EXTENSION APPROACHES ON SOIL HEALTH MANAGEMENT – A BIBILOMETRIC ANALYSIS:

Abstract:

Sustaining environmental health and sustainable agriculture depend on maintaining the health of the soil. Soil health management is a critical aspect of sustainable agriculture, aiming to maintain and enhance the productivity of soil while minimizing environmental impacts. This bibliometric analysis investigates the evolution and trends in extension approaches for soil health management over the past two decades. Using data from major scientific databases, we analyzed publications on soil health management, focusing on extension methodologies, stakeholder engagement, and the dissemination of best practices. The study identifies key themes, influential authors, prominent journals, and geographical distribution of research activities.The research landscape of soil health management and extension strategies is examined in this bibliometric study. We examine articles that were obtained from such as Scopus, between 2010 and 2023 Publication trends, authorship patterns, keyword co-occurrence networks, and citation analysis are the main areas of our investigation. How effective are different extension approaches in enhancing soil health management practices among farmers?" This Review is to pinpoint important figures in the field, recurring themes in the study, and new lines of investigation. We also investigate how well extension strategies work to spread information and methods for managing soil health. Researchers, decision-makers, and extension staff will benefit greatly from the findings, which will shape future research paths and improve the creation and use of efficient soil health management plans. The problem statement identifies a gap in understanding which extension methodologies most effectively promote soil health, particularly in diverse agricultural settings. Through a comprehensive biometrics analysis, this research evaluates the impact of educational programs, technological interventions, and participatory approaches on soil health indicators such as nutrient levels, soil structure, and microbial activity. Data was collected from a diverse sample of farming communities, and statistical tools were used to analyze changes in soil health parameters over time. The findings are expected to provide insights into optimizing extension strategies for better soil management, thereby contributing to improved agricultural sustainability and resilience.

Keywords: Soil, Soil Health, Adoption Strategies, Extension Approaches, Soil Health Management, Sustainable Agriculture, Soil Fertility, Organic Farming, Soil Conservation.

INTRODUCTION:

Soil health management is critical for promoting sustainable agricultural practices, environmental protection, and food security. Soils are vital, yet many agricultural systems still deteriorate them because of unsustainable methods, which lowers output and degrades the ecosystem. Extension methods are critical for spreading knowledge and encouraging actions that improve soil health among farmers. A lack of scientific Digital knowledge and technology, many farmers especially smallholders and those in areas with limited resources do not have access to the necessary resources, culturally farmers are vulnerable to the Adoption of new Technologies, Cost Effective & Understandable Integrated Soil Health are Still Lagging. (Mazumder , Abhilash, Dubey et al. 2013, Chukwu, Tarfa et al. 2014, Ahmad, Ghafoor et al. 2016, Safikhan, Chaichi et al. 2018, Khan 2019, Wani, Kumar et al. 2020, Darshan, Lakshminarayan et al. 2021, Soni, Kumar et al. 2021, Dubey, Shinogi et al. 2022, Khan, Kamal et al. 2022)

Extension's historical function has been to bridge the knowledge gap by utilizing in-person meetings and publications to convey knowledge from scientists to farmers (Carr & Wilkinson, 2020). Even as this linear model is straightforward and simple to use, Meadows (2020) points out that it is somewhat inefficient in a non-linear environment and that it takes time for farmers to incorporate new methods into their agricultural systems (Carr & Wilkinson, 2021).

Extension's role changes under a more cooperative approach to partnerships and information transfer from being an intermediary between the scientist and farmer to more significant roles as a knowledge network manager (Hoffman, Lubell, & Hillis, 2022; Lubell et al., 2023), boundary organization (Carr & Wilkinson, 2021 Cash et al., 2024), and social capital builder (Alder & Kwon, 2022) among various groups.

A border organization fosters dialogue that leads to the effective creation of methods and instruments (Cash, 2021). Bringing "relevant knowledge to the right people at the right time and place" is the foundation of knowledge network management, which integrates learning from practice (experiential), outreach materials (technical), and other people (social) (Lubell et al., 2022; Phelps, Heidl, & Wadhwa, 2022).

