Eurasian Journal of Soil Science 2025, 14(1), 9 - 21

Eurasian Journal of Soil Science

Journal homepage : http://ejss.fesss.org

Changing soil characteristics as affected by different land uses in a humid region, west of Iran

Pariya Heidari *, Mohammad Feizian

Department of Soil Science, Lorestan University, P.O. Box 68151-44316, Khorramabad, Iran

Article Info
Received : 17.03.2024
Accepted : 30.09.2024
Available online: 08.10.2024

Author(s)
P.Heidari *
M.Feizian

* Corresponding author

Abstract

Land use change, mostly from forest to conventional agriculture, has a detrimental impact on soil health and production. However, the impact of such LUC on soil biological characteristics is unknown. This study aimed to evaluate some of the physicochemical and biological properties of soil with varied land uses in the southwestern Khorramabad area. The research locations comprised diverse land use types including coniferous forest, broadleaf forest, farmland, and rangeland. According to the findings, there was no significant variation in bulk density (ρb) and bulk density at 33 kPa ($ρb_{33}$) for various land uses, but there was a significant difference between different soil layers. The amount of clay and silt varies dramatically across land uses. However, the quantity of sand used did not differ significantly across the usage (p <0.05). The results showed that the highest and lowest values of soil pH were observed in the coniferous forest and rangeland, respectively. Although the EC in coniferous forests was greater (0.17 dS m^{-1}) than in other land uses, there was no significant difference in the average soil EC in various land uses (p <0.01). In terms of soil organic carbon (SOC), the greatest value was found in broadleaf forests with an average of 1.517 (ton/ha), while the lowest content was observed in farmland with an average of 0.797 (ton/ha). The findings showed that there is a significant difference in soil nitrogen averages across different land uses followed by the decreasing order of broadleaf forest (0.11%)> rangeland (0.06%)> Farmland (0.05%)> coniferous forest (0.03%). The findings also suggested that the quantity of microbial respiration has considerably declined in all locations as land use has shifted from forest to pasture and farmland. Notably, farmland includes the greatest population of fungi, bacteria, and actinomycetes, with a significant difference from other uses (p <0.01). Additionally, the relationship between OC and other soil factors is the most significant in this study.

Keywords: Land use, Biological properties, Soil organic carbon, Lorestan province.

Introduction

In recent decades, there has been a growing concern about rising atmospheric greenhouse gas concentrations and global warming. Climate change has now become a major problem for all countries, causing significant effects on the environment, such as temperature rises, which have contributed to ecosystem deterioration (De Stefano and Jacobson, 2018; Mukherjee et al., 2024). Climate change has an impact on vegetation and species composition by modifying soil moisture and temperature regimes, as well as nutrient cycles, and changes in biomass (*i.e.*, material residues, aerial and subsurface biomass) seem to have an impact on organic carbon (OC) storage and cycling (Aminiyan et al., 2016; Kim et al., 2023; Yang et al., 2024). As a consequence, the soil's physical and chemical qualities are affected (Aminiyan et al., 2015a; Nadal-Romero et al., 2023).

The major axis of soil quality and health is soil organic carbon (SOC). Soil, being a main source of atmospheric carbon, may help to reduce greenhouse gas emissions by reducing carbon dioxide generation (Aryal et al.,

: https://doi.org/10.18393/ejss.1564167
: https://ejss.fesss.org/10.18393/ejss.1564167
Publisher : Federation of Eurasian Soil Science Societies
e-ISSN : 2147-4249

2020; Nave et al., 2024). In other words, soils are both a sink and a source of carbon, making them an essential component of the global carbon cycle with roughly 1206 Pg OC in the top 1 m depth, much exceeding the atmospheric carbon store (800 Pg) (Zdruli et al., 2017). Carbon storage in soil and plants revealed that about 60% of SOC is stored in the first 20 cm of soil surface (Ramesh et al., 2019). As a result, even a minor increase in soil carbon stores has a significant impact on decreasing greenhouse gas emissions into the environment (Basheer et al., 2024; Kopittke et al., 2024). Carbon sequestration, or flux of carbon, is a potential option for mitigating climate change by turning atmospheric CO_2 into stabilized SOC for a long time in soil, which also improves soil quality (Smith et al., 2020; Benslama et al., 2024). Demand for agricultural and forestry products will continue to rise as a result of population expansion and industrial progress, and consumption patterns will move toward products that have larger overall environmental impacts (Clerici et al., 2019; Payen et al., 2020). Agriculture and forestry are important contributors to ecosystem degradation and biodiversity loss (Aminiyan et al., 2018; Ekka et al., 2023).

Nowadays, the conversion of forests to rangelands or agricultural lands has become a major cause of environmental degradation and global climate change all over the world (Barati et al., 2023). Land use change is considered as the second greatest cause of carbon emissions after fuel consumption (Ramesh et al., 2019; Benslama et al., 2024). Reduced biomass-C inputs (i.e. roots, litter fall) and losses due to increased erosion and dissolved organic C leaching diminish SOC reserves when natural and agricultural ecosystems are converted (Aminiyan et al., 2015b; Tiefenbacher et al., 2021). As a result, land use change combined with poor management is one of the primary causes of greenhouse gas emissions and global warming in recent decades (Liu et al., 2023).

Forest soils have always been considered due to their high organic matter (OM) content and suitable structure (Kooch et al., 2023; Nave et al., 2024). However, changes in their management and use along with tillage practices generally have a major impact on the amount of soil organic matter (SOM) and other soil physical and chemical properties (Voltr et al., 2021; Yadav et al., 2021). One of the most important studies on environmental change is the connection between land use change and soil properties (Eze et al., 2023).

Land use changes and agricultural activity can negatively impact soil physical and chemical properties, leading to a considerable decrease in SOM and nutrients, porosity, fertility, aggregate stability, hydraulic conductivity, increased bulk density, increased erosion rate, and accelerated degradation of soil (Asmare et al., 2023; Ekka et al., 2023; Mirghaed and Souri, 2023; Ma et al., 2024). For instance, Padbhushan et al. (2022) reported that soils under natural forests had 36.1% higher SOM compared to converted croplands. Additionally, they reported that conversion of natural vegetation to pasture typically increases soil pH. This change is often due to the application of fertilizers and lime to enhance grass growth, which can lead to higher soil alkalinity (Padbhushan et al., 2022). It has been found that deforestation also increases soil erosion rates and bulk density, and reduces porosity, aggregate stability, and hydraulic conductivity (Molla et al., 2022). Cultivated lands have much lower levels of SOC, total nitrogen (TN), and available phosphorus compared to natural forests and pastures, thereby soils under natural forests had 36.1% higher organic carbon than converted croplands (Matano et al., 2015). Cultivation diminishes soil carbon within a few years of initial conversion from forest (Gebresamuel et al., 2022). The conversion of forest to cropland increases bulk density and reduces porosity and aggregate stability (Tellen and Yerima, 2018). Therefore, soil quality indices differed across all land uses and management regimes, revealing that the most essential systems in sustaining soil quality were natural forests and protected regions, whereas developed lands had much lower physical features (Zhao et al., 2021).

So far, numerous researchers have also investigated the effect of replacing natural and degraded forests with artificial forests on carbon sequestration and have highlighted the relevance of such studies (Liu et al., 2024; Wang et al., 2021). The comparison of SOC in natural pastures under wheat cultivation and areas under cultivation of perennial rangeland species indicated that the lowest amount of SOC was in the area under wheat cultivation (Saurabh et al., 2021). Additionally, the amount of SOC in the areas under cultivation of perennial rangeland species was close to natural rangeland (McGowan et al., 2019). As a result, studying changes in the physical, chemical, and biological characteristics of soil in various uses can not only demonstrate the implications and consequences of this transition but also help us figure out how to address the problem and avoid additional soil damage in these places (Tellen and Yerima, 2018; Voltr et al., 2021; Yadav et al., 2021).

Land-use changes in Iran have been more rapid in the last 50 years than at any time in Iran's history and are expected to continue at this rate or accelerate in the future (Azizi et al., 2022). Anthropogenic activities are degrading the rangelands of Iran, mostly due to land use change and subsequent intense rainfed or irrigated farming (Soleimani et al., 2019). The conversion of natural virgin rangelands into orchards and rainfed farmlands is the most typical land use change in the Lorestan province, west of Iran (Japelaghi et al., 2019). There has been a lack of research in this area so far to investigate the changes in soil characteristics and C sequestration in diverse land uses due to the unique climatic conditions of Lorestan Province and its varied land uses. The primary objective of this study was therefore to evaluate some of the physicochemical and biological properties of soil with varied land uses in the south-western Khorramabad area. The findings of this study might be useful in controlling and forecasting unfavorable changes caused by land use changes in other parts of the province.

