phosphorus, Plant Biodiversity and Climate Change. In *Sociology, Organic Farming, Climate Change and Soil Science*; Sustainable Agriculture Reviews 3; Springer: Dordrecht, The Netherlands, 2009. [CrossRef]

34. Kirschbaum, M.U.F. The temperature dependence of organic-matter decomposition—Still a topic of debate. *Soil Biol. Biochem.* **2006**, *38*, 2510–2518. [CrossRef]
35. Howden, S.M.; Crimp, S. Regional impacts: Australia. In *Crop Adaptation to Climate Change*; Yadav, S.S., Redden, R.J., Hatfield, J.L., Lotze-Campen, H., Hall, A.E., Eds.; John Wiley & Sons: Hoboken, NJ, USA, 2011; pp. 143–155.
36. Simon, J.; Dannenmann, M.; Pena, R.; Gessler, A.; Rennenberg, H. Nitrogen nutrition of beech forests in a changing climate: Importance of plant-soil-microbe water, carbon, and nitrogen interactions. *Plant Soil* **2017**, *418*, 89–114. [CrossRef]
37. Khan, S.; Anwar, S.; Sun, M.; Shafiq, F.; Khalilzadeh, R.; Gao, Z.-Q. Characterizing Differences in Soil Water Content and Wheat Yield in Response to Tillage and Precipitation in the Dry, Normal, and Wet Years at the Loess Plateau. *Int. J. Plant Prod.* **2021**, *15*, 655–668. [CrossRef]
38. Rosenblatt, A.E.; Schmitz, O.J. Climate Change, Nutrition, and Bottom-Up and Top-Down Food Web Processes. *Trends Ecol. Evol.* **2016**, *31*, 965–975. [CrossRef]
39. Jonasson, S.; Michelsen, A.; Schmidt, I.K.; Nielsen, E.V. Responses in microbes and plants to changed temperature, nutrient, and light regimes in the arctic. *Ecology* **1999**, *80*, 1828–1843. [CrossRef]
40. Wang, J.; Li, L.; Lam, S.K.; Zhang, X.; Liu, X.; Pan, G. Changes in nutrient uptake and utilization by rice under simulated climate change conditions: A 2-year experiment in a paddy field. *Agric. For. Meteorol.* **2018**, *250*, 202–208. [CrossRef]
41. Avila, J.M.; Gallardo, A.; Gómez-Aparicio, L. Pathogen-induced tree mortality interacts with predicted climate change to alter soil respiration and nutrient availability in Mediterranean systems. *Biogeochemistry* **2019**, *142*, 53–71. [CrossRef]
42. Yang, X.; Zhang, P.; Wei, Z.; Liu, J.; Hu, X.; Liu, F. Effects of elevated CO_2 and nitrogen supply on leaf gas exchange, plant water relations and nutrient uptake of tomato plants exposed to progressive soil drying. *Sci. Hortic.* **2021**, *292*, 110643. [CrossRef]
43. Luo, Y.; Peng, Q.; Li, K.; Gong, Y.; Liu, Y.; Han, W. Patterns of nitrogen and phosphorus stoichiometry among leaf, stem and root of desert plants and responses to climate and soil factors in Xinjiang, China. *Catena* **2020**, *199*, 105100. [CrossRef]
44. Macdonald, C.A.; Anderson, I.C.; Khachane, A.; Singh, B.P.; Barton, C.V.; Duursma, R.A.; Ellsworth, D.S.; Singh, B.K. Plant productivity is a key driver of soil respiration response to climate change in a nutrient-limited soil. *Basic Appl. Ecol.* **2020**, *50*, 155–168. [CrossRef]
45. Benbi, D.K.; Brar, J.S. A 25-year record of carbon sequestration and soil properties in intensive agriculture. *Agron. Sustain. Dev.* **2009**, *29*, 257–265. [CrossRef]
46. Elbasiouny, H.; Abowaly, M.; Abu Alkheir, A.; Gad, A.-A. Spatial variation of soil carbon and nitrogen pools by using ordinary Kriging method in an area of north Nile Delta, Egypt. *Catena* **2014**, *113*, 70–78. [CrossRef]
47. Hsu, C.-C.; Tsai, H.; Huang, W.-S.; Huang, S.-T. Carbon Storage along with Soil Profile: An Example of Soil Chronosequence from the Fluvial Terraces on the Pakua Tableland, Taiwan. *Land* **2021**, *10*, 447. [CrossRef]
