Open Journal of Soil Science, 2022, 12, 427-445
https://www.scirp.org/journal/ojss
ISSN Online: 2162-5379
ISSN Print: 2162-5360

The Effect of Vegetation Restoration in Soil Organic Carbon Storage

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How to cite this paper: Bacar, T.S., Cheng, Y.B., Wang, Y.Q. Kaboul, K. and Lopes, N.D.R. (2022) The Effect of Vegetation Restoration in Soil Organic Carbon Storage. *Open Journal of Soil Science*, **12**, 427-445.
https://doi.org/10.4236/ojss.2022.129017

Received: August 2, 2022
Accepted: August 29, 2022
Published: September 1, 2022

Abstract

This review paper has been made to assess the past studies reviewed regarding vegetation restoration and its impact on soil organic carbon content. A Vegetation Restoration is an influential technique that can be used to respond to these effects. As a response to the global biodiversity crisis, more restoration actions have been taken. The European Union Council's results on kinds of diversity after 2010 highlight words like stopping biodiversity loss and the breakdown of ecological systems in the European Union. The United Nations Conference on Biological Diversity's growth strategy for 2022, which includes restoring at least 15% of degraded ecosystems, has made this possible. Soil types are among the most vulnerable resources on the planet due to factors such as climate change, land degradation, and the reduction of biodiversity. Organic Carbon, the top meter of soil, could potentially store three times as much carbon as is found in the air and almost twice as much as in plants. For the systematic literature review, past papers on vegetation restoration have been extracted from the latest papers of 2013 and onwards to 2022. The summary of results included key findings of the papers, the interpretation of papers reviewed, and the relevant references. Thirty papers were reviewed and selected from authentic databases and assessed that vegetation restoration significantly affects soil organic carbon (SOC). The findings also exhibit that the primary sources of prediction for SOC dynamics include changes in soil properties, quality, the number of carbon inputs, and the composition of the C pool. Vegetation restoration also plays an important role in improving the services of ecosystems such as controlling the erosion of soil and increasing the carbon sequestration. Moreover, some papers concluded that vegetation restoration positively influences on the SOC. Moreover, to increase the generalizability of the study, implications and future research indications have also been included in the end.

Keywords

Vegetation Restoration, Soil Proportion, Soil Organic Carbon SOC

1. Introduction

1.1. Background

Environmental damage in the last few decades can be linked to the growth of agriculture in many parts of the world and the intensification of farming practices that went along with it. For example, Mehrabi *et al.* [1] research showed that 14 of the 21 most essential biome types are used in agriculture. In 2011, 491 billion hectares (ha) were used for farming. It is the same as about 38% of the Earth's total surface area [2]. Because of this, the natural plant cover was lost. In addition, more people and more land are being used for farming, which means farming practices are becoming more harmful. A Vegetation Restoration is a powerful tool that can be used to counteract these effects. As a response to the global biodiversity crisis, more restoration actions have been taken. The European Union Council's conclusions on species diversity after 2010 include words like stopping biodiversity loss and the breakdown of ecological systems in the European Union. The United Nations Conference on Biological Diversity's growth strategy for 2022, which includes restoring at least 15% of degraded ecosystems, has made this possible. Even though these policy initiatives are helpful, these understandings raise questions about how well humans can manage and restore ecosystems so that they continue to provide a wide range of ecosystem services and support different kinds of biodiversity [3]. It is often required to choose between, for example, agricultural output that satisfies the demands of society for food and fiber and, for example, the supply of other activities and the preservation of biodiversity [4].

Soil types are among the most vulnerable resources on the planet due to factors such as climate change, land degradation, and the reduction of biodiversity. There is a greater quantity of carbon stored in the Earth's soils than in the atmosphere or all of the plants that grow on land. It is because soil includes a natural ingredient called organic carbon. According to the soil organic carbon, the top meter of soil could potentially store three times as much carbon as is found in the air and almost twice as much as is found in plants (SOC) [5]. The constant movement of carbon through the world's ecosystems is called the global carbon cycle. Soil organic carbon (SOC) plays a small but essential part in this more significant cycle. More carbon is stored in SOC in the top meter of soil than in the atmosphere (about 800 PgC) and in land plants (around 500 PgC). So, the Soil's Organic Carbon Storage is more than the air and plants on land combined [6]. Soil Organic Carbon Storage is dynamic, moving into and out of different molecular shapes in the many carbon pools worldwide [7]. Small changes in the amount of carbon in the soil can significantly affect the amount of CO_2 in the air. However, not much research has been done on deep soil organic carbon storage. According to Jobbágy and Jackson [8], approximately fifty-six percent more SOC is stored in the layer of soil that extends from zero to three meters than in the layer of soil that extends from zero to one meter. Only thirty-four percent of the 136 Gt of carbon found in the zero to eight-meter soil profile is located in the zero-to-the-one-meter soil layer. While looking into the gully area, Liu *et al.* [9] found that almost eighty-five percent of the SOC storage in the zero to the two-meter layer was in the zero to four-meter layer.

