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Carbon and Nitrogen Stocks in Topsoil under Different Land Use/Land Cover Types in the Southeast of Spain

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Abstract: Land use plays a crucial role in the stock of soil organic carbon (SOC) and soil nitrogen (SN). The aim of this study was to assess and characterize the effects of various soil management practices on the physicochemical properties of soil in a Mediterranean region in southeastern Spain. Texture, soil moisture, bulk density, pH, electrical conductivity, equivalent $CaCO_3$ (%), soil organic matter and carbon, and Kjeldahl nitrogen were determined for the surface topsoil (0–5 cm, 180 samples) under three types of land cover: cropland, grassland, and urban soil. The main soil textures were silt, silt loam, and sandy loam with low percentages of soil moisture in all soil samples and lower bulk density values in cropland and grassland areas. The pH was alkaline and the electrical conductivity as well as the equivalent calcium carbonate content were moderate to high. Organic matter estimated using the LOI and WB methods varied in the order cropland > grassland > urban soil. The results obtained for SOC and SN indicate that cropland presented the highest stocks, followed by grassland and urban soil. The values determined for the C/N ratio were close to 10 in cropland and grassland, indicating that organic matter readily undergoes decomposition at these sites. Our results emphasize the importance of evaluating the effects and identifying the impacts of different soil management techniques, and further research is needed to better understand the potential to improve soil organic carbon and nitrogen storage in semiarid regions.

Keywords: soil organic carbon; soil nitrogen; land use; physicochemical properties; Spain

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1. Introduction

Soil, a complex system, is an indispensable element for sustainability [1]. Yet, the world's soils are under pressure from many factors, including land use change and climate change, both components of global change. However, different types of land use, particularly agriculture and forestry, result in increased or decreased carbon emissions into the atmosphere, accounting for nearly one-quarter of greenhouse gas emissions [2].

Soil is the largest reservoir of organic carbon in terrestrial ecosystems. Moreover, the soil organic carbon (SOC) dynamics are not only of vital importance for maintaining soil quality [3] but can also exert a substantial influence on the global carbon cycle, thereby contributing to global change [4]. SOC is essential for the proper functioning and stability of soils, influencing their chemical, physical, and biological properties [5–7]. These properties are essential for the maintenance of healthy farming systems and are therefore key factors to be considered in the management of soil. Nevertheless, climate change has a negative impact on the functioning of ecosystems, including agrosystems, by altering the biogeochemical cycles of carbon and nitrogen and changing nutrient bioavailability, thereby hampering food production and exacerbating biodiversity loss [8].

However, agricultural soils present vast potential for carbon storage on a global scale [9], and land management practices play a crucial role in achieving the sustainability goal of carbon storage. The findings from studies conducted on agricultural land by Ren et al. [10] highlight that optimizing management practices holds significant potential for sequestering and storing carbon. This approach has the potential to mitigate, to some extent, the decrease in soil organic carbon (SOC) attributable to the impacts of climate change. Another study by the same scientists [11] indicates that in cropland, SOC is a crucial determinant of soil quality, playing a key role in ensuring food security and the sustainability of agriculture. Human management practices, particularly sustainable agricultural techniques, have the capacity to raise soil carbon and nitrogen levels, consequently enhancing soil quality [12]. However, in an apparent contradiction, the abandonment of agricultural land reportedly contributes to increased soil carbon and nitrogen sequestration [13,14]. On the one hand is sustainable management via agroengineering techniques, and on the other is the absolute abandonment of agricultural management. Notwithstanding, it is necessary to maintain productive soils and food production as the world's population is growing, and the need to provide food may be compromised by a reduction in yields.

In addition, it has been emphasized that SOC in soil plays a central role in the global carbon balance. Carbon storage in agricultural soil results mainly from the accumulation of organic matter from crops, particularly biomass from different parts of plants [15], both above- and underground biomass, and similarly in forest and pasture areas.

Since forest carbon sinks are crucial for the strategy of carbon sequestration, understanding this physiological process as performed by living organisms and mainly by plants is required to enhance protection and sustainability in forest management [16,17]. Hence, it is crucial to recognize that forest management practices possess the potential to impact the stability and composition of soil carbon and nitrogen reserves [18].

Many improvements to management practices have been discussed and have the potential to enhance SOC stocks in managed grassland soils. In this ecosystem, improved grazing management practices, like optimizing grazing intensity or adopting holistic grazing planning, have the potential to contribute to carbon sequestration [19]. Overall, reducing grazing intensity or implementing spatial and temporal grazing exclusion measures typically leads to an increase in SOC stocks due to increased soil carbon input. This trend is particularly evident in semiarid environments, such as our study area.

However, the intensive utilization of land for cultivation, grazing, or construction, which involves the removal of native vegetation and disruption of the soil profile, can lead to soil degradation [20]. It is important to recognize the role of urban areas and urban soils as sources and sinks of carbon.

Urban soils are anthropogenic soils or soils affected by human activities linked to settlements, predominantly but not exclusively found in urban areas. Urbanization and the expansion of agricultural land often lead to deforestation and the depletion of biomass and soil carbon stocks [21], often involving soils composed of a mixture of materials distinct from those of adjacent agricultural or forest areas. These soils have been extensively transformed by human activity through the mixing, import and export of materials, as well as contamination [22]. In addition, soil horizons in urban areas undergo substantial changes, contributing to soil sealing and a reduction in soil organic carbon (SOC) [23,24]. Given that global climate change is projected to exert the most significant effects on the remaining forest or grassland soils, it is likely that highly disturbed, well-designed, and extensively managed urban soils may possess the most considerable potential for mitigating the drivers of climate change [25]. Soils are often dubbed as the 'brown infrastructure' that provides essential ecosystem services as part of urban land use planning. Their contribution to climate change mitigation is of paramount importance to the sustainability and resilience of densely populated regions around the world. It is essential to highlight that various environmental factors in urban areas, including the urban heat island effect and elevated concentrations of carbon dioxide (CO_2) in the atmosphere, impact the overall urban climate and share similarities with the factors anticipated to be significant within the framework of global climate change. As a result, urban areas can serve as models for anticipating future climate conditions.

Specifically, the assessment of soil quality hinges on the contents of soil organic carbon and nitrogen, which are pivotal elements in this evaluation [26,27]. Carbon and nitrogen, as well as oxygen and hydrogen, are the major constituents of soil organic matter [28]. Soil organic carbon and nitrogen are recognized as essential components because of their significant contributions to soil quality, fertility, and crop productivity. In addition, the percentage of nitrogen can regulate soil carbon stocks by affecting decomposition [29]. Several research studies conducted by Chen et al. (2021), Tang et al. (2023), and Wang et al. (2023) [30–32] highlight the growing complexity in comprehending the impacts of nitrogen addition on soil organic carbon changes. These studies revealed that SOC responses to nitrogen addition are divergent, highlighting that many factors influence this process. These findings suggest that the relationship between SN and SOC is complex and contingent on multiple variables, and the addition of nitrogen has a significant influence on SOC [33,34]. Given the robust interaction between the soil carbon and nitrogen cycles, it is imperative to conduct a comprehensive analysis of the effects of nitrogen addition on soil organic carbon dynamics [35,36]. In other studies carried out by Abbas et al. (2020), Puget and Lal (2005), and Baker et al. (2007) [37–39], the variations in SOC and nitrogen were evaluated under different types of soil management, leading to the assertion that SOC accumulation is intricately linked to maintenance of an equilibrium between the quality and quantity of soil organic matter (SOM), and this equilibrium is shaped by a combination of factors, including climatic variables, soil physical properties, and soil management practices.