48. Lal, R. Soil Carbon Sequestration Impacts on Global Climate Change and Food Security. *Science* **2004**, *304*, 1623–1627. [CrossRef] [PubMed]
49. Liang, F.; Li, J.; Zhang, S.; Gao, H.; Wang, B.; Shi, X.; Huang, S.; Xu, M. Two-decade long fertilization induced changes in subsurface soil organic carbon stock vary with indigenous site characteristics. *Geoderma* **2018**, *337*, 853–862. [CrossRef]
50. Cao, X.; Long, H.; Lei, Q.; Wu, S. Estimating Soil Carbon Sequestration Potential in Fine Particles of Top Soils in Hebei Province, China. In *Digital Soil Mapping Across Paradigms, Scales and Boundaries*; Zhang, G.-L., Ed.; Springer: Singapore, 2016. [CrossRef]
51. Xie, J.; Hou, M.; Zhou, Y.; Wang, R.; Zhang, S.; Yang, X.; Sun, B. Carbon sequestration and mineralization of aggregate-associated carbon in an intensively cultivated Anthrosol in north China as affected by long term fertilization. *Geoderma* **2017**, *296*, 1–9. [CrossRef]
52. Adhikari, K.R.; Dahal, K.R.; Chen, Z.-S.; Tan, Y.-C.; Lai, J.-S. Rice–wheat cropping system: Tillage, mulch, and nitrogen effects on soil carbon sequestration and crop productivity. *Paddy Water Environ.* **2015**, *15*, 699–710. [CrossRef]
53. Baqir, M.; Shah, A.B.; Kothari, R.; Singh, R.P. Carbon sequestration potential of plantation forestry and improvements in soil nutrient status in a subtropical area of northern India. *Environ. Sustain.* **2018**, *1*, 383–392. [CrossRef]
54. Dad, J.M.; Dand, S.A.; Pala, N.A. The effect of bi-culture cover crops on soil quality, carbon sequestration, and growth characteristics in apple orchards of North Western Himalayas. *Agrofor. Syst.* **2021**, *95*, 1745–1758. [CrossRef]
55. Laamrani, A.; Voroney, P.; Gillespie, A.; Chehbouni, A. Development of a Land Use Carbon Inventory for Agricultural Soils in the Canadian Province of Ontario. *Land* **2021**, *10*, 765. [CrossRef]
56. Yadav, G.S.; Lal, R.; Meena, R.S.; Babu, S.; Das, A.; Bhowmik, S.N.; Datta, M.; Layak, J.; Saha, P. Conservation tillage and nutrient management effects on productivity and soil carbon sequestration under double cropping of rice in north eastern region of India. *Ecol. Ind.* **2019**, *105*, 303–315. [CrossRef]
57. Dignac, M.-F.; Derrien, D.; Barre, P.; Barot, S.; Cécillon, L.; Chenu, C.; Chevallier, T.; Freschet, G.T.; Garnier, P.; Guenet, B.; et al. Increasing soil carbon storage: Mechanisms, effects of agricultural practices and proxies. A review. *Agron. Sustain. Dev.* **2017**, *37*, 14. [CrossRef]
58. Niu, L.; Manxia, C.; Xiumei, G.; Xiaohua, L.; Hongbo, S.; Zhaopu, L.; Zed, R. Carbon sequestration and Jerusalem artichoke biomass under nitrogen applications in coastal saline zone in the northern region of Jiangsu, China. *Sci. Total. Environ.* **2016**, *568*, 885–890. [CrossRef]
59. Laban, P.; Metternicht, G.; Davies, J. *Soil Biodiversity and Soil Organic Carbon: Keeping Drylands Alive*; IUCN: Gland, Switzerland, 2018; 24p. [CrossRef]
60. Goh, K.M. Carbon sequestration and stabilization in soils: Implications for soil productivity and climate change. *Soil Sci. Plant Nutr.* **2004**, *50*, 467–476. [CrossRef]
61. Eswaran, H.; Berg, E.V.D.; Reich, P. Organic Carbon in Soils of the World. *Soil Sci. Soc. Am. J.* **1993**, *57*, 192–194. [CrossRef]

62. Lal, R.; Follett, R.F.; Stewart, B.A.; Kimble, J.M. Soil carbon sequestration to mitigate climate change and advance food security. *Soil Sci.* **2007**, *172*, 943–956. [CrossRef]
63. Stout, B.; Lal, R.; Monger, C. Carbon capture and sequestration: The roles of agriculture and soils. *Int. J. Agric. Biol. Eng.* **2016**, *9*, 1–8.
