Selcuk Journal of Agriculture and Food Sciences

https://dergipark.org.tr/tr/pub/selcukjafsci

Research Article

(2024) 38(3), 542-552 DOI:10.15316/SJAFS.2024.048 e-ISSN: 2458-8377 Selcuk J Agr Food Sci

Bibliometric Analysis of Soil Classification Research in Soil Science from 1980 to 2023

Sinan Demir[1,*]

[1]Isparta University of Applied Sciences, Faculty of Agriculture, Department of Soil Science and Plant Nutrition, Isparta, Türkiye

HIGHLIGHTS

- Publication Focus: A total of 3612 papers out of 4467 documents show that "soil classification" is a major topic in academic publications.
- Growth Rate: Over time, interest in "soil classification" has increased, as evidenced by the 4.74% annual growth rate.
- Author Collaboration: To demonstrate the worldwide reach of the research, each paper had an average of 3.88 authors and a 23.66% international collaboration rate.
- Emerging Research Areas: The application of novel modeling and analysis methods, including artificial neural networks, random forests, support vector machines, gradient boosting, and deep learning methods, has increased recently.

Abstract

Bibliometric analyses shed light on research patterns and the influence of science. Based on 4467 papers from the Web of Science database, this article provides a bibliometric overview of soil science research on soil classification from 1980 to 2023. This study determines four time periods: 1980–1995, 1996–2005, 2006–2015, and 2016–2023. Research between 1980 and 1995 focused on basic subjects such as "adsorption," "classification," and "organic matter." The emphasis switched to environmental issues between 1996 and 2005, with "carbon," "contamination," and "soils" taking center stage. From 2006 to 2015, there was a continued focus on the environment, accompanied by more in-depth research on related subjects. Technological developments became more visible between 2016 and 2023, with particular attention paid to "carbon," "vegetation," "classification," "spatial prediction," "models," and "spectroscopy." Throughout, concepts like "classification," "soils," and "organic matter" were crucial, and after 2005, research on "contamination" and "heavy metals" grew more intense. Technological subjects, particularly "spectroscopy" and "spatial prediction," as well as regional studies, have gained importance. In conclusion, the analysis shows how basic research in soil classification has given way to increasingly intricate, technologically advanced studies that reflect a greater emphasis on the environment and the application of innovative techniques for accurate and thorough soil examinations.

Keywords: Bibliometric analysis; Soil classification; Spatial prediction; Soil ecology; Soil survey and mapping

Citation: Demir S (2024). Bibliometric Analysis of Soil Classification Research in Soil Science from 1980 to 2023. *Selcuk Journal of Agriculture and Food Sciences*,38(3), 542-552. https://doi.org/10.15316/SJAFS.2024.048
Correspondence: demirsinan.07@gmail.com

Received date: 05/08/2024

Accepted date: 27/11/2024

1. Introduction

Soil classification plays a critical role in agricultural productivity and environmental management (Talawar and Rhoades 1998; McBratney et al. 2000; McBratney et al. 2003; Minasny et al. 2019; Demir 2024). Over time, soil classification methods and techniques have evolved significantly to meet agricultural productivity and environmental conservation goals (Santos et al. 2000; Mermut et al. 2001; McBratney et al. 2003; Hou et al. 2020; Bhat et al. 2023; Demir and Dursun, 2024). Soil is a complex matrix of physical, chemical, and biological properties that are vital to plant growth and environmental sustainability (Minasny et al. 2014; Usharani et al. 2019; Adewara et al. 2024; Demir 2024). Soil classification is a systematic process used to determine and assess soil properties, providing critical information for optimizing soil use and management in agriculture (McBratney et al. 2000; Ma et al.2019; Demir 2024).

The effectiveness and accuracy of soil classification and analysis techniques directly impact the quality and efficiency of scientific research (Hartemink and Minasny 2014; Brevik et al. 2016; Ma et al.n2019; Srivastava et al. 2021; Wadoux and McBratney 2021; Esetlili et al. 2020; Demir and Başayiğit 2021; Azmin et al.m2024; Demir 2024). Soil classification typically involves the integration of various physical, chemical, and biological characteristics, which determine the precision of soil classification systems (McBratney et al. 2003; Dedeoğlum2020; Karaca et al. 2021; Demir et al. 2022; Dengiz et al. 2023; Demir 2024). In this context, analyzing and interpreting data related to soil properties can enhance classification and management strategies (McBratney et al. 2003; Arrouays et al. 2014; Brevik et al. 2016; Ma et al. 2019; Dede et al. 2022; Kerry et al. 2023).

