ISSN: 2476-6909; ECOPERSIA. 2020;8(3):155-161

An Evaluation on Impacts of Different Land Uses and Land Covers on Emission of Carbon Dioxide from the Soil (Case Study: Biabanak, Semnan Province)

ARTICLE INFO

Article Type
Original Research

Authors
Kamali N.[1] *PhD*,
Saberi M.[2] *PhD*,
Tarnian F.[3] *PhD*,
Sadeghipour A.*[4] *PhD*

How to cite this article
Kamali N, Saberi M, Tarnian F, Sadeghipour A. An Evaluation on Impacts of Different Land Uses and Land Covers on Emission of Carbon Dioxide from the Soil (Case Study: Biabanak, Semnan Province). ECOPERSIA. 2020;8(3):155-161.

[1]Rangeland Research Division, Research Institute of Forests & Rangelands, Agricultural Research, Education and Extension Organization (AREEO), Tehran, Iran
[2]Range & Watershed Management Department, Water & Soil Faculty, University of Zabol, Zabol, Iran
[3]Range & Watershed Management Department, Agriculture & Natural Resources Faculty, Lorestan University, Lorestan, Iran
[4]Arid Area's Management Department, Desert Studies Faculty, Semnan University, Semnan, Iran

****Correspondence***
Address: Desert Studies Faculty, Semnan University, Campus 1, Semnan, Iran. Postal code: 3513119111
Phone: +98 (23) 31535555
Fax: +98 (23) 31535556
a.sadeghipour@semnan.ac.ir

Article History
Received: November 1, 2019
Accepted: February 9, 2020
ePublished: September 20, 2020

ABSTRACT

Aims The present study aims to monitor and assess CO_2 emission from the soil of different land uses and land covers including rangelands, farmlands, mines, gravel lands, and bare lands (lands characterized with no vegetation) in monthly and annual temporal scales.
Materials & Methods Monthly carbon emission was monitored according to the alkali-trap method in a closed static chamber from mid-March 2015 to mid-February 2016. Data on emissions and land use were analyzed in a factorial experiment in a completely randomized design with four replications. To determine the relationship between temperature and humidity factors with changes in carbon emission in each land use, Pearson correlation coefficient was used.
Findings The highest (about 3.44g C/m^2/d) and the lowest (0.13g C/m^2/d) emission rate was found in mines (in July 2016) and in gravel lands (in January 2016), respectively. The results also showed a seasonal pattern (high in summer and low in winter) of CO_2 emission. It was found that while carbon emission positively correlated with soil moisture, it showed a negative correlation with soil temperature in mines.
Conclusion The results depicted that land management should include proper land use selection and improper land use changes should be avoided.

Keywords CO2 Emission; Factorial Experiment; Gravel Lands; Mines

CITATION LINKS

[1] The cost of sequestering carbon on private forest ... [2] Land-use and land-cover change carbon emissions between 1901 and 2012 constrained ... [3] Carbon sequestration potential estimates with changes ... [4] Historical overview of climate ... [5] Soil carbon dioxide emission ... [6] Cropping intensity enhances soil organic carbon ... [7] Effects of anthropogenic land cover change ... [8] Carbon emissions from land use and ... [9] Rates and spatial variations of soil ... [10] HHuman-induced erosion has offset one-third of carbon emissions from land cover ... [11] Enhancing crop yields in the developing countries through restoration of the soil organic carbon pool in agricultural ... [12] Soil carbon sequestration to mitigate ... [13] Soils and world food ... [14] Soil respiration and the ... [15] Five years of carbon fluxes and inherent water-use efficiency at two semi-arid pine forests with different disturbance ... [16] Soil carbon dioxide flux, carbon sequestration and crop productivity in a tropical dryland agroecosystem: Influence of organic inputs of varying resource ... [17] Carbon sequestration and soil carbon ... [18] Carbon emissions from land-use change ... [19] Soil organic carbon sequestration potential ... [20] Carbon sequestration efficiency in paddy ... [21] Can management induced changes in the ... [22] Retention and loss of water extractable carbon ... [23] Relationship between carbon sequestration ... [24] Soil organic carbon accumulation and ... [25] Geographic bias of field observations ... [26] Management and climate impacts on ... [27] Land use affects the net ecosystem ... [28] Biotic, abiotic, and management controls on the ... [29] Soil ... [30] Carbon input, loss and storage in ... [31] Standard methods for analysis ... [32] Historical carbon dioxide emissions ... [33] Hierarchy of responses to resource ... [34] Land management practices for ... [35] Management and climate effects on carbon dioxide ... [36] Carbon dioxide flux as affected by ... [37] Daily and seasonal patterns of carbon ... [38] Soil physical variability in relation ... [39] Influence of tillage practices and crop ... [40] Interactions between land ... [41] No long-term effect of land-use activities ... [42] Quantifying the relative importance of ...