64. Lal, R. Enhancing crop yields in the developing countries through restoration of the soil organic carbon pool in agricultural lands. *Land Degrad. Dev.* **2005**, *17*, 197–209. [CrossRef]
65. Yadav, G.S.; Das, A.; Babu, S.; Mohapatra, K.P.; Lal, R.; Rajkhowa, D. Potential of conservation tillage and altered land configuration to improve soil properties, carbon sequestration and productivity of maize based cropping system in eastern Himalayas, India. *Int. Soil Water Conserv. Res.* **2021**, *9*, 279–290. [CrossRef]
66. Fan, H.-Z.; Chen, Q.-R.; Qin, Y.-S.; Chen, K.; Tu, S.-H.; Xu, M.-G.; Zhang, W.-J. Soil carbon sequestration under long-term rice-based cropping systems of purple soil in Southwest China. *J. Integr. Agric.* **2015**, *14*, 2417–2425. [CrossRef]
67. Shahid, M.; Nayak, A.K.; Puree, C.; Tripathi, R.; Lal, B.; Gautam, P.; Bhattacharyya, P.; Mohanty, S.; Kumar, A.; Panda, B.B.; et al. Carbon and nitrogen fractions and stocks under 41 years of chemical and organic fertilization in a sub-humid tropical rice soil. *Soil Tillage Res.* **2017**, *170*, 136–146. [CrossRef]
68. Meena, R.S.; Sandeep, K.S.; Yadav, G.S. Soil Carbon Sequestration in Crop Production. In *Nutrient Dynamics for Sustainable Crop Production*; Meena, R.S., Ed.; Springer: Singapore, 2020; pp. 1–39. [CrossRef]
69. Liang, C.; Zhu, X. The soil Microbial Carbon Pump as a new concept for terrestrial carbon sequestration. *Sci. China Earth Sci.* **2021**, *64*, 545–558. [CrossRef]
70. Feng, Q.; An, C.; Chen, Z.; Wang, Z. Can deep tillage enhance carbon sequestration in soils? A meta-analysis towards GHG mitigation and sustainable agricultural management. *Renew. Sustain. Energy Rev.* **2020**, *133*, 110293. [CrossRef]
71. Crystal-Ornelas, R.; Thapa, R.; Tully, K.L. Soil organic carbon is affected by organic amendments, conservation tillage, and cover cropping in organic farming systems: A meta-analysis. *Agric. Ecosyst. Environ.* **2021**, *312*, 107356. [CrossRef]
72. Kumar, N.; Nath, C.; Hazra, K.; Das, K.; Venkatesh, M.; Singh, M.; Singh, S.; Praharaj, C.; Singh, N. Impact of zero-till residue management and crop diversification with legumes on soil aggregation and carbon sequestration. *Soil Tillage Res.* **2019**, *189*, 158–167. [CrossRef]
73. Nath, C.; Kumar, N.; Das, K.; Hazra, K.; Praharaj, C.; Singh, N. Impact of variable tillage based residue management and legume based cropping for seven years on enzymes activity, soil quality index and crop productivity in rice ecology. *Environ. Sustain. Indic.* **2021**, *10*, 100107. [CrossRef]
74. Kumari, R.; Kundu, M.; Das, A.; Rakshit, R.; Sahay, S.; Sengupta, S.; Ahmad, F. Long-Term Integrated Nutrient Management Improves Carbon Stock and Fruit Yield in a Subtropical Mango (*Mangifera indica* L.) Orchard. *J. Soil Sci. Plant Nutr.* **2019**, *20*, 725–737. [CrossRef]
75. Hazra, K.K.; Nath, C.P.; Singh, U.; Praharaj, C.S.; Kumar, N.; Singh, S.S.; Singh, N.P. Diversification of maize-wheat cropping system with legumes and integrated nutrient management increases soil aggregation and carbon sequestration. *Geoderma* **2019**, *353*, 308–319. [CrossRef]
76. Chandel, S.; Datta, A.; Yadav, R.K.; Dheri, G.S. Does Saline Water Irrigation Influence Soil Carbon Pools and Nutrient Distribution in Soil under Seed Spices? *J. Soil Sci. Plant Nutr.* **2021**, *21*, 949–966. [CrossRef]
77. Hübner, R.; Kühnel, A.; Lu, J.; Dettmann, H.; Wang, W.; Wiesmeier, M. Soil carbon sequestration by agroforestry systems in China: A meta-analysis. *Agric. Ecosyst. Environ.* **2021**, *315*, 107437. [CrossRef]