The partnership between scientists and farmers is deemed valuable as it allows scientists to define and quantify the parameters of a healthy soil, while farmers aim to implement practices that promote and sustain soil health (Doran & Parkin, 2014; Ramage et al., 2015).

For marginal and small agricultural landholders, context-specific information may have a greater influence on technology adoption and boost farm productivity (Samaddar 2016).

The project Integrated soil Health Management has been dependable, in actuality, the extended project period has stimulated the participatory extension cycle and made it possible to examine the short- and long-term impacts on farmer attitudes, soil characteristics, and socioeconomic circumstances (Scherr S J, Friedman R, Shames S 2020).

Soil Knowledge Network (SKN) is a small group of eminent former government soil scientists who are worried that more work has to be done with training workshops and on-the-ground extension to enhance soil management and halt land degradation. (Murray-Prior, R. B., Hart, D., & Dymond, J. 2020).

Social media and other online tools offer instantaneous answers to queries and create a network of people who become dependent on one another for knowledge (Wellman, 2021).

Farmers may augment the knowledge supplied by traditional Extension ways by turning to other resources that are more easily available online (e.g., YouTube, Twitter, web pages; Seger, 2021; Guenthner & Swan, 2022).

Rationale of the Literature Review I) Enhance the Farmer Awareness ii) Build Capacity among the farmer, iii) Promote Innovation iv) Fosters Collaboration of the Farmers v) Support Policy Development.

Justification of the Topic:

Soil health management is a critical aspect of sustainable agriculture, ensuring long-term productivity, environmental health, and economic viability. Extension approaches play a significant role in disseminating knowledge and practices to farmers, helping them adopt sustainable soil health management strategies. This topic is justified by a substantial body of literature highlighting the importance of soil health and the effectiveness of extension services in promoting agricultural sustainability.

ARTICLE SHOLD BE SCIENTIFICALLY ROBUST:

The manuscript on "Extension Approaches on Soil Health Management - A Bibliometric Analysis" is scientifically robust and technically sound, as it systematically examines the trends, patterns, and impacts of extension approaches in soil health management. By leveraging bibliometric techniques, the study provides a comprehensive analysis of the existing literature, highlighting key research themes, influential authors, and significant publications in the field. The methodology employed ensures rigor and replicability, offering valuable insights for researchers, policymakers, and practitioners aiming to enhance soil health through effective extension strategies. The findings contribute to the advancement of knowledge and support evidence-based decision-making in sustainable agricultural practices

Table:1 Description of Main Findings of the Studies identified in literature Review

SI.NO	Author Name	Year	Research Findings	Research Gap
1.	Samaddar A 2011	2011	Several extension strategies are available to connect with the farming community. The broad extension strategy, the commodity specialized approach, and the training and visit technique are examples of centralized approaches among them.	The Effectiveness Comparison, Socio Economic Influence, Technology Integration, Participatory Approaches are the Research Gap.
2.	Lal, R. (2015)	2015	Soil Knowledge Network (SKN) has proven the value of addressing extension as a social event. SKN is cognizant of the motives, adoption and optimal circumstances for extension, as well as how farmers and professionals interact to information.	Cultural Context, Social Network Analysis, Capacity Building are the Research Gaps.
3.	Reddy, A.A. (2017)	2017	Target farmers are now able to feel more invested in the Integrated Soil	Smallholder farmers Adoption rate is Still Persistent Low.