In recent years, bibliometric analyses have become increasingly popular in scientific research (Souza Oliveria Filho 2020; Mokhnacheva and Tsvetkova 2020; Altay and Kaplan 2023; Jia et al 2024; Tang et al. 2024; Xu et al. 2024; Chen et al. 2024). Bibliometric analyses are powerful tools for evaluating the impact and trends of scientific publications, providing detailed insights such as publication year, citation count, and author collaborations (Altay and Kaplan 2023; Jia et al. 2024). This study conducts a comprehensive bibliometric analysis to identify significant trends and contributions in soil classification research. Soil classification is essential for understanding soil properties, processes, and spatial distribution. By classifying soils, researchers and practitioners can better manage soil resources, promote sustainable agriculture, and mitigate environmental risks (Demir 2024). This study aims to contribute to the advancement of soil science and to support sustainable land-use practices by identifying significant trends and effective research strategies in soil classification.

2. Materials and Methods

For this study, the Web of Science (WoS) database was searched as of May 21, 2024, and 4467 documents on soil classification from 1980 to 2023 were found (see Table 1). The Web of Science database was meticulously searched using a targeted set of keywords, specifically including "soil classification" within the field of soil science, to identify relevant research. Then, using the "convert2pdf" function in R software, data pertinent to soil classification in soil science were extracted from the WoS database in plain text format (R Core Team 2016). Finally, a bibliometric analysis was performed using the R software Shiny program's "bibliometrix" package (Aria and Cuccurullo 2017). The R packages used in this study facilitated an in-depth analysis of publication patterns, keyword trends, and citation networks, enabling a comprehensive interpretation of the data (Table 1). A graphic representation of the patterns in keyword frequency and significance across the four designated periods was provided. This was accomplished by grouping relevant keywords using a clustering technique based on the Walktrap algorithm (Altay and Kaplan 2023).

Table 1. Main ınformation about the data

Timespan	1980-2023	
Sources (Journals, Books, etc.)	198	
Documents (n)	4467	
Document Contents	Keywords Plus (ID)	5754
	Author's Keywords (DE)	8854
Authors	Total Authors	11208
	Authors of Single-authored Documents	410
Authors Collaboration	Single-authored Documents	528
	Co-authors per Document	3.88
	International Co-authorships (%)	23.66
References	131800	

3. Results and Discussion

This analysis of the bibliometric data encompassing 4467 documents from 198 sources between 1980 and 2023 indicates that articles constitute the majority, with 3612 instances. Proceedings Papers and Reviews, 259 and 127, respectively. Other types include Book Chapters, Early Access articles, and different formats. The data indicate a consistent increase in the number of articles published in Soil Science about soil classification traits. The distribution of articles occurs over four significant periods: 16.03% between 1980 and 1995, 16.36% between 1996 and 2005, 29.51% between 2006 and 2015, and 38.10% between 2016 and 2023, with a notable peak in 2018. The temporal patterns and distribution of research output are shown in Figure 1. The results indicate a steady increase in the number of publications on soil classification characteristics within the field of soil science. This trend, as noted in previous studies by Minasny et al. (2010), Mokhnacheva and Tsvetkova (2020), Xu et al. (2022), and Jia et al. (2024), also emphasizes the growing research activities in soil science. Global concerns surrounding climate change, food security, and sustainability have emerged as significant factors driving heightened interest in soil science research.

