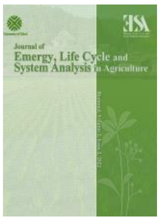
Journal of Emergy, Life Cycle and System Analysis in Agriculture

Journal homepage: jelsa.uoz.ac.ir



Changing carbon sequestration potentials based on different land uses; A review

Hossein Kazemi *[a], Hermann Klug [b], Samane Bakhshandeh [a], Behnam Kamkar [c]

[a] Department of Agronomy, Faculty of Plant Production, Gorgan University of Agricultural Sciences and Natural Resources (GUASNR), Gorgan, Iran
[b] Paris-Lodron University of Salzburg (PLUS), Interfaculty Department of Geoinformatics -Z_GIS, Schillerstr. 30, Building 15, 3rd Floor, 5020 Salzburg, Austria
[c] Department of Agrotechnology, Ferdowsi University of Mashhad, Mashhad, Iran

ARTICLE INFO

Article history:
Received: 6 January 2023
Accepted: 8 March 2023
Available online: 10 March 2023

Keywords:
Agriculture
Carbon sequestration
LULC
SOC

ABSTRACT

The organic carbon in soil is correlated with soil quality and is important for evaluating management practices and their related structural and functional consequences in land uses. Carbon input to different ecosystems varies with plant type, soil fertility, management practices, and climatic conditions. This review evaluates carbon sequestration potentials in various land uses, land use change effects on carbon sequestration, and ways to increase carbon sequestration in these land uses. According to various studies, protected forest ecosystems and cereal croplands had respectively the highest and lowest carbon sequestration rates compared to other ecosystems. In most of the reviewed cases, land use change reduces vegetation cover and prevents the maintenance of organic matter in the soil. Heavy soil destruction is based on the alteration of natural ecosystems into agroecosystems and urban land uses. In contrast, forests supply 20 to 100 times more carbon than croplands. Soil organic carbon content in agricultural lands is approximately 15-30% lower than in natural soils. Finally, it could be concluded that management practices and policies could strongly influence the carbon sequestration process. On the other hand, in all land uses, carbon sequestration potential can be increased by appropriate management activities. Thus, more attention to carbon sequestration for sustainability development and reasonable management is essential in landscape planning and policy support actions.

Highlights

- Carbon sequestration varies across ecosystems based on plant types, soil conditions, management, and climate.
- This review explores land use's impact on carbon storage and potential improvements.
- Land use changes that reduce vegetation or disturb soil typically reduce carbon storage.
- Converting natural ecosystems to agriculture or urban areas significantly reduces carbon storage.
- The article highlights the significance of carbon sequestration in sustainable development plans and policies.

1. Introduction

The atmospheric concentration of CO_2 increased by 31 percentage since 1750 (Sharma, 2005). Removing carbon from atmosphere and storing it in the terrestrial environment is one of the best options proposed to reduce greenhouse gas (GHGs) emissions (Albrecht and Kandji, 2003). One present approach for increasing global carbon storage and reducing CO_2 is carbon sequestration in soils. The carbon sequestration refers to the process of removing carbon from the atmosphere and depositing it in a reservoir while carbon storage refers to the quantity of carbon stored in a reservoir. The important variables in this approach are the capacity of soil carbon sequestration and some properties such as organic carbon amounts and bulk density (Olson, 2010). Soil organic carbon (SOC) sequestration was defined by Olson et al., (2013) as "the process of transferring CO_2 from the atmosphere into the soil through plants, plant residues, and other organic solids, which are stored or retained as a part of the humus". Recent studies have revealed that the dynamics of the SOC pool depends on the balance between input and output of carbon through different ways (Ding et al., 2012; Fan et al., 2014).

---

[*] Corresponding author.
E-mail address: hkazemi@gau.ac.ir
https://doi.org/10.22034/jelsa.2024.419541.1054

SOC is primarily governed by land use/land cover (LULC), soil genoform and climate. However, land use per se has a significant influence on the soil carbon sequestration (Upadhyay et al., 2005; Zhang et al., 2012; Ross et al., 2016). According to various studies, recognizing relations between LULC and SOC provides essential data for estimating the LULC change effects on carbon pools in soils and it can be used for guidelines of mitigating anthropogenic GHGs emissions (Ross et al., 2016).

Upadhyay et al., (2005) demonstrated that the carbon sequestration process is a function of LULC changes and agricultural practices which are determined by socioeconomic criteria such as population. In developing countries, past land use changes, especially agricultural expansion and deforestation, have seriously affected the global warming process through emissions of GHGs (The Environmental Literacy Council, 2015). These are affecting the climate system, supply of forestry products, biodiversity, and soil degradation. The environmental degradation (e.g. from forests to rangelands or croplands) and global climate change became a significant concern globally (Wali et al., 1999). Land use change with improper management is one of the major reasons for creating greenhouse effects and global earth warming during recent decades (Fitzsimmons et al., 2004). The agricultural sector is responsible for nearly one-third of global warming and climate change (Tan and Lal, 2005).

It seems that carbon sequestration programs are win-win strategies (Lal, 2004) everywhere and all the time. In fact, carbon sequestration potential can be doubled by proper management activities (Askari et al., 2014). It restores eroded soils, enhances purifies water, plant biomass, land covers, organic matters, and reduces the enrichment level of carbon in the atmosphere (Lal, 2004).

Land use change often reduces vegetation cover and consequently prevents the preservation of soil organic matter. Restoring degraded land (a land that has lost some degree of its natural productivity) towards natural vegetation cover reduces these effects, and serves in favor of the accumulation of carbon by mediating of increasing carbon inputs to the soils as organic matter. These changes support to improved soil functions and fertility (Upadhyay et al., 2006).

Estimations of soil carbon sequestration show the different impacts for each of the LULC. Specifically, the difference of carbon sequestration relates to the type of management in land uses. Thus, it is influenced by locations, plant species type and management operations (Mortenson and Shuman, 2002). There are many processes and factors determining the rate and direction of change in soil carbon when soil management practices and vegetation are changed. These factors and processes comprise:

(1) rising the amounts of organic matter,
(2) altering the decomposability of organic matter that enhance SOC,
(3) situating organic matters in a deeper position
(4) improving physical protection by improving aggregation or organic mineral aggregates. These processes usually occur, when soils are converted from the annual plants cultivation to permanent vegetation (Conant et al., 2001).

In some countries such as Brazil, land-use changes have a powerful influence on carbon emission. The assessment of carbon sequestration and accumulation in plant and soils is needed to stabilize sufficient land cover to reduce soil erosion (Brown and Pearce, 1994; Bellassen et al., 2008). Post and Kwon (2000) concluded that vegetation types and LULC changes significantly influence carbon flux and accumulation, also soil respiration. Soil carbon sequestration diminishes with increasing depth of soil. Rice (2000) stated grazed rangelands have more carbon sequestration potential than non-grazed rangeland and soil carbon sequestration is decreasing with depth. For example, in the 0-20 cm soil depth, organic carbon content was higher than in 20-40 cm depth (Chibsa and Ta’a, 2009).