The effects of vegetation restoration in soil organic carbon are crucial to forest ecosystems in areas like providing nutrients, carbon storage, managing water, building soil structure, and increasing biodiversity. Plants are the primary source of soil organic carbon for soils because they contribute on and below the surface. It also significantly impacts the Earth's temperature, moisture, pH, makeup, and activity levels, among other things [10]. So, in the agriculture field study, it is essential to systematically review the effects of vegetation restoration on soil organic carbon storage. It is possible to gain a better understanding of the patterns of vegetation restoration, soil organic carbon, and the storage of soil organic carbon over the past few years by reviewing several studies conducted on the following topic. Doing so would assist the authors in gaining a better understanding of the patterns that link the variables and vegetation restoration's effects on carbon matter. In addition, by studying previous studies, authors can better differentiate between the many methods that have been utilized in the past to make the vegetation restoration process more efficient in storing soil organic carbon.

Moreover, it will assist in making them comprehend the benefits acquired by employing those approaches in the real world and the downsides of those techniques, which will help them make better decisions in the future. The difficulty is that no systematic review has been presented of the literature, which can clearly explain the direct benefits and loopholes to the experts. It has been a problem since it arose because no such kind of systematic review has been submitted.

The objectives of this study are: to explore reported literature regarding the impact of vegetation restoration on organic carbon content in the soil; to investigate the literature on factors influencing the vegetation restoration; to evaluate the variation of soil organic carbon decomposition rates by vegetation restoration as reported by past studies; to explore the literature reports regarding the observed changes in the proportion of new and old soil organic carbon (SOC) and to report the explored factors controlling SOC.

1.2. Significance of the Study

This thorough review will have significant repercussions, not only in the academic realm but also in the broader world. There are very few systematic reviews conducted in the past on topics such as the process of restoring vegetation, the storage of organic carbon in the soil, and the influence that vegetation has on the storage of organic carbon in the ground. Given the circumstances, this indicated that reviewing the relevant literature was fraught with unique challenges. The findings of this research will contribute to a review of the relevant literature that will be used in the context of future investigations conducted in this environment. This research will be of great use to anyone who wants to understand more about how the storage of organic carbon in soil and vegetation restoration work together to assist farmers in increasing crop yields. Improving the overall performance of the plants is essential for the whole country because it helps minimize various types of air pollution, which is beneficial for people's health in the long term. It is why improving the overall performance of the plants is vital. This paper will encourage both environmental companies and the government to take essential steps toward implementing effective ways to help plants grow, which ultimately helps to breathe well in the less polluted country.

1.3. Conceptual Boundaries

Despite agriculture's role as a significant source of environmental deterioration, a new study finds that restoring vegetation on farmland can help farmers increase yields while benefiting local wildlife and providing other ecosystem services. It was discovered that this is the case even though agriculture is one of the leading causes of environmental devastation. However, these three benefits would only accrue on the landscape or global scales if vegetation restoration was carried out by soil separation, mainly secondary succession after agriculture abandonment and tree plantations. Moreover, field-level agriculture suffers when this restoration is implemented [11]. On the other side, the fundamental goal of vegetation restoration is to bring back the original mix of species and community structures. The primary purpose of rehabilitation is to "rebuild ecosystems," while the primary goal of restoration is to "repair, processes, production, and services" [12]. Both "reclamation" and "rehabilitation" can be used to talk about putting a piece of land that was once useless back to good use, but "reclamation" is usually used to talk about the process in more detail. Usually, the first step in any rehabilitation or restoration project is revegetation, which means putting plants back on land once covered in trees.

Soil Organic Carbon Storage is the process of absorbing carbon dioxide from the atmosphere and storing it in the soil. Photosynthesis, which occurs in plants and results in the storage of carbon as SOC, is the primary way plants contribute to this process. However, even in dry and semi-dry areas, this process extracts carbon from the soil at a much slower rate. As a result, soil carbon dioxide (CO_2) can be preserved in inorganic compounds such as secondary carbonates [13]. Another study found that carbon is present in all living things and is required for all life on Earth. Plant biomass, soil organic matter, and carbon dioxide are the most common forms of carbon in nature (CO_2). Carbon dioxide (CO_2) can exist in both the air and water. The long-term storage of carbon in natural reservoirs such as seas, soils, plants (particularly forests), and rocks is known as carbon storage. Even though the waters carry more carbon, soils contain 75 percent of the world's organic carbon. The volume of the land pool is three times that of all living organisms on land. As a result, the carbon cycle cannot function without healthy soils of various types throughout the planet [14].