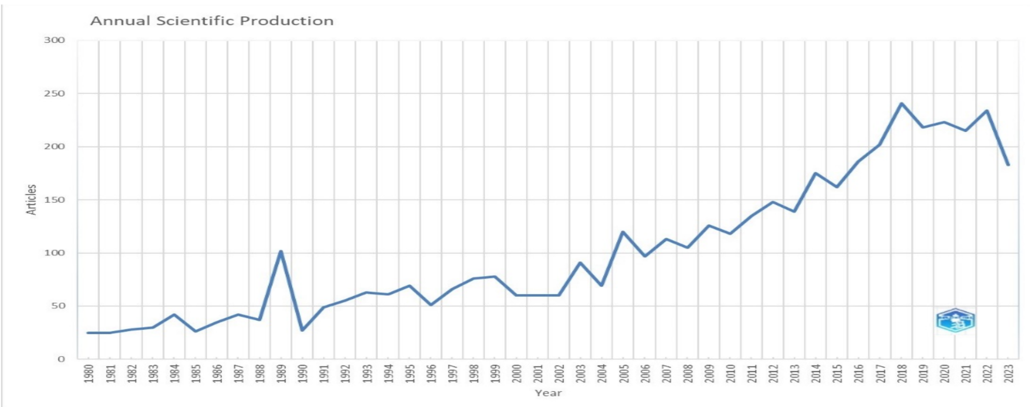

Figure 1. Published articles by years

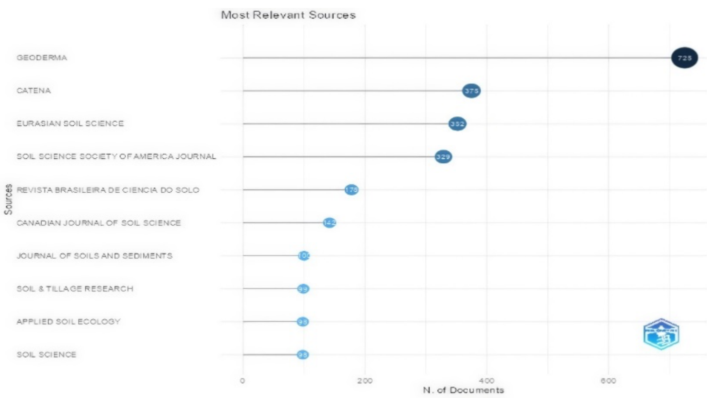

Figure 2. The journal sources of published articles

There are clear trends in the distribution of publications in soil science when journal sources for published papers are examined. The sources of the published papers are shown in Figure 2. With 725 publications, Geoderma has the highest number of publications overall. With 375 papers, Catena was next, followed by Eurasian Soil Science with 352 articles. The Revista Brasileira de Ciencia do Solo (178 articles) and the Soil Science Society of America Journal (329 articles) are two other noteworthy sources. Geoderma is the most prolific of the top journals, indicating its considerable impact on soil science research. Catena and Eurasian soil science have also made significant contributions to the literature on this topic. The distribution of papers in these journals suggests that the research is focused on highly influential publications. These results indicate that focusing on specific journals in studies in literature increases research quality and reliability (Mokhnacheva and Tsvetkova 2020; Jia et al. 2024).

The top 10 most referenced journals on soil classification were assessed out of 43.070 journals. The top ten journals that receive the most citations for soil science and soil classification are shown in Figure 3. Geoderma tops the list with the most citations, closely followed by Catena and the Soil Science Society of America Journal, all of which are heavily featured. Soil Science, Soil Biology and Biochemistry, and the European Journal of Soil Science are a few of the other renowned journals. The distribution of these publications' citations indicates how important and well-known they are in the field of soil classification research. This result aligns with previous studies that have highlighted the influence of these journals in shaping the discourse and knowledge base of soil science (Minasny et al. 2010; Brevik et al. 2016; Mokhnacheva and Tsvetkova 2020; Xu et al. 2022; Jia et al. 2024).

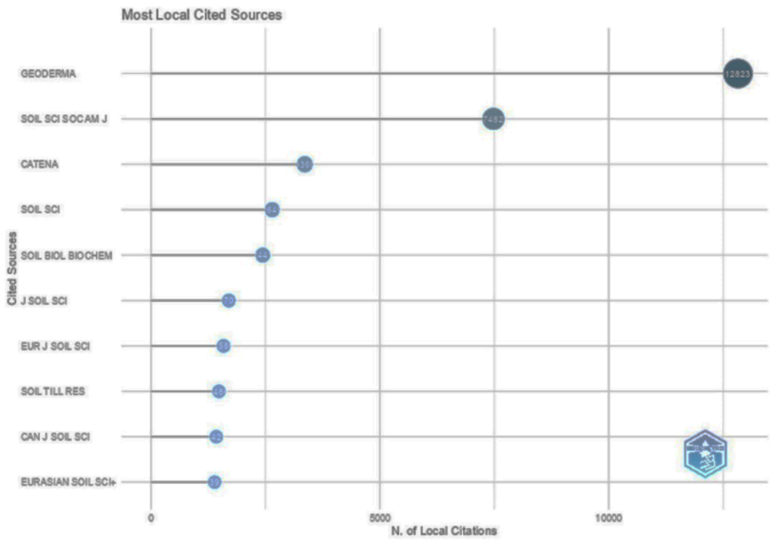

Figure 3. The most locally cited journals

Figure 4 provides information about country-based production between 1980 and 2023. Considering production data, the highest number of articles is seen in the United States (1641) and Brazil (1125), with China (997), Germany (606), and Russia (591) closely behind. Australia (513), Canada (408), France (403), and Italy (339) also contributed significantly to the research output. The fact that country-based production continues to increase over time reveals that studies in this field are a trend. Notably, in recent years, there has been a significant increase in research output in the United States, Brazil, and China, indicating a growing emphasis on this field in these countries. This trend aligns with findings in the literature, suggesting that the growing interest in soil science research is not merely a regional phenomenon but rather a response to pressing global challenges. Because soils are essential for carbon sequestration, crop production, and ecosystem resilience, concerns like climate change, food security, and sustainable development have increased the demand for advanced soil research. As a result, countries with strong research output, such as the USA, Brazil, and China, appear to be prioritizing soil studies as part of broader strategies to address environmental sustainability and resource management on both national and global scales (Minasny et al. 2010; Wang et al. 2015; Hartemink 2019; Jia et al. 2024).

