RC1: 'Comment on egusphere-2024-2047', Anonymous Referee #1, 30 Aug 2024 rep

Land-terracing activities have been widely developed in mountainous and hilly areas mainly in China and the world other places in order to inhibit soil erosion, increase soil moisture, and improve the soil qualities. This study seems to be a systematic work to well understand the impact of agricultural activities and ecological restoration measures on changes in soil carbon pools in terraced areas. as my assessment, this study has significant implications for agricultural management and ecological restoration in the terraced areas of the Loess Plateau in China and even instruct for the world other countries. Thus, I recommend acceptance for publication and also encourage authors well address and improve the shortcomings for the whole text in consideration on my suggestions below:

Response：Thank you very much for your high evaluation of our research work. We are pleased to receive your support and suggestions. We will seriously respond to and incorporate your recommendations to further enhance the quality of this research paper. We have limited the "Loess Plateau" section to the context of China in the full text to avoid any ambiguity. Additionally, we have included a brief introduction to the history of terracing in the "Loess Plateau" region in the introduction. We also explored the correlation between changes in soil carbon storage and the timing of terracing, aiming to reveal the impact of long-term terracing activities on the soil carbon pool in this area. In the Data and Methods section, we emphasized the representativeness of the study area. We added a discussion on the potential impact of climate change on changes in soil organic carbon. Regarding the issue of lower SOC content in abandoned orchard terraces compared to actively used terraces, we provided a detailed explanation of the reasons for this outcome. Finally, we highlighted the innovation and main contributions of this study at the end of the introduction to emphasize its novelty compared to existing research.

1) In the whole text, many places about Loess Plateau should be limited in China.

Response：Thank you very much for your suggestion. You reminded us that the scope of the "Loess Plateau" should be confined to China, which is very important for clarifying the research context and improving the accuracy of the article. We carefully reviewed the entire text and made revisions to the relevant content. The revised content is as follows:

Abstract

Terracing is widely used in mountainous and hilly areas worldwide to control soil erosion, increase soil moisture, and improve soil quality, potentially impacting soil carbon pools. This study investigates how agricultural activities and ecological restoration measures affect soil carbon pools in terraced areas of the Chinese Loess Plateau.

Introduction

Terraces are widely distributed and have created environmental benefits in countries in East Asia, the Mediterranean, and Southeast Asia (Wei et al., 2016). The terraced field construction in the Loess Plateau region of China has a long history. China has historically emphasized soil and water conservation as well as agricultural production, gradually developing and refining terracing techniques in this process. By 2005, the area had established terraced fields covering 14,790 square kilometers, accounting for 95.3% of the total arable land (Ma et al., 2015). This long history of terrace construction may influence the current processes and storage of soil organic carbon in the region. Terraced fields that were established earlier typically have higher soil organic carbon content. This is because these older terraces have undergone a longer process of soil organic matter accumulation, resulting in the accumulation of more fresh organic matter, which enhances soil organic carbon storage (Deng et al., 2014; Rong et al., 2021). In contrast, newly constructed terraces often have lower organic carbon content due to the removal of topsoil, which requires a longer time for soil organic matter reconstruction (Sidle et al., 2006). In the Chinese Loess Plateau region, a large amount of arable land has been converted to woodland and grassland through the implementation of afforestation and reforestation policies, and these measures have increased the organic carbon content of the soil (Rong et al., 2021).

Study Area

The study area is the typical terrace construction region of the Chinese Loess Plateau (Zhuanglang terracing) and the construction of this area began in the 1960s. By 2005, 14790 km2 of terraces have been built, accounting for 95.3% of the total arable land in the region.

2) Please briefly introduce the history of land terracing activities in the Loess Plateau. Different from other countries, Chinese terracing policy has a long history. I am wondering whether there has a correlation between the soil carbon variation and terracing time or not.

Response： Thank you very much for raising this constructive question. You pointed out that the history of terracing in China's Loess Plateau region differs from that of other countries, which is an important context that merits further exploration. We have added the following content in response to this point:

The terraced field construction in the Loess Plateau region of China has a long history. China has historically emphasized soil and water conservation as well as agricultural production, gradually developing and refining terracing techniques in this process. 85% of the terraced fields in the Loess Plateau region were formed between 1950 and 2000, by 2005, the area had established terraced fields covering 14,790 square kilometers, accounting for 95.3% of the total arable land (Ma et al., 2015). This long history of terrace construction may influence the current processes and storage of soil organic carbon in the region. Terraced fields that were established earlier typically have higher soil organic carbon content. This is because these older terraces have undergone a longer process of soil organic matter accumulation, resulting in the accumulation of more fresh organic matter, which enhances soil organic carbon storage (Deng et al., 2014; Rong et al., 2021). In contrast, newly constructed terraces often have lower organic carbon content due to the removal of topsoil, which requires a longer time for soil organic matter reconstruction (Sidle et al., 2006). Since 2000, in the Chinese Loess Plateau region, a large amount of arable land has been converted to woodland and grassland through the implementation of afforestation and reforestation

policies, and these measures have increased the organic carbon content of the soil (Rong et al., 2021).