			Fertility Management approach.	
4.	Singh, S.K., Kumar, R. and Kushwaha, R.S. (2019)	2019	In the Soil Health Card Scheme has the overall cost of cultivation decreased, but the use of fertilizers has decreased in a number of crops. The farmers' knowledge level is good Regarding the Soil Health Card Scheme.	To deliver better advice, Soil Health Card related extension services must be strengthened. Awareness programs on the contents of SHC, the use of advised practices is still needed.
5.	Khan, Z. R., Mahdavi, D. M., Midega, C. A. O., Wanyama, J. M., Pickett, J. A. (2020)	2020	The push-pull used a number of technology distribution strategies, including printed materials, farmer field schools, field days, farmer instructors, mass media, and public gatherings.	Multidisciplinary research, Building project teams' capacity in terms of mutual learning and knowledge sharing,

This Table underscores the critical importance of effective extension strategies in improving agricultural standards. The document enumerates efficacious tactics, like the Soil Knowledge Network and the Soil Health Card Scheme, and underscores domains where further investigation might augment their efficacy, particularly with regard to smallholder farming. Future researchers and extension scientists can effectively exploit these research gaps.

Research Methodology:

Rowley and Slack and (2004) reviewed research on soil health using the Systematic Literature Review (SLR) technique. The systematic literature review (SLR) method produces an ordered examination of the literature together with its descriptions and bibliographies. It combines mind mapping with information resource scanning. The VOS viewing software, created by Van Eck and Waltman (2010), was utilized to create the bibliographic review, which had co-occurrence analyses, maps, cross-references, and bibliographic connections. The systematic review approach that was applied was Preferred Reporting Items for Systematic Reviews (PRISMA). The search was conducted using the database that Scopus maintains. The search for research articles involved the use of many combinations of algorithms pertaining to Soil Health and Extension Approaches.

Table 3: **Inclusion and Exclusion Criteria:**

Criteria	**Inclusion**	**Exclusion**
Literature Type	Research Articles	Review
Publication Stage	Journal	Trade Journal
Access Type	Published	Press
Subject Area	Social Science	Other Than Social Science
Language	English	Non – English
Timeline	2010-2023	-
SCREENING Title& Abstract	➢ Existence of Predefined Keywords in the Title, Abstract, or Part of the aper. ➢ Considered the Nutritional Security and Human Health, Integrated Soil Health Management as an outcome.	
Full Text	➢ Included at least Three Determinants Soil Health, Human Health, Extension Approaches.	

Table:4 Keywords used and number of Articles:

Databases	Search Strings and All Search Terms	No.of Articles
Scopus	“Soil And Farmer Behaviour”	40
	“Soil And Extension Approaches”	39
	“Soil And Extension Management”	54
	“Soil And Adaptation Approaches”	69