Carbon input and sequestration to ecosystems varies with vegetation type, management practice, soil fertility, and climatic condition. Basically, vegetation type or plant community refers to members of a group or aspect of plants that are often found growing in area together. They differ from the life forms, photosynthesis cycle, morphology and etc. Thus, vegetation types have different ability to carbon sequestration. Carbon sequestration in soils has the capacity to mitigate GHGs emissions, as well as to improve soil biological, physical, and chemical properties. Soils can act as a net source or sink of CO_2 and thus influence the process of global climate change (Godde et al., 2016). Kay (2000) and Celik (2005) confirmed a negative correlation between erosion and soil organic material. Consequently, Zhang et al. (2012) presented a range of carbon input from 1.6 to 2.1 Mg carbon $ha^{-1}yr^{-1}$ in without chemical fertilizer consumption condition to 2.6–5.1 Mg carbon $ha^{-1}yr^{-1}$ for chemical fertilization treatment alone among some rice-rice cultivation systems in southern China. Also, climatic condition can be effect on carbon sequestration rate. For example, carbon uptake in the forest ecosystem may increase or decrease marginally with a corresponding increase or decrease in precipitation, however with an increase in temperature, carbon uptake may decrease significantly showing that warming may be the main climate factor that impacts carbon storage in a tropical dry forest (Dai and Dupuy, 2015). Based on available scientific knowledge, these different carbon sequestration potentials were reviewed in this paper.

2. Research gaps and objectives

The literature review confirmed different LULC have unlike effects on the carbon sequestration. However, the detailed processes and relations have not yet been described comprehensively. For that reason, this review aims to evaluate carbon sequestration rates in various land uses and LULC change effects on soil carbon sequestration. The objectives of this paper are the outline of carbon sequestration potentials in four important land uses affected by current human activities. These include agriculture, rangeland, forest, and urban land uses. The ways of increasing the carbon sequestration in these land uses and effects of land use changes in carbon sequestration or increasing the rate of CO_2 in the atmosphere are discussed.

3. Research method

To address our research objectives, we conducted an extensive literature review to the evaluation of carbon sequestration potentials based on different land uses and ways increase the carbon sequestration. To refine the collection of searched literature that met our criteria, Scopus, Science Direct and Web of Science as the world's main citation databases were used. The search in web was set from the date of the first related article until the year 2019. Most of the publications are concentrated between 2002 and 2019. Several papers were identified by assessment of the bibliographies in the papers. The following keywords were used at each query: 1) carbon sequestration, 2) changing land use, 3) agricultural land use, 4) rangeland, 5) forest, and 6) urban areas. The consequence of this search is introduced in the Results and Discussion sections.

4. Results

4.1. Carbon sequestration in agricultural land uses

In agricultural ecosystems, a large part of carbon is accumulated in the soil. The input of carbon to these soils is recognized by the net primary production and it's residual on the field. Also, loss of carbon is recognized by decomposition and destruction of topsoil through erosion. The decomposition rates are related to environment temperature, soil chemical and physical conditions. In addition, carbon loss occurs from the following ways: low residues on the topsoil, use of the moldboard plow (MP), conventional cultivation practices, crop residue burning, and conventional agriculture system performance (Table 1). Generally, low crop yields, increase of soil carbon and high decomposition of organic matter rates can increase the loss of carbon from agroecosystems (Freibauer et al., 2004). Increased yields haven't produced higher input of carbon treatment because increasing yields were principally obtained through changes in the cropping system (Evans, 1993). While yield increases, the amount of plant residue is decreasing (Freibauer et al., 2004).

Agricultural soils can be a source or a sink for carbon, which is dependent on the actual SOC (Vleeshouwers and Verhagen, 2002) and appropriate management practices (such as conservation tillage, cover crop and cropping rotation) on croplands can decrease the amounts of enrichment of CO_2 in the atmosphere (Lal, 2004). The existing high content of SOC in agricultural lands can be related to fertilization operation, where related actions can enhance and improve soil structure (Carter, 2002). The results of Mortenson and Shuman (2002) showed major differences in the carbon sequestration in the current land uses especially in protected forests and cereal croplands. Usually, cropland soils are depleted in SOC as compared to soils under other regions. Agricultural land use shows the SOC losses of 30–40% compared to natural or semi-natural ecosystems (Don et al., 2011; Poeplau et al., 2011; Poeplau and Don, 2015). Previously, McGill et al., (1988) estimated that SOC of agriculture lands was approximately 15 to 30% lower than soils of natural ecosystems.

Many reports have recommended no-tillage (NT) as a practice to mitigate GHGs emissions through soil carbon sequestration (Ogle et al., 2012; West and Marland, 2002; Johnson et al., 2007). In croplands, NT method has been suggested to replace chisel and moldboard plow (MP) systems as a way to sequester SOC (Luo et al., 2010; Ogle et al., 2012). Baker et al. (2007) and Luo et al. (2010) for example suggested to farmers, altering from MP systems to NT as having great potential for SOC sequestration. Challenges still continue to understand the complete impact of NT adoption on soil organic carbon pools (Ogle et al., 2012). Gonçalves et al., (2019) were used as a database for long term soil management based on the conservation agriculture principles include minimum tillage, maintain crop residues and diversity. Their results demonstrated that SOC continuously increased after conservation management performance adoption in 1985 until 2015 and the carbon sequestration potential for sub-tropical croplands was 2.5 Pg carbon at 0-20 cm and 11.7 Pg carbon at 0-100 cm. Principally, conservation agriculture is a farming system that maintains a permanent soil cover to assure its protection and avoids soil tillage. It reduces land degradation and increase biodiversity and water and nutrient use efficiency (FAO, 2016). In another study, Zhang et al. (2013) analyzed the soil carbon sequestration based on the DNDC model and resulted in that NT system can be the main advance in green technology in North China. Alam et al., (2019) concluded that rice fields under non-puddled system and with increased crop residue retention are an effective GHGs mitigation alternative in "Northwest Bangladesh".

Sewage sludge amendments or organic manure, incorporation of straw and intensification through ley rotations have been suggested as those approaches for increasing carbon inputs in agricultural land uses are (Smith et al., 1997). Recently, the production of winter cover crops was introduced by Mazzoncini et al., (2011). Principally, cover crops termed catch crops or intercrops are those plants replaced bare fallow in winter and are plowed under as green manure before the sowing of the main plant. These crops have a considerably high SOC than the main crop (Poeplau and Don, 2015).