Material and Methods

Study area

Lorestan province is located in the west of Iran between 66° 51’-50° 3’ E longitude and 32° 37’-34° 22’ N latitude (Figure 1). Its altitude is 1160 meters above sea level. The province is located in the west of the country and the middle part of the Zagros Mountains and along the two rainy aerial fronts of the Mediterranean from the west and the Indian Ocean from the south, which has significant and potential resources. The average annual temperature for a period of 25 years is 17.9°C, which has a thermal heating regime, and the warmest month of July is 30.1°C, and the lowest temperature is related to January with a temperature of 6.1°C. The average monthly rainfall of Khorramabad station is 519 mm, which has a humid regime and the highest rainfall is from November to April, the months of June to September are dry and the rainfall is almost zero. The area of the Lorestan province is 28300 ha. The soil humidity and thermal regimes are xeric and thermic, respectively. Moreover, the studied soils are under the category of Inseptisol with calcareous rock parent material.

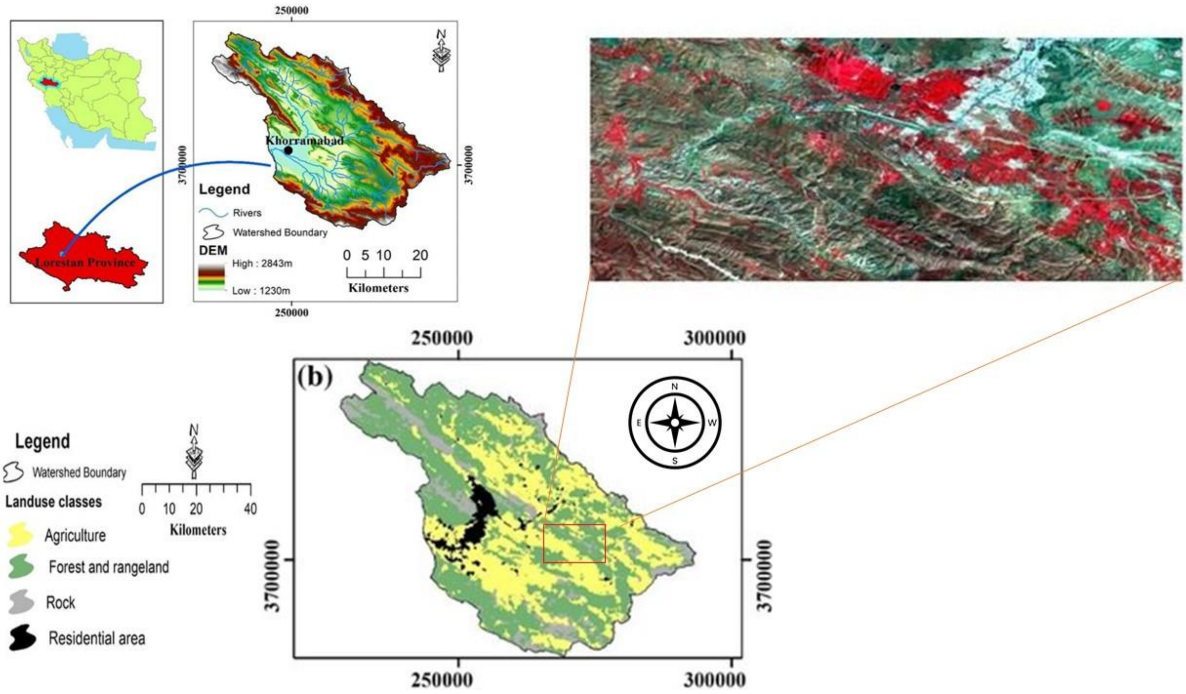


Figure 1. The map of the studied area in the Khorramabad region

Sampling, treatment, and analysis of soil

8 soil samples were randomly taken from the body of soil profiles for each of four land uses (i.e., farmland, coniferous forest, broadleaf forest, and rangeland) in three replications. In doing so, around 10 kg of the soil was taken from each land use and quickly transported to the lab. Afterward, the samples were spread on dry paper and air-dried. Then, the soil was sieved to remove gravel, large roots, and plant residues using an 8-mm sieve followed by a 2-mm sieve in preparation for further procedures. One kilogram of each sample was transferred to the laboratory in plastic bags and inside an ice flask and stored at 4 °C for biological analyses. The percentage of sand, silt, and clay was determined using the hydrometer method (Gee and Or, 2002). Soil

pH, and electrical conductivity (EC) were measured in a 1:2.5 (soil: water) extraction by a pH-meter (Metrohm) and an EC-meter (Metrohm), respectively (Rayment and Lyons, 2011). The content of total organic carbon in soil samples was analyzed by the modified Walkley and Black method (Aminiyan et al., 2015b; Walkley and Black, 1934). Also, total nitrogen (TN) was determined using the Kjeldahl method (Bremner, 1996), and soil available phosphorous by the Olsen method (Peperzak et al., 1959).

Soil bulk density (ρb) in undisturbed soil samples was measured with cylinders. To estimate BD at 33 kPa moisture content the following formula was employed, which was established by (Kern, 1994).

$$\rho b_{33} = (\rho b_{OD}\ 0.880) + 0.046 \qquad \text{Eq (1)}$$

where ρb_{33} was bulk density at 33 kPa moisture and ρb_{OD} was oven-dried bulk density.

The colony count technique was utilized to estimate the quantity of bacteria, fungi, and actinomycetes. The fresh soil solution was sequentially diluted with saline buffer to produce an optimum number of colonies on each plate. The media of nutrient agar (NA) bacteria, potato dextrose agar (PDA) for fungi, and rose Bengal starch casein nitrate agar (RBSCNA) for actinomycetes were utilized (Aminiyan et al., 2018). Briefly, in doing so, the fresh soil suspension was serially diluted with saline buffer to obtain an appropriate number of colonies on each plate. Each dilution was plated in triplicate and the population was expressed as the number of colonies forming units (log CFU. g^{-1} soil). After preparing each specific media in plates 0.1 ml of soil suspension of each serial dilution was spread across the plates (spread plate method). The plates were incubated at 28 °C for 3, 4, and 14 days for bacteria, fungi, and actinomycetes, respectively.

Moreover, the Isermeyer technique was used to determine soil respiration (Isermeyer, 1952). The 50 grams of soil samples (weighted dry equivalent) were wet to 80% of their water-holding capacity with distilled water and placed in sealed jars containing 25 mL of 0.5 M NaOH. For basal respiration (BR), the samples were incubated at 25 °C for 7 days, followed by titration of NaOH with 0.25 M HCl (Aminiyan et al., 2018).

Statistical data analysis

After data collection, Kolmogorov–Smirnov test was applied to investigate the normal distribution of data at a confidence level of 95%. Statistical analyses such as descriptive statistics were conducted by MS Excel 2016. Also, one-way analyses of variance (ANOVA) were used for the mean comparison using SPSS Version 19 at 5% (p<0.05) and 1% (p<0.01) significant levels.

Results and Discussion

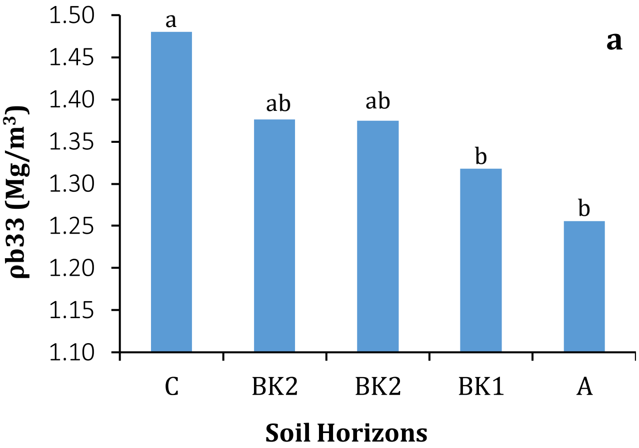
Soil physical properties

The results did not show a significant difference between bulk density (ρb) and bulk density at 33 kPa (ρb_{33}) at different land uses (Table 1), while did show a significant difference (p <0.05) between different soil horizons (Figure 2a,b). The average of ρb ranged from 1.29 to 1.36 (Mg/m^3) in all studied land uses. Additionally, the average of ρb_{33} varied from 1.41 to 1.49 (Mg/m^3) in the studied land uses. The lowest ρb_{33} was observed in broadleaf forests, while the highest was observed in farmland (Table 1). As illustrated in Figure 2a,b, ρb_{33} and ρb exhibited a significant difference, which increased at the surface horizons and decreased with increasing depth, owing to the reduction in organic matter with depth. Hajabbasi et al. (2007) found no significant change in ρb as a consequence of land use change in their investigations, which is in line with the findings of this study. As also shown in Figure 2a,b, ρb rises with increasing depth in the studied land uses. It can be expected that tillage and topsoil disturbance reduce organic matter and consequently soil degradation, thus reducing soil pores and increasing ρb (Li et al., 2021). Therefore, the ρb increases with the lowering of the proportion of SOM, lightening of texture, and disintegration of soil structure during forest-to-farmland conversion (Antón et al., 2021).