Introduction

Today, global warming is found to be a major challenge to attain sustainable development [1]. Such phenomenon has devastating impacts on natural ecosystems and organism's life through interruptions imposed on natural trends like flooding frequencies, drought periods and strengths, changes in climatic and ecological balances. This event could affect on deterioration of ecosystem production potential [2, 3]. One of the most vital greenhouse gases causing global warming is CO_2, whose rise in the atmosphere has been recorded in recent decades [4]. CO_2 emission is defined as a process of returning carbon sequestrated in the soil to the atmosphere during soil respiration [5, 6]. This can even be exacerbated via other agricultural operations such as biomass burning, plowing, tillage, and drainage and also management of natural ecosystems [2]. Anthropogenic land use change is an important factor in soil carbon loss [7, 8]. Since the beginning of human agricultural activities on land, significant changes in land carbon reservoirs have been observed [9, 10]. About 34% of the total amount of carbon emitted in the atmosphere results from land use change, 66% of which is corresponded to the combustion of fossil fuels [11]. While agricultural development was the main cause of increasing atmospheric carbon dioxide concentrations in the past, the main determinant factor today is fossil fuel combustion from industries and vehicles [12, 13]. Increasing carbon emission will have two major consequences, with one being the long-term accumulation of the concentration of greenhouse gases into the atmosphere, and the second one, reflecting as reduction of the content of the organic matter in the soil and destruction of soil structure [5]. With the latter, carbon used by the plants will be unavailable and vegetation will be deteriorated [11]. Indeed, rising CO_2 concentrations in the atmosphere will cause more carbon emission from the soil. Here, world environmental policymakers express their concerns about soil respiration changes and that increased respiratory activity in the soil has led to increased carbon emission [5].

Deforestation, rangeland deterioration, and land cover change accounted for 12.5% of the carbon emitted to the atmosphere between 1990 and 2010 [8]. Enormous anthropogenic activities applied in the rangelands have contributed to the loss and disruption of carbon flux [14, 15]. Different land uses and land covers play a significant role in carbon sequestration and emission. Hence proper land management and land use selection, commensurate to the conditions of each area, would increase carbon sequestration and reduce carbon emission [16].

Many studies have shown various factors affecting carbon sequestration. These factors include bulk density, fertilizer application and quantity, crop management systems and management practices [17-19], the return of plant and organic residues to the soil, microbial activity and soil structure [20], management practices such as irrigation, soil fertilization and cultivation type [21], clay percentage, calcium ions, carbon and CEC [22], soil reaction, gravel, silt, clay and pebble and gravel percent [23], climatic conditions, temperature, soil moisture, texture and soil type, previous land use, return of organic matter to the soil, soil disturbance and soil organic matter [24].

Powers *et al.* [25] reported that the effect of land use change on carbon variation has been the most important factor in carbon studies. They also emphasize that it is impossible to monitor carbon emission and sequestration in different climatic zones in the absence of knowledge on land uses and management [14]. In addition to overgrazing, change of the land use from forest and rangeland to agricultural lands combined with traditional agricultural practices increase carbon emission. Rangeland management practices are important in addition to environmental factors such as temperature and precipitation on soil-to-atmosphere carbon exchanges. Therefore, knowledge on type and amount of gas exchange is essential for finding a correct land management method towards more carbon sequestration and less carbon emission [26-28]. The present study aimed to shed light on the impacts of different land uses and land covers on CO_2 emission at different months and seasons for one year. Hence, the main hypothesis was to test the effects of land use and land cover on CO_2 emission.