In agricultural systems, the plants with C4 carbon fixation pathway remarkably lead to the greater carbon accumulation and consequently increased the carbon supply in the soil. Srinivasarao et al., (2016) conducted a study with two levels of CO_2 of 550 and 700 m-mol mol^{-1} on some C3 and C4 crops under rainfed conditions, during 2005–2010. Observations revealed that the carbon pool and carbon management indicators decreased at 700 m-mol mol^{-1} levels of CO_2. Their results indicated that the higher root biomass of C4 plants contributed to the higher carbon input and stock in the soil. In another study, Yan et al., (2013) investigated the carbon input and SOC stabilization in paddy and upland soils under different fertilization practices. Their results indicated that the carbon sequestration efficiency was better in paddy soil than in upland soil, which may be attributed to greater physical and chemical stabilizations but lower microbial activity in paddy fields. As a conclusion, we can increase the carbon sequestration in agricultural land use by some methods and systems include NT system, sewage sludge amendments, organic manure, ley-farming rotation, cover crops, cropping higher biomass plants (C4 plants), agrobiodiversity, organic farming systems, conservation agriculture systems, agroforestry, perennial crop cultivation, crop residue mulch and intercropping system (Table 1). Agrobiodiversity is the sub-set of general biodiversity directly developed and managed by humans. It refers to the biodiversity of agroecosystems along with species of crops and farm animals, and the genetic variance within populations, varieties and races (Kazemi et al., 2018). According to the International Federation of Organic Agriculture Movements (IFOAM, 2004), organic farming is an agricultural system that promotes environmentally, socially and economic sound production of food and fibers, and excludes the use of synthetically compounded pesticides, fertilizers, livestock feed, growth regulators and genetically modified organisms. Organic farming considerably increases the carbon storage in the soil than the other current agricultural systems. Also, agroforestry is the collective term for land use systems and technologies in which woody perennials (such as trees and shrubs) and agricultural crops or animals are used deliberately on same parcel of land in some form of spatial and temporal arrangement (FAO, 2020). This integrated system has the capacity to carbon sequestration.

Table 1. Ways to reduce / increase of carbon sequestration in different land uses.

Land use	Loss of carbon sequestration by…	Increase of carbon sequestration by …
Agriculture	Topsoil erosion High decomposition of organic matter Low crop residue Moldboard plow (MP) systems Conventional cultivation practices Conventional agriculture system Crop residue burning	No-tillage system Sewage sludge amendments Organic manure Ley- farming rotation Cover crops Cropping higher biomass plants (C4 plants) Agrobiodiversity Organic farming Conservation agriculture Agroforestry Intercropping systems Perennial crops cultivation Crop residue mulch
Rangeland	Traditional management Over-grazing Low precipitation Convert to farms	Exclosure Converting marginal agricultural lands to pastures High precipitation Chemical fertilizers Irrigation management Sowing legumes and grasses or other species adapted to the environment Improvement of soil fauna Grazing management Sustainable grazing Sowing improved species Direct inputs of water, fertilizer or organic matter Restore degraded lands
Forest	Deforestation Fuel-wood utilization Loss of soil Changes in land use	Protected forests Growth of wood biomass species Conserve forest soils Tax for CO_2 emissions
Urban	Urbanization	Urban design Urban forests Urban green spaces Green roofs Street trees Urban agriculture Urban Parks Cultivation of conifers species, turfs, and home lawns

4.2. Carbon sequestration in rangeland land use

Rangelands include the biggest and various resources of the land surface (Reeder and Schuman, 2002; Lund, 2007). Because of the rangelands extent, a little variation in soil carbon contents of rangelands would have a great effect on GHGs and carbon sequestration (Follett et al., 2001). The conventional management of these ecosystems had resulted in physiognomic and floristic changes, losses of SOC, and desertification (Golluscio et al., 1998; Lal, 2002). Thus, providing political and financial incentives to organize rangelands sustainability as carbon sinks offer major carbon sequestration situation.

Principally, the major differences between rangelands and pastures are the kind of vegetation and level of management that each land area receives. Basically, rangelands are those lands on which the native vegetation is predominantly grasses, grass-like plants, forbs, or shrubs suitable for grazing or browsing use. They include natural grassland, savanna, many wetlands, some deserts, tundra, and certain forb and shrub communities. But, pastures are those lands that are primarily used for production of adapted, domesticated forage plants for livestock (EPA, 2020)

Typically, in rangelands, the vegetations have a huge influence on SOC and a large amount of SOC is form in the topsoil as a result of the influence and presence of biotic processes (Conant et al., 2001). If the vegetation mass is improved, the amount of carbon within the plant-soil system increases (Mahdavi et al., 2011). The results from Askari et al. (2014) demonstrate that the highest amount of organic carbon was observed in rangelands in comparison to other land uses. Yazdanshenas et al., (2018) reported that carbon storage depends on type of vegetation and soil surface cover in rangelands of Isfahan province (Iran).

Rangelands continuously have been grazed by animals, and as such, those rangelands exhibited a little amount of SOC. For instance, Joneidi Jafari (2009) concluded that grazing management has a significant influence on the capacity of soil carbon sequestration. Subsequently, the livestock density and deforestation led to an approximately 12 percentage decrease in soil carbon in Iran.

Based on the results of Askari et al., (2014), the amount of SOC in the first 20 cm of the topsoil of rangeland is the highest and consequently, carbon sequestration is the highest. The lowest amount of SOC and carbon sequestration observed in converted rangeland to farm. As a result, no significant difference was seen among land uses and different depths for carbon sequestration except for soil surface layer of rangeland (Table 2).

Table 2. The mean amount of carbon sequestration in different land uses in two soil depths (Askari et al., 2014).

Land use type	Soil layer depth(cm)	Organic carbon percent	Carbon sequestration (ton ha^{-1})
Agriculture	0-20	1.35	29.16b
	20-40	0.9	23.98b
Rangeland	0-20	1.9	50.92a
	20-40	1.08	25.04b
Olive planting	0-20	1.25	27.48b
	20-40	1.37	31.51b
Converted rangeland to farm	0-20	0.82	20.04b
	20-40	0.66	14.99b

The results of another study (Niknahad Gharmakher et al., 2015) revealed significant differences between SOC in different soil depths under different management systems (Table 3). They calculated that the carbon sequestration on the grazing and exclosure systems were about 52.45 and 71.78 ton carbon ha^{-1}, respectively. Feyisa et al., (2017) addressed the effects of enclosure management (15–37 years old) on carbon sequestration in East African rangelands. They reported that enclosure system had a significant role in carbon sequestration and, SOC was higher in this system than open grazing systems.

Restoring degraded rangelands is important to carbon sequestering. In addition, shifting marginal agricultural lands to pastures can sequester carbon. Similar to agricultural lands, management alternatives for improving rangelands include use of fertilizers, grazing management, irrigation management, sowing grasses and legumes, planting stress-resistant species, and enhancement of soil fauna (those organisms that inhabit the soil) (Follett et al., 2001; Lal, 2004; Niknahad Gharmakher, 2015). These activities can enhance productivity in rangelands while promoting carbon sequestration. Overall, the rate of carbon sequestration in the grasslands is reduced by inappropriate management, overgrazing, converted rangeland to farms, and low annual precipitation (Table1).

Table 3. The mean of soil carbon rate on exclosure and grazing area in two soil depths. (Niknahad Gharmakher et al., 2015).

Region	Soil layer depth(ton ha^{-1})	Organic carbon percent	Soil Carbon organic (ton/ha)	Total soil Carbon organic (ton ha^{-1})
Exclosure	0-10	6.08	42.12a	71.78a
	10-20	3.655	29.66b	
Grazing area	0-10	4.06	26.87a	52.45b
	10-20	3.38	25.58a	

4.3. Carbon sequestration in forest land use

A number of pools and fluxes characterize the carbon cycle in forest ecosystems. Pools are locations of carbon in the forest, forest floor, and soil. Each pool contains a quantity of carbon that is referred to as the stock. Carbon transfers between pools happen through different processes (fluxes), including photosynthesis, combustion, and respiration (Byrne and Black, 2003).