Table 1. The mean content of soil bulk density (ρb) in undisturbed soil, soil bulk density at 33 kPa (ρb_{33}) moisture, and mean percentage of sand, silt, and clay particles for all studied land uses (p <0.05)

Land-use Type	ρb_{33} (Mg/m^3)	ρb (Mg/m^3)	Sand (%)	Silt (%)	Clay (%)	Soil Texture
Coniferous forest	1.29 a	1.42 a	17.99 b	29.70 ab	52.31 a	Clay
Broadleaf Forest	1.29 a	1.41 a	22.08 ab	30.23 ab	42.97 b	Clay, Clay loam
Rangeland	1.33 a	1.46 a	23.70 a	31.68 a	44.62 b	Clay, Clay loam
Farmland	1.36 a	1.49 a	20.25 ab	27.43 b	52.28 a	Clay

The different letters indicate the mean difference is statistically significant at the level of 0.05 among the treatments (p <0.05)



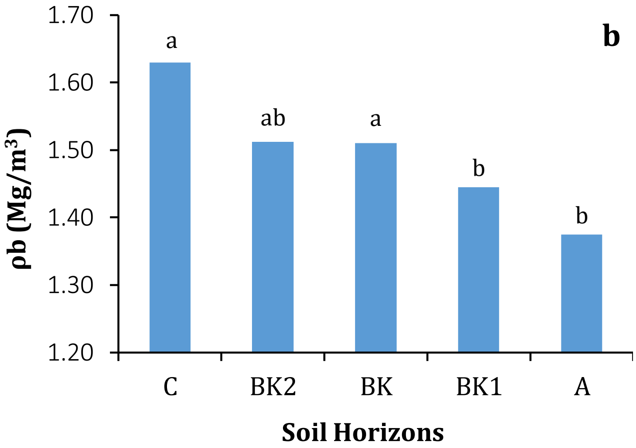


Figure 2. The mean comparison of a) ρb33 and b) ρb (Mg/m^3) in all studied land uses. The different letters indicate the mean difference is statistically significant at the level of 0.05 among the treatments (p <0.05)

The soil texture is a critical component of the soil that affects the capacity of the soil to store water, aeration, temperature, CEC, and the ability to provide nutrients, as well as plant development and reproduction. According to Table 1, the quantity of clay and silt significantly differed across the land uses. However, there was no significant change in the amount of sand across the uses (p <0.05). As overall can be seen in all land uses, clay content was >42% (ranging from 42.97 to 52.31%), and silt and sand contents were <32 (ranging from 27.43% to 31.68%) and 24% (ranging from 17.99% to 23.7%), respectively. Based on the USDA classification, soil texture ranged from clay to clay loam classes (Table 1). Accordingly, clay class was the dominant texture in coniferous forests and farmland, while clay and clay loam textures were simultaneously found in broadleaf forests and rangeland (Table 1). The results of some earlier studies showed that soil texture changes as a consequence of land-use change, with a considerable reduction in soil clay and enhancement in silt content due to erosion, loss of surface layers, and exposure of deep layers in rangeland use (Khormali and Shamsi, 2009; Nazari, 2013). By changing moisture availability and nutrient delivery to microbial degradation, soil texture may also affected in the forest area (Manral et al., 2020). These results were in accordance with our findings.

Soil chemical properties

Soil reaction or pH indicates soil acidity or alkalinity. Changes in agricultural land use could greatly affect the availability of nutrient substances like nitrogen (N), phosphorus (P), and other nutrients by modifying soil qualities including texture, structure, organic matter, and pH (Asmare et al., 2023; Hasanpori et al., 2020; Qi et al., 2018). Land use change is one of the factors that has an impact on soil quality. The pH level of the soil was evaluated for various land uses because pH impacts many soil characteristics and because land use change might affect pH level and soil calcium carbonate (Boroumand et al., 2015; Tellen and Yerima, 2018; Hasanpori et al., 2020).

As illustrated in Figure 3a, soil pH varied from 7.31–7.57 in the different land-use systems. The coniferous forest had the highest soil pH, whereas rangeland had the lowest (Figure 3a). The slightly high level of soil pH is most likely due to management practices like fertilization. This also might be owing to the applied chemical fertilizers, increased organic matter decomposition, and increased carbon dioxide and soluble carbonate leaching as a result of soil deterioration (Rad et al., 2018). In past investigations, it has been reported that the change in land use from rangeland to farmland increased soil pH (Boroumand et al., 2015; Hashemi Rad et al., 2018; Tellen and Yerima, 2018). The findings of Qi et al. (2018) showed that for all investigated land uses, soil pH was much lower in the top layer than in the lower layer, despite no significant variations across the land uses. However, land use change in the southwestern region of Khorramabad has not affected soil pH (Hasanpori et al., 2020). Because soil pH depends on the soil's parent material, the changes that occur during formation depend on rainfall (Augusto et al., 2017). Given that the studied land uses have the same parent materials and are in the same climatic zone, their pH has not changed. Although the EC in the coniferous forest was higher (0.17 dS m^{-1}) than in the other land uses, the average of soil EC in different land uses did not show a significant difference (p <0.01) (Figure 3b). EC measures the concentration of soluble salts, can vary due to differences in vegetation type, root architecture, and organic matter decomposition, which may lead to higher salt concentrations in coniferous forests compared to other land uses (Teramage et al., 2023). Also, vegetation cover plays a significant role in influencing soil electrical conductivity (EC) variability through various mechanisms related to soil chemistry, moisture retention, and organic matter dynamics (Szymański et al., 2019). Therefore, alteration in EC can be attributed to the uniformity of parent materials, vegetation cover, and the stabilizing effects of climate. In this context reported that no significant difference observed between the EC of forest and rangeland soils. Therefore, the earlier reported results were consistent with our findings (Rad et al., 2018; Varasteh Khanlari et al., 2019). The amount of SOM is a key indicator of its productivity (Wang et al., 2018). Because of its determining effects on the physical, chemical, and biological properties of the soil, such as the ability to keep and provide water, the nutrient cycle, plant root growth, current intensity of gases, and soil preservation. The SOM also plays a key role in soil quality stability, crop production, and environmental quality (Aminiyan et al., 2018; Ramesh et al., 2019; Smith et al., 2020). In terms of SOC, there is a substantial difference between various land uses (p <0.01) (Table 2). This table reveals that SOC content was the greatest in broadleaf forests with an average of 1.517 (ton/ha), while was the lowest in farmland use with an average of 0.797 (ton/ha). It indicates agricultural activities have a role in lowering SOC because plowing accelerates the degradation of soil organic materials (Nayak et al., 2019). Also, the plowing can lead to the discharge of OC from the soil solum as a result of carbon mineralization and CO_2 gas emission (Wasige et al., 2014; Yellajosula et al., 2020). Another factor contributing to the loss of SOM is the intensification of erosion in agricultural regions. Soil erosion rises as a result of land use change, and OM with a high carbon content is transferred to the surface soil (da Cunha et al., 2021; Telo da Gama et al., 2021). Furthermore, during tillage operations, deep soil layers with a lower percentage of OC are mixed with a surface layer with a greater percentage of OC, resulting in a reduction in topsoil OC relative to the initial state (Saurabh et al., 2021; Zhang et al., 2022). Raiesi and Beheshti (2022) also showed that the conversion of rangelands into farmlands significantly reduces SOM. Carbon is stored as OM in the soil, but these reserves are affected by farming. When pastures are cultivated, the amount of SOC begins to decrease, and this reduction depends on climatic factors and the intensity of cultivation (Yellajosula et al., 2020; Kooch et al., 2021).