Materials and Methods

Site selection and description

The study area is nestled over in the arid-zone of Iran extending 5777.2ha. It is stretched between south Sorkheh on the north, Biabanak on the east and Asadabad on the west. This region is located between 53°08′36″ to 53°14′36″ E and 35°25′01″ to 35°19′30″ N the Greenwich meridian. The study area is spanned between

946.65 and 1232.75m above sea level. According to Semnan synoptic station, its average annual precipitation is 145.1mm and its average annual temperature is around 18°C.

Having delineating the study area using satellite images, aerial photos, field visits and reconnaissance, a land use and land cover map was generated using GIS (Figure 1). Rangelands, Farmlands, Mines, gravel, and bare lands had 2075.18, 133.01, 30.54, 904.23, and 2695.92 hectares area, respectively.

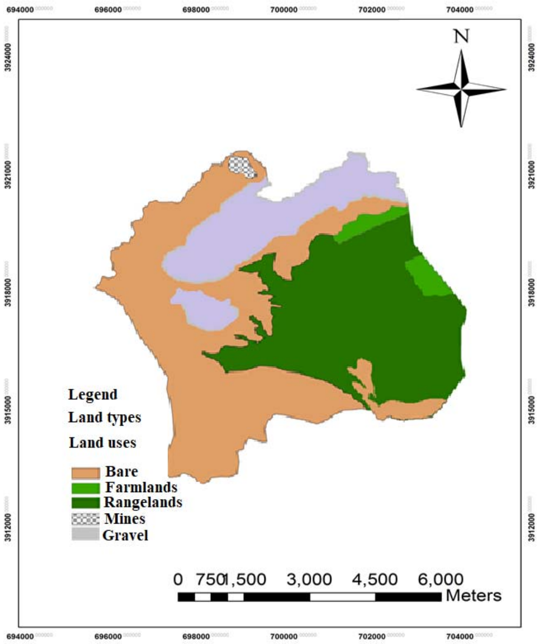

Figure 1) Land uses/land cover map in the study area of Sorkheh

Carbon emission measurement

Carbon emission was measured following Anderson [29] with some modifications in the procedure. Semi-permanent CO_2 trapping assembly made from polyvinyl chloride (PVC) columns (18-36cm) with tight lid having air tight silicon seal-inserted 5cm deep into the soil [30] in each treatment plot this ensures a yearlong approximate monitoring of CO_2 evolution by batch trapping of CO_2 Carbon emission sampling is initiated in mid-March 2015 and continued monthly till mid-February 2016. Alkali trap, a glass jar with 10ml 1N NaOH, was placed for one day in each column and the lid of the column was tightly sealed with paraffin film. The trapped CO_2 was analyzed by titrating it with 0.1N HCl in the presence of excessive $BaCl_2$ and few drops of phenolphthalein. A screw capped alkali trap placed in one of the columns was taken as control. Amount of CO_2 or C evolved from the soil during the exposure of alkali was calculated following Gupta *et al.* [31] equation:

$$C \text{ or } CO_2 \text{ (mg)} = (B-V)\ NE$$

Where, B is the volume (ml) of acid needed to titrate NaOH in the jars from the control cylinders, V is the volume (ml) of acid needed to titrate the NaOH in the jars exposed the soil atmosphere, N is the normality of the acid, and E is the equivalent weight. To express the data in terms on carbon, E is 6, to express it as CO_2, E is 22.

Soil moisture and temperature

Moisture and temperature were taken simultaneously in the middle of each month from mid-March 2015 to mid-February 2016. Soil moisture was determined gravimetrically and the temperature data was obtained from a field weather station in Sorkheh, Semnan Province, Iran.