2. Methodology

2.1. Review Aims

The main emphasis and focus of the study are to wisely classify and combine the concerning literature to assess the different kinds of factors that can be considered in analyzing the impact of vegetation restoration on soil organic carbon storage. Moreover, the study also intended to identify various factors controlling soil organic carbon, the impact of vegetation restoration on organic carbon content in the soil, factors influencing the vegetation restoration, soil organic carbon decomposition rates by vegetation restoration along with changes in the proportion of new and old soil organic carbon.

2.2. Review Design

This review is based on a systematic literature review (SLR). Such a review is considered with the motive of detecting, selecting, and analytically assessing research on a specific topic to ensure the provision of an answer to a clearly expressed question as explained in the previous section [15]. The researcher is comprised on the design of this SLR on the methodology of PRISMA which is the abbreviation of, Preferred Reporting Items for Systematic Reviews and Meta-Analyses that reviews the minimal substances that are accurate to be included in a review or a meta-analysis paper. PRISMA is a commonly known and much-used technique for the writing and reporting of systematic reviews. It assists and supports a clear and transparent recording of research findings in a review.

2.3. Review Search Methods

The failure to perform a detailed and comprehensive search for a systematic literature review can be a consequence of biases in the results reported and can be a cause of decreasing authenticity of the decisions of review. [16]. It is advisable and wise to search different databases for extraction of related references. However, this task is thorough and burdensome [17]. To develop an authentic and accurate database selection and search strategy for this review, the researcher has reviewed the databases available to select the ones having the most related papers on the topic of vegetation restoration and soil organic carbon content. After analyzing different databases like SCOPUS, Web of Science, EMBASE, ProQuest, Ebsco, ScienceDirect, and Google Scholar. To make the collected data reliable and valid, the experts wrote articles published in various journals and also revised by different experts before the publication, so the data collected was reliable and complete. As for the timeline of the papers collected, the researcher confined it from 2013 and onwards *i.e.*, the research between 2013 and 2020 was viewed more and relevant papers were involved. Moreover, the researcher adopted to comprise only agricultural topic papers in the English language. For searching, an extensive set of keyword sequences were used in the search that comprised the following terms: soil organic carbon, carbon content, vegetation restoration, soil proportion, etc.

2.4. Inclusion Exclusion Criteria for Review

The researcher holds detailed research in this review. The papers that are included are mostly quantitative but qualitative were also included as they were not completely excluded and were found relevant. The researcher analytically assessed the published research in vegetation restoration and its impact on soil organic carbon content between January 2013 and January 2022. The main reason for emphasizing these years is that vegetation restoration is a very extensive and wide topic and its impact on soil organic carbon content could be realized if viewed in detail so that fluctuations regarding the systems, policies and various aspects related to agriculture could be assessed. Analysis of the studies directed in this time duration can further enhance the understanding related to different issues that can lead towards enhancement of knowledge about vegetation restoration and how this can have an influence upon soil organic carbon content. The researcher thus eliminated any articles or books that were not printed in peer-reviewed periodicals and papers that were not available in understandable English language were also excluded from the data set of those papers which were included in this review.

2.5. Search Outcomes of the Review Process

The detailed research to collect relevant papers resulted in the collection of 132 papers. At the end of the process of overviewing and removal of papers that were photocopies or whose full text could not be assessed, 62 papers were left of the initial research 132. All the saved references from the different databases included in the study were then further added to the software which is used in this study for the management of references, *i.e.* Endnote Version 9.2. Further elimination after the researcher had reviewed the abstracts and titles of papers led to the deletion of 15 articles, leaving a set of 55 articles. The detailed review of the remaining 55 studies took to the dropping off of further 10 studies by the reviewers which were based on the fact that they did not meet the required category of the review. Finally, a set of 45 studies was extracted which was further reduced to 30 papers after full screening and views. **Figure 1** given below exhibits the PRISMA flow diagram that is followed in this study which clearly illustrates the data extraction and the steps of selection.

2.6. Data Abstraction and Synthesis Techniques

The data extracted for this review comprised of the following information: key findings, interpretation, and concerning references. This data was firstly extracted and then sorted using Excel. The researcher used Nvivo software to read,

