

Article

Opportunities to Increase Soil Carbon Stocks Under Climate Change Conditions

M. Khakimova¹, S. Z. Buriyeva²^{1,2} Karshi State Technical University.

Citation: Khakimova M., Buriyeva S. Z. Opportunities to Increase Soil Carbon Stocks Under Climate Change Conditions. American Journal of Biology and Natural Sciences 2026, 3(2), 112-115.

Received: 15th Nov 2025Revised: 22nd Dec 2025Accepted: 14th Jan 2026Published: 10th Feb 2026

Copyright: © 2026 by the authors. Submitted for open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>)

Abstract: This paper discusses the two challenges, i.e., how agriculture could effectively achieve carbon neutrality and what kind of supporting strategies could be developed, as these foreign scholars failing to feature in the dedicated studies on this issue has been reviewed and presented here. Methods for achieving carbon neutrality by enhancing soil productivity, mitigating emissions, and establishing sustainable agroecosystems in the context of climate change are examined. The agrochemical characteristics of light gray soils in the research field are also analyzed. Also analyzed are projects for the environment implemented in the Republic of Uzbekistan and, specifically policies of the state to address soil degradation and carbon release. Scientific findings in the breeding of climate-resilient crops and stabilizing agricultural systems are provided as one of the most important weather changes adaptation strategies. The article adds that carbon-neutral agriculture is key to avoiding global environmental issues.

Keywords: Carbon Neutrality, Greenhouse Gases, Soil Fertility, Soil Carbon Sequestration, Agroforestry, Climate Change, FAO, Environmental Policy and Conditions in Uzbekistan, Ecological Sustainability, Humus, Total NPK.

Introduction

Climate change is considered to be one of the most critical environmental challenges in this century. The cause of this response is largely attributed to anthropogenic CO₂ emissions--generated predominantly from fossil fuel burning, cement production, and land-use change (particularly deforestation)--as the predominant forcing factor in the system Ciais et al., 2013 [7], [10]. Agriculture and land use change activities release around 9.3 billions tons of carbon dioxide equivalent (CO₂-eq.) into the atmosphere, according to FAO data. emissions globally. Over half the emissions (5.3 billion tons CO₂-eq.) arise from on-farm crop and livestock production, while land resources and land-use change – associated activities contribute to nearly 4 billion tons CO₂-eq. [9], [10].

The agricultural industry is a two-way sector in decarbonization of the economy; it constitutes both emissions and sequestration as sources. 3.4 Agriculture is the only sector that has the unique potential if we're going to transition an emitting sector of CO₂ into a storing one, and out of all other human-managed ecosystems, closest competitor is rangelands (Depascale et al., 2011) accruing C from atm in its life form (Carbon Cycle Institute 10) The estimated potential for global climate change mitigation in 2030 is approximately 5500-6000 million tons of CO₂ equivalent per year, within the agricultural sector excluding emissions and losses related to biomass [10], [13].

In this regard, a number of solutions to combat land degradation, mitigate its negative consequences and maintain soil fertility and conservation of biodiversity are reflected in President's Decree No. 277 of the Republic of Uzbekistan dated June 10, 2022 by focusing on the use of modern scientific achievements and technologies [1]. In addition to the challenge of cessation of water, soil salinization and land destruction under the influence/impact of increasing average air temperatures in the region, as well as adjustments to climate change in agriculture and soften adverse climatic effects (emissions sweepers greenhouse gases) been solved with cooperation foreign countries' environmental funds, FAO and other relevant institutions [6]. Besides, Resolution No.783 of the Cabinet Action of Ministers of the Republic of Uzbekistan dated 25 November 2024 "On a series of measures to reduce the negative environmental impact from industrial entities" lays down the legal grounds for realization a number other environmental projects in collaboration with industrial enterprises within other normative acts [26].