Experimental design and data analysis

Carbon emission data on different land uses were analyzed as a factorial experiment in a completely randomized design with 12 replications in each treatment. Analysis of variance (ANOVA) using the general linear model (GLM) procedure (SPSS 17, released 2008) was used to determine the effects of different land uses, seasons, months, and their possible interactions on carbon emission. Differences between means of carbon emitted across the months, seasons, and different land uses confirmed by Duncan test ($p \leq 0.05$). To study the effects of soil moisture and temperature on carbon emission changes in different land uses, the Pearson correlation was used due to the homogeneity and normality of the data.

Findings

Land use change is one of the most important reasons for the return of carbon from the soil to the atmosphere, whose importance, despite its very effective role, has not been much considered by the scientists [32]. In the study areas, there is a negative correlation between the soil moisture content and carbon emissions rate from the soil only in the mine land use, that is, as moisture content in this land use decreases, soil emission increases. At the same time, a positive correlation between carbon emissions and temperature in both agricultural and mine land was found, so that an increase in temperature has led to higher emissions. The highest and lowest carbon emissions were recorded in summer and the winter, respectively. The highest and lowest emission rate was attributed to mines land use in July (about 3.44g C/m^2/d) and gravel lands in January (0.13g C/m^2/d), respectively. Correlation analysis of carbon emissions in all land uses and soil moisture content only shows a negative correlation between mining and emission rate, that is, the more the moisture content was in the soil, the less the emission measured. There also is a positive correlation between the amount of carbon emission and mining, gravel land- and farmland. That is, increasing soil temperature leads to an increase in the carbon emissions of these land uses (Table 1).

Table 1) Correlation between carbon emission in different land uses with temperature and moisture

Land uses/land covers	Temperature	Moisture
Gravel lands	0.006	0.488
Bare lands	0.552	-0.46
Rangelands	0.586	-0.433
Farmlands	0.586*	-0.44
Mines	0.725**	-0.623*

*: Significant difference at 5% level; **: Significant difference at 1% level

Carbon emission

The results of variance analysis of the effects of different months on carbon emissions in each of the land uses are shown in Table 2.

In the current study, carbon emission of different land uses is significantly different across the year. The highest amount of carbon emission belongs to mines, and the least simultaneously goes to rangeland, gravel, and bare lands. While the highest emission rate was found in mines land use in July (about 3.44g C/m^2/d), the least emission rate was estimated for gravel lands and bare lands in January (0.13g C/m^2/d). The highest emission was observed in gravel lands in July (3.04g C/m^2/d) and the lowest was in gravel land uses in January (0.13g C/m^2/d; Diagram 1).

Analysis of the seasonal variation of emissions throughout the year also shows the difference among the rates of emission for land uses in different seasons of the year (Table 3).

At the same time, summer and winter accounted for the highest and lowest carbon emission in mines and gravel lands, respectively (Diagram 2).

Table 2) Analysis of variance of carbon dioxide emission at months and different land uses

Sources of variations	MS	F
Month	6.211	369.631**
Land use	2.677	159.334**
Land use* month	0.279	16.632**

*: Significant difference at 5% level; **: Significant difference at 1% level

Table 3) Analysis of variance of seasonal effects and different land uses on carbon emission

Sources of variations	MS	F
Land use	3.646	921.661**
Month*land use	0.781	187.226**
Season* emission rate	0.191	741.45**