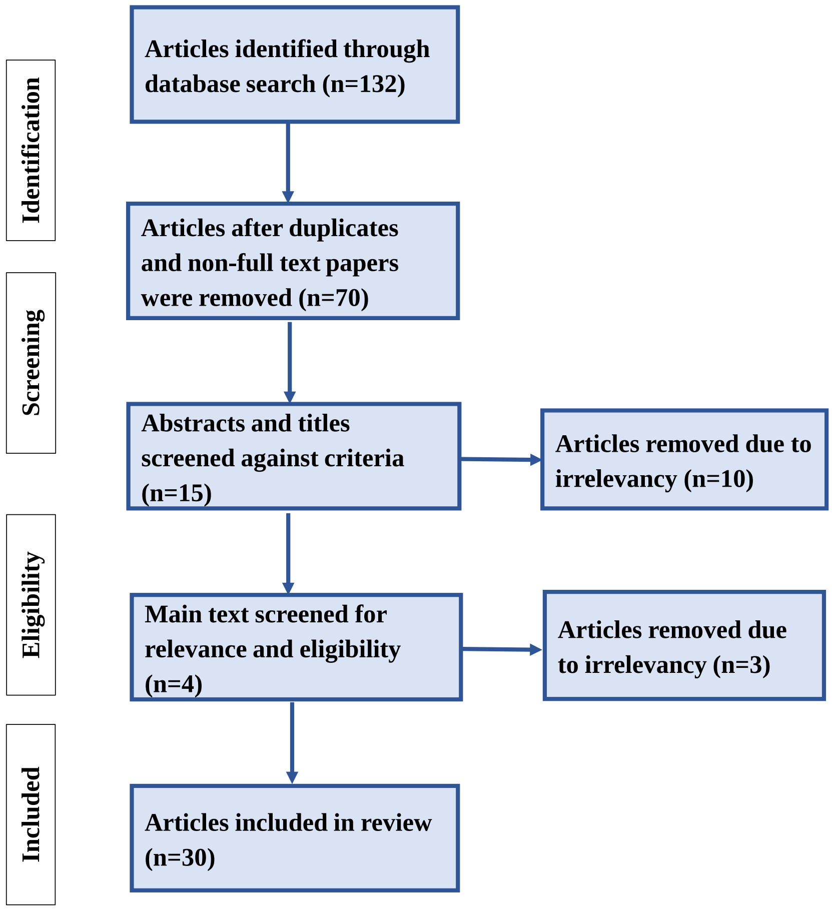

Figure 1. PRISMA flow chart items for systematic reviews and meta-analyses.

code, and mark the research papers for the concerned information extraction and categorization of the papers. The researcher has not achieved meta-analysis in this review as it does not comprise the objectives of the current study and the studies which were included in heterogeneous, due to which a more detailed and thematic analysis approach was measured to be suitable in this study. To assess the study characteristics, the researcher used VosViewer software.

3. Results

3.1. Characteristics of Study

The above table, *i.e.*, Table 1 illustrates the studies extracted from different years, *i.e.*, from 2013-2022. These studies are purely related to the concerned topic of vegetation and soil organic carbon. Moreover, the type of studies is also presented in one column which states whether the relevant study is of quantitative nature, experimental study, a review or a meta-analysis. The names of authors and year titles are stated in the first two columns. This table shows the detailed characteristics of the study, which means the studies that will be reviewed in SLR. From the findings of the table, it has been concluded that more studies are experimental study based and very few are quantitative or other based studies.

Table 1. Illustrates the studies extracted from 2013-2022.

Author	Year	Title	Type
Gong *et al.*	2017	Effects of vegetation restoration on soil organic carbon sequestration at multiple scales in semi-arid Loess Plateau, China	Experimental study
Hu *et al.*	2018	Effects of environmental factors on soil organic carbon under natural or managed vegetation restoration	Experimental study
Deng, kim, peng & Shangguan *et al.*	2018	Controls of soil and aggregate-associated organic carbon variations following natural vegetation restoration	Experimental study
P. Shi *et al.*	2021	Effects of 15-year vegetation restoration on organic carbon in soil aggregates on the Loess Plateau, China.	Experimental study
Lan *et al.*	2021	Long-term vegetation restoration increases deep soil carbon storage in the Northern Loess Plateau	Experiment study
Gu *et al.*	2018	Effects of vegetation restoration on soil organic carbon mineralization	Experimental study
Zhang, Xiao, Huo *et al.*	2021	Key factors influencing on vegetation restoration in the gullies of the mollisols	Quantitative
G. Poley & J. Mcdermid	2020	A systematic review of the factors influencing the estimation of vegetation aboveground	Experimental group
Hu *et al.*	2021	Soil carbon accumulation with increasing temperature under both managed and natural vegetation restoration	Experimental study
Qiu, Wu, Shi *et al.*	2021	Quantifying the responses of evapotranspiration and its components to vegetation restoration and climate change	Experimental study
He, Wang *et al.*	2022	Vegetation recovery and recent degradation in different karst landforms of southwest China	Focus group
Gill, Fehmi *et al.*	2022	Biotic and abiotic factors important for palmer's agave restoration in lehmann lovegrass dominated areas	Experimental study
Lal, *et al.*	2018	A holistic perspective of factors affecting soil organic carbon	Experiment study
Arunrat *et al.*	2020	Factors controlling soil organic carbon sequestration of highland agricultural areas	Review
Luo, feng *et al.*	2017	Soil organic carbon dynamics jointly controlled by climate, carbon inputs, soil properties and soil carbon fractions	Review paper
Bernal *et al.*	2016	Limits to soil carbon stability; deep, ancient soil carbon decomposition stimulated by new labile organic inputs	Focus study
Luo, Wang *et al.*	2016	A meta-analysis of the temporal dynamics of priming soil carbon decomposition by fresh carbon inputs across ecosystems.	Quantitative
Frey *et al.*	2014	Chronic nitrogen additions suppress decomposition and sequester soil carbon in temperate forests.	Experimental study
Xu *et al.*	2015	The variations in soil microbial communities, enzyme activities and their relationships with soil organic matter decomposition along the northern slope of changbai mountain.	Experimental Study
Riggs, Hobbie *et al.*	2015	Nitrogen addition changes grassland soil organic matter decomposition.	Quantitative
S.Shi & Han *et al.*	2014	Effects of 15-year vegetation restoration on organic carbon in soil aggregates on the loess plateau, China.	Experimental study