In this context, our study focuses on assessing the impacts of various soil management situations on soil properties within a Mediterranean region in southeastern Spain, identifying the differences associated with land use in the topsoil (0–5 cm) and also quantifying variations in the soil properties.

2. Materials and Methods

2.1. Study Area

The study was conducted in an area in the southeast of Spain, specifically in the province of Alicante, situated at coordinates 38.14 N and 0.73 W (Figure 1). The predominant climate of the area is semiarid hot-summer Mediterranean according to the Köppen–Geiger classification (BSh) [40]. The average annual rainfall ranges from 300 to 600 mm, characterized by temporal and spatial variability in precipitation. This variability gives rise to periods of severe drought juxtaposed with episodes of highly intense and dramatic flood events. Additionally, the temperatures are mild overall, reaching above 18 °C [41]. It is generally accepted that soil temperature increment leads to a higher rate of carbon loss, although findings in some published studies contradict this consensus [42–44] because this process depends on the actual temperature reached. According to [45,46], the main types of soils in the whole area are Calcaric fluvisols and Anthrosols with an SOM (%) between 1.9 and 2.6, and the pH ranges between 8.1 and 8.4 due to the calcareous nature of the lithology.

2.2. Sampling

Sampling was carried out between September (autumn) 2020 and May (spring) 2021 in several representative sites (different types of land use and land cover, LULC) and comprised field sampling and measurements covering various land use/cover types (Figure 2). A total of 58 sampling areas (with three-point replication accounting 174 soil samples) were analyzed, corresponding to 24 for cropland (horticultural and trees crops, farming systems), 17 for grassland (pasture areas of sheep and goats), and 17 for urban soils (garden and open spaces without soil sealing). These zones were chosen because they correspond to areas whose coverage is completely defined by the type of use and land cover being analyzed, without influence from other uses. In the field, we employed a portable Garmin handheld Global Positioning System (GPS) receiver for precise location tracking. At each point, topsoil samples of 0–5 cm depth were collected using a stainless steel cylinder (5 cm diameter and 5 cm height) that was immediately closed and transferred to plastic bags to avoid water loss before being transported to the laboratory for further analysis. In total, there were 180 soil samples.

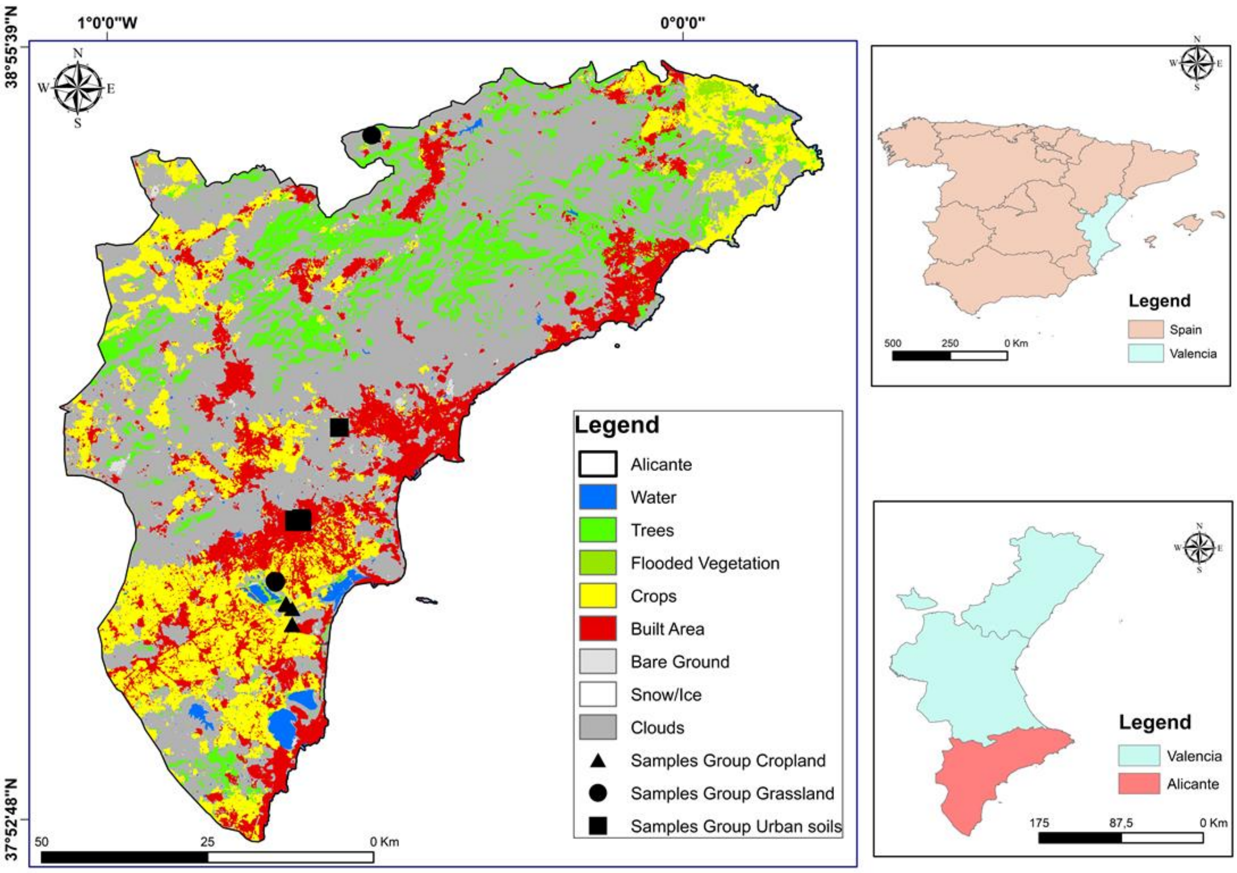

Figure 1. Location of sampling areas of this study.

All samples were air-dried at 105 °C, and the soil moisture and bulk density were then determined. The samples were then delicately disaggregated to pass through a 2 mm mesh sieve, with the coarse fragments (>2 mm) set aside. For fine earth, the determined soil properties were texture (soil granulometry), pH, electrical conductivity (EC), equivalent calcium carbonate, organic carbon and matter, and Kjeldahl nitrogen.

pH is used as an indicator of acidity, electrical conductivity is mainly used as an indicator of salinity, the total carbonate content reflects carbonate accumulation, and organic matter is usually linked to the addition of organic fertilizers by farmers, among other practices, such as those associated with the increasing of soil carbon storage to mitigate climate change [47]. Soil bulk density is crucial for estimating changes in soil organic carbon (SOC) stocks, as it varies with land use, and therefore needs to be considered in the calculations [48].