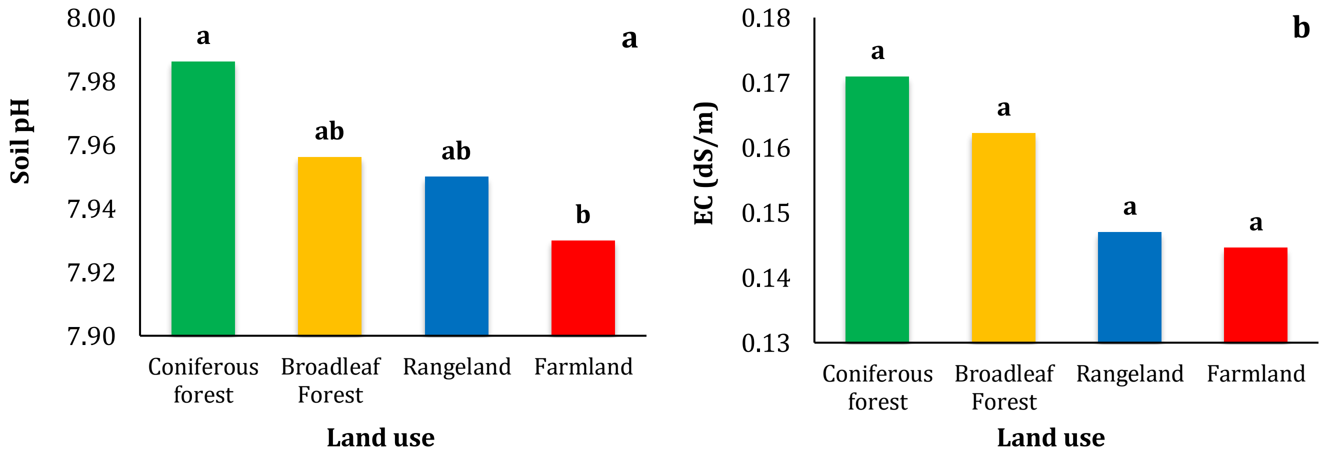


Figure 3. The mean comparison of a) soil pH and b) EC (dS/m) in all studied land uses. The different letters indicate the mean difference is statistically significant at the level of 0.05 among the treatments (p <0.05)

The findings demonstrate that there is a considerable difference between the averages of soil nitrogen in various land uses (Table 2). The TN value in the broadleaf forest is considerably different from other land uses (p <0.05). As also given in Table 2, the content of TN in the land uses followed the decreasing order of broadleaf forest (0.11%)> rangeland (0.06%)> Farmland (0.05%)> coniferous forest (0.03%). Nitrogen has been identified as the most critical soil component determining SOC level in several recent studies (Qiu et al., 2018; Jahangir et al., 2021; Wu et al., 2021). The vertical and horizontal distributions of TN concentration and stock were influenced by anthropogenic disturbance. This is confirmed by the findings of this study, which found that natural land use categories had greater nutrient levels than either agricultural or urban areas. Greater SOC and TN concentrations in forestry areas may be attributed to higher residue decomposition from surface litter inputs that enhanced SOC (Nwaogu et al., 2018). The increase in SOC content has been closely associated with an increase in TN content (Diwediga et al., 2017). On the other side, low levels of SOC and TN as found in farmland and rangeland may be explained by poor soil conditions due to the use of plant residues as animal food and fuel, as well as unsustainable management approaches which exacerbated soil erosion (Li et al., 2017; Rezapour and Alipour, 2017; da Cunha et al., 2021). The conversion of crop wastes to humus and the increase in soil aeration due to plowing cause a decline in soil nitrogen, which results in an increase in soil microorganisms and the disruption of soil nitrogen balance (Fenton et al., 2018; Gaël et al., 2021).

Consequently, agricultural activities and practices can lead to the accelerated decomposition and mineralization of the available OM, thereby lowering SOC and TN concentrations and stocks (Aguilera-Huertas et al., 2021; Wei et al., 2021).

Table 2. Mean content of soil organic carbon (SOC) (ton/ha) and the percentage of total nitrogen (TN %) in the studied land uses

Land-use type	SOC (ton/ ha)	TN (%)
Broadleaf Forest	1.5173 a	0.10950 a
Rangeland	1.0951 b	0.06063 b
Coniferous forest	0.9319 bc	0.03875 b
Farmland	0.7970 c	0.05550 b

The different letters indicate the mean difference is statistically significant at the level of 0.05 among the treatments ($p < 0.05$)

Soil biological properties

Land use change may impose a detrimental influence on soil microbial properties. As shown in Figure 4a, there is a significant variation in the rate of microbial respiration in different land uses ($p < 0.05$). Forest uses have the highest rate of microbial respiration, whereas arable land has the lowest (Figure 4a). Changes in SOC and soil moisture had the greatest impact on soil respiration (Aminiyan et al., 2018). The presence of greater SOM content in forest use is one of the causes of increased microbial activity and, as a result, microbial respiration (Wu et al., 2020). In agricultural uses, however, the soil is regularly plowed upside down, causing the aggregates to break down and exposing the organic matter inside to microbial attack (Aminiyan et al., 2015a).

The results indicated that the amount of microbial respiration has decreased dramatically in all sites as land use has changed from forest to pasture and arable land (Figure 4a). These results were consistent with the findings of Rasouli-Sadaghiani et al. (2018) and Zheng et al. (2019). One of the effective reasons for the existence of more microbial respiration in the forest ecosystem is the suitable conditions for microbial activity, including adequate carbon supply and the litter layer used by soil microorganisms (Soleimani et al., 2019). In an assessment of land use change on soil quality characteristics in Iran, (Zarafshar et al., 2020) found that microbial respiration in forest lands is greater than in arable lands. Bakhshandeh et al. (2019) showed that soil microbial respiration in agricultural lands is significantly less than in forest use. Because microbial respiration is an indicator of organic carbon mineralization, it is highest in places where organic carbon is the highest (Rasouli-Sadaghiani et al., 2018; Fan and Han, 2020). More microbial respiration is typically seen by soil scientists as a sign of high soil quality because greater microbial activity leads to higher microbial respiration (Babur et al., 2021). Moreover, Kooch et al. (2021a) reported that soil microbial respiration is greatly reduced as a result of forest degradation and farming, which supports the findings of this study.

As illustrated in Fig 4b, the largest population of fungi, bacteria, and actinomycetes is related to agricultural use and has a significant difference with other uses ($p < 0.01$). Bacteria are an essential component of soil microorganisms and make up the majority of the microbial population (Odelade and Babalola, 2019). As a result, they outnumber the whole population of fungi, algae, and protozoa because of their involvement in carbon and nitrogen cycles, as well as other modifications and interactions with higher plants (Aminiyan et al., 2018). Bacterial diversity reacted to changes in land use and soil properties (Wehr, 2018). The findings of Barnett et al. (2020) revealed that the greatest bacterial alpha diversity was found in agricultural soils, whereas the lowest was found in forest soils. They found that soil pH and land use have interactive impacts on bacterial community assembly, which changes depending on pH class. These findings support the idea that soil pH is a master variable that drives soil bacterial communities, but they also demonstrate the need to understand intricate interactions between soil pH and other soil properties in community formation. Yang et al. (2020) reported contrarily that the bacterial diversity of the forest and grassland samples was similar, and the clustering analysis revealed no significant differences in their communities between the two environments. In Hawaii, Brazil, and Ecuador, a comparison of bacterial populations from forest, rangeland, and sugarcane areas revealed that agricultural soils have a bigger microbial population than forest grounds (Wehr, 2018), which was in line with our findings.

Also, land use changes affect the structure of soil fungal populations such as population and diversity (Fernández-Bravo et al., 2021). Plant species in forest cover, grass species in rangeland cover, and other plant species in agriculture and a mixture of forest and agricultural cover (forest-crop) may play a key role in fungal changes (Mueller et al., 2014; Zarafshar et al., 2020). The role of fungi in soil is very complex. Fungi can affect the nutrient cycle of soil, have symbiotic and pathogenic communities with other plants and animals, and interact with other microorganisms (Deveau et al., 2018; Odelade and Babalola, 2019). Sui et al. (2019)

demonstrated that arable land and forest land had identical bacterial and fungal community patterns, whereas marsh wetland communities were different. They concluded that the key drivers of soil fungal community compositions as land use changed are soil pH, SOC, TN, accessible nitrogen, and total phosphorus concentrations.