Continued

Tian *et al.*	2015	Effects of long-term fertilization and residue management on soil organic carbon changes in paddy soils of China: a meta-analysis.	Experimental study
Munoz-Rojas	2015	Impact of land use and land cover changes on organic carbon stocks in mediterranean soils	Experimental study
Weissert Salmond *et al.*	2016	Variability of soil organic carbon stocks and soil co2 efflux across urban land use and soil cover types.	Quantitative
Angst *et al.*	2018	Soil organic carbon stocks in topsoil and subsoil controlled by parent material, carbon input in the rhizosphere, and microbial-derived compounds.	Quantitative
Balesdent *et al.*	2018	Atmosphere–soil carbon transfer as a function of soil depth.	Quantitative
Hopkins *et al.*	2014	Increased belowground carbon inputs and warming promote loss of soil organic carbon through complementary microbial responses.	Meta-analysis
Lugato, Lavallee *et al.*	2021	Different climate sensitivity of particulate and mineral-associated soil organic matter.	Meta-analysis
Li *et al.*	2018	Soil labile organic carbon fractions and soil organic carbon stocks as affected by long-term organic and mineral fertilization regimes in the North China Plain.	Experimental study
Hobley, Wilson, Wilkie, Gray, & *et al.*	2015	Drivers of soil organic carbon storage and vertical distribution in Eastern Australia.	Experimental study

3.2. Type of Papers

Figure 2 shows the types of studies that are included in the review. By observing the figure, it can be assessed that more studies were related to experimental type and as compared to that meta-analysis and quantitative studies were very few. The papers that were reviewed were based on experimental types.

3.3. Years Distributions of Paper

Figure 3 explains the characteristics of the paper with regard to the distribution of years. It can be clearly seen that more papers were included from the years 2018 and 2022; the reason for the inculcation of these years was to keep the data latest and draw authentic conclusions/results from the review. Papers from the year 2019 were also moderate in number and for 2017 papers reviewed were a bit less. The fewer papers included from various years is a justification for dropping these papers, as seen in Prisma chart. Many papers were dropped due to duplication of titles or irrelevancy. So, the graphical representation of the year's distribution of papers is shown below.

3.4. Impact of Vegetation Restoration on Organic Carbon Content in the Soil

In the study by Gong Li, Liu Gouhua, Wang Meng, Ye Xin, Wang Hao, And Li Zhongshan as referenced in Table 2, it was concluded that vegetation restoration has been projected as an effective tool for increasing both the organic carbon content, *i.e.*, soil carbon stocks and the plant biomass. In this research, 204 publications with a total of 733 observations were examined; the particular focus was on the effects of vegetation restoration on soil organic carbon (SOC). This study was conducted in China. The study conducted by Pei-Lei Hu, Shu-Juan Liu, Ying-Ying Ye in the year 2018 concluded findings that to expand the scientific study of soil organic carbon (SOC) gatherings in restored ecosystems, 246

Table 2. Summary of main findings mentioned in this research.