Soil texture was assessed according to the USDA using the Bouyoucos densimeter method [49], and pH and EC were measured at a temperature of 25 °C using the procedure described by the United States Salinity Laboratory, with a soil/water ratio of 1/2.5 (w/v) for the pH and 1/5 (w/v) for the EC [50]. Soil moisture (SM) content was gravimetrically assessed by drying the soil at 105 °C for 24 h, while the equivalent calcium carbonate content ($CaCO_3$) was assessed through the acid digestion method utilizing a calcimeter [51]. Soil bulk density (BD) was assessed using the core method [52]. The SOM was estimated using two methods: loss on ignition, known as the LOI method [53,54], giving the total SOM_{LOI} content, and the Walkley–Black method [55], in which oxidable organic carbon (%) is given as OC_{WB}. Next, the percentage of oxidizable soil organic matter (SOM_{WB}) was obtained by applying the conversion factor of 1.742 [56]. Soil nitrogen (SN) was analyzed using the Kjeldahl method [57,58]. The SOC and SN stocks were determined according to each selected depth of land use using the equations proposed by Pearson et al. (2007) [59].

$$\text{SOC stock} = \text{BD} \times \text{D} \times \text{C} \quad (1)$$

$$\text{SN stock} = \text{BD} \times \text{D} \times \text{N} \quad (2)$$

where

SOC = soil organic carbon stock per unit area in t ha^{-1};
BD = soil bulk density in g cm^{-3};
D = depth of soil horizon at which the sample was taken in cm;
C = organic carbon concentration in %;
SN = soil nitrogen stock per unit area in t ha^{-1};
N = nitrogen concentration in %.

Figure 2. Sampling areas for cropland soil (**A**), grassland soil (**B**), and urban soil (**C**).

2.3. Statistical Analysis

The descriptive statistics applied to the soil samples included parameters such as the mean, maximum (max), minimum (min), and standard deviation (SD). The confidence interval (CI) based on Student's t-distribution and ANOVA F-tests (in the tables, means with the same letter indicate a homogenous group in which the samples are not significantly different) were also applied to statistically test the equality of means at a significance level of 0.05.

3. Results

3.1. Soil Basic Properties

Table 1 provides information on the primary characteristics of the physicochemical parameters measured in the soils corresponding to the three types of studied LULC: cropland, grassland, and urban soils.

Table 1. Descriptive statistics and F test of the soil parameters analyzed for each land use.

Land Use Type		Clay (%)	Loam (%)	Sand (%)	SM (%)	BD (Mg/m^3)	pH	EC (dS/m)	$CaCO_3$ (%)	SOM_{LOI} (g/kg)	OC_{WB} (g/kg)	SOM_{WB} (g/kg)	SN (g/kg)
Cropland	Min	5.7	56.1	11.7	3.1	1.06	7.50	0.19	8.77	36.9	7.3	12.6	0.86
	Max	12.2	82.5	35	28	1.31	8.30	9.26	11.70	73.9	31.1	53.6	3.06
	Mean	7	74.1	18.9	7.6	1.20	7.90	2.04	10.04	53.3	18.4	31.7	1.79
	SD	1.6	7.7	6.6	5.6	0.07	0.26	2.09	0.64	10.4	5.9	10.1	0.68
	CI	0.7	3.2	2.7	2.3	0.03	0.11	0.86	0.27	0.43	0.24	0.4	0.03
	F test	a	a	a	a	a	a	a	a	a	a	a	a
Grassland	Min	5.7	30.9	21.3	7.0	1.03	7.10	0.17	8.22	24.5	5.5	09.4	0.34
	Max	16.4	72.3	63.3	39.4	1.50	8.20	0.45	10.54	72.8	25.2	43.4	2.42
	Mean	8.8	50.3	40.1	13.8	1.28	8.00	0.30	9.50	39.8	13.2	22.7	1.23
	SD	4.2	13.1	14.6	0.7	0.13	0.13	0.10	0.70	13.2	0.6	10.9	0.56
	CI	2.1	6.5	7.3	4.7	0.07	0.07	0.05	0.35	0.66	0.3	0.5	0.05
	F test	b	b	b	b	b	b	b	a	a	a	a	a
Urban Soil	Min	5.74	38.2	25.8	2.9	1.27	8.08	0.13	4.13	21.0	2.7	4.6	0.20
	Max	7	68.1	55.6	12.3	1.60	8.90	2.41	19.14	42.8	11.5	19.8	1.33
	Mean	6.2	54.5	39.3	5.6	1.42	8.58	0.83	12.95	29.5	7.4	12.7	0.51
	SD	0.39	9.4	9.19	2.3	0.07	0.28	0.75	4.68	7.0	2.5	4.3	0.36
	CI	0.2	4.7	4.6	1.1	0.04	0.14	0.37	2.33	0.34	0.1	0.2	0.02
	F test	c	b	b	c	b	ac	c	b	b	b	b	b

Min = minimum; Max = maximum, SD = standard deviation, CI = confidence interval.

From Table 1, it can be seen that the main soil textures are silt, silt loam, and sandy loam for all the soil samples. The siltiest soils were found to be located in the cultivation areas. Soil texture influences soil carbon storage, as fine soil particles can favor the formation of clay–humus complexes and preserve soil organic matter [60]. Although soil moisture varies greatly on the soil surface as a result of the environmental conditions and soil management (for instance, irrigation), the obtained values reveal that a low percentage of water was retained in the topsoil (0–5 cm depth). The highest mean value was, however, found in grassland, probably because some of the samples correspond to mountainous regions. The bulk density values were lower in cropland and grassland and higher in urban soils, reflecting the compaction expected in the disturbed soils of urban areas.

The mean pH values were close to 8 in cropland and grassland, but urban soils evidenced a higher pH. The electrical conductivity was in the range of 0.19–9.26 dS/m, representing the non-saline to highly saline soils in cropland areas associated with the presence of some samples close to the salt flats of Santa Pola and the Natural Park of el Hondo (Alicante), the non-saline soils of grassland zones, and the urban soils, exhibiting a certain variability, ranging from 0.13 to 2.41 dS/m. In general, moderate to high EC values are frequent in this region, where geological factors in combination with a semiarid climate and intensive agricultural practices create conditions that contribute to elevated salinity on the surface [61]. The equivalent calcium carbonate content of these soils showed an average percentage close to or slightly over 10%, although the differences between urban soils and the others were statistically significant, with a higher amount of carbonate found in urban areas.

The soil organic matter estimated using LOI, SOM_{LOI}, varied in the order cropland > grassland > urban soils. Nevertheless, no statistical significance between cropland and grassland was found, which differed from urban soil, where the mean value was the lowest. This corroborates the negative effect of human activities on urban soils, diminishing the soil organic matter and increasing the bulk density.

The values for oxidable organic carbon (OC_{WB}), obtained by applying the Walkley–Black method, followed the same trend as SOM_{LOI}. SOM_{WB} was estimated, and the results are given under the values estimated by LOI, confirming that differences are found between both techniques in estimating the total content of soil organic matter. Finally, as with the soil organic matter, the Kjeldahl nitrogen content of the soils follows the sequence cropland > grassland > urban soil.