Forest management can extremely influence the carbon budgets and fluxes. Forests can have a key influence on climate change through the carbon emission or sequestration. In forest ecosystems, carbon is captured in the tree biomass and also in soils (Sedjo and Sohngen, 2012). Joneidi Jafari (2009) indicated that in forest areas including species from Aceraceae and Rosaceae families, and lack of invasive species in lower stands, carbon sequestration can be increased by around 23 percentages in the forest soil of Iran. In another project, Mortazavi Jahromi (2006) has revealed that the tree biomass is straightly associated to carbon sequestration and usually, protected forests in Iran have the highest amounts of carbon sequestration than other studied land uses.

Forests accumulate 20–100 times more carbon per unit area than agricultural lands and therefore have a serious responsibility in reducing GHGs, and thus increasing the SOC (Brown and Pearce, 1994). In research of Jafari and Mesri (2015) in Iran, the amounts of carbon sequestration for seven land uses were estimated (Table 4). This research showed that each ecosystem had a special impact on the carbon sequestration amount. Based on this research, the highest and lowest of carbon sequestration amount were obtained in the protected forests and cereal agroecosystems, respectively. Also, the protected forest had 2-5 times more carbon sequestration than other studied land uses (Jafari and Mesri, 2015). Chu et al., (2019) were assessed the forest carbon sequestration in the “Three North Shelterbelt Program” region (China), using the

InVEST model during 1990–2015. Their results showed that carbon sequestration reduced by 13.37 Pg carbon with a reduced rate of 1.92% in 1990–2015 and shrubs were more appropriate than trees. In another study, carbon sequestration amount is calculated at 274,571 tons for experimental forest of "National Taiwan University, in Nantou County" (Taiwan) (Chang et al., 2017).

With the literature, we demonstrate carbon sequestration varies in forest ecosystems. This land use plays an important role in the carbon budgets and fluxes, thus, a comprehensible understanding of this role is necessary to increase the SOC content and consequently carbon sequestration rate. According to various studies, land use changes, deforestation, soil erosion and wood consumption can reduce the carbon sequestration potential in the forest ecosystems (Table1).

Table 4. Variations of carbon sequestration in different land uses (Jafari and Mesri, 2015).

Land sue	Organic carbon percent	Bulk density (gr.cm^2)	Carbon sequestration (ton.ha^{-1}) (depth 0-30 cm)
Protected forest	8.57a	10a	257100a
Open forest	2.75b	10a	82500b
Walnut –apple garden	3.60b	7a	75600b
Walnut garden	3.80b	8a	91200b
Rangeland	4.67b	8a	112080b
Frijol farmland	3.54b	7a	74340b
Cereal cropland	4.22b	4b	50640b

4.4. Carbon sequestration in urban land use

Urbanization severely changes the ecosystems functions and structure, environmental equilibrium (a state of dynamic equilibrium within a community of organisms), disrupts cycling of carbon, other elements, and water. Lal and Augustin (2012) predicted that in 2050, about 70 percentages of the people will live in cities on a global scale. The number of megacities reached to 37 in 2017. Yet, urban regions have a huge carbon sink capacity in soils and biota. Effective management and judicious planning can increase SOC in these ecosystems and offset some of the anthropogenic emissions. In urban land use, main components with regards to carbon sequestration include turfs, green roofs, home lawns, urban forests, park and recreational/sports facilities and urban agriculture (Table 1). A lawn is a piece of residential, commercial or industrial land on which grass grows. Basically, turf is the term used by horticulturists referring to grass that is mowed and maintained with the same uses as a lawn. Grass used in a landscape customarily is referred to as a lawn while grass used on a baseball field or golf course is referred to as turf. Turf is valuable in the landscape for environmental contributions such as protecting soil from erosion, capturing runoff water, reducing dust and heat irradiation (Peffley, 2016).

Urban regions release a high amount of the GHGs (Svirejeva-Hopkins et al., 2004) and supply somewhere about 40 - 85% of total GHGs emissions (Satterthwaite, 2008). At the global scale, the study of ten cities shows how a balance of technical factors (urban design and shape, power generation, and waste processing) and geophysical factors (climate, gateway status and access to resources) indicate the GHGs attributable to these cities (Kennedy et al., 2009). The effects of development of urban on climate change are intensified by reduce of carbon contents (Hutyra et al., 2011a). In addition, soils have a low carbon sequestration in the urban land use (Pouyat et al., 2006; Sallustio et al., 2015).

A united approach is required for soil carbon management in the urban land use. The main factors such as the managers and users, local professionals, NGOs and local government affect on the carbon management in urban regions (Lorenz and Lal, 2015).

Urban forests accumulate carbon. They influence on air temperature and also change carbon releases from many urban sources (Nowak, 1993) such as transport, services, and goods production and household consumption (Abdollahi et al., 2000; Wilby and Perry, 2006; Gill et al., 2007). Some researches propose that urban trees may be an important carbon sinks in the carbon cycle (Velasco et al., 2016; Nowak et al., 2013). For example, the total tree carbon content and carbon sequestration in urban regions of the U.S. were estimated at 643 and 25.6 million tons per year, respectively. The entire urban tree carbon storage and sequestration were calculated as 7.69 and 0.28 kg C m^2 of tree cover per year, respectively (Nowak et al., 2013). Velasco et al. (2016) were analyzed the CO_2 flux in Mexico City and Singapore. Their results suggested that vegetation in sub-tropical regions either acts as an emission sink or source of carbon and the biogenic influence to the total CO_2 flux is 1.4% in Mexico City and 4.4% in Singapore. Capability of CO_2 sequestration and economic value of four parks in Rome (Italy) were analyzed by Gratani et al., (2016). Results indicated that tree-lined streets/avenues presented the highest amounts of carbon sequestration and the economic value of this sequestration was $ 23,537/ha.

Nowadays, many indices apply for estimation of carbon sequestration potential. For instance, Scharenbroch (2012) used growth rates, life spans, maximum tree sizes, and tolerances to urban stress for tree species. Hostetler and Escobedo (2016) recommended that green space with mowed, pruned shrubs and trees, and irrigated and fertilized lawns are better for the performance of carbon sequestration programs.

The soil carbon stocks of urban green spaces were calculated in three cities with rapid development in South Korean. Based on results, the soil carbon stock was 105.6 for Seoul, 26.4 for Daejeon and 43.6 for Daegu (Yoon et al., 2016). In this respect, Abbasnejad and Khajeddin (2012) evaluated the urban reforestation effect on carbon sequestration by Quick Bird satellite imageries. Their survey shows that the reforestation on a barren area increased sequestration amounts of carbon.

Nowadays, the effects of urban expansion patterns on GHGs and carbon sequestration are issues of the scientific societies all around the world. Typically, urban land use plays an important function in the GHGs emissions, thus, a clear understanding of this problem can improve the potential of carbon sequestration in urban. In final, we can increase the carbon sequestration in this land use by urban forests, urban green spaces, green roofs, street trees, urban design, urban agriculture, cultivation of conifers species, turfs and home lawns and urban parks (Table 1).