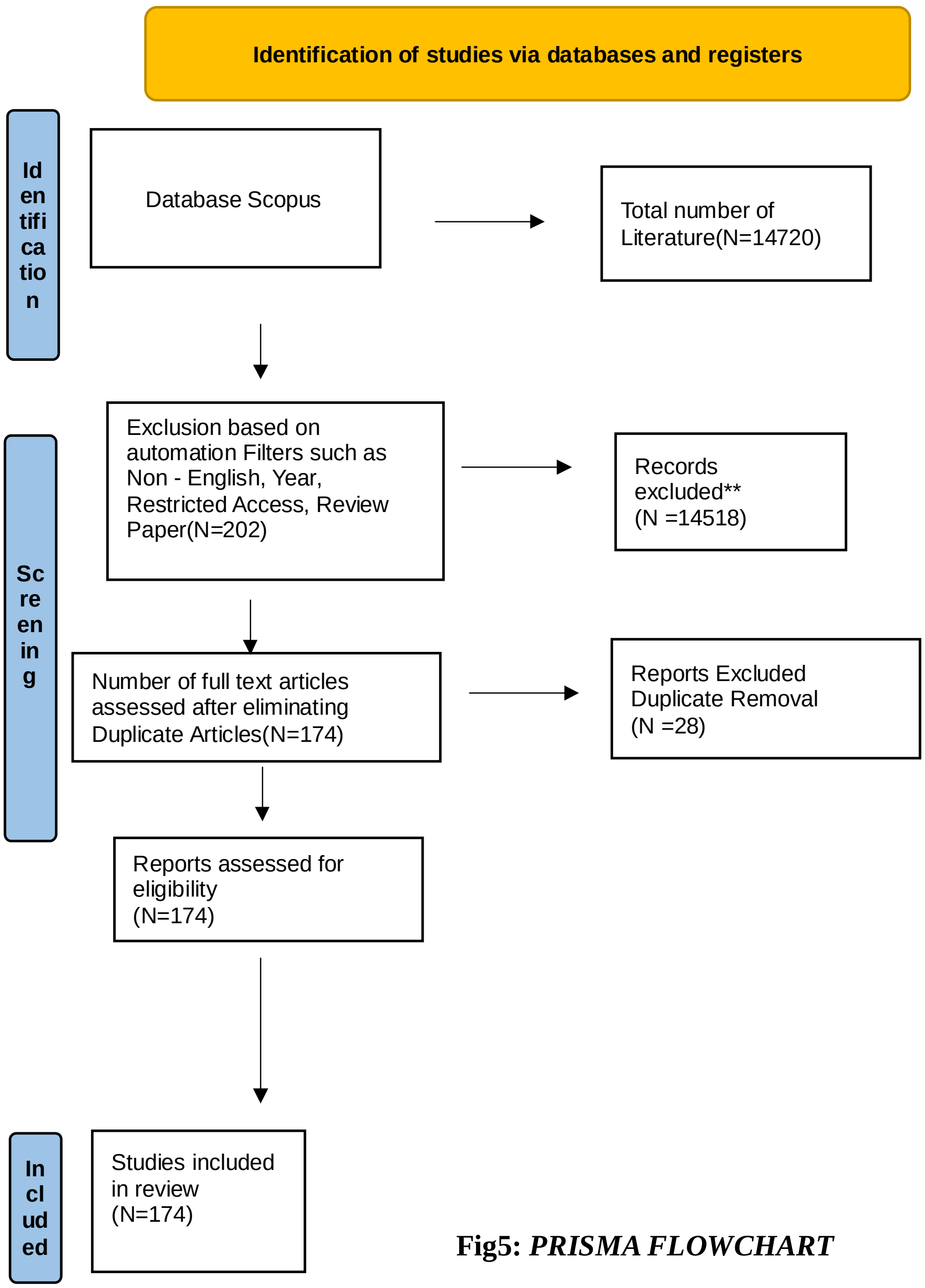


Fig5: ***PRISMA FLOWCHART***

Results and Discussion:

In all, 14,720 objects were located using the database search. Based on the inclusion and exclusion criteria established during the initial identification process (e.g., non-English, restricted access, review papers, etc.), the automatic filters in the databases identified 14518 articles as ineligible and deleted them from the records. This indicates that although if soil health is not always taken into account in research measuring human health and food security, it is in many cases. Out of the 202 items that remained, 28 were removed after duplicates were removed. A total of 174 publications were chosen for quantitative analysis based on criteria including applicability, relevance, and clarity in addressing Soil Health and Extension Approach variables.