*: Significant difference at 5% level; **: Significant difference at 1% level

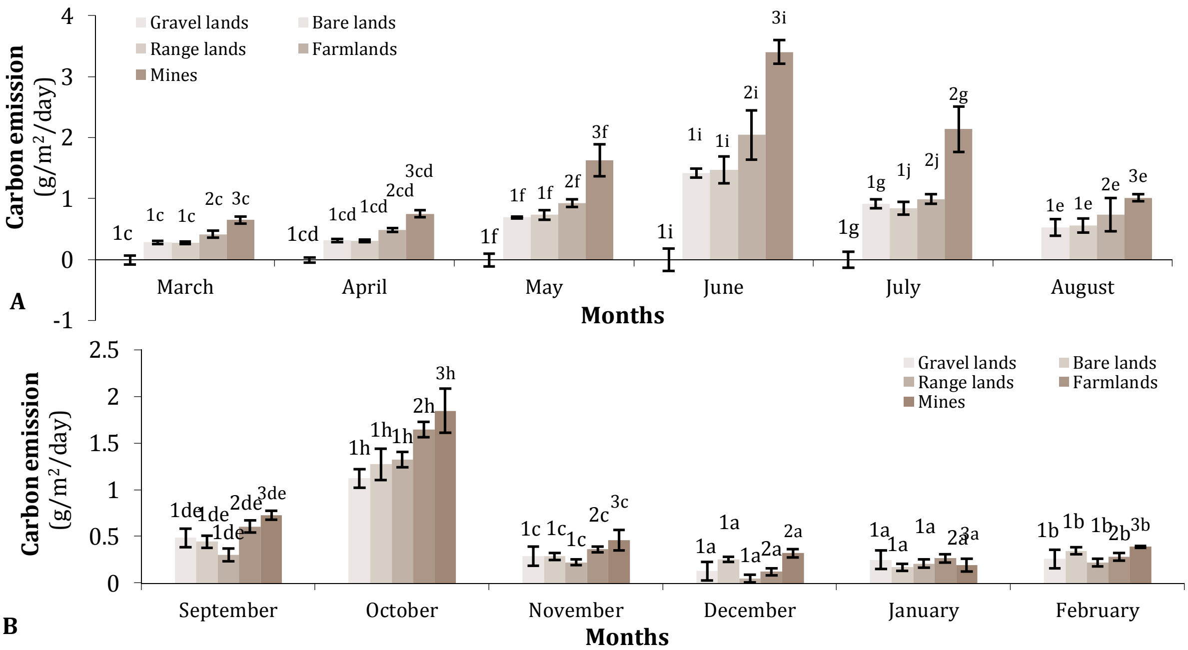

Diagram 1) The interaction effect of different land uses and months on carbon dioxide emissions rates; A: the first half of the year and B: the second half of the year

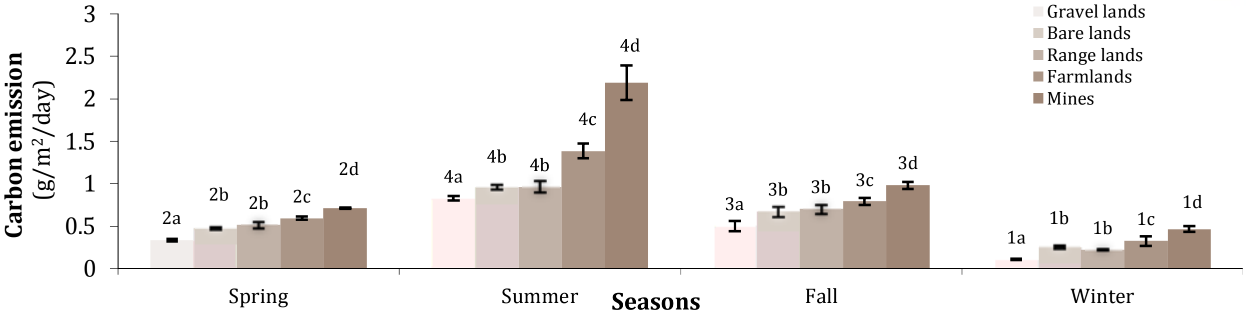

Diagram 2) The interaction effects of different seasons and land uses on carbon dioxide emissions rates

Discussion and Conclusion

Land management practices, in conjunction with fluctuations of the environmental factors (such as rainfall and temperature), can significantly affect the soil and atmosphere carbon exchange. Thus, recognizing these gas exchanges is essential for finding an appropriate land management practice for more carbon assimilation from the atmosphere to the soil and fewer carbon emissions from the soil to the atmosphere [26, 28, 33, 34].