Figure 5 presents information about the most cited studies from around the world. When the 10 most cited studies in this field are evaluated, 9114 citations have been provided to these studies. Among these studies, the first four most cited studies are MCBRATNEY AB, 2003 GEODERMA (2274), ZELLES L, 1999; BIOL FERT SOILS (1596), WESTOBY M, 1998; PLANT SOIL (1412), and BONGERS T, 1998; and APPL SOIL ECOL (869). The significant citation counts of these studies highlight their foundational contributions within soil science and ecology, particularly by advancing methodologies and enhancing our understanding of soil processes and ecosystem interactions. McBratney et al. (2003) in Geoderma introduced a groundbreaking framework for digital soil mapping that integrates diverse environmental data layers, such as terrain attributes and climate factors, into predictive models, transforming soil mapping practices. Zelles (1999) in Biology and Fertility of Soils focused on the use of phospholipid fatty acid (PLFA) analysis to characterize microbial communities, a method that provides critical insights into soil biology and microbial ecology. Westoby et al. (1998) in Plant and Soil proposed the leaf-height-seed (LHS) scheme, which became a widely used model in plant ecology for comparing ecological strategies and understanding plant responses to environmental changes. Bongers (1998) in Applied Soil Ecology introduced a functional diversity framework for nematodes, which serves as an indicator of soil health and quality, highlighting the role of nematode communities in soil ecosystem functioning. These highly cited works reflect the interdisciplinary impact of soil science research that spans fields such as ecology, biology, and environmental science. Their influence stems from their ability to integrate soil science with broader ecological frameworks, making them critical resources for research on sustainable land management, biodiversity, and ecosystem resilience. Their methodologies and results remain valuable for addressing contemporary issues related to soil health, agricultural productivity, and climate resilience, reinforcing the relevance of soil science within global environmental studies.