Our results showed that actinomycetes have a higher population in farmland than in forest and rangeland (Figure 4b). In the study of Luo et al. (2020), it reveals that the actinobacteria in the secondary forest were significantly higher than in plantation forest land use. They also concluded that the soil microbial community composition was mainly controlled by TN and pH. Overall, altered land-use type initiated changes in the physicochemical characteristics of the soils, which affected the composition of microbial communities. Additionally, it could be concluded that the identity of affected microbial properties by various soil parameters under various land usages (i.e., type of soil physicochemical and biological characteristics) in the original ecosystem depends on the original nature of each ecosystem in different areas.

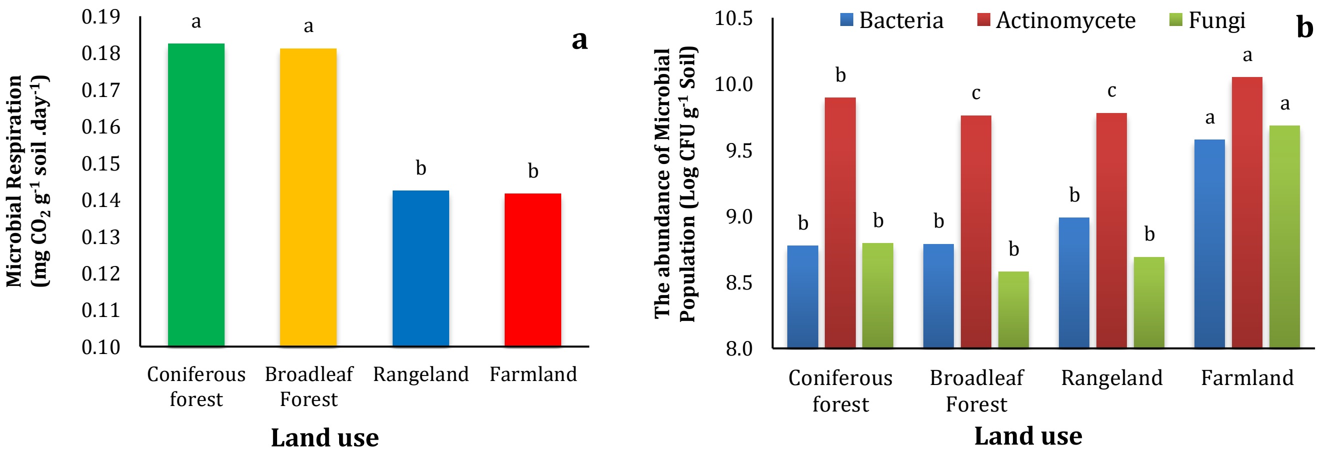


Figure 4 (a) Comparison of microbial respiration content (mg CO_2 g^{-1} soil day^{-1}) and (b) the abundance of Bacteria, Fungi, and Actinomycete (Log CFU g^{-1} soil) colonies between all of the land uses. The different letters indicate the mean difference is statistically significant at the level of 0.05 among the treatments (p <0.05)

Correlation analysis of soil properties

Examining the relationships between soil factors and the extent to which each of them is affected by each other will guide managers in controlling these factors in the desired direction (Table 3). The objective of this investigation into the interaction between soil qualities is to find out the relationship between SOC and other soil parameters as well as to identify the most essential factors impacting it.

Table 3. Correlation matrix for different soil characteristics in different land uses of Khoramabad region

16OC	Sand	Silt	Clay	ρb	EC	pH	TN	MR [a]	
OC	1								
Sand	0.38*	1							
Silt	0.37*	-0.25	1						
Clay	-0.61**	-0.75**	-0.37*	1					
ρb	-0.65**	-0.27	-0.22	0.42*	1				
EC	0.09	-0.20	0.02	0.18	-0.18	1			
pH	-0.00	-0.38*	-0.09	0.29	-0.10	0.27	1		
TN	0.97**	0.41	0.29	-0.59**	-0.62**	-0.15	0.27	1	
MR	0.60**	0.01	0.34	-0.23	0.52**	0.09	0.48**	0.47**	1

[a] MR: Microbial Respiration; * P<0.05; ** P<0.01

The findings of the soil factor correlation analysis reveal that the majority of the components analyzed have a significant relationship. The correlation between OC and other soil parameters is the most significant in this research. SOC had a strong relationship with TN (r= 0.971), ρb (r= -0.65), clay (r= -0.61), and microbial respiration (r= 0.60) at a level of (p <0.01). Also, a correlation was observed between SOC and sand and silt contents (p <0.05). However, no significant correlation was observed between SOC pH and EC (Table 3). A significant correlation between SOC and other properties has been reported in past studies, pointing to a significant correlation between organic carbon and soil reaction (Liu et al., 2021). However, Amighi et al. (2013) reported that there is no significant relationship between OC and pH, which is consistent with the results of the present study. Soil texture is also a relevant and influential factor in SOC and significant correlations have been observed between them (Varamesh et al., 2014). Also, another research noted a significant correlation between SOC and TN (El Tahir et al., 2009). Other studies have emphasized the significant relationship between SOC and TN levels (Wang et al., 2018). They consider nitrogen communication management as a very important precondition for maintaining SOC levels in forest ecosystems. Given the above, it can be said that proper management of factors affecting the amount of soil organic carbon, in addition to helping to increase levels and storage, will also help the sustainability of the ecosystem.

Conclusion

The results of the present study conducted in the southwestern region of Khorramabad city show that land use change had a significant impact on the physical, chemical, and biological properties of soil. The amount of carbon content was more significantly different than the other soil traits in different land uses. There was a significant correlation between SOC content and physical, chemical, and biological properties in soils with different uses. Among these, the strongest correlations are related to TN, ρb, and microbial respiration. The results of the current study showed that land use changes such as forest change to cultivated lands can significantly affect soil properties and change soil formation processes and is certainly the most important factor that affects the protection of natural ecosystems.

Acknowledgments

The authors express their gratitude to Lorestan University, Khorramabad, Iran, for funding this study. The authors also extend their sincere appreciation to the editor and the anonymous reviewers for evaluating the manuscript and offering valuable feedback to enhance the paper.

References

Aguilera-Huertas, J., Lozano-García, B., González-Rosado, M., Parras-Alcántara, L., 2021. Effects of management and hillside position on soil organic carbon stratification in mediterranean centenary olive grove. *Agronomy* 11(4): 650.

Amighi, S.J., Asgari, H., Sheikh, V.B., Sardo, M.S., 2013. Effects of agroforestry systems on carbon sequestration and improvement soil quality. *International Journal of Agriculture* 3(4): 822.

Aminiyan, M.M., Hosseini, H., Heydariyan, A., 2018. Microbial communities and their characteristics in a soil amended by nanozeolite and some plant residues: Short time in-situ incubation. *Eurasian Journal of Soil Science* 7(1): 9-19.

Aminiyan, M.M., Shorafa, M., Pourbabaee, A.A., 2024. Mitigating the detrimental impacts of low-and high-density polyethylene microplastics using a novel microbial consortium on a soil-plant system: Insights and interactions. *Ecotoxicology and Environmental Safety* 283: 116805.

Aminiyan, M.M., Sinegani, A.A.S., Sheklabadi, M., 2015a. Aggregation stability and organic carbon fraction in a soil amended with some plant residues, nanozeolite, and natural zeolite. *International Journal of Recycling of Organic Waste in Agriculture* 4(1): 11-22.

Aminiyan, M.M., Sinegani, A.A.S., Sheklabadi, M., 2015b. Assessment of changes in different fractions of the organic carbon in a soil amended by nanozeolite and some plant residues: incubation study. *International Journal of Recycling of Organic Waste in Agriculture* 4(4): 239-247.

Aminiyan, M.M., Sinegani, A.A.S., Sheklabadi, M., 2016. The effect of zeolite and some plant residues on soil organic carbon changes in density and soluble fractions: Incubation study. *Eurasian Journal of Soil Science* 5(1): 74-83.

Antón, R., Ruiz-Sagaseta, A., Orcaray, L., Arricibita, F.J., Enrique, A., Soto, I.d., Virto, I., 2021. Soil water retention and soil compaction assessment in a regional-scale strategy to improve climate change adaptation of agriculture in Navarre, Spain. *Agronomy* 11(3): 607.

Aryal, J.P., Sapkota, T.B., Khurana, R., Khatri-Chhetri, A., 2020. Climate change mitigation options among farmers in South Asia. *Environment, Development and Sustainability* 22(4): 3267-3289.