5. Discussion

At the global scale, LULC change is widely identified as a net storage of GHGs. To address this issue, associations between SOC, LULC classes, and in the first step LULC change must be investigated at the local scale (Ross et al., 2016). The first step toward soil destruction could be the conversion of natural areas into agricultural areas (Luciuk et al., 2000). In this regard, we can refer to the experiences of Xun et al., (2010) in China. They considered the LULC change effects on SOC, the nutrient in the semi-arid regions and carbon decomposition. Their results indicated that changing from cultivated land to shrub land or pastureland caused increasing soil carbon sequestration and improvement of soil nutrient fixation.

The loss of SOC usually observed during agriculture may be reversed by changing such system to permanent pasture (Jones et al., 2016). Many researchers have confirmed that the introduction of pastures for grazing after farming may recover soil structure due to enhance in SOC and roots activity and act as a buffer to SOC loss after harvesting (Elliott, 1986; Conant et al., 2001; Guo and Gifford, 2002).

The literature review showed that the LULC has a significant effect on SOC (Jones et al. 2016). The degree of the impact of LULC conversion differs and depending on the type of activity undertaken post-conversion and the ecosystem's resistance to change (Schipper et al., 2010; Seybold et al., 1999). This effect is exclusively high in intensive agricultural systems (Jastrow et al., 1996). Globally, carbon sequestration showed a negative relationship with initial carbon stocks in soil, and the effects of climatic variables on soil carbon sequestration are different between the LULC conversion types (Deng et al., 2016).

Based on available scientific knowledge, the correlation between biodiversity and SOC has been acknowledged with the coincidence of change with biomass value and carbon content. According to this, all practices that increase biodiversity in all land uses, can improve ecosystems potential to sequester carbon (Kazemi et al., 2018; Hajjar et al., 2008). Considering the carbon sequestration rate in the world, carbon sequestration potential can be increased by appropriate management activities in all land uses.

6. Conclusion and Outlook

This paper aimed to detect changes in carbon sequestration potentials based on different land uses. The results of the literature review show that almost land use changes have considerably reduced soil carbon in the past. Soil carbon stocks significantly increased after conversions from croplands to grassland but declined after change from grassland to cropland, forest to cropland, and forest to urban.

Based on results, a number of opinions need to be emphasized. First, the carbon sequestration rate is related to the carbon input rate in ecosystems. Carbon sequestration rates vary by climate, soil properties, topography, human-related activities, and management history. Some studies shown that the effects of climatic elements on carbon sequestration were closely associated to the land use change type. Also, in all land uses, current carbon sequestration potential can be increased by appropriate management activities.

Second, similar findings were reported by many researchers that indicated organic carbon sequestration in natural land uses is more than converted ecosystems. In addition, soils in urban areas have very low carbon rates. Soils under agriculture are depleted in carbon as compared to soils under natural areas and farming leads to SOC<30–40% than natural ecosystems.

Third, according to various studies, the protected forests and croplands under cereal production had the highest and lowest carbon sequestration compared to other land uses, respectively. Thus, more attention to carbon sequestration for sustainability development and reasonable management is essential in these land uses.

Fourth, management option can enhance productivity while promoting soil carbon sequestration in rangelands, forests, croplands, and urban areas. Accordingly, we recommend the following management practices to increase carbon sequestration in agroecosystems: application of conservation tillage, no-tillage system, cover crops, residue mulch, use of compost, green manure and manure in field’s fertilization, agrobiodiversity and other sustainable systems of water and soil. It is also suggested that the following options be developed in urban ecosystems: conserved urban green space, cultivation of conifers species, turfs and home lawns, developing urban agriculture, green roofs, parks, urban forests, and other effective management practices can enhance carbon pool in urban. Similar to urban land uses, management alternatives for improving rangelands include the use of grazing management plan, irrigation, and fertilizers management, sowing improved legumes and grasses and improvement of soil fauna. Moreover, according to various studies protected forests, growth of wood biomass species, conserve forest soils, tax for CO_2 emission increase the carbon sequestration potential in the forests.

Finally, it could be concluded that today, the soil carbon sequestration is a successful and win-win strategy in the all countries and ecosystems. Thus, this paper proposes that supplementary researches are required in order to introduce carbon sequestration ways in different land uses. Also, more attention to carbon sequestration for sustainability development and reasonable management is essential in landscape planning and policy support actions.

References

Abbasnejad, B., & Khajeddin, S.J. (2012). Effect of urban reforestation on carbon sequestration in arid soils using remote sensing technology. *Journal of RS GIS for Natural Resources Science, 3*, 57-71.

Abdollahi, K.K., Ning, Z.H., & Appeaning, A. (2000). Global climate change and the urban forest. Baton Rouge: GCRCC and Franklin Press.

Alam, M.K., Bell, R.W., & Biswas, W.K. (2019). Increases in soil sequestered carbon under conservation agriculture cropping decrease the estimated greenhouse gas emissions of wetland rice using life cycle assessment. *Journal of Cleaner Production, 224*, 72-87. **doi:10.1016/j.jclepro.2019.03.207**

Albrecht, A., & Kandji, S.T. (2003). Carbon sequestration in tropical agroforestry systems. *Agriculture, Ecosystems & Environment, 99*, 15–27. **doi:10.1016/S0167-8809(03)00138-5**

Askari, H.R., Kavoosi, S., & KiaKianian, M. (2014). Land-use change effects on soil carbon sequestration in Agh-Abad, Golestan province of Iran. *International Journal of Agricultural Crop Sciences, 7*(14), 1381-1384.

Ayele, T., Beyene, S., & Esayas, A. (2013). Changes in land use on soil physicochemical properties: the case of small holders fruit-based land use systems in Arba Minch, southern Ethiopia. *International Journal of Current Research, 5*(10), 3203-3210.

Baker, J. M., Ochsner, T. E., Venterea, R. T., & Griffis, T. J. (2007). Tillage and soil carbon sequestration—What do we really know?. *Agriculture, ecosystems & environment*, *118*(1-4), 1-5. **doi:10.1016/j.agee.2006.05.014**

Bellassen, V., Crassous, R., Dietzsch, L., & Schwartzman, S. (2008). *Reducing emissions from deforestation and degradation: what contribution from carbon markets?* Climate Report, 14, 1-45.

Bordbar, K., & Mortazavi Jahromi, S.M. (2006). Evaluation of carbon storage potential in forestations of Eucalyptus and Acacia in the western region of Fars province. *Journal of Research and Development in Natural Resources, 70*, 95-103.

Brown, K., & Pearce, D. (1994). *The economic value of non-market benefits of tropical forests: carbon storage.* In J. Weiss (Ed.), The Economics of Project Appraisal and the Environment: New Horizon in Environmental Economics (pp. 102–119). Aldershot: Edward Elgar.

Byrne, K.A., & Black, K. (2003). Carbon Sequestration in Irish Forests. *Environmental Science, 3*, 1-6.

Carter, M.R. (2002). Soil quality for sustainable land management: organic matter and aggregation interactions that maintain soil functions. *Agronomy Journal, 94*, 38–47. **doi:10.2134/agronj2002.3800**

Celik, I. (2005). Land-use effects on organic matter and physical properties of soil in a southern Mediterranean highland of Turkey. *Soil and Tillage Research, 83*, 270–277. **doi:10.1016/j.still.2004.08.004**

Chang, F.C., Ko, C.H., Yang, P.Y., Chen, K.S., & Chang, K.H. (2017). Carbon sequestration and substitution potential of subtropical mountain Sugi plantation forests in central Taiwan. *Journal of Cleaner Production, 167*(20), 1099-1105. **doi:10.1016/j.jclepro.2017.08.163**

Chibsa, T., & Ta'a, A. (2009). Assessment of soil organic matter under four land use systems, in Bale Highlands, Southeast Ethiopia. *World Applied Sciences Journal, 6*(9), 1231-1246.