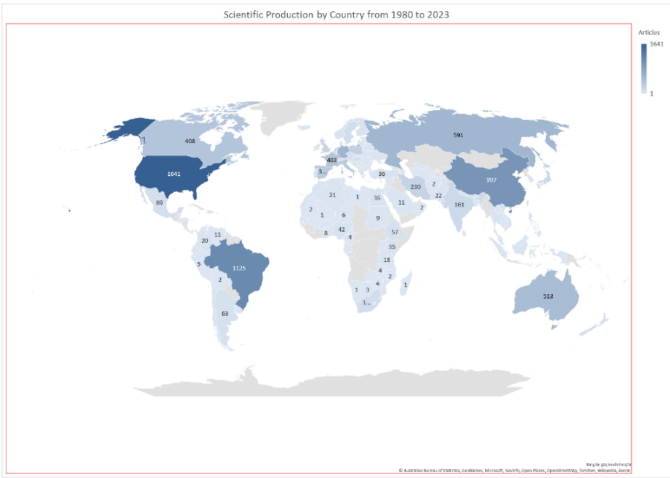

Figure 4. Production by country between 1980 and 2023

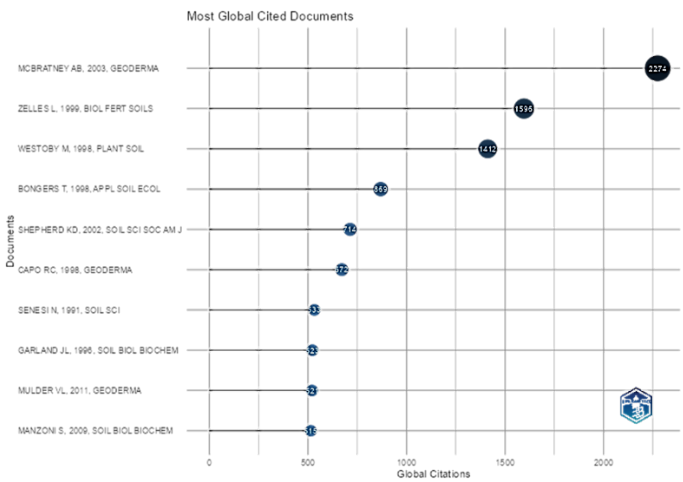

Figure 5. The top publications globally in terms of citation count

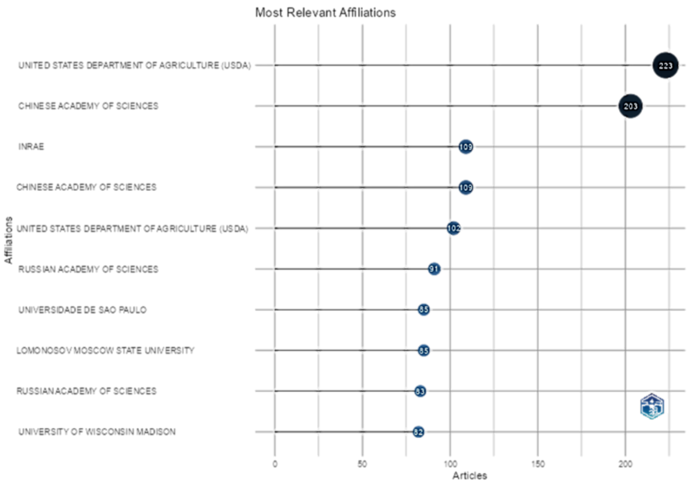

Figure 6. The top scientific affiliations

The top 10 academic institutions with the most published scientific articles are depicted in Figure 6. With 223 articles, the United States Department of Agriculture (USDA) ranks first. The Chinese Academy of Sciences has published 203 articles since the publication of the USDA. The Chinese Academy of Sciences and the French National Research Institute for Agriculture, Food, and Environment (INRAE) contained 109 articles. Other notable organizations included the Russian Academy of Sciences (91 articles), the Universidade de São Paulo and Lomonosov Moscow State University (both 85 articles), the United States Department of Agriculture (102 articles), the Russian Academy of Sciences (83 articles), and the University of Wisconsin-Madison (82 articles). These data highlight that institutions in China and the USA lead in the number of published articles. Similar trends have been reported in other soil science studies, indicating that these countries consistently contribute the highest volume of research in this field (Jia et al. 2024).

Figure 7 illustrates the proximity of the trend topic keywords used in the studies. The trends are represented visually, demonstrating changes in keyword frequency and relevance across the four specified periods. The figure employs a clustering approach (walktrap) to group related keywords, providing a clear view of how research themes have evolved.

Between 1980 and 1995, research in soil science predominantly focused on the fundamental aspects of soil properties and their classification. Key topics during this period included adsorption and classification, which underscored the importance of understanding soil characteristics and developing categorization techniques. The prominence of studies from England suggests a geographical concentration or significant contribution from this region. Research has also concentrated on forest ecosystems and soil growth factors, as evidenced by the frequent use of keywords such as “forest” and “growth.” Hydraulic conductivity and models were also central themes, reflecting growing interest in the physical properties of soil and predictive modeling techniques. The study of optimal interpolation and organic matter was important for understanding soil quality and its components. Notably, the frequent use of keywords like "adsorption" and "mineralogy" indicates a strong focus on soil chemistry and fundamental classification methods.

From 1996 to 2005, there was a notable expansion in research themes. Classification continues to be a major area of interest, emphasizing its continued importance in soil science. The role of organic matter remained central, with substantial research into its impact on soil health. This period also saw the rise of prediction methods, reflecting an increasing interest in forecasting soil properties and conditions. The focus shifted to soil composition and characteristics, with keywords like soils and texture becoming more significant. This era marked a broader interest in environmental management and advanced modeling techniques, as evidenced by the emergence of terms related to environmental impacts and predictive models.

The period between 2006 and 2015 saw a shift in research emphasis toward carbon dynamics and soil classification. The focus on carbon emissions and classification reflects ongoing interests in these areas. However, new critical topics, including contamination and heavy metals, have emerged, highlighting growing concerns about soil pollution and environmental contamination. Research has continued to emphasize soils, with an expansion into various aspects of soil science, including physical and chemical properties. The increased focus on keywords like "contamination" and "spatial prediction" during this period indicates heightened concern with soil quality, pollution, and advancements in analytical techniques.

In the most recent period, from 2016 to 2023, research trends have shifted toward the refinement of soil classification systems and a deeper understanding of soil properties. Classification and soils remain prominent areas of study. The integration of plant-soil interactions has become increasingly significant, as evidenced by the rise in research on vegetation. Additionally, spatial prediction has gained importance, reflecting advancements in soil-wettability prediction techniques across various spatial scales. The continued prevalence of terms related to "heavy metals" and "vegetation" suggests a sustained focus on pollution impacts and the role of vegetation in soil management. This ongoing research reflects an evolving understanding of soil science, addressing both historical concerns and emerging issues in the field. Such studies build on a foundation of previous research, as highlighted in recent literature, emphasizing the critical role of soil health in global ecological and agricultural sustainability (Minasny et al. 2010; Lehman et al. 2020; Brichi et al. 2023; Jia et al. 2024; Feng et al. 2024).