78. Mayer, S.; Wiesmeier, M.; Sakamoto, E.; Hübner, R.; Cardinael, R.; Kühnel, A.; Kögel-Knabner, I. Soil organic carbon sequestration in temperate agroforestry systems—A meta-analysis. *Agric. Ecosyst. Environ.* **2021**, *323*, 107689. [CrossRef]
79. Madigan, A.P.; Zimmermann, J.; Krol, D.J.; Williams, M.; Jones, M.B. Full Inversion Tillage (FIT) during pasture renewal as a potential management strategy for enhanced carbon sequestration and storage in Irish grassland soils. *Sci. Total Environ.* **2021**, *805*, 150342. [CrossRef]
80. Shi, S.; Peng, C.; Wang, M.; Zhu, Q.; Yang, G.; Yang, Y.; Xi, T.; Zhang, T. A global meta-analysis of changes in soil carbon, nitrogen, phosphorus and sulfur, and stoichiometric shifts after forestation. *Plant Soil* **2016**, *407*, 323–340. [CrossRef]
81. Pimentel, D.; Burgess, M. Maintaining sustainable and environmentally friendly fresh produce production in the context of climate change. In *Global Safety of Fresh Produce*; Woodhead Publishing: Sawston, UK, 2014; pp. 133–139. [CrossRef]
82. Rice, C. Carbon Cycle in Soils | Dynamics and Management. *Encycl. Soils Environ.* **2005**, 164–170. [CrossRef]
83. Powlson, D.; Cai, Z.; Lemanceau, P. 7 Soil Carbon Dynamics and Nutrient Cycling. *Soil Carbon Sci. Manag. Policy Mult. Benefits* **2014**, *71*, 98.
84. Grover, M.; Maheswari, M.; Desai, S.; Gopinath, K.; Venkateswarlu, B. Elevated CO_2: Plant associated microorganisms and carbon sequestration. *Appl. Soil Ecol.* **2015**, *95*, 73–85. [CrossRef]
85. Sánchez-Navarro, V.; Zornoza, R.; Faz, A.; Fernández, J.A. Comparing legumes for use in multiple cropping to enhance soil organic carbon, soil fertility, aggregates stability and vegetables yields under semiarid conditions. *Sci. Hortic.* **2018**, *246*, 835–841. [CrossRef]
86. Zhang, D.; Yao, P.; Zhao, N.; Cao, W.; Zhang, S.; Li, Y.; Huang, D.; Zhai, B.; Wang, Z.; Gao, Y. Building up the soil carbon pool via the cultivation of green manure crops in the Loess Plateau of China. *Geoderma* **2018**, *337*, 425–433. [CrossRef]
87. Meena, A.L.; Jha, P.; Dotaniya, M.L.; Kumar, B.; Meena, B.P.; Jat, R.L. Carbon, Nitrogen and Phosphorus Mineralization as Influenced by Type of Organic Residues and Soil Contact Variation in Vertisol of Central India. *Agric. Res.* **2019**, *9*, 232–240. [CrossRef]

88. Nieder, R.; Benbi, D.K. *Carbon and Nitrogen in the Terrestrial Environment*; Springer Science & Business Media: Dordrecht, The Netherlands, 2008; 432p. [CrossRef]
89. Elbasiouny, H.; Abowaly, M.; Gad, A.; Abu_Alkheir, A.; Elbehiry, F. Restoration and sequestration of carbon and nitrogen in the degraded northern coastal area in Nile Delta, Egypt for climate change mitigation. *J. Coast. Conserv.* **2016**, *21*, 105–114. [CrossRef]
90. Elbasiouny, H.; Elbehiry, F. Soil carbon and nitrogen stocks and fractions for improving soil quality and mitigating climate change. *Egypt. J. Soil Sci.* **2019**, *59*, 131–144. [CrossRef]
91. Singh, G.; Sangwan, S.; Narwal, E.; Annapurna, K. Microbial Proteins and Soil Carbon Sequestration. In *Adaptive Soil Management: From Theory to Practices*; Rakshit, A., Ed.; Springer: Singapore, 2017; pp. 131–139. [CrossRef]
92. Hines, F.L. Nitrogen, sulfur, and phosphorus and the sequestering of carbon. In *Soil Processes and the Carbon Cycle*; Lal, R., Kimble, J.M., Follett, R.F., Stewart, B.A., Eds.; CRC Press: Boca Raton, FL, USA, 1997; pp. 315–319.