Asmare, T.K., Abayneh, B., Yigzaw, M., Birhan, T.A., 2023. The effect of land use type on selected soil physicochemical properties in Shihatig watershed, Dabat district, Northwest Ethiopia. *Heliyon* 9(5): e16038

Augusto, L., Achat, D.L., Jonard, M., Vidal, D., Ringeval, B., 2017. Soil parent material—A major driver of plant nutrient limitations in terrestrial ecosystems. *Global Change Biology* 23(9): 3808-3824.

Azizi, P., Soltani, A., Bagheri, F., Sharifi, S., Mikaeili, M., 2022. An integrated modelling approach to urban growth and land use/cover change. *Land* 11(10): 1715.

Babur, E., Dindaroğlu, T., Solaiman, Z.M., Battaglia, M.L., 2021. Microbial respiration, microbial biomass and activity are highly sensitive to forest tree species and seasonal patterns in the Eastern Mediterranean Karst Ecosystems. *Science of the Total Environment* 775: 145868.

Bakhshandeh, E., Hossieni, M., Zeraatpisheh, M., Francaviglia, R., 2019. Land use change effects on soil quality and biological fertility: a case study in northern Iran. *European Journal of Soil Biology* 95: 103119.

Barati, A.A., Zhoolideh, M., Azadi, H., Lee, J.-H., Scheffran, J., 2023. Interactions of land-use cover and climate change at global level: How to mitigate the environmental risks and warming effects. *Ecological Indicators* 146: 109829.

Barnett, S.E., Youngblut, N.D., Buckley, D.H., 2020. Soil characteristics and land-use drive bacterial community assembly patterns. *FEMS Microbiology Ecology* 96(1): fiz194.

Basheer, S., Wang, X., Farooque, A.A., Nawaz, R.A., Pang, T., Neokye, E.O., 2024. A review of greenhouse gas emissions from agricultural soil. *Sustainability* 16(11): 4789.

Benslama, A., Benbrahim, F., Navarro-Pedreño, J., Lucas, I.G., Vidal, M.M.J., Almendro-Candel, M.B., 2024. Organic carbon management and the relations with climate change. In: Frontier Studies in Soil Science. Núñez-Delgado, A. (Ed.). Springer, Cham. pp. 109-133.

Boroumand, M., Ghajar Sepalnou, M., Bahmanyar, M.A., Salek Gilani, S., 2015. Evaluation of the effects of land use change from forest areas into agricultural lands on some chemical properties of soil (Case Study: Zarin Abad, Sari, Iran). *Physical Geography Research Quarterly* 47(3): 435-449.

Bremner, J.M., 1996. Nitrogen-total. In: Methods of Soil Analysis: Part 3 Chemical Methods, 5.3. 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 Book Series No. 5. ASA-SSSA Madison WI, USA, pp. 1085– 1121.

Clerici, N., Cote-Navarro, F., Escobedo, F.J., Rubiano, K., Villegas, J.C., 2019. Spatio-temporal and cumulative effects of land use-land cover and climate change on two ecosystem services in the Colombian Andes. *Science of the Total Environment* 685: 1181-1192.

da Cunha, E.R., Santos, C.A.G., da Silva, R.M., Panachuki, E., de Oliveira, P.T.S., de Souza Oliveira, N., dos Santos Falcão, K., 2021. Assessment of current and future land use/cover changes in soil erosion in the Rio da Prata basin (Brazil). *Science of The Total Environment* 818: 151811.

De Stefano, A., Jacobson, M.G., 2018. Soil carbon sequestration in agroforestry systems: a meta-analysis. *Agroforestry Systems* 92(2): 285-299.

Deveau, A., Bonito, G., Uehling, J., Paoletti, M., Becker, M., Bindschedler, S., Hacquard, S., Hervé, V., Labbé, J., Lastovetsky, O.A., 2018. Bacterial–fungal interactions: ecology, mechanisms and challenges. *FEMS Microbiology Reviews* 42(3): 335-352.

Diwediga, B., Le, Q.B., Agodzo, S., Wala, K., 2017. Potential storages and drivers of soil organic carbon and total nitrogen across river basin landscape: The case of Mo river basin (Togo) in West Africa. *Ecological Engineering* 99: 298-309.

Ekka, P., Patra, S., Upreti, M., Kumar, G., Kumar, A., Saikia, P., 2023. Land Degradation and its impacts on biodiversity and ecosystem services. In: Land and Environmental Management through Forestry. Raj, A., Jhariya, M.K., Banerjee, A., Nerma, S., Bargali, K. (Eds.). Wiley & Sons. Inc. pp. 77-101.

Eze, S., Magilton, M., Magnone, D., Varga, S., Gould, I., Mercer, T.G., Goddard, M.R., 2023. Meta-analysis of global soil data identifies robust indicators for short-term changes in soil organic carbon stock following land use change. *Science of the Total Environment* 860: 160484.

Fan, L., Han, W., 2020. Soil respiration after forest conversion to tea gardens: A chronosequence study. *Catena* 190: 104532.

Fenton, T., Brown, J., Mausbach, M., 2018. Effects of long-term cropping on organic matter content of soils: implications for soil quality. In: Soil quality and soil erosion. Lal, R. (Ed.). CRC Press, pp. 95-124.

Fernández-Bravo, M., Gschwend, F., Mayerhofer, J., Hug, A., Widmer, F., Enkerli, J., 2021. Land-use type drives soil population structures of the entomopathogenic fungal genus Metarhizium. *Microorganisms* 9(7): 1380.

Gaël, M.O.R., Neil-Yohan, M., Alexis, N., Jeremy, S., Davi-Lin, M.E., Guirema, A.M., Aubin, O.J., Eric, R., Michel, M.M., 2021. Carbon and nitrogen stocks under various land cover in Gabon. *Geoderma Regional* 25: e00363.

Gebresamuel, G., Molla, B., Teka, K., Negash, E., Haile, M., Okolo, C.C., 2022. Changes in soil organic carbon stock and nutrient status after conversion of pasture land to cultivated land in semi-arid areas of northern Ethiopia. *Archives of Agronomy and Soil Science* 68(1): 44-60.

Gee, G.W., Or, D., 2002. Particle-size analysis. In: Methods of Soil Analysis: Part 4 Physical Methods, 5.4. Dane, J.H., Topp G.C. (Eds.), SSSA Book Series. Soil Science Society of America, Madison, Wisconsin, USA. pp. 255–293.

Hajabbasi, M., Basalatpour, A., Maleki, A., 2007. Effect of shifting rangeland to farmland on some physical and chemical properties of south and southwest soils of Isfahan. *Journal of Scince Technology of Agriculture Natural Resource* 11(42): 525-534. [in Persian]

Hasanpori, R., Sepehry, A., Barani, H., 2020. Effect of Rangeland Conversion to Dryland Farming on Soil Chemical Properties (Case study: Kian rangelands, Lorestan, Iran). *Journal of Rangeland Science* 10(1): 49-56. [in Persian]

Hashemi Rad, S., Kiani, F., Meftah Helghi, M., Hematzadeh, Y., 2018. Effect of land use on physical and chemical parameters of soil and sediment in Qarnave and Yelcheshme watersheds, Golestan Province, Iran. *Environmental Resources Research* 6(2): 89-102.

Isermeyer, H., 1952. Eine einfache Methode zur Bestimmung der Bodenatmung und der Karbonate im Boden. *Zeitschrift für Pflanzenernährung, Düngung, Bodenkunde* 56(1-3): 26-38.

Jahangir, M.M.R., Islam, S., Nitu, T.T., Uddin, S., Kabir, A.K.M.A., Meah, M.B., Islam, R., 2021. Bio-compost-based integrated soil fertility management improves post-harvest soil structural and elemental quality in a two-year conservation agriculture practice. *Agronomy* 11(11): 2101.

Japelaghi, M., Gholamalifard, M., Shayesteh, K., 2019. Spatio-temporal analysis and prediction of landscape patterns and change processes in the Central Zagros region, Iran. *Remote Sensing Applications: Society and Environment* 15: 100244.

Kern, J.S., 1994. Spatial patterns of soil organic carbon in the contiguous United States. *Soil Science Society of America Journal* 58(2): 439-455.

Khormali, F., Shamsi, S., 2009. Investigation of the quality and micromorphology of soil evolution in different landuses of a loess hillslope of Golestan province, a case study in Ghapan region. *Journal of Agricultural Sciences and Natural Resources* 16(3): 14-26.

Kim, D.G., Kirschbaum, M.U., Eichler-Löbermann, B., Gifford, R.M., Liáng, L.L., 2023. The effect of land-use change on soil C, N, P, and their stoichiometries: A global synthesis. *Agriculture, Ecosystems & Environment* 348: 108402.