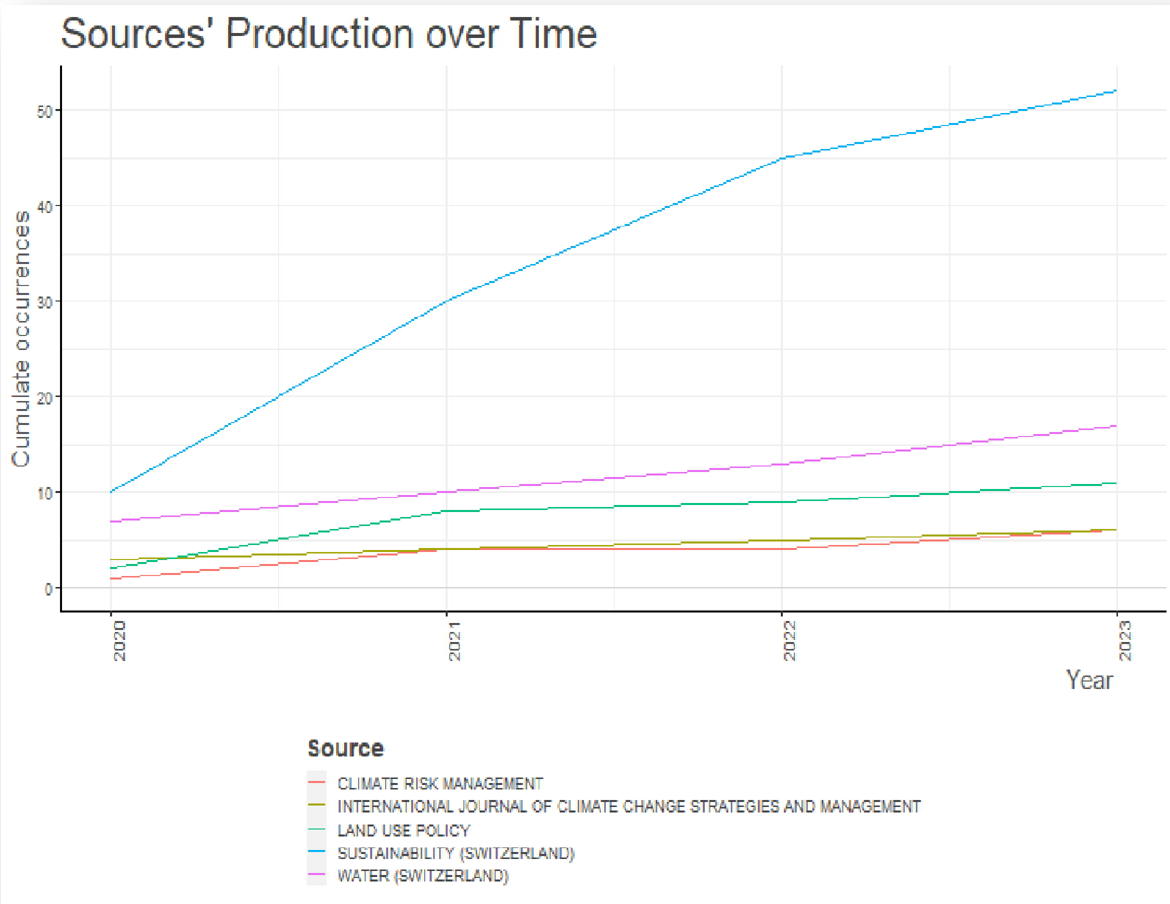
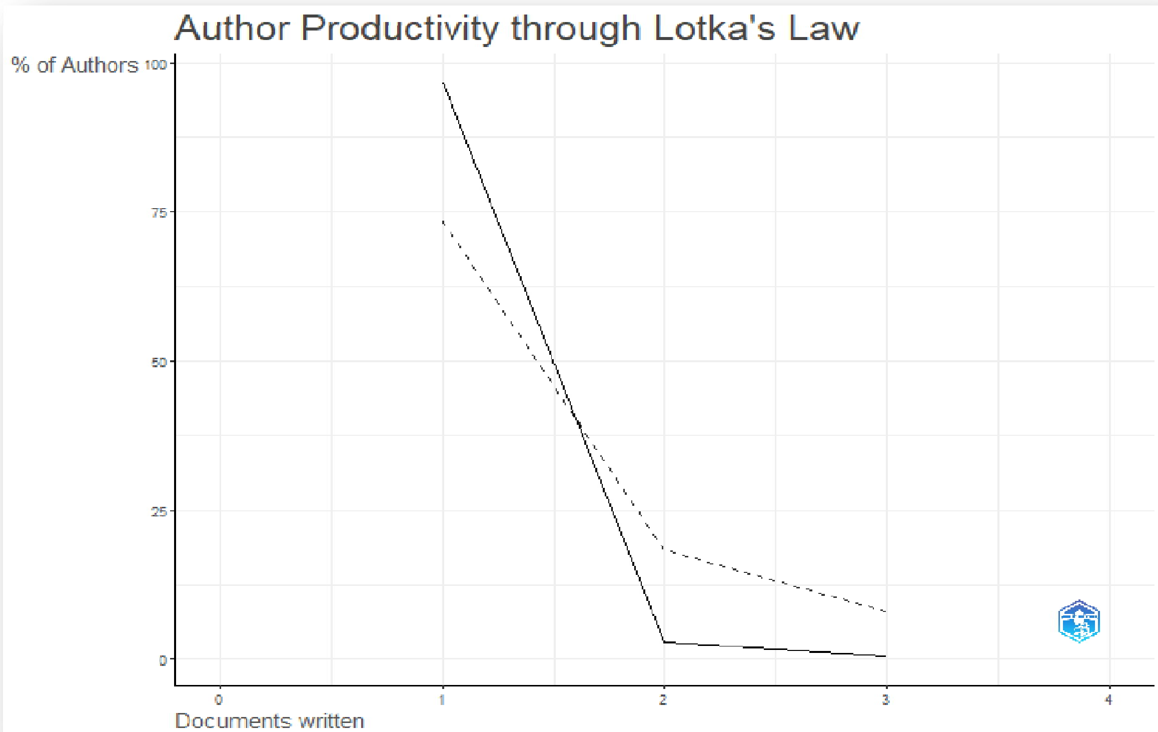