Literature Review

Systematic and accurate observations of atmospheric CO₂ concentration were used since 1959 when C.D. Keeling started the measurements at Mauna Loa (Hawaii) and the South Pole (Keeling et al., 1976a, b) [12,13]. From the analysis of ice cores and air inclusion in ice, it is stated that the global average level of atmospheric CO₂ in 1750 is approximately 278 ± 2 ppm (Etheridge et al., 2006) using a facing page translation into XML Implementing been measureme.3 AGB end1^LWX nationalsource on World Wide Web sH SbC SoS fNOp soils ecosystems are likely ranging from some have yet to be distribution their values of source For examination the negative see right hand column Figure omics Co x 9W y Iterable Ellingham T.No known copyright restrictions.] a """"i11INRR% figurelung ratio rltt flo!...;'/,,,,'4 rgcm = >>>- IHMIRM igf!'7'n» :""""I u : ' ' M* ir sp Vjmm £r i #U~ ! \ Nrffftnr « HMXRWO W3 " QCOOH SCI-XCH\ - hogsir?> eHS re ro oh Rating **Appear.Dept.

It reached 400.0 ± 0.1 ppm by the end of the year 2015 (WMO, 2016), which is higher than found in any ice core record for at least the last 800,000 years (Lüthi et al., 2008) [14].

Institutional foundations have been laid for the creation of such a hybrid carbon regulating mechanism, but its success depends on a specialized infrastructure targeted at long-term climate projects. Essential elements of such infrastructure would be:

- a) Carbon polygon experiments - experimental "laboratories" dedicated to fundamental and applied research tracking, assessing and measuring fluxes of climate-relevant gases and sequestration into soils and vegetation- including economic valuation of the processes;
- b) Carbon farms (these could be running as supplementary to carbon polygons or autonomously for commercial purposes)—cross sections of land with high levels of capture and locking of CO₂ (as well as other greenhouse gasses) [15], [24].

Cover crops have the potential for reducing climate change through carbon sequestration - capturing atmospheric CO₂ in plants and storing it in soil. Research shows that cover crops grown on about 8.1 million ha can sequester over 66 million tons of CO₂ equiv per year, an amount equivalent to the emissions of an estimated 13 million cars [4], [6], [12], [13], [22].

In her scientific works N.P.Muraveva singled out five agro-soil processes, and indicated that two of them are equivalent to Ring frosts as an indicator of the intensity 517agro-soil regions for Qarshi and Guzor regions with prevalence of light gray soils, as well as for Lower Kashkadarya region with desert-zone soils [18], [20].

In the southern taiga, the processes of humus formation in the biocenoses of light (graugropø) and typical graugrop are expressed by a considerable accumulation of newly synthesized humic acids, which afterwards move into more mobile forms and fractions [3]. For light gray and ordinary gray soils, the type of humus is presented as humate-fulvate [17], [19].

Materials and Methods

The subject: The light gray soils of the Guzor district of the Kashkadarya Region, located in the zone of influence of Shurtan Gas Chemical Plant. In 2024, young seedlings of paulownia were planted

around the site of the Shurtan Gas Chemical Complex, and soils samples from this territory were taken to determine its agrochemical properties.

Field studies were conducted according to the methodologies “Dala tajribalarni o’ tkazish uslublari” (UZPITI, Tashkent, 2007). References and genetic horizons were sampled for soil, processed in the laboratory using Ye. V. Arinushkina’s “Руководство по химическому анализу почв” (Moscow, 1970) and “Методика агрохимических, агрофизических и микробиологических исследований в поливных хлопковых районах”.

The humus content in the soil was estimated by the Tyurin method (GOST 26213–91) and mobile phosphorus and exchangeable potassium were analyzed using the Machigin–Protasov method.