Christopher, P., & Don, A. (2015). Carbon sequestration in agricultural soils via cultivation of cover crops–A meta-analysis. *Agriculture, Ecosystems & Environment, 200*, 33–41. **doi:10.1016/j.agee.2014.10.024**

Chu, X., Zhan, J., Li, Z., Zhang, F., & Qi, W. (2019). Assessment on forest carbon sequestration in the Three-North Shelterbelt Program region, China. *Journal of Cleaner Production, 215*, 382-389. **doi:10.1016/j.jclepro.2018.10.110**

Conant, R.T., Paustian, K., & Elliott, E.T. (2001). Grassland management and conversion into grassland: effects on soil carbon. *Ecological Applications, 11*, 343–355. **doi:10.1890/1051-0761(2001)011[0343:GMACIG]2.0.CO;2**

Dai, Z., & Dupuy, J.M. (2015). Assessing the effect of climate change on carbon sequestration in a Mexican dry forest in the Yucatan Peninsula. *Ecological Complexity, 24*, 46-56. **doi:10.1016/j.ecocom.2015.06.002**

Deng, L., Zhu, G., Tang, Z., & Shangguan, Z. (2016). Global patterns of the effects of land-use changes on soil carbon stocks. *Global Ecology and Conservation, 5*, 127–138. **doi:10.1016/j.gecco.2015.12.004**

Ding, X., Han, X., Liang, Y., Qiao, Y., Li, L., & Li, N. (2012). Changes in soil organic carbon pools after 10 years of continuous manuring combined with chemical fertilizer in a Molli sol in China. *Soil Tillage Research, 122*, 36–41.

Don, A., Schumacher, J., & Freibauer, A. (2011). Impact of tropical land-use change on soil organic carbon stocks – a meta-analysis. *Global Change Biology, 17*, 1658–1670.

Elliott, E.T. (1986). Aggregate structure and carbon, nitrogen, and phosphorus in native and cultivated soils. *Soil Science Society of America Journal, 50*, 627–633.

Evans, L.T. (1993). *Crop evolution, adaptation, and yield*. Cambridge University Press.

Fan, J., Ding, W., Xiang, J., Qin, S., Zhang, J., & Ziadi, N. (2014). Carbon sequestration in an intensively cultivated sandy loam soil in the North China Plain as affected by compost and inorganic fertilizer application. *Geoderma, 230–231*, 22–28.

Feyisa, K., Beyene, S., Angassa, A., Said, M.Y., Leeuw, J.D., Abebe, A., & Megersa, B. (2017). Effects of enclosure management on carbon sequestration, soil properties, and vegetation attributes in East African rangelands. *Catena, 159*, 9-19.

Fitzsimmons, M.J., Pennock, D.J., & Thorpe, J. (2004). Effects of deforestation on ecosystem carbon densities in central Saskatchewan, Canada. *Forest Ecology and Management, 188*, 349-361.

Follett, R.F., Kimble, J.M., & Lal, R. (2001). *The potential of U.S. grazing lands to sequester carbon and mitigate the greenhouse effect*. CRC Press.

Food and Agriculture Organization of the United Nations. (2020). Agroforestry. Retrieved April 14, 2020, from https://www.fao.org/agroforestry/basic-knowledge/en/

Freibauer, A., Rounsevell, M.D.A., Smith, P., & Verhagen, J. (2004). Carbon sequestration in the agricultural soils of Europe. *Geoderma, 122*, 1–23.

Gill, S.E., Handley, J.F., Ennos, A.R., & Pauleit, S. (2007). Adapting cities for climate change: The role of the green infrastructure. *Building and Environment, 33*, 115-133.

Godde, C. M., Thorburn, P. J., Biggs, J. S., & Meier, E. A. (2016). Understanding the impacts of soil, climate, and farming practices on soil organic carbon sequestration: a simulation study in Australia. *Frontiers in plant science*, *7*, 185451.

Golluscio, R.A., Deregibus, V.A., & Paruelo, J.M. (1998). Sustainability and range management in the Patagonian steppes. *Austral Ecology, 8*, 265–284.

Gonçalvesa, D.R.P., de Moraes Sá, J.C., Mishrac, U., Fornari, A.J., Furlan, F.J.F., Ferreira, L., A. Inagakie, T.M., Romaniw, J., Ferreira, A.O., & Briedis, C. (2019). Conservation agriculture based on diversified and high-performance production system leads to soil carbon sequestration in subtropical environments. *Journal of Cleaner Production, 219*, 136-147.

Gratani, L., Varone, L., & Bonito, A. (2018). Carbon sequestration of four urban parks in Rome. *Urban Forestry & Urban Greening, 19*, 184-193.

Guo, L.B., & Gifford, R.M. (2002). Soil carbon stocks and land use change: A meta-analysis. *Global Change Biology, 8*, 345–360.

Hajjar, R., Jarvis, D.I., & Gemmill-Herren, B. (2008). The utility of crop genetic diversity in maintaining ecosystem services. Agriculture, *Ecosystems & Environment, 123*, 261–270.

Hebert, K., Karam, A., & Parent, L.E. (1991). Mineralization of nitrogen and carbon in soils amended with composted manure. *Biological Agriculture & Horticulture, 7*, 336-361.

Hostetler, M., & Escobedo, F. (2016). What types of urban green space are better for carbon dioxide sequestration? The Wildlife Ecology and Conservation Department, UF/IFAS Extension, University of Florida. Retrieved from http://edis.ifas.ufl.edu

Hutyra, L. R., Yoon, B., & Alberti, M. (2011). Terrestrial carbon stocks across a gradient of urbanization: A study of the Seattle, WA region. *Global Change Biology, 17*(2), 783–797. **doi:10.1111/j.1365-2486.2010.02238.x**

Hutyra, L.R., Yoon, B., Hepinstall-Cymerman, J., & Alberti, M. (2011). Carbon consequences of land cover change and expansion of urban lands: A case study in the Seattle metropolitan region. *Landscape and Urban Planning, 103(*1), 83–93.

International Federation of Organic Agriculture Movements. (2004). *What is organic agriculture?* IFOAM, Bonn.

Jafari, Z., & Mesri, S. (2015). Soil carbon sequestration capacity in different land uses (Case study: Award watershed in Mazandaran province). *Environmental Resources Research, 3*(2), 139-150.

Jastrow, J., Miller, R. M., & Boutton, T. W. (1996). Carbon dynamics of aggregate-associated organic matter estimated by carbon-13 natural abundance.*Soil Science Society of America Journal, 60*, 801–807.

Johnson, J. M. F., Franzluebbers, A. J., Weyers, S. L., & Reicosky, D. C. (2007). Agricultural opportunities to mitigate greenhouse gas emissions. *Environmental Pollution, 150*, 107-124. **doi:10.1016/j.envpol.2007.06.030**

Joneidi Jafari, H. (2009). *Investigating the influence of ecological factors and management on the rate of carbon sequestration (Case study: the rangeland of Semnan province).* [Thesis, Faculty of the Natural Resources, University of Tehran].