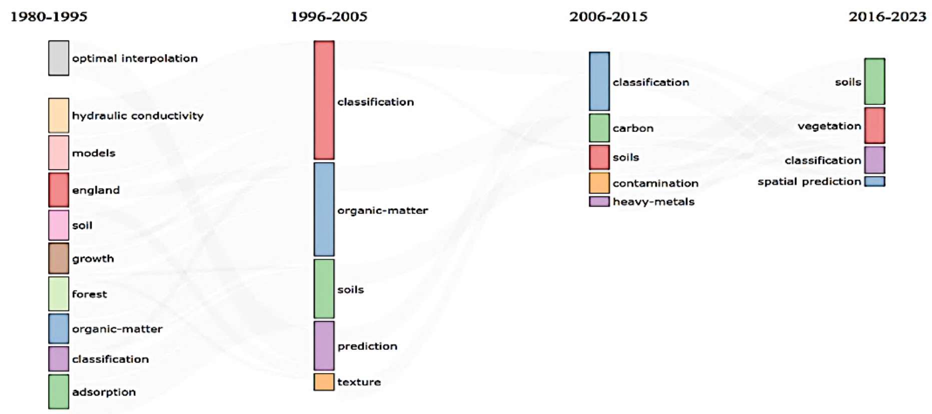

Figure 7. Interrelation of trending keywords by period

The closeness of the trend topic keywords used in the studies is illustrated in Figure 8. An analysis of keywords in the field of soil science revealed three distinct groups. The analysis of keyword metrics in soil science research (Figure 8) reveals distinct clusters with varying degrees of centrality and influence (Jia et al., 2024). An analysis of keywords in the field of soil science revealed three distinct groups. In the first group, this cluster is notable for its high betweenness centrality and significant PageRank scores, which highlights its central role in the research network (Xu et al. 2022). Key nodes in this cluster include "classification," "organic-carbon," "model," and "vegetation." Among these, "classification" stands out with its highest betweenness centrality of 312.01 and a PageRank of 0.139, underscoring its critical role in connecting various research topics (Mcbartney et al. 2003; Xu et al. 2022). Other important nodes such as "organic-carbon" and "model" also exhibit notable betweenness centrality values (8.68 and 5.64, respectively) and moderate PageRank scores, which emphasize their relevance to the research field. Keywords like "erosion" and "spatial prediction" have lower metrics, which indicates their more specialized or emerging roles (Mao et al. 2018; Bezak et al. 2021). In the second group, this cluster comprises keywords such as "organic-matter," "carbon," and "management," which show substantial PageRank and betweenness centrality values. "Organic-matter" and "carbon" are particularly significant, with high betweenness centrality values (20.95 and 14.95) and PageRank scores (0.040 each), reflecting their central roles in discussions about soil quality and carbon dynamics (Brichi et al. 2023; Feng et al. 2024). Keywords like "nitrogen" and "water" also possess noteworthy scores, emphasizing their importance in soil management and environmental studies (Zhang et al. 2020). In the third group, this cluster includes keywords like "soils," "genesis," and "evolution." Although these keywords have lower betweenness centrality than the first and second keywords, they still contribute to the broader understanding of soil science. "Soils" has a moderate betweenness centrality of 2.90 and a PageRank of 0.016, indicating its foundational role in the field. Keywords such as "genesis" and "evolution" have lower metrics but continue to be relevant for specific research areas (Xu et al. 2022).

In conclusion, the analysis highlights the hierarchical structure of research keywords, with terms like "classification" and "organic-matter" being highly central and influential within soil science research. Figure 8's clustering and ranking of keywords offer important information about the field’s focal regions and changing trends.

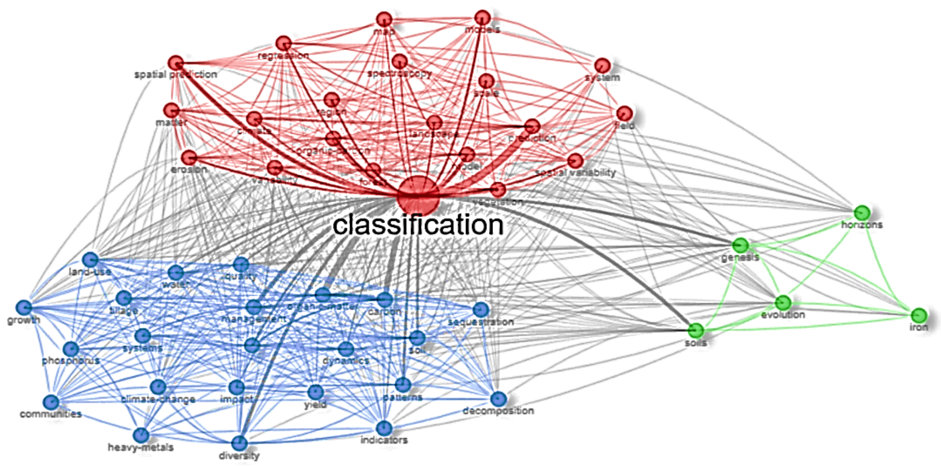

Figure 8. Interrelations among trending keywords

4. Conclusions

This bibliometric analysis of 4467 papers on soil classification from 1980 to 2023, sourced from the Web of Science database, revealed significant trends and shifts in research focus. Early research (1980–1995) centered on fundamental topics like 'adsorption' and 'classification,' evolving to environmental concerns such as carbon and contamination between 1996 and 2005. From 2006 to 2015, the emphasis shifted toward soil pollution and advanced analytical methods, while the most recent period (2016–2023) highlighted advancements in technological approaches, including “spectroscopy” and “spatial prediction.” Key institutions, notably from the USA and China, lead research output, and influential journals such as Geoderma and Catena dominate the field. Additionally, Türkiye’s research has moderate betweenness centrality (0.0744) and PageRank (0.0066), indicating its significant role in regional collaborations and knowledge sharing. This underscores Turkey's significant contribution to enhancing regional research and information dissemination. The data shows a growing focus on incorporating technological innovations and addressing environmental challenges in soil science research. In the future, research is expected to build on this trend, with a greater emphasis on integrating emerging technologies and interdisciplinary methods. This approach will likely enhance efforts to tackle complex environmental issues and improve soil management practices.