Themes	Main findings	Interpretation	References
Impact of vegetation restoration on the organic carbon content	Vegetation restoration has been projected as an effective tool for increasing the organic carbon content. Significantly higher SOCC was found in natural vegetation restoration as compared to the managed vegetation and tillage land. Natural vegetation restoration can enhance soil organic carbon (SOC).	The transformation and conversion to planted forests took in greater SOC accumulation as compared to another land usage.	[31]-[36]
Factors influencing vegetation restoration	Vegetation restoration highly relates to the progress of gully erosion. Soil organic matter influences vegetation restoration to a greater extent. Temperature, rainfall, and wind also proved to be important factors.	Soil taken from the densely cultivated land and assessed at a given interval of time proved to be a great positive enhancement factor for vegetation restoration	[37]-[42]
Factors controlling soil organic carbon	Various factors, especially soil, water, and crop management, impact SOC sequestration. The carters of soil organic carbon storage are more likely to be distinct in significance about factors that are controlling for SOC	The primary sources of prediction for SOC dynamics include changes in soil properties, quality, the number of carbon inputs, and the composition of the C pool.	[5] [18] [19]
Soil organic carbon (SOC) decomposition rates by vegetation restoration	GGP improved the content of SOC. The increased accumulation of organic carbon in the soil led to an increased rate of decomposition of SOC to maintain the balance between the atmospheric CO_2 and C pools in the soil. The Inorganic N decreases the priming effect, while the organic N is found to have a positive priming effect. The organic inputs are found to be effective for SOC.	The decomposition rate of soil organic carbon shows a positive and significant relationship with total bacterial, microbial, actinomycetes PLFAs and soil enzyme activities. Thus, the enzymatic activity, as well as the structure of the microbial community, are found to be associated with the decomposition rate of SOC.	[20] [21] [22] [23] [24] [43]
Changes in proportion of new and old soil organic carbon	The incorporation of Carbon is lowered in the upper layer of soil as compared to the depth of the soil as a result of "land use for crops." The soil dynamics, as well as the land use, are found to be dependent on the depth of the soil The vegetation, as well as the characteristics of the soil, play an essential role in increasing the SOC stock, which in return also increases the efflux of CO_2 in the atmosphere.	The fertilization by carbon dioxide and warming is found to significantly impact the stocks of SOC in new soil.	[25]-[30]

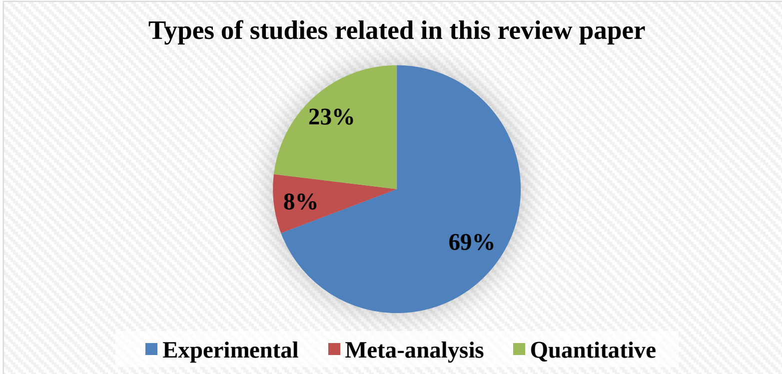

Figure 2. The types of studies included in the review.

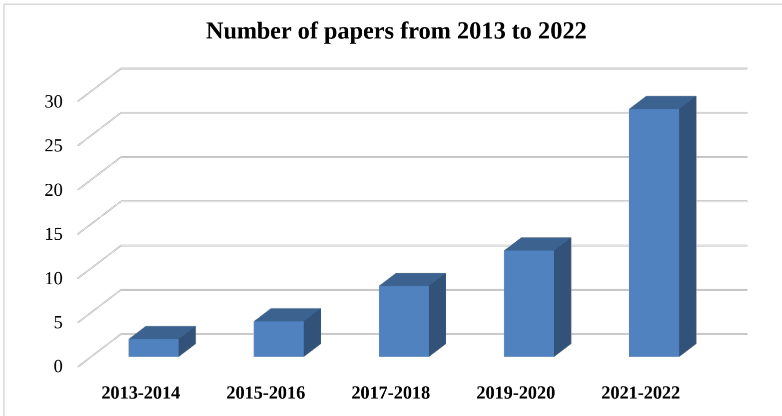

Figure 3. Distribution of papers from 2013 to 2022.

samples of soil were used from a rocky catchment in an ecologically fragile area of China and measured the influence of vegetation restoration on soil organic carbon, Significantly higher SOCC was found in natural vegetation restoration as compared to the managed vegetation and tillage land. The third study's results were extracted from the study of Lei Deng Loess Plateau of China, where it was concluded that natural vegetation restoration could enhance soil organic carbon (SOC). This was further supported by the comparison of healthy land with that abandoned farmland. The study by Peng Shi in 2021 illustrated that the effects of 15-year restoration vegetation on the organic carbon content of soil aggregates in China were assessed, where it was concluded that major land effective for soil organic carbon was grassland, forestland, shrub land, and slopping cropland. These lands were found to enhance vegetation restoration by enhancing the organic carbon content of soil masses by improving the soil stability aggregates and decreasing the erosion of soil. The results obtained from the findings concluded that SOC has been increased by 45.33%, 24.43%, 30.29%, and 27.98% at soil depths of 0 - 20 cm, 20 - 40 cm, 40 - 60 cm, and >40 cm layers. Moreover, the transformation and conversion to planted forests took in greater SOC accumulation as compared to another land usage. The proportion of dissimilarities in soil organic carbon content was greater in natural vegetation re-establishment than in achieved vegetation restoration, and this proportion increased along with the successional gradient.