Jones, A. R., Orton, T. G., & Dalal, R. C. (2016). The legacy of cropping history reduces the recovery of soil carbon and nitrogen after conversion from continuous cropping to permanent pasture. *Agriculture, Ecosystems & Environment, 216*, 166–176.

Kay, B. D. (2000). *Soil structure*. In E. M. Sumner (Ed.), Handbook of Soil Science (pp. 229-264). CRC Press.

Kazemi, H., Klug, H., & Kamkar, B. (2018). New services and roles of biodiversity in modern agroecosystems: A review. *Ecological Indicators, 93*, 1126–1135.

Kennedy, C., Steinberger, J., Gasson, B., Hansen, Y., Hillman, T., Havránek, M., Pataki, D., Phdungsilp, A., Ramaswami, A., & Villalba Mendez, G. (2009). Greenhouse gas emissions from global cities. *Environmental Science & Technology, 43*, 7297–7302.

Lal, R. (2002). Soil carbon dynamics in cropland and rangeland. *Environmental Pollution, 116*, 353–362.

Lal, R. (2004). Soil carbon sequestration to mitigate climate change. *Geoderma, 123*, 1-22.

Lal, R., & Augustin, B. (2012). *Carbon sequestration in urban ecosystems.* Springer.

Lemenih, M., Karltun, E., & Olsson, M. (2005). Assessing soil chemical and physical property responses to deforestation and subsequent cultivation in smallholders farming system in Ethiopia. Agriculture, *Ecosystems & Environment, 105*, 373-386.

Li, D. J., Niu, S. L., & Luo, Y. Q. (2012). Global patterns of the dynamics of soil carbon and nitrogen stocks following afforestation: A meta-analysis. *New Phytologist Journal, 195*, 172–181.

Lorenz, K., & Lal, R. (2015). Managing soil carbon stocks to enhance the resilience of urban ecosystems. *Carbon Management, 6*(1-2), 35-50.

Luciuk, G. M., Boonneau, M. A., Boyle, D. M., & Vibery, E. (2000). *Prairie rehabilitation, administration paper, carbon sequestration additional environmental,* *benefits of forests in the Prairie Farm Rehabilitation Administration*. 22, 191-194.

Lund, H. G. (2007). Accounting for the world's rangelands. *Rangeland, 29,* 3–10.

Luo, Z., Wang, E., & Sun, O. J. (2010). Can no-tillage stimulate carbon sequestration in agricultural soils? A meta-analysis of paired experiments. *Agriculture, Ecosystems & Environment, 139*, 224–231.

Mahdavi, M., Arzani, H., Mesdaghi, M., Mahdavi, K., Mahmodi, J., & Alizadeh, M. (2011). Estimation of soil carbon sequestration rate in steppes (Case study: Saveh Rudshur steppes). *Journal of Rangeland Science, 1*(3), 175- 182.

Martinez-Mena, M., Lopez, J., Almagro, M., Boix-Fayos, V., & Albaladejo, J. (2008). Effect of water erosion and cultivation on the soil carbon stock in a semi-arid area of South-East Spain. *Soil and Tillage Research, 99*, 119-129.

Mazzoncini, M., Sapkota, T.B., Bàrberi, P., Antichi, D., & Risaliti, R. (2011). Long-term effect of tillage, nitrogen fertilization and cover crops on soil organic carbon and total nitrogen content. *Soil and Tillage Research, 114*, 165–174.

McGill, W.B., Dormaar, J.F., & Reinl-Dwyer, E. (1988). *New perspectives on soil organic matter quality, quantity and dynamics on the Canadian prairies. In Proceedings of the 34th Annual CSSS/AIC Meeting* (pp. 30-48). Calgary, AB.

Mortenson, M., & Shuman, G.E. (2002). *Carbon sequestration in rangeland inter-seeded with yellow-flowering Alfalfa (Medicago sativa spp. Falcata). In USDA Symposium on Natural Resource Management to Offset Greenhouse Gas Emission.* University of Wyoming.

Nelson, R.E. (1982). *Carbonate and gypsum*. In A.L. (Ed.), Methods of Soil Analysis (pp. 123-134). American Society of Agronomy, Madison, Wisconsin, USA.

Niknahad Gharmakher, H., Jafari Foutami, B.I., & Sharifi, C.A. (2015). Effects of grazing exclusion on plant productivity and carbon sequestration (Case study: Gomishan rangelands, Golestan province, Iran). *Journal of Rangeland Science, 5*(2), 123-134.

Nosetto, M.D., Jobbagy, E.G., & Paruelo, J.M. (2006). Carbon sequestration in semi-arid rangelands. *Arid Environments, 67*, 142–156.

Nowak, D.J. (1993). Atmospheric carbon reduction by urban trees. *Journal of Environmental Management, 37*, 207-217.

Nowak, D.J., Greenfield, E.J., Hoehn, R.E., & Lapoint, E. (2013). Carbon storage and sequestration by trees in urban and community areas of the United States. *Environmental Pollution Journal, 178,* 229-236.

Noy-Meier, I. (1973). Desert ecosystems: environment and producers. *Annual Review of Eco Systems, 4*, 25–51.

Oesterheld, M., Loreti, J., Semmartin, M., & Paruelo, J.M. (1999). *Grazing, fire, and climate effects on primary productivity of grasslands and savannas.* In L.R. Walker (Ed.), Ecosystems of Disturbed Ground (pp. 287–306). Elsevier, Amsterdam.

Ogle, S.M., Swan, A., & Paustian, K. (2012). No-till management impacts on crop productivity, carbon input and soil carbon sequestration. *Agricultural Ecosystems & Environment, 149*, 37–49.

Olson, K.R. (2010). Impacts of tillage, slope and erosion on soil organic carbon retention. *Soil Science, 175*, 562–567.

Olson, K.R. (2013). Soil organic carbon sequestration, storage, retention and loss in U.S. croplands: Issues paper for protocol development. *Geoderma, 195–196,* 201–206.

Paffley, E. (2016). *What's the difference between lawn and turf?* Lubbock Avalanche Journal. Retrieved from https://www.lubbockonline.com.

Pei, S.F., Fu, H., & Wan, C.G. (2008). Changes in soil properties and vegetation following exclosure and grazing in degraded Alxa desert steppe of Inner Mongolia, China. *Agricultural Ecosystems & Environment, 124,* 33–39.

Poeplau, C., Don, A., Vesterdal, L., Leifeld, J., Van Wesemael, B., Schumacher, J., & Gensior, A. (2011). Temporal dynamics of soil organic carbon after land-use change in the temperate zone – carbon response functions as a model approach. *Global Change Biology, 17*, 2415–2427.

Poeplau, C.H., & Don, A. (2015). Carbon sequestration in agricultural soils via cultivation of cover crops–A meta-analysis. *Agricultural Ecosystems & Environment, 200,* 33–41.

Post, W.M., Izaurralde, R.C., Mann, L.K., & Bliss, N. (2001). Monitoring and verifying changes of organic carbon in soil. *Climate Change, 51,* 73–99.