3.2. SOC and SN Stocks across Land Use Systems

In all soils, the contents of soil organic carbon and soil nitrogen were higher in cropland and grassland than in urban soil. The values for the C/N ratio, calculated based on consideration of the parameters OC_{WB} and SN, are shown in Table 2. Cropland and grassland farming systems gave values of the C/N ratio close to 10. The C/N ratio is directly shaped by factors like land use/cover, the introduced amendments, fertilization intensity, and the rate of organic matter decomposition [62]. In our study, the C/N ratio was higher in urban soil than in cropland and grassland (Table 2), which means there is less organic matter decomposition than in farming systems, as indicated by other studies [63].

Table 2. C/N ratio, soil organic matter, soil organic carbon, and Kjeldahl nitrogen stocks corresponding to different land use types in the first 5 cm of topsoil.

Land Use	C/N	SOM_{LOI} Stock t ha^{-1}	SOM_{WB} Stock t ha^{-1}	SOC Stock t ha^{-1}	SN Stock t ha^{-1}
Cropland	10.27	31.980	19.020	11.040	1.074
Grassland	10.73	25.472	14.528	8.448	0.787
Urban soil	14.51	20.945	9.017	5.254	0.362

The results for estimation of the contents of soil organic matter stocks using the LOI and Walkley–Black methods, and the organic carbon (Walkley–Black) and Kjeldahl nitrogen stocks based on the previous equations [59], are shown in Table 2.

The obtained results indicate that the highest stocks of organic carbon and nitrogen in the first 5 cm of the soil are associated with cropland use. In such agricultural systems, the extended use of organic amendments and the contribution of plant remains from crops can favor an increase in organic matter, as appears to be the case. Grassland areas, which are used for grazing and pasture, have less SOM stock. It is important to consider that although grass is the food for livestock and no organic fertilization is carried out, cattle waste provides the soil with a source of organic matter. It is possible, however, that the contribution of organic matter to soil will decrease and, as a consequence, there will be a reduction in carbon storage. Urban soils exhibit the lowest stocks of carbon and nitrogen, which can accordingly be attributed to the lower sources of organic matter added to the soil.

4. Discussion

As previously mentioned, soil organic carbon and nitrogen play a key role in determining soil quality, and their relationships can be assessed to determine their effect on soil carbon storage [26,27,64,65]. Differences in carbon storage between different soil types reflect variations in a number of factors, including management practices and soil fertility [66], but the C/N ratio, which is determined by the type of land use, should also be considered. The influence of crop management practices has been demonstrated in several meta analyses [67–69].

In research on the impact of land management by West and Post (2002), Lu et al. (2021), and Du et al. (2020) [70–72] considering agricultural soils, it was found that no-tillage, rotation diversity, manure amendment after a long experimental implementation period, and cover cropping can favor soil organic carbon (SOC) and soil nitrogen (SN) sequestration compared with conventional techniques, especially in the top 20 cm of soil [69].

These findings were also validated by other studies [73–75] demonstrating the influence of crop residue on the accumulation of soil organic carbon (SOC) in the topsoil.

Enhancements in soil organic carbon (SOC) within the same soil profile positively influence soil fertility parameters, leading to improvements in soil structure [76,77]. The first few centimeters of soil arguably represent the most dynamic part, with exchange between soil and atmosphere, and the addition of organic matter to the surface has an important role as a source of greenhouse gases or as a carbon sink.

Our results are consistent with the majority of related studies, affirming significant variations in the distribution and storage of soil organic carbon (SOC) and soil nitrogen (SN) associated with land use/cover and management practices [78,79].

The study by Birch and Friend [80] showed that SOC and SN concentrations were higher in land when used for irrigation-based fruit production rather than rainfed crop production, but tillage led to a decrease in SN and SOC contents [81].

Conversely, other studies, such as in west–central Indiana (USA) [82], have reported higher stocks of SOC and SN in grassland than in cropland, which can be affected by many factors, including soil depth, vegetation cover, and climate [83]. Puget and Lal [38] noted that at a depth of 0–5 cm, the SOC stock was more than 1.5 times greater for a Mollisol used as pastureland than for forest soils in central Ohio. This difference is a reflection of the higher density of grass roots in the upper layer.

Gelaw et al. [84] stated that the concentration of SOC/SN stocks in the 0–5 cm topsoil in tree- and grass-based land use systems compared to rainfed crop production signifies the risk of releasing large amounts of CO_2 from the surface soil when converting from these land use types to arable land use.

In their study, Wang et al. [85] discovered that the conversion from cropland to pasture or permanent forest yields the most significant increase in soil carbon and nitrogen storage. Conversely, conversion from nearly all other land use types to cropland or other monocultures resulted in a decrease in storage values. This underscores the importance of adopting sustainable land management practices to enhance soil quality.

In the same way, the study carried out by Li et al. [86] showed that cultivation practices generally lead to soil compaction, reduced litterfall, and increased exposure of physically preserving particulate organic matter to rapid oxidation, resulting in a reduction in soil organic carbon and total nitrogen, especially in soil corresponding to the first 0–5 cm in depth.

On the other hand, the carbon stocks in urban soils, particularly organic carbon, remain among the least explored carbon reservoirs. Traditionally, studies on urban ecosystems have been overlooked by ecologists and soil scientists [87,88]. The study by Vasnev et al. [89] indicates that urban SOC should not be ignored in regional and global carbon assessments and the urban SOC content significantly exceeds the non-urban SOC content.

The study of Martín et al. (2019) [90] revealed that forestlands generally have higher SOC contents compared to grasslands and croplands in Spain. However, we speculate that environmental factors were likely dominant in contributing to those observations, as forests are usually situated on higher lands and in soils of low interest for agriculture. In our study, cropland exhibited higher stocks of SOC and SN compared to other land cover types, such as grassland and urban soil. This observation is aligned with the results reported by Guan et al. (2015) [58]. In another study carried out in the Basque Country of Spain, Ganuza and Almendros (2003) [91] reported that soil organic carbon (SOC) and soil nitrogen (SN) reached maximum values in pasture soils.

The observations from our results are consistent with those of Mendoza-Ponce and Galicia (2010) [92], where land use and land cover change (LULCC) seem to play a dominant role in carbon and nitrogen storage due to the uneven distribution in different land use types. Based on these results, it is recommended to adopt regulations that encourage the use of cover crops to enhance soil organic carbon (SOC) and nitrogen storage as well as those that promote cover cropping, diverse crop rotations, and no-till practices. Livestock management regulations and wetland protection contribute to improving soil. Appropriate manure management regulations and urban planning for green spaces can further boost carbon sequestration and soil fertility for various land use methods.