In the present study, rangelands, gravel lands, and bare lands showed the lowest emission rate. This is comparable to the study of Peichla *et al.* [35] where forage grazing on the stocking rate resulted in a lower emission rate than machinery harvesting like mowing. On the other hand, Jabro *et al.* [36] reported that in rangelands subjected to overgrazing, carbon emission increases significantly, mostly due to soil structure collapse by livestock, loss of soil moisture by livestock trampling, increased activity of microorganisms due to the feces left by the livestock in rangeland, degradation of vegetation and the increased bare soil under erosion.

The seasonal pattern of the carbon emissions is due to changes in the angle of suns's rays on the soil surface changing soil temperature and humidity, microorganism's activity and litter decomposition. Such results are in line with findings of many researchers [37-39]. Land use change (deforestation and rangelands deterioration) and land cover change accounted for 12.5% of the carbon emitted to the atmosphere from 1990 to 2010 [8]. Powers *et al.* [25] believe that such land use changes make it impossible to monitor carbon emission and sequestration in different climatic zones particularly in absence of knowledge on land use management [14].

In addition to overgrazing, land uses change from forest and rangelands to agricultural lands and traditional agricultural practices increase carbon emissions. Forest and rangeland management practices are important on soil-to-atmosphere carbon exchanges having knowledge on type and amount of gas exchanges is essential for finding the correct land management method in order to increase carbon sequestration from the atmosphere to the soil and decrease carbon emission from soil to the atmosphere [26-28].

It is anticipated that, by the year 2300, due to incorrect management decisions and changes in land use 490 Pg of carbon will be emitted from the soil to the atmosphere [40]. The main reason for the return of carbon from soil to the atmosphere is the anthropogenic interference that results in carbon dissociation. A 30-year study of soil carbon changes indicates the significant impact of land management and land use on the amount of carbon emissions in the tropics. The use of rangeland under severe fires and lack of proper management is the most important reason for carbon emissions from the soil to the environment [41].

Given substantial changes in climate (e.g. global warming) and its impact on vegetation, the significant role of this on the carbon cycle and atmospheric carbon changes should also be taken into account [42].

The results of the current study showed that the highest CO_2 emissions occurred in the mining areas (about 3.44g C/m^2/d). Mining causes a great waste in the amount of carbon in the soil due to the great disruption in the soil. Gravel cover (0.13g C/m^2/day) has the lowest rate of CO_2 emissions. Overall, the results suggested that improper land use changes should be avoided.

Acknowledgments: The authors are grateful to research affairs of University of Zabol for financial support.

Ethical permissions: The case was not reported by the authors.

Conflicts of interests: The authors declare that they have no conflicts of interests.

Authors' Contribution: Nadia Kamali (First author), Introduction author/Original researcher/Discussion author (30%); Morteza Saberi (Second author), Methodologist/Original researcher/Statistical analyst (30%); Farajollah Tarnian (Third author), Assistant/Discussion author (20%); Ahmad Sadeghipour (Fourth author), Introduction author/Assistant (20%)

Funding/Support: The authors are grateful to research affairs of university of Zabol for the financial support (Grant number: UOZ-GR-9618-72).