3) Widely terracing lands have been distributed almost all over the Loess Plateau and covering many kinds of climate types. In this text, a small county of Zhuanglang was selected as research area. Please give an evaluation on its representativeness of terracing lands. I think the climate changes should also play important roles for SOC variation even the similar terracing condition.

Response： We have carefully considered and revised the suggestions you provided. The rationale for selecting the Zhuanglang terraced fields as a representative example of terraced agriculture is explained in detail below:

Zhuanglang County is located in the central region of the Loess Plateau, characterized by typical geographical and climatic conditions, making it a representative area for studying terraced farming systems on the plateau. Construction in this region began in the 1960s. By 2005, a total of 14,790 square kilometers of terraced fields had been cultivated, accounting for 95.3% of the region's arable land. The terraced fields are primarily horizontal terraces, with a relatively complete system that effectively reflects the characteristics of traditional terraced agriculture in the area. Zhuanglang terraces belong to the loess hilly terrain area with gullies and complex topography, and the elevation is between 1521m-1784m. The climate type is temperate continental, with warm, humid summers and cold, dry winters. More than 60% of precipitation occurs in summer and autumn (July - October), with an annual rainfall of 542mm and an average annual temperature of 7.5℃. The dominant soil type in this area is fine loessial soil, the natural vegetation is mainly herbaceous, shrubs, coniferous forests, and locust trees, and the crops are wheat, maize, potatoes, and apple trees. Due to the constraints of soil properties and irrigation water sources in this region, the growth of crops depends on natural rainfall. In recent years, however, there has been a significant increase in abandoned terraces, highlighting the widespread issue of terrace abandonment in the Loess Plateau area.

We believe that your viewpoint regarding the significant role of climate change in the

variations of soil organic carbon is very accurate. However, the time frame of our observations is too short to effectively analyze the relationship between changes in soil organic carbon and climate change. We will analyze this aspect in the discussion section.

4.2 Effect of terraces abandonment on SOC

As in other parts of the world, industrialization and urbanization have led to a large population flock from rural to urban areas as in China, resulting in the abandonment of a large number of productive potential farmlands (Wiesmeier et al., 2012; Cai et al., 2016). Furthermore, climate change induced extreme weather events such as drought and heavy rainfall can also accelerate soil erosion and loss of soil organic carbon in the abandoned terraces (Lal, 2004). We measured the physicochemical properties of the soil in terraced fields with different usage statuses (Table 2). The results show that the soil bulk density in abandoned terraces is significantly higher compared to the actively used ones. This increased bulk density may lead to reduced soil aeration, thereby inhibiting the decomposition of organic matter. Furthermore, the soil pH in abandoned terraces has also decreased, which may affect the stability of organic matter. However, climate change can also impact the vegetation succession on abandoned terraces, which in turn affects the soil organic carbon dynamics (Davidson & Janssens, 2006). When the terraced fields were abandoned in this research, the SOC content of the abandoned terraces was lower than that of the terraces in use. This is caused by the limited abandoned time. Abandoned terraces may have accumulated a significant amount of organic matter during their previous use. However, due to a lack of fertilization now, this organic matter is gradually being mineralized and decomposed, which reduces the soil organic carbon (SOC) content (Lal, 2004; Wiesmeier et al., 2019). In contrast, terraces that are still in use maintain higher SOC levels thanks to continual fertilization (Nardi et al., 2004). Additionally, the abandoned terraces are more susceptible to climate change induced soil disturbance and erosion, leading to the loss of nutrient-rich topsoil, which further decreases SOC levels (Zhao et al., 2013). Our data also shows that the surface soil organic carbon (SOC) content in abandoned terraced fields (0-15 cm) is significantly

lower than that in actively used terraced fields, which may be related to higher soil bulk density, lower pH, and surface soil erosion (Table 2). To produce significant environmental benefits, the land must remain abandoned for an extended period to accumulate substantial amounts of both plant biomass and the species that constitute intact ecological communities. This process can take decades to reach levels of carbon sequestration or biodiversity comparable to those of undisturbed ecosystems (Crawford et al., 2022; Poorter et al., 2016). Due to the limited water resources available in semi-arid areas, a longer natural or assisted recovery time is required. Therefore, the duration of land abandonment is a crucial factor influencing the dynamic changes SOC (Djuma et al., 2020; Badalamenti et al., 2019). In related studies in other regions, soil carbon stocks increased by 13% and 16% in cropland abandoned for 15 and 35 years, respectively (Novara et al., 2014). With the abandonment of disposal time extended, vegetation types gradually transition to grassland, scrub, and forest and the death of plants and animals return to the soil as organic matter, increasing the number of soil aggregates and further increasing the carbon content of the soil (Liu et al., 2020). Therefore, ecological restoration of newly abandoned terraces should be carried out as soon as possible. After short-term abandonment, the terraced fields showed a special change pattern at different depths in this study. SOC content first decreased and then increased with increasing soil depth. The decrease in surface SOC was controlled by the decrease in agricultural fertilizer inputs, while the increase in deep SOC was caused by the inability to utilize deep soil nutrients due to the death of crop roots.