The influence of land use change on soil organic carbon (SOC) extends beyond the surface soil, with notable relative changes observed in the subsoil. This underscores the significance of conducting sufficiently deep soil sampling [48]. Based on this consideration, a limitation of our study is that storing rates may have been overestimated if decreases occurred at depths in the soil profile greater than those we assessed. Further work is required to understand the findings in order to direct future research toward a more thorough exploration of variations in soil organic carbon (SOC) and soil nitrogen (SN) sequestration at greater depths. However, the findings of this study can contribute to comprehending the role of soil as an organic carbon sink and, moreover, represent the addition of some valuable data for use toward understanding the results obtained from using remote sensing techniques, which mainly detect the surface properties of soil with low depth penetration.

5. Conclusions

In the studied semiarid area, cropland had higher levels of soil carbon and nitrogen storage than the other analyzed areas corresponding to different types of land use, probably due to the addition of organic amendments and plant residues. In grassland, the use of grass to feed livestock seems to result in the reduced addition of plant waste and, consequently, carbon storage. In contrast, urban soils exhibited the lowest levels of carbon and nitrogen storage.

Our results are in line with several previously mentioned studies. However, additional research is necessary to gain a better understanding of the potential for enhancing soil organic carbon (SOC) and soil nitrogen (SN) storage under various types of land use in semiarid regions impacted by changing environmental conditions.

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References

1. Brevik, E.C.; Cerdà, A.; Mataix-Solera, J.; Pereg, L.; Quinton, J.N.; Six, J.; Van Oost, K. The interdisciplinary nature of SOIL. *Soil* **2015**, *1*, 117–129. [CrossRef]
2. Veni, V.G.; Srinivasarao, C.; Reddy, K.S.; Sharma, K.L.; Rai, A. Soil health and climate change. In *Climate Change and Soil Interactions*; Elsevier: Amsterdam, The Netherlands, 2020; pp. 751–767.
3. Mao, X.; Zheng, J.; Yu, W.; Guo, X.; Xu, K.; Zhao, R.; Xiao, L.; Wang, M.; Jiang, Y.; Zhang, S.; et al. Climate-induced shifts in composition and protection regulate temperature sensitivity of carbon decomposition through soil profile. *Soil Biol. Biochem.* **2022**, *172*, 108743. [CrossRef]
4. Bradford, M.A.; Weider, W.R.; Bonan, G.B.; Fierer, N.; Raymond, P.A.; Crowther, T.W. Managing uncertainty in soil carbon feedbacks to climate change. *Nat. Clim. Chang.* **2016**, *6*, 751–758. [CrossRef]
5. Bongiorno, G.; Bünemann, E.K.; Oguejiofor, C.U.; Meier, J.; Gort, G.; Comans, R.; Mäder, P.; Brussaard, L.; De Goede, R. Sensitivity of labile carbon fractions to tillage and organic matter management and their potential as comprehensive soil quality indicators across pedoclimatic conditions in Europe. *Ecol. Indic.* **2019**, *99*, 38–50. [CrossRef]
6. Kooch, Y.; Ehsani, S.; Akbarinia, M. Stratification of soil organic matter and biota dynamics in natural and anthropogenic ecosystems. *Soil Tillage Res* **2020**, *200*, 104621. [CrossRef]
7. Gualberto, A.V.S.; de Souza, H.A.; Sagrilo, E.; Araujo, A.S.F.; Mendes, L.W.; de Medeiros, E.V.; Pereira, A.P.D.; Costa, D.P.; Vogado, R.F.; Cunha, J.R.; et al. Organic C Fractions in Topsoil under Different Management Systems in Northeastern Brazil. *Soil Syst.* **2023**, *7*, 11. [CrossRef]
8. Pires, D.; Orlando, V.; Collett, R.L.; Moreira, D.; Costa, S.R.; Inácio, M.L. Linking nematode communities and soil health under climate change. *Sustainability* **2023**, *15*, 11747. [CrossRef]