Results and Discussion

Irrigated light gray soils occur on broad undulating plains of loess and loess-like fine alluvial deposits, infrequently conical hillsides. They became semi-hydromorphic and hydromorphic soils due to a long-range irrigation. These are light gray soils which differ by the availability of an agroirrigation layer. The irrigated light gray soils are generally found on flat land, and thus irrigation erosion hardly develops during the fallow process, being very slightly developed. The soils of the submontane plains are mechanical medium and light loamy, weakly skeletal and weakly gypsum in places, on conical outcrops are loamy-tiley heavy with a layer of gravel to 1-2 m. Light gray soils can achieve salinization; there are non-saline, low saline and medium saline soil in addition to [3], [23].

The graph below shows the results of an analysis of soil samples extracted from the area under study. According to which are described, agrochemical characteristics of the light gray soils of Guzar district (the area surrounding Shurtangaz chemical complex) of Kashkadarya region, among them contents humus and general NPK elements (Figs 1-2).

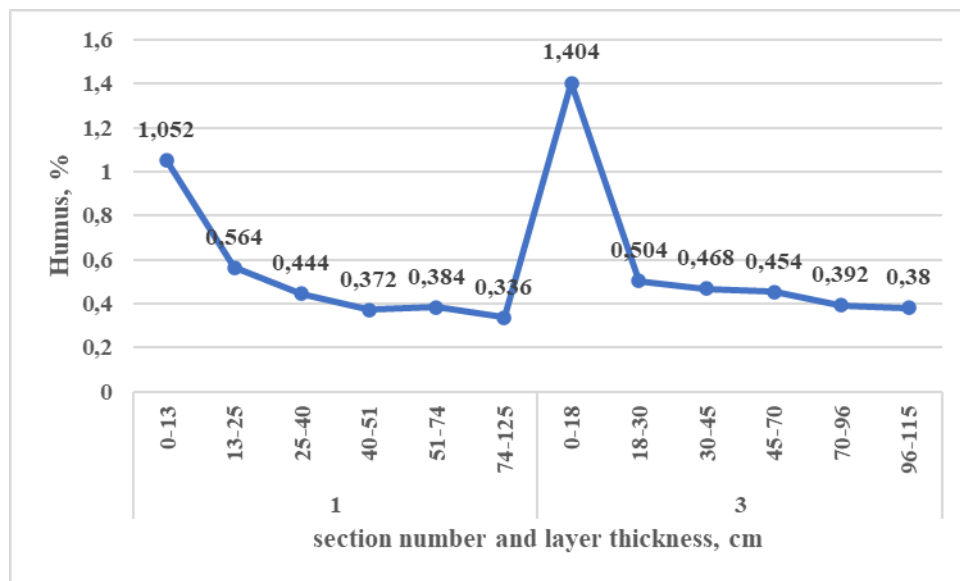


Figure 1. Agrochemical properties of light gray soils, humus %.

Weak development of the horizons characterizes the morphological structure of light-gray earths caused by insufficient differential process in their formation (low humus content, a relatively thin 15–20-cm humus layer, 3–5-cm sod-plowed surface horizon.). In the territory of light gray soils, thickness of the low-humus horizon (A+B) does not exceed 40 cm; within it, humus layer makes up ~20 cm on the average and sod type upper horizon – 3-5 cm. As such, light gray soils are characterized by low contents of organic matter which are lower compared to light desert soil, although the sod horizon contains higher levels of humus [23], [25].

According to the analysis, humus ranged from a minimum of 0.372% to 1.052–1.404% in the layers of 0–13, 25 and 45 cm, respectively with mean values fall between (0.468–0.564%). This value decreased (0.336–0.392%) in the lower horizons (51 to 70 cm up to 115–125 cm) (Fig1). The low humus content is mainly due to the limited accumulation of plant residues at the upper sod level and by the dry climate in the study area, where organic residues decompose very quickly during favourable hydrothermal periods (May–June–July).

Because drip irrigation was established after the paulownia saplings were planted, shallow soil moisture accumulation was found at a depth of less than 50 cm.