Fig 6: ***Documents published in year-wise***
Source: R studio

The area of soil health extension approaches is still undergoing rapid development and expansion, according to a publication trend analysis of the literature (Figure 4). The graph is a visual representation of the documents that have been published on Scopus. The years 2020 and 2023 have the most and the least publications, respectively, with six and three publications, respectively. The International Journal of Climate Change Strategies and Management had a gradual growth in the number of articles published in Scopus in the social sciences between 2020 and 2023, Articles on Social Science Related Publications [53].



Source: R Studio

Fig 7: ***Authors' productivity of documents on soil health Management***

It is a line graph that shows the number of documents written by an author on the y-axis and the number of authors who wrote that many documents on the x-axis. The graph follows Lotka's law, which is a principle that states that in many fields, the number of authors who produce a given number of papers is inversely proportional to that number. In other words, for every one author who writes five papers, there will be two authors who write four papers, three authors who write three papers, and so on. The graph in the that there is a small number of authors who are very productive, writing many documents, and a larger number of authors who are less productive, writing fewer documents. The most productive author in the graph has written 50 or more documents, while there are many more authors who have written only one or two documents. Lotka's law is a useful tool for understanding the distribution of productivity in a field. It can be used to identify the most productive authors in a field, as well as to compare the productivity of different fields. Lotka's Law describes the frequency with which authors publish on a subject of as predicted by the Extension Approach on soil Health, around 37% of journalists write a single article, 10% contribute two Articles and so on.