Kooch, Y., Ghorbanzadeh, N., Haghverdi, K., Francaviglia, R., 2023. Soil quality cannot be improved after thirty years of land use change from forest to rangeland. *Science of The Total Environment* 856: 159132.

Kooch, Y., Mehr, M.A., Hosseini, S.M., 2021a. Soil biota and fertility along a gradient of forest degradation in a temperate ecosystem. *Catena* 204: 105428.

Kooch, Y., Piri, A.S., Tilaki, G.A.D., 2021b. Tree cover mediate indices related to the content of organic matter and the size of microbial population in semi-arid ecosystems. *Journal of Environmental Management* 285: 112144.

Kopittke, P.M., Dalal, R.C., McKenna, B.A., Smith, P., Wang, P., Weng, Z., van der Bom, F.J., Menzies, N.W., 2024. Soil is a major contributor to global greenhouse gas emissions and climate change. *EGUsphere* 1-18.

Li, H., Yao, Y., Zhang, X., Zhu, H., Wei, X., 2021. Changes in soil physical and hydraulic properties following the conversion of forest to cropland in the black soil region of Northeast China. *Catena* 198: 104986.

Li, Z., Liu, C., Dong, Y., Chang, X., Nie, X., Liu, L., Xiao, H., Lu, Y., Zeng, G., 2017. Response of soil organic carbon and nitrogen stocks to soil erosion and land use types in the Loess hilly–gully region of China. *Soil and Tillage Research* 166: 1-9.

Liu, J., Liu, X., Lyu, M., Wang, J., Li, Y., Guo, J., 2021. Changes in soil carbon and nitrogen stocks and microbial community after forest conversion in a subtropical region. *Scandinavian Journal of Forest Research* 36(7-9): 575-584.

Liu, M., Chen, Y., Chen, K., Chen, Y., 2023. Progress and hotspots of research on land-use carbon emissions: A global perspective. *Sustainability* 15(9): 7245.

Liu, X., Lie, Z., Reich, P.B., Zhou, G., Yan, J., Huang, W., Wang, Y., Peñuelas, J., Tissue, D.T., Zhao, M., Wu, T., Wu, D., Xu, W., Li, Y., Tang, X., Zhou, S., Meng, Z., Liu, S., Chu, G., Zhang, D., Zhang, Q., He, X., Liu, J., 2024. Long-term warming increased carbon sequestration capacity in a humid subtropical forest. *Global Change Biology* 30(1): e17072.

Luo, D., Cheng, R.-M., Liu, S., Shi, Z.-M., Feng, Q.-H., 2020. Responses of soil microbial community composition and enzyme activities to land-use change in the eastern Tibetan Plateau, China. *Forests* 11(5): 483.

Ma, S., Wang, L.-J., Jiang, J., Zhao, Y.-G., 2024. Land use/land cover change and soil property variation increased flood risk in the black soil region, China, in the last 40 years. *Environmental Impact Assessment Review* 104: 107314.

Manral, V., Bargali, K., Bargali, S., Shahi, C., 2020. Changes in soil biochemical properties following replacement of Banj oak forest with Chir pine in Central Himalaya, India. *Ecological Processes* 9: 30.

Matano, A.-S., Kanangire, C.K., Anyona, D.N., Abuom, P.O., Gelder, F.B., Dida, G.O., Owuor, P.O., Ofulla, A.V., 2015. Effects of land use change on land degradation reflected by soil properties along Mara River, Kenya and Tanzania. *Open Journal of Soil Science* 5(1): 20-38.

McGowan, A.R., Nicoloso, R.S., Diop, H.E., Roozeboom, K.L., Rice, C.W., 2019. Soil organic carbon, aggregation, and microbial community structure in annual and perennial biofuel crops. *Agronomy Journal* 111(1): 128-142.

Mirghaed, F.A., Souri, B., 2023. Contribution of land use, soil properties and topographic features for providing of ecosystem services. *Ecological Engineering* 189: 106898.

Molla, E., Getnet, K., Mekonnen, M., 2022. Land use change and its effect on selected soil properties in the northwest highlands of Ethiopia. *Heliyon* 8(8): e10157.

Mueller, R.C., Paula, F.S., Mirza, B.S., Rodrigues, J.L., Nüsslein, K., Bohannan, B.J., 2014. Links between plant and fungal communities across a deforestation chronosequence in the Amazon rainforest. *The ISME Journal* 8(7): 1548-1550.

Mukherjee, S., Keswani, K., Nath, P., Paul, S., 2024. A study on the correlation of anthropogenic activities with climate change. *Environmental Quality Management* 33(4): 59-71.

Nadal-Romero, E., Khorchani, M., Gaspar, L., Arnáez, J., Cammeraat, E., Navas, A., Lasanta, T., 2023. How do land use and land cover changes after farmland abandonment affect soil properties and soil nutrients in Mediterranean mountain agroecosystems? *Catena* 226: 107062.

Nave, L.E., DeLyser, K., Domke, G.M., Holub, S.M., Janowiak, M.K., Keller, A.B., Peters, M.P., Solarik, K.A., Walters, B.F., Swanston, C.W., 2024. Land use change and forest management effects on soil carbon stocks in the Northeast US. *Carbon Balance and Management* 19(1): 5.

Nayak, A., Rahman, M.M., Naidu, R., Dhal, B., Swain, C., Nayak, A., Tripathi, R., Shahid, M., Islam, M.R., Pathak, H., 2019. Current and emerging methodologies for estimating carbon sequestration in agricultural soils: A review. *Science of the Total Environment* 665: 890-912.

Nazari, N., 2013. Land use change from pasture to irrigated and dry farming arable land and its effect on soil properties in Miyaneh region, Iran. *Journal of Water and Soil Conservation* 17: 125-139. [in Persian]