3.5. Factors Influencing the Vegetation Restoration

Vegetation restoration highly relates to the progress of gully erosion and is mainly estimated from both the properties of soil and the competition of species in gullies. McDermid in his systematic review of factors influencing vegetation restoration. Soil organic matter influences vegetation restoration to a greater extent. As it has proven to be an important factor influencing vegetation restoration. Temperature and rainfall proved to be critical factors for vegetation restoration along with other seasonal changes that relatively impact VR. Plant growth is not possible below 6 degrees no matter how heavy the rainfall is. Wind and air proved to affect vegetation restoration also; Persistent and strong wind in a one-way direction may permanently disfigure the trees and bend them in the direction the wind continuously falls. Landforms known as geomorphic factors also affect vegetation restoration. This study by Nath in 2022 explains that steep slopes, which are usually rapid run-off, have less density of vegetation than the drier side of leeward. That is the reason in Nigeria, there richer vegetation restoration trends are observed. High mountains have a sequence of vegetation all their own. The warmer slopes resulted in normally forested with deep soils. Results from the studies showed that in the context of China, climate change and strong winds from various directions force the plants to wear an umbrella shape and thus exhibit a thin end to the wind. High mountains have a sequence of vegetation all their own. The warmer slopes resulted in normally forested with deep soils. Moreover, the results showed that regression and structural equation model analysis was used for estimating the factors including soil properties and the competition of species that influence vegetation restoration. These factors proved to be highly correlated with vegetation restoration. Soil taken from the densely cultivated land and assessed at a given interval of time proved to be a great positive enhancement factor for vegetation restoration. A longitudinal study comprising monsoon and dry seasons estimated the respective impact on soil and results showed that these factors significantly affect vegetation restoration.

3.6. Factors Controlling Soil Organic Carbon

A study by Lal [5] stated that the stock of SOC can be protected by adopting best management practices which are subjected to complex rotations, no soil disturbance, ground cover, and integrated nutrient management. Arunrat *et al.* [18] were of the view that the density of SOC is higher at high elevations due to low temperature and the high content of clay while chemical fertilizers increase the density of SOC, increasing crop yields. The findings of [19] study, showed that climate, inputs of Carbon, properties of soil and carbon pools play a significant role in controlling the soil organic carbon. Climate change and soils are proven to attract significant study attention for the atmosphere. Mechanisms of SOC soil organic carbon stabilization have received huge attention recently because of their significance in controlling the global C cycle. Nutrient management strategies impact on soil organic carbon concluded by the study by Juan Li in China 2018. This study was designed to explore the changes in soil due to nutrient management that later proved to be a greater controlling factor in soil organic carbon. Results indicated that treatments that included organic manure had significantly greater SOC concentrations and stocks as compared to unfertilized treatments or minerals. The use of organic manure thus contributes to increased improvement in nutrient cycling services in North China Plain. The primary sources of prediction for SOC dynamics include changes in soil properties, quality, the number of carbon inputs, and the composition of the C pool. Results from the studies showed that in the context of China, climate change and strong winds from various directions force the plants to wear an umbrella shape and thus exhibit a thin end to the wind. Different factors such as bulk density, elevation, K_2O as well as N fertilizers are found to control the density of SOC.

3.7. Soil Organic Carbon (SOC) Decomposition Rates by Vegetation Restoration

The decomposition rates of SOC are highly influenced by the enzymatic activity and microbial community. To determine this theme, 6 related studies were focused on. One such study stated that the C pools in deep soil are found to be more vulnerable to anthropogenic and environmental change. It also impacts the decomposition of SOC, influencing the net exchange of CO_2 between the atmosphere and the land [20]. Whereas, Luo *et al.* [21] were of the view that the decomposition of soil organic carbon increases by an average of 14% when inputs of new Carbon are utilized while the forest soils had a low decomposition rate (1%) due to no input of fresh Carbon while other ecosystems were found to have more decomposition rate (>24%). One study also stated that using fertilizers results in nitrogen enrichment in the soil, decreasing microbial activity due to a decrease in fungal biomass and higher accumulation rates of lignin. This decreases the rate of decomposition of SOC thus, increasing the content of SOC in the soil [22]. A study by [23], also stated that different factors, including "the mean annual temperature (MAT), the mean annual precipitation (MAP) and soil temperature, silt and clay fraction, total phosphorus and nitrate nitrogen," are found to impact the microbial community in the soil, which influences the decomposition rate of SOC. Whereas the enzymatic activity is dependent on soil nutrients. Riggs *et al.* [24] concluded that microbial respiration was found to be decreased by 29% of the overall organic matter due to the addition of nitrogen. This resulted in the accumulation of large reserves of Organic Carbon in the soil while, introduced "the Grain for Green Program (GGP)" in 1999 in China. This program was beneficial in increasing SOC by "48.1%, 25.4% and 25.5% at soil depths of 0 - 20 cm, 20 - 40 cm and 40 - 60 cm, respectively". From such findings, it was concluded that inputs of fresh Carbon significantly impact the decomposition rate of SOC and the factors like climate and land management play an essential role in this regard while enrichment of Nitrogen leads to increased accumulation of soil carbon. This is due to the suppression of decomposition of soil organic carbon rather than increased carbon inputs.