References

1- Huang CH, Kronrad GD. The cost of sequestering carbon on private forest lands. For Policy Econ. 2001;2(2):133-42.
2- Li W, Ciais P, Peng S, Yue C, Wang Y, Thurner M, et al. Land-use and land-cover change carbon emissions between 1901 and 2012 constrained by biomass observations. Biogeosciences. 2017;14:5053-67.
3- Tan Z, Lal R. Carbon sequestration potential estimates with changes in land use and tillage practice in Ohio, USA. Agric Ecosyst Environ. 2005;111(1-4):140-52.
4- Le Treut H, Somerville R, Cubasch U, Ding Y, Mauritzen C, Mokssit A, et al. Historical overview of climate change. In: Solomon SD, Qin M, Manning Z, Chen M, Marquis KB, Averyt M, et al, editors. Climate change 2007: The physical science basis. Cambridge: Cambridge University Press; 2007. pp. 95-122.
5- Sainju UM, Jabro JD, Stevens WB. Soil carbon dioxide emission and carbon content as affected by irrigation, tillage, cropping system, and nitrogen fertilization. J Environ Qual. 2008;37(1):98-106.
6- Sherrod LA, Peterson GA, Westfall DG, Ahuja LR. Cropping intensity enhances soil organic carbon and nitrogen in a no-till agroecosystem. Soil Sci Soc Am J. 2003;67(5):1533-43.
7- Pongratz J, Reick CH, Raddatz T, Claussen M. Effects of anthropogenic land cover change on the carbon cycle of the last millennium. Glob Biogeochem Cycles. 2009;23(4):GB4001.
8- Houghton RA, House JI, Pongratz J, Van Der Werf GR, DeFries RS, Hansen MC, et al. Carbon emissions from land use and land-cover change. Biogeosciences. 2012(12):5125-42.
9- Cerdan O, Govers G, Le Bissonnais Y, Van Oost K, Poesen J, Saby N, et al. Rates and spatial variations of soil erosion in Europe: A study based on erosion plot data. Geomorphology. 2010;122(1-2):167-77.
10- Wang Z, Hoffmann T, Six J, Kaplan JO, Govers G, Doetterl S, et al. Human-induced erosion has offset one-third of carbon emissions from land cover change. Nat Clim Chang. 2017;7(5):345-9.
11- Lal R. Enhancing crop yields in the developing countries through restoration of the soil organic carbon pool in agricultural lands. Land Degrad Dev. 2006;17(2):197-209.
12- Lal R. Soil carbon sequestration to mitigate climate change. Geoderma. 2004;123(1-2):1-22.
13- Lal R. Soils and world food security. Soil Tillage Res. 2009;102:1-4.
14- Luo Y, Zhou X. Soil respiration and the environment. Cambridge: Elsevier Academic Press; 2006.
15- Vickers D, Thomas C, Pettijohn C, Martin JG, Law B. Five years of carbon fluxes and inherent water-use efficiency at two semi-arid pine forests with different disturbance histories. Tellus B Chem Phys Meteorol. 2012;64(1):17159.
16- Singh KP, Ghoshal N, Singh S. Soil carbon dioxide flux, carbon sequestration and crop productivity in a tropical dryland agroecosystem: Influence of organic inputs of varying resource quality. Appl Soil Ecol. 2009;42(3):243-53.
17- Brar BS, Singh K, Dheri GS. Carbon sequestration and soil carbon pools in a rice-wheat cropping system: Effect of long-term use of inorganic fertilizers and organic manure. Soil Tillage Res. 2013;128:30-6.
18- Lai L, Huang X, Yang H, Chuai X, Zhang M, Zhong T, et al. Carbon emissions from land-use change and management in China between 1990 and 2010. Sci Adv. 2016;2(11):e1601063.
19- Qin Z, Huang Y, Zhuang Q. Soil organic carbon sequestration potential of cropland in China. Glob Biogeochem Cycles. 2013;27(3):711-22.
20- Yan X, Zhou H, Zhu QH, Wang XF, Zhang YZ, Yu XC, et al. Carbon sequestration efficiency in paddy soil and upland soil under long-term fertilization in southern China. Soil Tillage Res. 2013;130:42-51.
21- Sanderman J. Can management induced changes in the carbonate system drive soil carbon sequestration? A review with particular focus on Australia. Agric Ecosyst Environ. 2012;155:70-7.
22- Nguyen TT, Marschner P. Retention and loss of water extractable carbon in soils: Effect of clay properties. Sci Total Environ. 2014;470-471:400-6.
23- Islam KK, Anusontpornperm S, Kheoruenromne I, Thanachit S. Relationship between carbon sequestration and physico-chemical properties of soils in salt-affected areas, Northeast Thailand. Kasetsart J Nat Sci. 2014;48:560-76.
24- Corsi S, Friedrich T, Kassam A, Pisante M, De Moraes Sà J. Soil organic carbon accumulation and greenhouse gas emission reduction from conservation agriculture. A literature review. Rome: FAO; 2012.
25- Powers JS, Corre MD, Twine TE, Veldkamp E. Geographic bias of field observations of soil carbon stocks with tropical land-use changes precludes spatial extrapolation. Proc Natl Acad Sci. 2011;108(15):6318-22.
26- Zeeman MJ, Hiller R, Gilgen AK, Michna P, Plüss P, Buchmann N, et al. Management and climate impacts on net CO2 fluxes and carbon budgets of three grasslands along an elevational gradient in Switzerland. Agric For Meteorol. 2010;150(4):519-30.
27- Schmitt M, Bahn M, Wohlfahrt G, Tappeiner U, Cernusca A. Land use affects the net ecosystem CO2 exchange and its components in mountain grasslands. Biogeosciences. 2010;7(8):2297-2309.
28- Wohlfahrt G, Anderson-Dunn M, Bahn M, Balzarolo M, Berninger F, Campbell C, et al. Biotic, abiotic, and management controls on the net ecosystem CO2 exchange of European mountain grassland ecosystems. Ecosystems. 2008;11(8):1338-51.
29- Anderson JP, Page AL, Miller RH, Keeney DR. Soil respiration. In: Page AL, editor. Methods of soil analysis, part 2. 2nd Edition. Madison: American Society of Agronomy; 1982. pp. 831-71.
30- Suman A, Singh KP, Singh P, Yadav RL. Carbon input, loss and storage in sub-tropical Indian Inceptisol under multi-ratooning sugarcane. Soil Tillage Res.