Nwaogu, C., Okeke, O.J., Fashae, O., Nwankwoala, H., 2018. Soil organic carbon and total nitrogen stocks as affected by different land use in an Ultisol in Imo Watershed, southern Nigeria. *Chemistry and Ecology* 34(9): 854-870.
Odelade, K.A., Babalola, O.O., 2019. Bacteria, fungi and archaea domains in rhizospheric soil and their effects in enhancing agricultural productivity. *International Journal of Environmental Research and Public Health* 16(20): 3873.
Padbhushan, R., Kumar, U., Sharma, S., Rana, D., Kumar, R., Kohli, A., Kumari, P., Parmar, B., Kaviraj, M., Sinha, A.K., Annapurna, K., Gupta, V.V.S.R., 2022. Impact of land-use changes on soil properties and carbon pools in India: A meta-analysis. *Frontiers in Environmental Science* 9: 794866.
Payen, F.T., Sykes, A., Aitkenhead, M., Alexander, P., Moran, D., MacLeod, M., 2020. Soil organic carbon sequestration rates in vineyard agroecosystems under different soil management practices: A meta-analysis. *Journal of Cleaner Production* 290: 125736.
Peperzak, P., Caldwell, A., Hunziker, R., Black, C., 1959. Phosphorus fractions in manures. *Soil Science* 87(5): 293-302.
Qi, Y., Chen, T., Pu, J., Yang, F., Shukla, M.K., Chang, Q., 2018. Response of soil physical, chemical and microbial biomass properties to land use changes in fixed desertified land. *Catena* 160: 339-344.
Qiu, K., Xie, Y., Xu, D., Pott, R., 2018. Ecosystem functions including soil organic carbon, total nitrogen and available potassium are crucial for vegetation recovery. *Scientific Reports* 8: 7606.
Rad, M.H., Ebrahimi, M., Shirmohammadi, E., 2018. Land use change effects on plant and soil properties in a mountainous region of Iran. *Journal of Environmental Science and Management* 21(2):47-56.
Raiesi, F., Beheshti, A., 2022. Evaluating forest soil quality after deforestation and loss of ecosystem services using network analysis and factor analysis techniques. *Catena* 208: 105778.
Ramesh, T., Bolan, N.S., Kirkham, M.B., Wijesekara, H., Kanchikerimath, M., Rao, C.S., Sandeep, S., Rinklebe, J., Ok, Y.S., Choudhury, B.U., Wang, H., Tang, C., Wang, X., Song, Z., Oliver, W., Freeman II, O.W., 2019. Soil organic carbon dynamics: Impact of land use changes and management practices: A review. *Advances in Agronomy* 156: 1-107.
Rasouli-Sadaghiani, M., Barin, M., Moghaddam, S.S., Damalas, C., Ghodrat, K., 2018. Soil quality of an Iranian forest ecosystem after conversion to various types of land use. *Environmental Monitoring and Assessment* 190: 447.
Rayment, G.E., Lyons, D.J., 2011. Soil chemical methods: Australasia. CSIRO publishing. 495p.
Rezapour, S., Alipour, O., 2017. Effect of deforestation on fertility attributes of Mollisols in the NW of Iran. *Chemistry and Ecology* 33(3): 213-228.
Saurabh, K., Rao, K., Mishra, J., Kumar, R., Poonia, S., Samal, S., Roy, H., Dubey, A., Choubey, A.K., Mondal, S., 2021. Influence of tillage based crop establishment and residue management practices on soil quality indices and yield sustainability in rice-wheat cropping system of Eastern Indo-Gangetic Plains. *Soil and Tillage Research* 206: 104841.
Smith, P., Soussana, J.F., Angers, D., Schipper, L., Chenu, C., Rasse, D.P., Batjes, N.H., Van Egmond, F., McNeill, S., Kuhnert, M., Arias-Navarro, C., Olesen, J.E., Chirinda, N., Fornara, D., Wollenberg, E., Álvaro-Fuentes, J., Sanz-Cobena, A., Klumpp, K., 2020. How to measure, report and verify soil carbon change to realize the potential of soil carbon sequestration for atmospheric greenhouse gas removal. *Global Change Biology* 26(1): 219-241.
Soleimani, A., Hosseini, S.M., Bavani, A.R.M., Jafari, M., Francaviglia, R., 2019. Influence of land use and land cover change on soil organic carbon and microbial activity in the forests of northern Iran. *Catena* 177: 227-237.
Sui, X., Zhang, R., Frey, B., Yang, L., Li, M.-H., Ni, H., 2019. Land use change effects on diversity of soil bacterial, Acidobacterial and fungal communities in wetlands of the Sanjiang Plain, northeastern China. *Scientific Reports* 9: 18535.
Szymański, W., Maciejowski, W., Ostafin, K., Ziaja, W., Sobucki, M., 2019. Impact of parent material, vegetation cover, and site wetness on variability of soil properties in proglacial areas of small glaciers along the northeastern coast of Sørkappland (SE Spitsbergen). *Catena* 183: 104209.
Tellen, V.A., Yerima, B.P., 2018. Effects of land use change on soil physicochemical properties in selected areas in the North West region of Cameroon. *Environmental Systems Research* 7: 3.
Telo da Gama, J., Loures, L., Lopez-Piñeiro, A., Quintino, D., Ferreira, P., Nunes, J.R., 2021. Assessing the long-term impact of traditional agriculture and the mid-term impact of intensification in face of local climatic changes. *Agriculture* 11(9): 814.
Teramage, M.T., Asfaw, M., Demissie, A., Feyissa, A., Ababu, T., Gonfa, Y., Sime, G., 2023. Effects of land use types on the depth distribution of selected soil properties in two contrasting agro-climatic zones. *Heliyon* 9(6): e17354.
Tiefenbacher, A., Sandén, T., Haslmayr, H.-P., Miloczki, J., Wenzel, W., Spiegel, H., 2021. Optimizing carbon sequestration in croplands: A Synthesis. *Agronomy* 11(5): 882.
Varamesh, S., Hosseini, S.M., Behjou, F.K., Fataei, E., 2014. The impact of land afforestation on carbon stocks surrounding Tehran, Iran. *Journal of Forestry Research* 25(1): 135-141.
Varasteh Khanlari, Z., Golchin, A., Alamdari, P., Mosavi Kupar, S.A., 2019. The effects of changing forest land to paddy field on the physical and chemical properties of the soil and determining sensitive ındices to land use change. *Iranian Journal of Soil and Water Research* 50(8): 1911-1925.
Voltr, V., Menšík, L., Hlisnikovský, L., Hruška, M., Pokorný, E., Pospíšilová, L., 2021. The soil organic matter in connection with soil properties and soil inputs. *Agronomy* 11(4): 779.

Walkley, A., Black, I.A., 1934. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil Science* 37(1): 29-38.
Wang, M., Chen, H., Zhang, W., Wang, K., 2018. Soil nutrients and stoichiometric ratios as affected by land use and lithology at county scale in a karst area, southwest China. *Science of the Total Environment* 619-620: 1299-1307.
Wang, Y., Chen, L., Xiang, W., Ouyang, S., Zhang, T., Zhang, X., Zeng, Y., Hu, Y., Luo, G., Kuzyakov, Y., 2021. Forest conversion to plantations: A meta-analysis of consequences for soil and microbial properties and functions. *Global Change Biology* 27(21): 5643-5656.
Wasige, J.E., Groen, T.A., Rwamukwaya, B.M., Tumwesigye, W., Smaling, E.M.A., Jetten, V., 2014. Contemporary land use/land cover types determine soil organic carbon stocks in south-west Rwanda. *Nutrient Cycling in Agroecosystems* 100(1): 19-33.
Wehr, N.H., 2018. Responses of soil invertebrate and bacterial communities to the removal of nonnative feral pigs (Sus scrofa) from a Hawaiian tropical montane wet forest. Master Thesis, University of Hawai'i at Manoa. Natural Resources & Environmental Management (Ecology, Evolution, & Conservation Biology). 99p.
Wei, L., Ge, T., Zhu, Z., Luo, Y., Yang, Y., Xiao, M., Yan, Z., Li, Y., Wu, J., Kuzyakov, Y., 2021. Comparing carbon and nitrogen stocks in paddy and upland soils: Accumulation, stabilization mechanisms, and environmental drivers. *Geoderma* 398: 115121.
Wu, X., Xu, H., Tuo, D., Wang, C., Fu, B., Lv, Y., Liu, G., 2020. Land use change and stand age regulate soil respiration by influencing soil substrate supply and microbial community. *Geoderma* 359: 113991.
Wu, Y., Zhou, H., Chen, W., Zhang, Y., Wang, J., Liu, H., Zhao, Z., Li, Y., You, Q., Yang, B., Liu, G., Xue, S., 2021. Response of the soil food web to warming and litter removal in the Tibetan Plateau, China. *Geoderma* 401: 115318.
Yadav, G.S., Das, A., Babu, S., Mohapatra, K.P., Lal, R., Rajkhowa, D., 2021. 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. *International Soil and Water Conservation Research* 9(2): 279-290.
Yang, Y., Cheng, H., Liu, L., Dou, Y., An, S., 2020. Comparison of soil microbial community between planted woodland and natural grass vegetation on the Loess Plateau. *Forest Ecology and Management* 460: 117817.
Yang, Z., Ohno, T., Singh, B., 2024. Effect of land use change on molecular composition and concentration of organic matter in an oxisol. *Environmental Science & Technology* 58(29): 13169–13170.
Yellajosula, G., Cihacek, L., Faller, T., Schauer, C., 2020. Soil carbon change due to land conversion to grassland in a semi-arid environment. *Soil Systems* 4(3): 43.
Zarafshar, M., Bazot, S., Matinizadeh, M., Bordbar, S.K., Rousta, M.J., Kooch, Y., Enayati, K., Abbasi, A., Negahdarsaber, M., 2020. Do tree plantations or cultivated fields have the same ability to maintain soil quality as natural forests? *Applied Soil Ecology* 151: 103536.
Zdruli, P., Lal, R., Cherlet, M., Kapur, S., 2017. New world atlas of desertification and issues of carbon sequestration, organic carbon stocks, nutrient depletion and implications for food security. In: Carbon management, technologies, and trends in mediterranean ecosystems. Erşahin, S., Kapur, S., Akça, E., Namlı, A., Erdoğan, H. (Eds.). Springer, Cham. pp. 13-25.
Zhang, J., Wang, Y., Dai, J., Xu, H., 2022. How does tillage accelerate soil production and enhance soil organic carbon stocks in mudstone and shale outcrop regions?, In: Saljnikov, E., Mueller, L., Lavrishchev, A., Eulenstein, F. (Eds.). Advances in understanding soil degradation. Springer, Cham. pp. 245-255.
Zhao, X., Tong, M., He, Y., Han, X., Wang, L., 2021. A comprehensive, locally adapted soil quality indexing under different land uses in a typical watershed of the eastern Qinghai-Tibet Plateau. *Ecological Indicators* 125: 107445.
Zheng, Q., Hu, Y., Zhang, S., Noll, L., Böckle, T., Richter, A., Wanek, W., 2019. Growth explains microbial carbon use efficiency across soils differing in land use and geology. *Soil Biology and Biochemistry* 128: 45-55.