Funding: This research did not receive any external funding.

Data Availability Statement: The corresponding author will provide the datasets created and analyzed during the current work upon reasonable request.

Acknowledgments: The Web of Science database was used in this investigation. We express our sincere gratitude to the Web of Science team for their indispensable role in facilitating the availability and accessibility of this significant material.

Conflicts of Interest: The authors declare no competing interests.

References

Adewara OA, Adebayo-Olajide TC, Ayedun JS, Kotun BC, Adeleke AJ, Brown A D, Ogunbanwo ST (2024). Soil formation, soil health and soil biodiversity. In Aransiola SA, Babaniyi BR, Aransiola AB, Maddela NR (eds), Prospects for Soil Regeneration and Its Impact on Environmental Protection. Earth and Environmental Sciences Library. Springer, Cham. AG Switzerland, pp. 95-121.

Altay Y, Kaplan S (2023). Bibliometric analyzes of some major effect genes associated with meat yield traits in livestock. *Selcuk Journal of Agriculture and Food Sciences* 37(3): 608-617.

Arrouays D, Grundy MG, Hartemink AE, Hempel JW, Heuvelink GB, Hong SY, Zhang GL (2014). GlobalSoilMap: Toward a fine-resolution global grid of soil properties. *Advances in Agronomy* 125: 93-134.

Azmin SNFLM, Rahman HM, Lim NNMH, Arbaiy N (2024). Machine learning for soil classification: challenges and opportunities. *Journal of Applied Science, Technology and Computing* 1(1): 29-38.

Bezak N, Mikoš M, Borrelli P, Alewell C, Alvarez P, Anache JAA, Panagos P (2021). Soil erosion modelling: A bibliometric analysis. *Environmental Research* 197: 111087.

Bhat SA, Hussain I, Huang NF (2023). Soil suitability classification for crop selection in precision agriculture using GBRT-based hybrid DNN surrogate models. *Ecological Informatics* 75: 102109.

Brevik EC, Calzolari C, Miller BA, Pereira P, Kabala C, Baumgarten A, Jordán A (2016). Soil mapping, classification, and pedologic modeling: History and future directions. *Geoderma* 264: 256-274.

Brichi L, Fernandes JV, Silva BM, Vizú JDF, Junior JN, Cherubin MR (2023). Organic residues and their impact on soil health, crop production and sustainable agriculture: A review including bibliographic analysis. *Soil Use and Management* 39(2): 686-706.

Chen J, Chen S, Liu Z, Wu L, Xiang H, Zhang J, Wei H (2024). A Bibliometric Analysis on Research Progress of Earthworms in Soil Ecosystems. *Biology* 13(6): 385.

de Souza Oliveira Filho J (2020). A bibliometric analysis of soil research in Brazil 1989–2018. *Geoderma Regional* 23: e00345.

Dede V, Turan İD, Dengiz O, Serin S, Pacci S (2022). Effects of periglacial landforms on soil erosion sensitivity factors and predicted by artificial intelligence approach in Mount Cin, NE Turkey. *Eurasian Soil Science* 55(12): 1857-1870.

Dedeoğlu M (2020). Generation of land quality index for agricultural usage at Güvenç basin, Turkey. *Applied Ecology & Environmental Research* 18(1): 1829-1845.

Demir S, Başayiğit L (2021). Fizyografyadaki değişimin profil gelişimine ve toprak özellikleri üzerine etkisi. *Türkiye Tarımsal Araştırmalar Dergisi* 8(3): 261-272.

Demir S, Alaboz P, Dengiz O, Şenol H, Yilmaz K, Başkan O (2022). Physico-chemical and mineralogical changes of lithic xerorthent soils on volcanic rocks under semi-arid ecological conditions. *Earth Sciences Research Journal* 26(4): 291-301.

Demir S (2024). Determination of suitable agricultural areas and current land use in Isparta Province, Türkiye, through a linear combination technique and geographic information systems. *Environment, Development and Sustainability* 26: 13455-13493.

Demir S, Dursun İ (2024). Assessment of pre-and post-fire erosion using the RUSLE equation in a watershed affected by the forest fire on Google Earth Engine: the study of Manavgat River Basin. *Natural Hazards* 120(3): 2499-2527.

Dengiz O, Demirağ Turan İ (2023). Soil quality assessment for desertification based on multi-indicators with the best-worst method in a semi-arid ecosystem. *Journal of Arid Land* 15(7): 779-796.