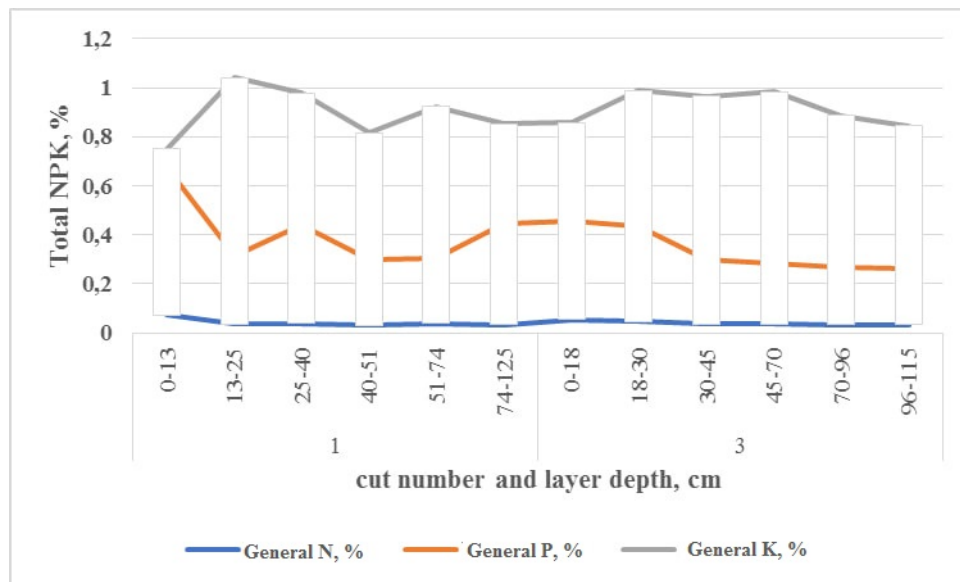


Figure 2. Agrochemical properties of light gray soils, total NPK, %.

Total NPK contents were compared as follows. In the upper horizons (0–13–18 cm), mean total nitrogen varied from 0.0532 to 0.0728 per cent, total phosphorus from 0.433 to 0.675 per cent and potassium from 0.75 to 0.99%. The total NPK contents reduced towards the bottomsoil layers (40–70–115 cm) (Figure 2).

Soil agrochemical and physicochemical properties are significantly involved in plant growth and development. The general soil N amount have a direct relationship with the humus content, and soils rich in organic material contain higher levels of nitrogen whereas, K is mostly dependent on their granulometric composition of the mineral fraction and the parent rock [16], [21]. Accordingly, the study of soil agrochemical properties allows to make preliminary conclusions about organic substances of soil resources – SOM and content and reserves of OC. All of these parameters are tightly linked.

Conclusion

Climate change is among the most pressing global challenges of the 21st century, highlighting an immediate necessity for practical initiatives to secure food and mitigate greenhouse gas emissions. While global warming, desertification, and the control of greenhouse effect still pose serious challenges, the negative influence can be alleviated by carbon neutrality. Various strategies to make agriculture sustainable and climate-resilient can be deemed effective, such as increasing and conserving soil carbon stocks; decreasing greenhouse gases from livestock and crop production; planting trees (i.e., afforestation) or creating “carbon farms”; managing of soil organic matter; facilitating the appropriate fertilization systems and choosing suitable crop varieties in cropping systems. Taken together, these activities are critical mobilizers to enhance the capacity of agriculture for climate change mitigation.

Improvement of soil fertility should focus on the complex improvement of soils from the perspective of the biological, mechanical, and physical conditions under a consideration to agrochemical properties. According to the results of the study, humus contents in sods of LG soils are low because plant residues do not accumulate and are broken down rapidly due to the arid nature of region under conditions favorable for hydrothermal conditions (May–June–July). Total NPK values showed a direct relationship with humus, and consequently, the total NPK values also had low values.