9. McGuire, A.D.; Anderson, L.G.; Christensen, T.R.; Dallimore, S.; Guo, L.; Hayes, D.J.; Heimann, M.; Lorenson, T.D.; Macdonald, R.W.; Roulet, N. Sensitivity of the carbon cycle in the Arctic to climate change. *Ecol. Monogr.* **2009**, *79*, 523–555. [CrossRef]
10. Ren, W.; Banger, K.; Tao, B.; Yang, J.; Huang, Y.; Tian, H. Global pattern and change of cropland soil organic carbon during 1901-2010: Roles of climate, atmospheric chemistry, land use and management. *Geogr. Sustain.* **2020**, *1*, 59–69. [CrossRef]
11. Ren, W. Towards an Integrated Agroecosystem Modeling Approach for Climate-Smart Agriculture Management. In *Bridging among Disciplines by Synthesizing Soil and Plant Processes*; ASA, CSSA, SSSA: Madison, WI, USA, 2019; Volume 8, pp. 127–144.
12. Fiorini, A.; Boselli, R.; Maris, S.C.; Santelli, S.; Ardenti, F.; Capra, F.; Tabaglio, V. May conservation tillage enhance soil C and N accumulation without decreasing yield in intensive irrigated croplands? Results from an eight-year maize monoculture. Agriculture. *Ecosyst. Environ.* **2020**, *296*, 106926. [CrossRef]
13. Deng, L.; Wang, G.L.; Liu, G.B.; Shangguan, Z.P. Effects of age and land-use changes on soil carbon and nitrogen sequestrations following cropland abandonment on the Loess Plateau, China. *Ecol. Eng.* **2016**, *90*, 105–112. [CrossRef]
14. Zhang, R.; Zhao, X.; Zhang, C.; Li, J. Impact of rapid and intensive land use/land cover change on soil properties in arid regions: A case study of Lanzhou new area, China. *Sustainability* **2020**, *12*, 9226. [CrossRef]
15. Johansson, E.; Muneer, F.; Prade, T. Plant Breeding to Mitigate Climate Change—Present Status and Opportunities with an Assessment of Winter Wheat Cultivation in Northern Europe as an Example. *Sustainability* **2023**, *15*, 12349. [CrossRef]
16. Zhu, C.; Wang, Z.; Ji, B.; Wang, J.; Xu, C.; Xie, B. Measurement and Spatial Econometric Analysis of Forest Carbon Sequestration Efficiency in Zhejiang Province, China. *Forests* **2022**, *13*, 1583. [CrossRef]
17. Zhang, Z.; He, J.; Huang, M.; Zhou, W. Is Regulation Protection? Forest Logging Quota Impact on Forest Carbon Sinks in China. *Sustainability* **2023**, *15*, 13740. [CrossRef]
18. Zhou, X.; Zhou, Y.; Zhou, C.; Wu, Z.; Zheng, L.; Hu, X.; Chen, H.; Gan, J. Effects of cutting intensity on soil physical and chemical properties in a mixed natural forest in southeastern China. *Forests* **2015**, *6*, 4495–4509. [CrossRef]
19. McSherry, M.E.; Ritchie, M.E. Effects of grazing on grassland soil carbon: A global review. *Glob. Chang. Biol.* **2013**, *19*, 1347–1357. [CrossRef]
20. Shekhovtseva, O.G.; Mal'tseva, I.A. Physical, chemical, and biological properties of soils in the city of Mariupol, Ukraine. *Eurasian Soil Sci.* **2015**, *48*, 1393–1400. [CrossRef]
21. Olorunfemi, I.E.; Fasinmirin, J.T.; Olufayo, A.A.; Komolafe, A.A. Total carbon and nitrogen stocks under different land use/land cover types in the Southwestern region of Nigeria. *Geoderma Reg.* **2020**, *22*, e00320. [CrossRef]
22. Hillel, D.; Hatfield, J.H.; Powlson, D.S.; Rosenzweig, C.; Scow, K.M.; Singer, M.J.; Sparks, D.L. *Encyclopedia of Soils in the Environment*; Elsevier/Academic Press: Amsterdam, The Netherlands, 2005.
23. Liu, X.; Li, T.; Zhang, S.; Jia, Y.; Li, Y.; Xu, X. The role of land use, construction and road on terrestrial carbon stocks in a newly urbanized area of western Chengdu, China. *Landsc. Urban Plan.* **2016**, *147*, 88–95. [CrossRef]
24. Zambon, I.; Benedetti, A.; Ferrara, C.; Salvati, L. Soil matters? A multivariate analysis of socioeconomic constraints to urban expansion in Mediterranean Europe. *Ecol. Econ.* **2018**, *146*, 173–183. [CrossRef]
25. Pouyat, R.V.; Trammell, T.L. Climate change and urban forest soils. *Dev. Soil Sci.* **2019**, *36*, 189–211.
26. Dikgwatlhe, S.B.; Chen, Z.D.; Lal, R.; Zhang, H.L.; Chen, F. Changes in soil organic carbon and nitrogen as affected by tillage and residue management under wheat–maize cropping system in the North China Plain. *Soil Tillage Res.* **2014**, *144*, 110–118. [CrossRef]
27. Shao, Y.; Xie, Y.; Wang, C.; Yue, J.; Yao, Y.; Li, X.; Liu, W.; Zhu, Y.; Guo, T. Effects of different soil conservation tillage approaches on soil nutrients, water use and wheat-maize yield in rainfed dry-land regions of North China. *Eur. J. Agron* **2016**, *81*, 37–45. [CrossRef]
28. Mahdi, S.S.; Choudhury, S.R.; Gupta, S.K.; Jan, R.; Bangroo, S.A.; Bhat, M.A.; Wani, O.A.; Bahar, F.A.; Dhekale, B.; Dar, S.A. Impact of Climate Change on Soil Carbon-Improving Farming Practices Reduces the Carbon Footprint. In *Innovative Approaches for Sustainable Development: Theories and Practices in Agriculture*; Springer: Cham, Switzerland, 2022; pp. 299–310.
29. Gao, M.; Zhu, F.; Hobbie, E.A.; Zhu, W.; Li, S.; Gurmesa, G.A.; Wang, A.; Fang, X.; Zhu, J.; Gundersen, P.; et al. Effects of nitrogen deposition on carbon allocation between wood and leaves in temperate forests. *Plants People Planet* **2023**, *5*, 267–280. [CrossRef]
30. Chen, Q.; Hu, Y.; Hu, A.; Niu, B.; Yang, X.; Jiao, H.; Ri, X.; Song, L.; Zhang, G. Shifts in the dynamic mechanisms of soil organic matter transformation with nitrogen addition: From a soil carbon/nitrogen-driven mechanism to a microbe-driven mechanism. *Soil Biol. Biochem.* **2021**, *160*, 108355. [CrossRef]
31. Tang, B.; Rocci, K.S.; Lehmann, A.; Rillig, M.C. Nitrogen increases soil organic carbon accrual and alters its functionality. *Glob. Chang. Biol.* **2023**, *29*, 1971–1983. [CrossRef] [PubMed]
32. Wang, C.; Wang, X.; Zhang, Y.; Morrissey, E.; Liu, Y.; Sun, L.; Qu, L.; Sang, C.; Zhang, H.; Li, G.; et al. Integrating microbial community properties, biomass and necromass to predict cropland soil organic carbon. *ISME Commun.* **2023**, *3*, 86. [CrossRef]
33. Jiang, Z.; Zhong, Y.; Yang, J.; Wu, Y.; Li, H.; Zheng, L. Effect of nitrogen fertilizer rates on carbon footprint and ecosystem service of carbon sequestration in rice production. *Sci. Total Environ.* **2019**, *670*, 210–217. [CrossRef]
34. Keller, A.B.; Borer, E.T.; Collins, S.L.; DeLancey, L.C.; Fay, P.A.; Hofmockel, K.S.; Leakey, A.D.B.; Mayes, M.A.; Seabloom, E.W.; Walter, C.A.; et al. Soil carbon stocks in temperate grasslands differ strongly across sites but are insensitive to decade-long fertilization. *Glob. Chang. Biol.* **2022**, *28*, 1659–1677. [CrossRef]
35. Chen, J.; Xiao, W.; Zheng, C.; Zhu, B. Nitrogen addition has contrasting effects on particulate and mineral-associated soil organic carbon in a subtropical forest. *Soil Biol. Biochem.* **2020**, *142*, 107708. [CrossRef]