Table 2 Soil Properties Data of Different Types of Sampling Points

Land types	Planting method	Vegetation types	0-5cm		5-15cm		15-30cm		30-60cm		60-100cm	
			Bulk density	pH value	Bulk density	pH value	Bulk density	pH value	Bulk density	pH value	Bulk density	pH value
Terrace	Single vegetation	Wheat	1.26	8.07	1.27	8.06	1.31	8.13	1.34	8.20	1.36	8.19
		Apple trees	1.26	8.11	1.27	8.11	1.31	8.15	1.34	8.21	1.36	8.21
		Potatoes	1.26	8.14	1.29	8.13	1.32	8.17	1.33	8.23	1.35	8.23
		Legumes	1.26	8.10	1.28	8.09	1.31	8.15	1.33	8.22	1.36	8.21
		Maize	1.25	8.08	1.28	8.08	1.32	8.14	1.35	8.21	1.37	8.20

		Robinia pseudoacacia L.	1.26	8.09	1.27	8.08	1.31	8.13	1.33	8.23	1.37	8.19
		Pinus tabuliformis Carr.	1.26	8.11	1.28	8.11	1.33	8.15	1.36	8.20	1.37	8.20
		Medicago sativa L.	1.26	8.12	1.28	8.11	1.33	8.16	1.36	8.21	1.37	8.22
		Vegetable	1.26	8.13	1.28	8.12	1.31	8.16	1.33	8.21	1.36	8.21
	Multiple vegetation	Apple tree-legumes	1.25	8.08	1.28	8.08	1.33	8.14	1.34	8.22	1.37	8.19
		Apple tree-potatoes	1.24	8.10	1.28	8.10	1.34	8.15	1.36	8.22	1.37	8.21
Sloping land	Single vegetation	Wheat	1.26	8.08	1.28	8.08	1.32	8.14	1.35	8.21	1.36	8.20
		Grassland	1.23	8.06	1.27	8.06	1.31	8.12	1.34	8.17	1.37	8.18
Abandoned terraces	Multiple vegetation	Apple trees and weeds	1.24	8.10	1.27	8.09	1.31	8.15	1.34	8.21	1.37	8.20

4) The SOC content of the abandoned apple tree terraces were lower than that of the in-use apple tree terraces. Generally, this seems to be contradicted with the observed facts in the world. I think it may be collected with seasonal fertilizers addition.

Response：Your observation is very accurate. Our research findings indeed contradict general observations. We have provided an explanation for the reasons behind this result, specifically:

When the terraced fields were abandoned in this research, the SOC content of the abandoned terraces was lower than that of the terraces in use. This is caused by the short abandoned time. Abandoned terraces may have accumulated a significant amount of organic matter during their previous use. However, due to a lack of fertilization now, this organic matter is gradually being mineralized and decomposed, which reduces the soil organic carbon (SOC) content (Lal, 2004; Wiesmeier et al., 2019). In contrast, terraces that are still in use maintain higher SOC levels thanks to continual fertilization (Nardi et al., 2004). Additionally, abandoned terraces are more susceptible to soil disturbance and erosion, leading to the loss of nutrient-rich topsoil,

which further decreases SOC levels (Deng et al., 2016).Our data also shows that the surface soil organic carbon (SOC) content in abandoned terraced fields (0-15 cm) is significantly lower than that in actively used terraced fields, which may be related to higher soil bulk density, lower pH, and surface soil erosion (Table 2).

5) The key scientific issues seem to be clear. However, I didn't catch what are the main novelties of this study. Please summarized some sentences to well address them at the end of the introduction section.

Response：We would like to thank the reviewers for their valuable feedback. We have added the following content at the end of the introduction to clarify the innovative aspects of this study:

Therefore, we collected soil samples from terraced fields and slopes, including terraces with different land uses and crop types. Our focus was on three main aspects: (1) comparing the soil organic carbon (SOC) characteristics of terraces under various land use types, cropping patterns, and ecological restoration vegetation; (2) investigating the impact of terraced land abandonment on the dynamic changes of SOC; and (3) exploring how different types of vegetation influence the accumulation and distribution of SOC within terraced systems. This study provides innovative insights for comprehensively understanding the carbon cycling processes in the terraced systems of the Loess Plateau, proposing targeted management measures to promote the sustainable development of terraced agriculture and mitigate climate change.