3.8. Changes in the Proportion of New and Old Soil Organic Carbon

This study focused on five themes that mentioned in **Table 2**. The main findings of these studies showed that fertilization is done by incorporating carbon compounds, the rates of SOC increase compared to the fertilization treatments provided by inorganic fertilizers and manure application is found to impact the C sequestration significantly greatly [25]. According to [26], the changes related to land use and land cover in Mediterranean Soils from 1956 to 2007 resulted in the loss of about 16 × 8 Tg SOC. However, afforestation resulted in increasing C sequestration to 8 × 62 Mg ha^{-1} in the topsoil. Another study showed that the median SOC stocks were found to be higher in the parkland soils when compared to soils of the urban forest. Contrary to this, the efflux of CO_2 was found to be quite similar in both parkland soils as well as soils of the urban forest [27]. However, [28] was of the view that the fraction of clay plays a crucial role in contributing to 80% of the stocks of SOC. The higher root growth in the subsoil increases SOC stocks. The findings of another study showed that the incorporation of Carbon has a recent depth of 10 cm in the soil globally and the aridity index is used to explain the allocation of SCO in deep soil layers [29]. Hopkins *et al.* [30] also supported the argument that high carbon input increases overall SOC, also improving the decomposition rate of SOC. Thus, it was concluded that the proportion of SOC is different when soil is fertilized by inorganic fertilizers, and incorporation of Carbon utilizing straw return or manure application and afforestation is found to be effective in increasing the soil organic carbon, whereas deforestation gradually decreases the SOC.

4. Conclusion

The studies concluded that vegetation restoration plays an integral role in improving the agricultural status of an economy; moreover, vegetation restoration plays an integral role in improving the services of ecosystems, such as controlling the erosion of soil and increasing carbon sequestration. Moreover, some papers concluded that vegetation restoration impacts positively on the SOC. And above all, it converts solar energy into biomass and forms the basis of all food chains. Despite benefiting soil organic carbon, vegetation restoration converts the carbon dioxide into oxygen crucial for survival. Ecological interactions do for an ecosystem is store carbon in the soil. Carbon can be lost or gained depending on what people do. The amount of organic matter in the soil is often shown by the amount of organic carbon in the ground (SOC). Some studies were of support that the SOC levels result from how photosynthesis, respiration, and breakdown work together. Photosynthesis is the process by which carbon dioxide is turned into plant matter. Root biomass and shoot litter are used to figure out how much SOC goes into the soil. The primary sources of C in soil are the growth and breakdown of plant roots and the microbes that eat carbon-rich molecules. Mycorrhizae are fungi that live in the soil and form relationships with many plants' roots. The sources give the fungi carbon, and the fungi provide the plant phosphorus. Carbon is lost from the soil as carbon dioxide (CO_2) when microorganisms breathe. It happens when organic matter breaks down. A small amount of the original carbon stays in the soil by turning organic matter into humus. It gives dark-colored carbon-rich soils their dark color [44].

4.1. Implications of the Study

This study practically and theoretically ensures a provision of meaningful implication as it is a sound addition in reviewing literature for next researchers who would like to conduct the same study in this context. Furthermore, agricultural sectors can also get practical benefits from such sort of studies which is an opportunity for them to identify the lacking parts or those sections/aspects that need improvement or that hinder the vegetation restoration phases in the path of improving the quality of soil organic carbon along with the changes in the proportion of new and old soil organic carbon.

4.2. Limitations of the Study

As this study is comprised mostly of papers that were reviewed of experimental group study type, in future, those reviews can also be made that include papers from quantitative studies as sample and survey techniques in agricultural sectors can also be adopted to study variations in results as if the vegetation restoration's impact on soil organic carbon. Moreover, better and more insightful information can be obtained by testing the study under another context with a different methodology. A longitudinal study would be better suitable to draw results as studying and analyzing the context of soil under various seasons and different periods would help assist the researcher in exploring better aspects and results of vegetation restoration-related topics.

Acknowledgements

I would like to thank my mentor Mr./Mrs. ALBERTINA Dias Nambeia for her time and the effort that she ensured to provide during the whole year. Her useful advice and suggestions were really supportive to me during the completion of this project.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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