36. Sun, T.; Mao, X.; Han, K.; Wang, X.; Cheng, Q.; Liu, X.; Zhou, J.; Ma, Q.; Ni, Z.; Wu, L. Nitrogen addition increased soil particulate organic carbon via plant carbon input whereas reduced mineral− associated organic carbon through attenuating mineral protection in agroecosystem. *Sci. Total Environ.* **2023**, *899*, 165705. [CrossRef] [PubMed]
37. Abbas, F.; Hammad, H.M.; Ishaq, W.; Farooque, A.A.; Bakhat, H.F.; Zia, Z.; Cerdà, A. A review of soil carbon dynamics resulting from agricultural practices. *J. Environ. Manag.* **2020**, *268*, 110319. [CrossRef] [PubMed]
38. Puget, P.; Lal, R. Soil organic carbon and nitrogen in a Mollisol in central Ohio as affected by tillage and land use. *Soil Tillage Res.* **2005**, *80*, 201–213. [CrossRef]
39. Baker, J.M.; Ochsner, T.E.; Venterea, R.T.; Griffis, T.J. Tillage and soil carbon sequestration-what do we really know? *Agric. Ecosyst. Environ.* **2007**, *118*, 1–5. [CrossRef]
40. Chazarra Bernabé, A.; Flórez García, E.; Peraza Sánchez, B.; Tohá Rebull, T.; Lorenzo Mariño, B.; Criado Pinto, E.; Moreno García, J.V.; Romero Fresneda, R.; Botey Fullat, R. Mapas Climáticos de España (1981–2010) y ETo (1996–2016). Available online: https://www.aemet.es/es/conocermas/recursos_en_linea/publicaciones_y_estudios/publicaciones/detalles/MapasclimaticosdeEspana19812010 (accessed on 31 January 2024).
41. Melendez-Pastor, I.; Hernández, E.I.; Navarro-Pedreño, J.; Almendro-Candel, M.B.; Gómez Lucas, I.; Jordán Vidal, M.M. Occurrence of pesticides associated with an agricultural drainage system in a mediterranean environment. *Appl. Sci.* **2021**, *11*, 10212. [CrossRef]
42. Brevik, E.C. An introduction to soil science basics. In *Soils and Human Health*; Brevik, E.C., Burgess, L.C., Eds.; CRC Press: Boca Raton, FL, USA, 1997; pp. 3–28.
43. Coughenour, M.B.; Chen, D.X. Assessment of grassland ecosystem responses to atmospheric change using linked plant–soil process models. *Ecol. Appl.* **1997**, *7*, 802–827.
44. Hättenschwiler, S.; Handa, I.T.; Egli, L.; Asshoff, R.; Ammann, W.; Körner, C. Atmospheric CO2 enrichment of alpine treeline conifers. *New Phytol.* **2002**, *156*, 363–375. [CrossRef]
45. IUSS Working Group WRB. *World Reference Base for Soil Resources 2014, Update 2015 International Soil Classification System for Naming Soils and Creating Legends for Soil Maps*; World Soil Resources Reports No. 106; FAO: Rome, Italy, 2015.
46. Niñerola, V.B.; Navarro-Pedreño, J.; Lucas, I.G.; Pastor, I.M.; Vidal, M.M.J. Geostatistical assessment of soil salinity and cropping systems used as soil phytoremediation strategy. *J. Geochem. Explor.* **2017**, *174*, 53–58. [CrossRef]
47. Navarro-Pedreño, J.; Almendro-Candel, M.B.; Zorpas, A.A. The increase of soil organic matter reduces global warming, myth or reality? *Science* **2021**, *3*, 18. [CrossRef]
48. Don, A.; Schumacher, J.; Freibauer, A. Impact of tropical land-use change on soil organic carbon stocks—A meta-analysis. *Glob. Chang. Biol.* **2011**, *17*, 1658–1670. [CrossRef]
49. Gee, G.W.; Or, D. Particle-size analysis. In *Methods of Soil Analysis*; Part 4. Physical Methods; Campbell, G., Horton, R., Jury, W.A., Nielsen, D.R., van Es, H.M., Wierenga, P.J., Dane, J.H., Topp, G.C., Eds.; SSSA, ASA: Madison, WI, USA, 2002; pp. 255–294.
50. U.S. Salinity Laboratory Staff. *Diagnosis and Improvement of Saline and Alkali Soils*; Handbook No. 60; United States Department of Agriculture: Washington, DC, USA, 1954; 160p.
51. Perry, R.S.; Adams, J.B. Desert varnish: Evidence for cyclic deposition of manganese. *Nature* **1978**, *276*, 489–491. [CrossRef]
52. Blake, G.R.; Hartge, K.H. Bulk density. In *Methods of Soil Analysis*, 2nd ed.; Part 1, Physical and Mineralogical Methods; Agronomy Monograph 9, American Society of Agronomy-Soil Science Society of America: Madison, WI, USA, 1986; pp. 363–375.
53. Gustafsson, Ö.; Haghseta, F.; Chan, C.; MacFarlane, J.; Gschwend, P.M. Quantification of the dilute sedimentary soot phase: Implications for PAH speciation and bioavailability. *Environ. Sci. Technol.* **1996**, *31*, 203–209. [CrossRef]
54. Poot, A.; Quik, J.T.; Veld, H.; Koelmans, A.A. Quantification methods of Black Carbon: Comparison of Rock-Eval analysis with traditional methods. *J. Chromatogr. A* **2009**, *1216*, 613–622. [CrossRef] [PubMed]
55. Walkley, A.; Black, I.A. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil Sci.* **1934**, *37*, 29–38. [CrossRef]
56. Shamrikova, E.V.; Kondratenok, B.M.; Tumanova, E.A.; Vanchikova, E.V.; Lapteva, E.M.; Zonova, T.V.; Lu-Lyan-Min, E.I.; Davydova, A.P.; Libohova, Z.; Suvannang, N. Transferability between soil organic matter measurement methods for database harmonization. *Geoderma* **2022**, *412*, 115547. [CrossRef]
57. Bremner, J.M. Nitrogen-total. In *Methods of Soil Analysis*; Part 3 Chemical Methods; Sparks, D.L., Page, A.L., Helmke, P.A., Loeppert, R.H., Soltanpour, P.N., Tabatabai, M.A., Johnston, C.T., Sumner, M.E., Eds.; SSSA, ASA: Madison, WI, USA, 1996; pp. 1085–1121.
58. Guan, F.; Tang, X.; Fan, S.; Zhao, J.; Peng, C. Changes in soil carbon and nitrogen stocks followed the conversion from secondary forest to Chinese fir and Moso bamboo plantations. *Catena* **2015**, *133*, 455–460. [CrossRef]
59. Pearson, T.R. *Measurement Guidelines for the Sequestration of Forest Carbon (Vol. 18)*; US Department of Agriculture, Forest Service, Northern Research Station: Madison, WI, USA, 2007.
60. Schillaci, C.; Acutis, M.; Lombardo, L.; Lipani, A.; Fantappie, M.; Märker, M.; Saia, S. Spatio-temporal topsoil organic carbon mapping of a semi-arid Mediterranean region: The role of land use, soil texture, topographic indices and the influence of remote sensing data to modelling. *Sci. Total Environ.* **2017**, *601*, 821–832. [CrossRef]
61. Benslama, A.; Khanchoul, K.; Benbrahim, F.; Boubehziz, S.; Chikhi, F.; Navarro-Pedreño, J. Monitoring the variations of soil salinity in a palm grove in Southern Algeria. *Sustainability* **2020**, *12*, 6117. [CrossRef]