Pouyat, R.V., Yesilonis, I.D., & Nowak, D.J. (2006). Carbon storage by urban soils in the United States. *Journal of Environmental Quality, 35*(4), 1566–1575.

Reeder, J.D., & Schuman, G.E. (2002). Influence of livestock grazing on carbon sequestration in semi-arid mixed-grass and short-grass rangelands. *Environmental Pollution, 116*, 457–463.

Rice, C.W. (2000). *Soil organic C and N in rangeland soils under elevated CO2 and land management. In Proceedings of Advances in Terrestrial Ecosystem Carbon Inventory, Measurements, and Monitoring* (pp. 3-5). Raleigh, North Carolina.

Rice, C.W., Garcia, F., & Hampton, C. (1994). Soil microbial response in tall grass prairie to elevated CO2. *Plant and Soil, 16*5, 62-75.

Ross, C.W., Grunwald, S., Myers, D.B., & Xiong, X. (2016). Land use, land use change and soil carbon sequestration in the St. Johns River Basin, Florida, USA. *Geoderma Regional, 7*, 19–28.

Sallustio, L., Quatrini, V., Geneletti, D., Corona, P., & Marchetti, M. (2015). Assessing land take by urban development and its impact on carbon storage: Findings from two case studies in Italy. *Environmental Impact Assessment Review, 54*, 80–90.

Satterthwaite, D. (2008). Cities' contribution to global warming: notes on the allocation of greenhouse gas emissions. *Environment and Urbanization, 20*(2), 539–549.

Scharenbroch, B. (2012). *Urban trees for carbon sequestration. In Carbon Sequestration in Urban Ecosystems* (pp. 121-138).

Schipper, L.A., Parfitt, R.L., Ross, C., Baisden, W.T., Claydon, J.J., & Fraser, S. (2010). Gains and losses in C and N stocks of New Zealand pasture soils depend on land use. *Agriculture, Ecosystems & Environment, 139,* 611–617.

Schlesinger, W.H. (1997). *Biogeochemistry: An Analysis of Global Change.* Academic Press.

Sedjo, R., & Sohngen, B. (2012). Carbon sequestration in forests and soils. *Annual Review of Resource Economics, 4*, 127-144.

Seybold, C., Herrick, J., & Brejda, J. (1999). Soil resilience: a fundamental component of soil quality. *Soil Science, 164*, 224–234.

Sharma, B. K. (2005). *Air Pollution.* Geol Publishing House.

Solberg, B. (1997). Forest biomass as carbon sink-economic value and forest management/policy implications. *Critical Reviews in Environmental Science and Technology, 27*, 323–333.

Srinivasarao, Ch., Kundu, S., Shanker, A.K., Naik, R.P., Vanaja, M., Venkanna, K., Sankar, G.R.M., & Rao, V.U.M. (2016). Continuous cropping under elevated CO2: Differential effects on C4 and C3 crops, soil properties and carbon dynamics in semi-arid alfisols. *Agriculture, Ecosystems & Environment, 218,* 73–86.

Svirejeva-Hopkins, A., Schellnhuber, H.J., & Pomaz, V.L. (2004). Urbanised territories as a specific component of the global carbon cycle. *Ecological Modelling, 173,* 295–312.

Tan, Z.X., & Lal, R. (2005). Carbon sequestration potential estimates with changes in land use and tillage practice in Ohio, USA. *Agriculture, Ecosystems & Environment, 111*, 140-152.

The Environmental Literacy Council. (2015). *Land use changes and climate.* Retrieved from https://enviroliteracy.org/air-climate-weather/climate/land-use-changes-climate/

United States Environmental Protection Agency. (2020). *Agricultural pasture, rangeland, and grazing.* Retrieved March 25, 2020, from https://www.epa.gov

Upadhyay, T.P., Prem, L., & Solberg, B. (2005). A review of carbon sequestration dynamics in the Himalayan region as a function of land-use change and forest/soil degradation with special reference to Nepal. *Agriculture, Ecosystems & Environment, 105*, 449–465.

Upadhyay, T.P., Solberg, B., & Sankhayan, P.L. (2006). Use of models to analysis land-use changes, forest/soil degradation and carbon sequestration with special reference to Himalayan region: A review and analysis. *Forest Policy and Economics, 9*, 349–371.

Velasco, E., Roth, M., Norford, L., & Molina, L.T. (2016). Does urban vegetation enhance carbon sequestration? *Landscape and Urban Planning, 148,* 99-107.

Vleeshouwers, L.M., & Verhagen, A. (2002). Carbon emission and sequestration by agricultural land use: a model study for Europe. *Global Change Biology, 8,* 519–530.

Wali, M.K., Evrendilek, F., West, T., Watts, S., Pant, D., Gibbs, H., & McClead, B. (1999). Assessing terrestrial ecosystem sustainability: usefulness of regional carbon and nitrogen models. *Natural Resources, 35,* 20-33.

Wei, X., Huang, L., Xiang, Y., Shao, X., & Gale, W. (2014). The dynamics of soil organic carbon and nitrogen after conversion of forest to cropland. *Agricultural and Forest Meteorology, 194*, 188-196.

Wei, X.R., Shao, M.A., Gale, W., & Li, L.H. (2014). Global pattern of soil carbon losses due to the conversion of forests to agriculture. *Scientific Reports, 4,* Article 1062.

West, T.O., & Marland, G. (2002). Net carbon flux from agricultural ecosystems: methodology for full carbon cycle analyses. *Environmental Pollution, 116*, 439-444.

Wilby, R.L., & Perry, G.L.W. (2006). Climate change, biodiversity, and the urban environment: a critical review based on London, UK. *Progress in Physical Geography, 30*, 73-98.

Xun, L., Feng-Min, L., Da-Qian, L., Guo-Jun, S. (2010). Soil organic carbon, carbon fractions, and nutrients as affected by land use in the semi-arid region of the loess plateau of China. *Pedosphere, 20*(2), 146-152.

Yan, X., Zhou, H., Zhu, Q.H., Wang, X.F., Zhang, Y.Z., Yu, X.C., & Peng, X. (2013). Carbon sequestration efficiency in paddy soil and upland soil under long-term fertilization in southern China. *Soil and Tillage Research, 130,* 42-51.

Yazdanshenas, H., Tavili, A., Jafari, M., & Shafeian, E. (2018). Evidence for the relationship between carbon storage and surface cover characteristics of soil in rangelands. *Catena, 167*, 139-146.

Yoon, T.K., Seo, K.W., Park, G.S., Son, Y.M., & Son, Y. (2016). Surface soil carbon storage in urban green spaces in three major South Korean cities. *Forests, 7*(115), 1-11.

Zhang, M.Y., Wang, F.J., Chen, F., Malemela, M.P., & Zhang, H.L. (2013). Comparison of three tillage systems in the wheat-maize system on carbon sequestration in the North China Plain. *Journal of Cleaner Production, 54*, 101-107.

Zhang, W.J., Xu, M.G., Wang, X.J., Huang, Q.H., Nie, J., Li, Z.Z., Li, S.L., Hwang, S.W., & Lee, K.B. (2012). Effects of organic amendments on soil carbon sequestration in paddy fields of subtropical China. *Journal of Soils and Sediments, 12,* 457–470.