Esetlili MT, Kurucu Y, Özden N, Şanlı FB, Özen F, Bolca M (2020). Stereo foto yorumlama teknikleri ile toprak etüd ve haritalama çalışmalarında multispektral verilerin katkısı. *Journal of Agriculture Faculty of Ege University* 57(4): 140-150.

Feng Z, Miao Q, Shi H, Li X, Yan J, Gonçalves JM, Feng W (2024). Global trends and networks in soil fertility enhancement techniques: a bibliometric analysis. *Journal of Soil Science and Plant Nutrition* 24(3): 4099-4117.

Hartemink AE, Minasny B (2014). Towards digital soil morphometrics. *Geoderma*, 230: 305-317.

Hartemink AE (2019). Open access publishing and soil science–Trends and developments. *Geoderma Regional* 18: e00231.

Hou D, Bolan NS, Tsang DC, Kirkham MB, O'connor D (2020). Sustainable soil use and management: An interdisciplinary and systematic approach. *Science of the Total Environment* 729: 138961.

Jia L, Wang W, Zvomuya F, He H (2024). Trends in Soil Science over the Past Three Decades (1992–2022) Based on the Scientometric Analysis of 39 Soil Science Journals. *Agriculture* 14(3): 445.

Karaca S, Dengiz O, Turan İD, Özkan B, Dedeoğlu M, Gülser F, Ay A (2021). An assessment of pasture soils quality based on multi-indicator weighting approaches in semi-arid ecosystem. *Ecological Indicators* 121: 107001.

Lehmann J, Bossio DA, Kögel-Knabner I, Rillig MC (2020). The concept and future prospects of soil health. *Nature Reviews Earth & Environment* 1(10): 544-553.

Ma Y, Minasny B, Malone BP, Mcbratney AB (2019). Pedology and digital soil mapping (DSM). *European Journal of Soil Science* 70(2): 216-235.

Mao G, Shi T, Zhang S, Crittenden J, Guo S, Du H (2018). Bibliometric analysis of insights into soil remediation. *Journal of Soils and Sediments* 18: 2520-2534.

McBratney AB, Odeh IO, Bishop TF, Dunbar MS, Shatar TM (2000). An overview of pedometric techniques for use in soil survey. *Geoderma* 97(3-4): 293-327.

McBratney AB, Santos MM, Minasny B (2003). On digital soil mapping. *Geoderma* 117(1-2): 3-52.

Mermut AR, Eswaran H (2001). Some major developments in soil science since the mid-1960s. *Geoderma* 100(3-4): 403-426.

Minasny B, Hartemink AE, McBratney A (2010). Individual, country, and journal self-citation in soil science. *Geoderma* 155(3-4): 434-438.

Minasny B, Berglund Ö, Connolly J, Hedley C, de Vries F, Gimona A, Widyatmanti W (2019). Digital mapping of peatlands–A critical review. *Earth-Science Reviews* 196: 102870.

Mokhnacheva YV, Tsvetkova VA (2020). Bibliometric analysis of soil science as a scientific area. *Eurasian Soil Science* 53: 838-844.

Santos MM, Guenat C, Bouzelboudjen M, Golay F (2000). Three-dimensional GIS cartography applied to the study of the spatial variation of soil horizons in a Swiss floodplain. *Geoderma* 97(3-4): 351-366.

Srivastava P, Shukla A, Bansal A (2021). A comprehensive review on soil classification using deep learning and computer vision techniques. *Multimedia Tools and Applications* 80(10): 14887-14914.

Talawar S, Rhoades RE (1998). Scientific and local classification and management of soils. *Agriculture and Human Values* 15: 3-14.

Tang S, Wang C, Song J, Ihenetu SC, Li G (2024). Advances in studies on heavy metals in urban soil: a bibliometric analysis. *Sustainability* 16(2): 860.

Usharani KV, Roopashree KM, Naik D (2019). Role of soil physical, chemical and biological properties for soil health improvement and sustainable agriculture. *Journal of Pharmacognosy and Phytochemistry* 8(5): 1256-1267.

Wadoux AMC, McBratney AB, Minasny B (2020). Understanding spatial variation in soil properties through geostatistical simulation. *Geoderma* 365: 114227.

Xu J, Li Y, Zhang M, Zhang S (2024). Sustainable agriculture in the digital era: past, present, and future trends by bibliometric analysis. *Heliyon*.

Xu Y, Lyu J, Liu H, Xue Y (2022). A bibliometric and visualized analysis of the global literature on black soil conservation from 1983–2022 based on CiteSpace and VOSviewer. *Agronomy* 12: 2432.

Zhang H, Liu X, Yi J, Yang X, Wu T, He Y, Tian P (2020). Bibliometric analysis of research on soil water from 1934 to 2019. *Water* 12: 1631.