62. Tedone, L.; Alhajj Ali, S.; De Mastro, G. The Effect of Tillage on Faba Bean (*Vicia faba* L.) Nitrogen Fixation in Durum Wheat ((Triticum turgidum L. subsp. Durum (Desf))-Based Rotation under a Mediterranean Climate. *Agronomy* **2022**, *13*, 105. [CrossRef]
63. Lou, Y.; Xu, M.; Chen, X.; He, X.; Zhao, K. Stratification of soil organic C, N and C: N ratio as affected by conservation tillage in two maize fields of China. *Catena* **2012**, *95*, 124–130. [CrossRef]
64. Chen, B.; Coops, N.C. Understanding of coupled terrestrial carbon, nitrogen and water dynamics—An overview. *Sensors* **2009**, *9*, 8624–8657. [CrossRef] [PubMed]
65. Xia, L.; Xia, Y.; Li, B.; Wang, J.; Wang, S.; Zhou, W.; Yan, X. Integrating agronomic practices to reduce greenhouse gas emissions while increasing the economic return in a rice-based cropping system. *Agric. Ecosyst. Environ.* **2016**, *231*, 24–33. [CrossRef]
66. Ngo, K.M.; Turner, B.L.; Muller-Landau, H.C.; Davies, S.J.; Larjavaara, M.; bin Nik Hassan, N.F.; Lum, S. Carbon stocks in primary and secondary tropical forests in Singapore. *For. Ecol. Manag.* **2013**, *296*, 81–89. [CrossRef]
67. Guo, L.B.; Gifford, R.M. Soil Carbon Stocks and Land Use Change: A Meta Analysis. *Glob. Chang. Biol.* **2002**, *8*, 345–360. [CrossRef]
68. Berthrong, S.T.; Jobbágy, E.G.; Jackson, R.B. A global meta-analysis of soil exchangeable cations, pH, carbon, and nitrogen with afforestation. *Ecol. Appl.* **2009**, *19*, 2228–2241. [CrossRef] [PubMed]
69. Poeplau, C.; Don, A.; Vesterdal, L.; Leifeld, J.; Van Wesemael, B.A.S.; Schumacher, J.; Gensior, A. Temporal dynamics of soil organic carbon after land-use change in the temperate zone–carbon response functions as a model approach. *Glob. Chang. Biol.* **2011**, *17*, 2415–2427. [CrossRef]
70. West, T.O.; Post, W.M. Soil organic carbon sequestration rates by tillage and crop rotation: A global data analysis. *Soil Sci. Soc. Am. J.* **2002**, *66*, 1930–1946. [CrossRef]
71. Lu, X.; Hou, E.; Guo, J.; Gilliam, F.S.; Li, J.; Tang, S.; Kuang, Y. Nitrogen addition stimulates soil aggregation and enhances carbon storage in terrestrial ecosystems of China: A meta-analysis. *Glob. Chang. Biol.* **2021**, *27*, 2780–2792. [CrossRef]
72. Du, Y.; Cui, B.; Wang, Z.; Sun, J.; Niu, W. Effects of manure fertilizer on crop yield and soil properties in China: A meta-analysis. *Catena* **2020**, *193*, 104617. [CrossRef]
73. Mishra, U.; Ussiri, D.A.N.; Lal, R. Tillage effects on soil organic carbon storage and dynamics in Corn Belt of Ohio USA. *Soil Tillage Res.* **2010**, *107*, 88–96. [CrossRef]
74. Dong, W.; Hu, C.; Chen, S.; Zhang, Y. Tillage and residue management effects on soil carbon and CO_2 in a wheat–corn double-cropping system. *Nutr. Cycl. Agroecosyst.* **2008**, *83*, 27–37. [CrossRef]
75. Tedone, L.; Verdini, L.; De Mastro, G. Effects of Different Types of Soil Management on Organic Carbon and Nitrogen Contents and the Stability Index of a Durum Wheat–Faba Bean Rotation under a Mediterranean Climate. *Agronomy* **2023**, *13*, 1298. [CrossRef]
76. Ljubičić, N.; Popović, V.; Ćirić, V.; Kostić, M.; Ivošević, B.; Popović, D.; Pandžić, M.; El Musafah, S.; Janković, S. Multivariate Interaction Analysis of Winter Wheat Grown in Environment of Limited Soil Conditions. *Plants* **2021**, *10*, 604. [CrossRef] [PubMed]
77. Kostić, M.; Ljubičić, N.; Ivošević, B.; Popović, S.; Radulović, M.; Blagojević, D.; Popović, V. Spot-based proximal sensing for field-scale assessment of winter wheat yield and economical production. *Agric. For.* **2021**, *67*, 103–113. [CrossRef]
78. Wu, H.; Guo, Z.; Peng, C. Land use induced changes of organic carbon storage in soils of China. *Glob. Chang. Biol.* **2003**, *9*, 305–315. [CrossRef]
79. Bárcena, T.G.; Kiær, L.P.; Vesterdal, L. Soil carbon stock change following afforestation in northern Europe: A meta-analysis. *Glob. Chang. Biol.* **2014**, *20*, 2393–2405. [CrossRef]
80. Birch, H.F.; Friend, M.T. The organic-matter and nitrogen status of East African soils. *J. Soil Sci.* **1956**, *7*, 156–168. [CrossRef]
81. Ali, S.A.; Tedone, L.; Verdini, L.; Cazzato, E.; De Mastro, G. Wheat response to no-tillage and nitrogen fertilization in a long-term faba bean-based rotation. *Agronomy* **2019**, *9*, 50. [CrossRef]
82. Omonode, R.A.; Vyn, T.J. Vertical distribution of soil organic carbon and nitrogen under warmseason native grasses relative to croplands in westcentral Indiana, USA. *Agric. Ecosyst. Environ.* **2006**, *117*, 159–170. [CrossRef]
83. Liu, Q.; Xu, C.; Han, S.; Li, X.; Kan, Z.; Zhao, X.; Zhang, H. Strategic tillage achieves lower carbon footprints with higher carbon accumulation and grain yield in a wheatmaize cropping system. *Sci. Total Environ.* **2021**, *798*, 149220. [CrossRef]
84. Gelaw, A.M.; Singh, B.R.; Lal, R. Soil organic carbon and total nitrogen stocks under different land uses in a semi-arid watershed in Tigray, Northern Ethiopia. *Agric. Ecosyst Environ.* **2014**, *188*, 256–263. [CrossRef]
85. Wang, T.; Kang, F.; Cheng, X.; Han, H.; Ji, W. Soil organic carbon and total nitrogen stocks under different land uses in a hilly ecological restoration area of North China. *Soil Tillage Res.* **2016**, *163*, 176–184. [CrossRef]
86. Li, Y.; Han, J.; Wang, S.; Brandle, J.; Lian, J.; Luo, Y.; Zhang, F. Soil organic carbon and total nitrogen storage under fifferent land uses in the Naiman Banner, a semiarid degraded region of northern China. *Can. J. Soil Sci.* **2014**, *94*, 9–20. [CrossRef]
87. Byrne, L.B. Habitat structure: A fundamental concept and framework for urban soil ecology. *Urban Ecosyst.* **2007**, *10*, 255–274. [CrossRef]
88. Grimm, N.B.; Grove, J.G.; Pickett, S.T.; Redman, C.L. Integrated approaches to long-term studies of urban ecological systems: Urban ecological systems present multiple challenges to ecologists—Pervasive human impact and extreme heterogeneity of cities, and the need to integrate social and ecological approaches, concepts, and theory. *BioScience* **2000**, *50*, 571–584.
89. Vasenev, V.I.; Stoorvogel, J.J.; Vasenev, I.I. Urban soil organic carbon and its spatial heterogeneity in comparison with natural and agricultural areas in the Moscow region. *Catena* **2013**, *107*, 96–102. [CrossRef]

90. Martín, J.R.; Álvaro-Fuentes, J.; Gonzalo, J.; Gil, C.; Ramos-Miras, J.J.; Corbí, J.G.; Boluda, R. Assessment of the soil organic carbon stock in Spain. *Geoderma* **2016**, *264*, 117–125. [CrossRef]
91. Ganuza, A.; Almendros, G. Organic carbon storage in soils of the Basque Country (Spain): The effect of climate, vegetation type and edaphic variables. *Biol. Fertil. Soils* **2003**, *37*, 154–162. [CrossRef]
92. Mendoza-Ponce, A.; Galicia, L. Aboveground and belowground biomass and carbon pools in highland temperate forest landscape in Central Mexico. *Forestry* **2010**, *83*, 497–506. [CrossRef]