REFERENCES

- [1] O‘zbekiston Respublikasi Prezidentining 2022 yil 10-iyundagi “Yerlar degradatsiyasiga qarshi kurashishning samarali tizimini yuritish chora-tadbirlari to‘g‘risida”gi PQ-277 son qarori
- [2] O‘zbekiston Respublikasi Prezidentining 2024-yil 24-iyundagi “Iqlim o‘zgarishiga nisbatan barqaror agroekotizimni yaratish hamda qishloq xo‘jaligi mahsulotlari yetishtiruvchilarning iqlim o‘zgarishi bilan bog‘liq xavflarga moslashuvchanligini oshirish chora-tadbirlari to‘g‘risida”gi PQ-233 son qarori
- [3] O‘zbekiston Respublikasi tuproq qoplamlari Atlasi. O‘zbekiston Respublikasi yer resurslari, geodeziya, kartografiya va davlat kadastr davlat qo‘mitasi. – Toshkent, 2010. B. 23-25
- [4] Bertrand S, Roberts AS, Walker W. Cover crops for climate change adaptation and mitigation agriculture and climate series. 2022. Accessed 6 September 2023.
- [5] Buyanovski, G.A., Wagner, G.H. 1998. Changing role of cultivated land in the global carbon cycle. *Biology and Fertility of Soils* 27: 242-245
- [6] Carbon Cycle Institute. Carbon Farming; 2020. Accessed 19 August 2023
- [7] Ciais P, Sabine C, Bala G, Bopp L, Brovkin V, Canadell J, Chhabra A, DeFries R, Galloway J, Heimann M, Jones C, Quéré CL, Myneni RB, Piao S, Thornton P (2013) Carbon and other biogeochemical cycles In: Stocker TF, Qin D, Plattner G-K et al (eds) *Climate change 2013: the physical science basis. Contribution of working group I to the fifth assessment report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, pp 465–570
- [8] Etheridge DM, Steele LP, Langenfelds RL, Francey RJ, Barnola JM, Morgan VI (1996) Natural and anthropogenic changes in atmospheric CO₂ over the last 1000 years from air in Antarctic ice and firn. *J Geophys Res D: Atmos* 101(D2):4115–4128. doi:10.1029/95jd03410
- [9] Food and Agriculture Organization. Emissions Due To Agriculture. Global, Regional and Country Trends 2000–2018. FAOSTAT, Analytical Brief Series №18. Rome; 2020
- [10] Gafurova L.A., Ergasheva O.X., Usmanova Y.A., Global iqlim o‘zgarishi sharoitida uglerod neytralligiga erishishdagi agrobiotexnologiyalar. O‘zbekiston agrar xabarnomasi №5 (23) 2025. – B. 113-116.
- [11] Gafurova L.A., Ergasheva O.X., Usmanova Y.A., Xakimova M. Global iqlim o‘zgarishi sharoitida uglerod neytralligiga erishishdagi agrobiotexnologiyalar. O‘zbekiston agrar xabarnomasi №3 (21/2) 2025. Maxsus son 1-qism. -B. 235-238 .
- [12] Heimpel GE, Yang Y, Hill JD, Ragsdale DW. Environmental consequences of invasive species: Greenhouse gas emissions of insecticide use and the role of biological control in reducing emissions. *PLoS One*. 2013; 8(8):72293.
- [13] Keeling CD, Adams JAJ, Ekdahl CAJ, Guenther PR (1976a) Atmospheric carbon dioxide variations at South Pole. *Tellus* 28(6):552–564
- [14] Keeling CD, Bacastow RB, Bainbridge AE, Ekdahl CA, Guenther PR, Waterman LS, Chin JFS (1976b) Atmospheric carbon dioxide variations at Mauna Loa Observatory, Hawaii. *Tellus* 28 (6):538–551
- [15] Lüthi D, Le Floch M, Bereiter B, Blunier T, Barnola J-M, Siegenthaler U, Raynaud D, Jouzel J, Fischer H, Kawamura K, Stocker TF (2008) High-resolution carbon dioxide concentration record 650,000-800,000 years before present. *Nature* 453(7193):379–382. doi:10.1038/nature06949