2009;104(2):221-6.
31- Gupta IC, Yaduvanshi NP, Gupta SK. Standard methods for analysis of soil plant and water. Unknown publisher city: Scientific Publishers; 2012.
32- Arneth A, Sitch S, Pongratz J, Stocker BD, Ciais P, Poulter B, et al. Historical carbon dioxide emissions caused by land-use changes are possibly larger than assumed. Nat Geosci. 2017;10(2):79-84.
33- Schwinning S, Sala OE. Hierarchy of responses to resource pulses in arid and semi-arid ecosystems. Oecologia. 2004;141(2):211-20.
34- The National Academies of Sciences, Engineering, and Medicine. Land management practices for carbon dioxide removal and reliable sequestration. Washington, D.C.: The National Academies of Sciences, Engineering, and Medicine; 2018.
35- Peichl M, Carton O, Kiely G. Management and climate effects on carbon dioxide and energy exchanges in a maritime grassland. Agric Ecosyst Environ. 2012;158:132-46.
36- Jabro JD, Sainju U, Stevens WB, Evans RG. Carbon dioxide flux as affected by tillage and irrigation in soil converted from perennial forages to annual crops. J Environ Manag. 2008;88(4):1478-84.
37- Eamus D, Hutley LB, O'Grady AP. Daily and seasonal patterns of carbon and water fluxes above a north Australian savanna. Tree Physiol. 2001;21(12-13):977-88.
38- Gupta RD, Arora S, Gupta GD, Sumberia NM. Soil physical variability in relation to soil erodibility under different land uses in foothills of Siwaliks in NW India. Trop Ecol. 2010;51(2):183-97.
39- Bilandžija D, Zgorelec Ž, Kisić I. Influence of tillage practices and crop type on soil CO2 emissions. Sustainability. 2016;8(1):90.
40- Mahowald NM, Randerson JT, Lindsay K, Munoz E, Doney SC, Lawrence P, et al. Interactions between land use change and carbon cycle feedbacks. Glob Biogeochem Cycles. 2017;31(1):96-113.
41- Oliver V, Oliveras I, Kala J, Lever R, Teh YA. No long-term effect of land-use activities on soil carbon dynamics in tropical montane grasslands. Biogeosci Discuss. 2017:1-25.
42- Davies-Barnard T, Valdes PJ, Singarayer JS, Wiltshire AJ, Jones CD. Quantifying the relative importance of land cover change from climate and land use in the representative concentration pathways. Glob Biogeochem Cycles. 2015;29(6):842-53.