93. E Richardson, A.; A Kirkby, C.; Banerjee, S.; Kirkegaard, J. The inorganic nutrient cost of building soil carbon. *Carbon Manag.* **2014**, *5*, 265–268. [CrossRef]
94. Knops, J.M.; Tilman, D. Dynamics of soil nitrogen and carbon accumulation for 61 years after agricultural abandonment. *Ecology* **2000**, *81*, 88–98. [CrossRef]
95. de Oca, P.C.M. Effect of Land Use, Climate and Soil Structure on Soil Organic Carbon in Costa Rican Ecoregions. Ph.D. Thesis, The Ohio State University, Columbus, OH, USA, 2009.
96. Bouajila, A.; Gallali, T. Land use effect on soil and particulate organic carbon, and aggregate stability in some soils in Tunisia. *Afr. J. Agric. Res.* **2010**, *5*, 764–774.
97. Cambardella, C.A.; Elliott, E.T. Particulate Soil Organic-Matter Changes across a Grassland Cultivation Sequence. *Soil Sci. Soc. Am. J.* **1992**, *56*, 777–783. [CrossRef]
98. Su, Y.Z.; Liu, W.J.; Yang, R.; Chang, X.X. Changes in Soil Aggregate, Carbon, and Nitrogen Storages Following the Conversion of Cropland to Alfalfa Forage Land in the Marginal Oasis of Northwest China. *Environ. Manag.* **2009**, *43*, 1061–1070. [CrossRef]
99. Wu, H.; Tang, J.; Huang, H.; Chen, W.; Meng, Y. Net Carbon Sequestration Performance of Cropland Use in China's Principal Grain-Producing Area: An Evaluation and Spatiotemporal Divergence. *Land* **2021**, *10*, 714. [CrossRef]
100. Don, A.; Schumacher, J.; Scherer-Lorenzen, M.; Scholten, T.; Schulze, E.-D. Spatial and vertical variation of soil carbon at two grassland sites—Implications for measuring soil carbon stocks. *Geoderma* **2007**, *141*, 272–282. [CrossRef]
101. Zapata, F. Introduction to nitrogen management in agricultural systems. In *Guidelines on Nitrogen Management in Agricultural Systems*; International Atomic Energy Agency: Seibersdorf, Austria, 2008; p. 1.
102. Qadir, M.; Noble, A.D.; Schubert, S.; Thomas, R.T.; Arslan, A. Sodicity-induced land degradation and its sustainable management: Problems and prospects. *Land Degrad. Dev.* **2006**, *17*, 661–676. [CrossRef]
103. Choudhury, S.G.; Yaduvanshi, N.P.S.; Chaudhari, S.K.; Sharma, D.R.; Nayak, D.C.; Singh, S.K. Effect of nutrient management on soil organic carbon sequestration, fertility, and productivity under rice-wheat cropping system in semi-reclaimed sodic soils of North India. *Environ. Monit. Assess.* **2018**, *190*, 117. [CrossRef] [PubMed]
104. Srinivasarao, C.; Lal, R.; Kundu, S.; Thakur, P.B. Conservation Agriculture and Soil Carbon Sequestration. In *Conservation Agriculture*; Farooq, M., Siddique, K.H.M., Eds.; Springer International Publishing: Cham, Switzerland, 2015. [CrossRef]
105. Lal, R. Residue management, conservation tillage and soil restoration for mitigating greenhouse effect by CO_2 enrichment. *Soil Tillage Res.* **1997**, *43*, 81–107. [CrossRef]
106. Upadhyay, S.K.; Singh, D.P. Effect of salt-tolerant plant growth-promoting rhizobacteria on wheat plants and soil health in a saline environment. *Plant Biol.* **2014**, *17*, 288–293. [CrossRef]
107. Mahmud, A.A.; Upadhyay, S.K.; Srivastava, A.K.; Bhojiya, A.A. Biofertilizers: A Nexus between soil fertility and crop productivity under abiotic stress. *Curr. Res. Environ. Sustain.* **2021**, *3*, 100063. [CrossRef]
108. Upadhyay, S.K.; Saxena, A.K.; Singh, J.S.; Singh, D.P. Impact of Native ST-PGPR (*Bacillus pumilus*; EU927414) on PGP Traits, Antioxidants Activities, Wheat Plant Growth and Yield under Salinity. *Clim. Chang. Environ. Sustain.* **2019**, *7*, 157. [CrossRef]
109. Upadhyay, S.K.; Edrisi, S.A. Developing sustainable measures to restore fly ash contaminated lands: Current challenges and future prospects. *Land Degrad. Dev.* **2021**, *32*, 4817–4831. [CrossRef]