- [16] Makarova M.V., Abakumov E.V., Shevchenko E.V., Paramonova N.N., Pakhomova N.V., Lvova N.A., Vetrova M.A., Foka S.C., Guzov Iu.N., Ivakhov V.M., Ionov D.V., Khoroshavin A.V., Kostsov V.S., Mikushev S.V., Mikhailov E.F., Pavlovsky A.A., Titov V.O. From carbon polygon to carbon farm: The potential and ways of developing the sequestration carbon industry in the Leningrad Region and St. Petersburg. UDC 504.064, 504.062, 550.5, 631.4, 630 Вестник СПбГУ. Науки о Земле. 2023 Т. 68. Вып. 86-b.
- [17] Musayev B.S. Agrokimyo. Darslik. «Sharq nashriyoti» –Toshkent 2001, – В 79-80
- [18] Муравьева Н.Т., Селитренникова З.Б. Особенности гумусообразования в основных почвах Узбекистана. /В кн.: География и классификация почв Азии. М.: Наука 1965, - с. 65
- [19] Муравьева Н.Т. Агропочвенное районирование орошаемых и возможных к орошению земель Кашкадарьинской области. В кн. Часть-I. Ташкент, изд. САГУ, 1959. - С. 174-197
- [20] Ochilov S.Q. Qashqadaryo vohasi sug'oriladigan tuproqlarning kimyoviy xossalari, gumusli holati va unumdorligini oshirish yo'llari. b.f.f.d. (PhD) ilmiy darajasini olish uchun tayyorlangan diss. – Farg'ona 2019, -18 b.
- [21] Qurbonov M.M. Qashqadaryoning konus yoyilmalaridagi degradatsiyaga uchragan tuproqlarning unumdorligini oshirish yo'llari. b.f.f.d. (PhD) ilmiy darajasini olish uchun tayyorlangan diss. – Toshkent 2022, -15 b.
- [22] Saidova M., Yadgarov A., Kodirova D., Kuchkarova N., Ergasheva O. Reclamation status of irrigated grass-alluvial soils based on geoinformation systems in Uzbekistan //E3S Web of Conferences. – EDP Sciences, 2024. – Vol. 563. – p. 03042
- [23] Tiwari H, Naresh RK, Kumar L, Kattaria SK, Tewari S, Saini A, et al. Millets for food and nutritional security for small and marginal farmers of north west india in the context of climate change: A review. Int J Plant Soil Sci. 2022; 34(23):1694-1705
- [24] Usmanova Y.A., Xurramov J.F., Ergasheva O.X. Qashqadaryo viloyati G'uzor tumani och-tusli bo'z tuproqlarning tabiiy-iqlim sharoiti. Yangi O'zbekiston: ilmiy tadqiqotlar 2-qism. Toshkent, Noyabr 2025. -B. 194-196
- [25] Усманова Ю., Хайруллаева С. Изменение климата и адаптационные технологии по углеродному земледелию: состояние и перспективы // ФГБНУ ФИЦ «Почвенный институт им. В.В. Докучаева» «Материалы Международной научной конференции XXVII Докучаевские молодежные чтения «Информационная емкость знаний о почве» / Под ред. Б.Ф. Апарина. – СПб., 27-февраля-1 марта 2025 года. Санкт-Петербург, – С. 172-173
- [26] Xoliqulov Sh., Uzoqov P., Boboxo'jayev I. Tuproqshunoslik. Darslik. –Toshkent 2013, «N.Doba» XТ matbaa bo'limi, – В. 430-431
- [27] <https://lex.uz/docs/7233437>