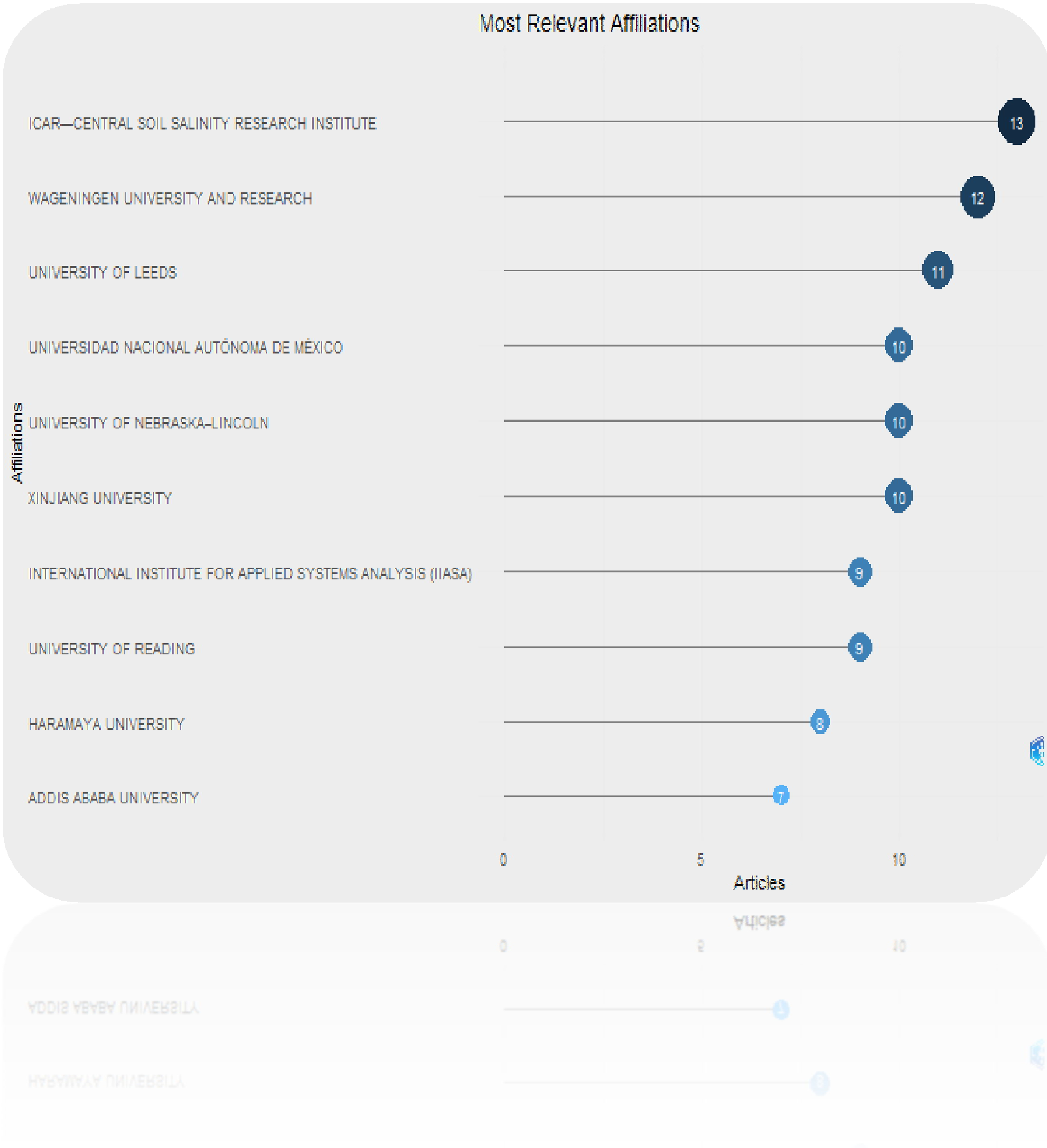
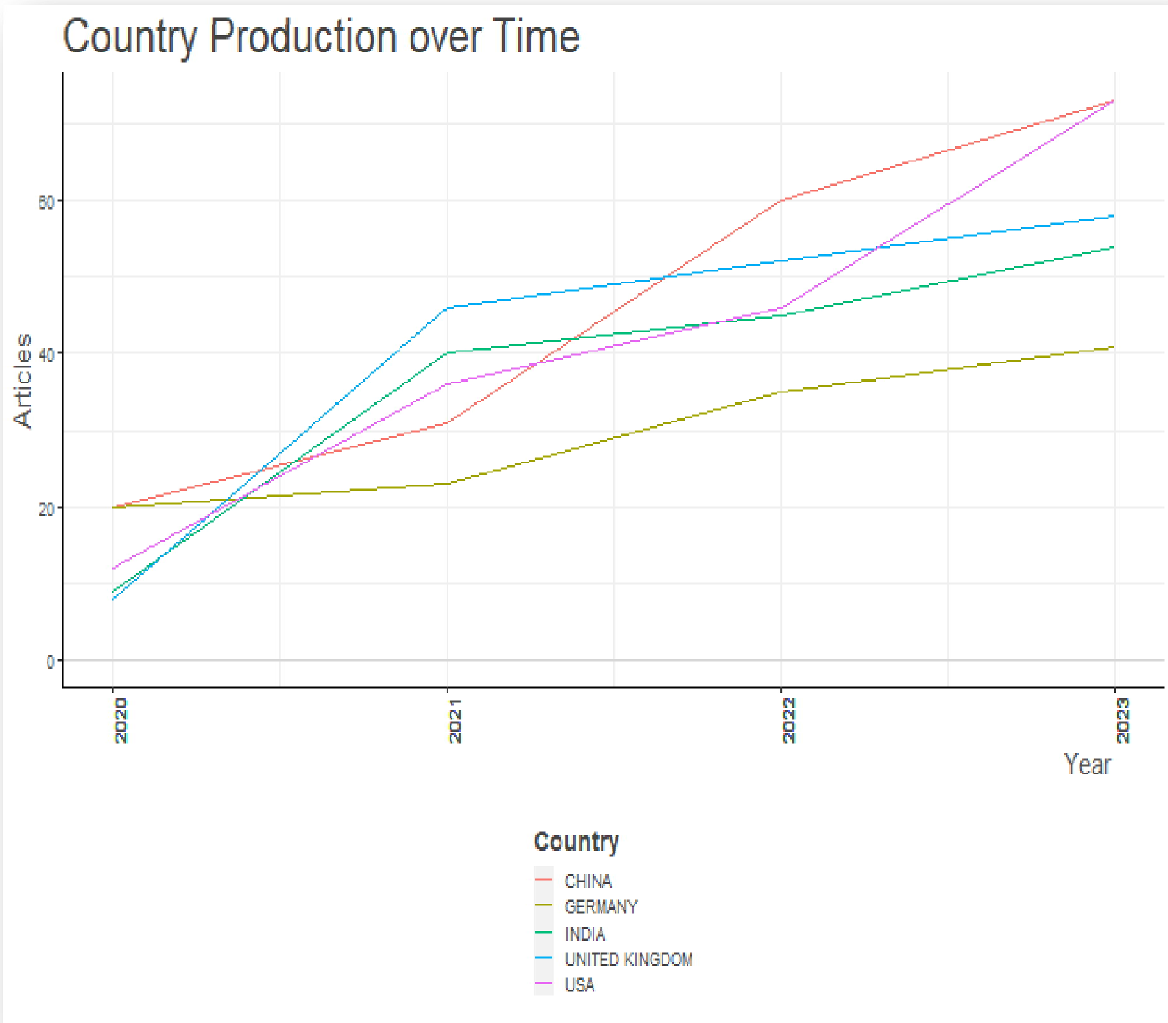


Fig8: ***Most Relevant Affiliations on Soil Health Management***

Publications published throughout time in the top ten journals according to Scopus are referred to as Soil Health Extension Approaches. The most significant contribution to links was given by the Indian Council of Agricultural Research Central Soil Salinity Research Institute [13] publications. The university Addis Ababa has the fewest publications [07], making up the least number of affiliations. The Social Science in the fields of technology transfer, impact assessment, and human resource development was the main emphasis of the Central Soil Salinity Research Institute.

Fig 6: ***Country Production over Time***



The Graph shows top five counties with frequent publishing are denoted by numbers in the year of 2023. When it comes to the publishing of papers about Soil Health Management on Extension Approaches, China [73] leads the globe, followed by Germany, India, United Kingdom and USA [54,46,41,12 publications, respectively]. It demonstrates that while many nations produce very few papers on soil health management on Extension Approaches, there is still room for other nations to do high-caliber Extension Approaches and publish their findings.

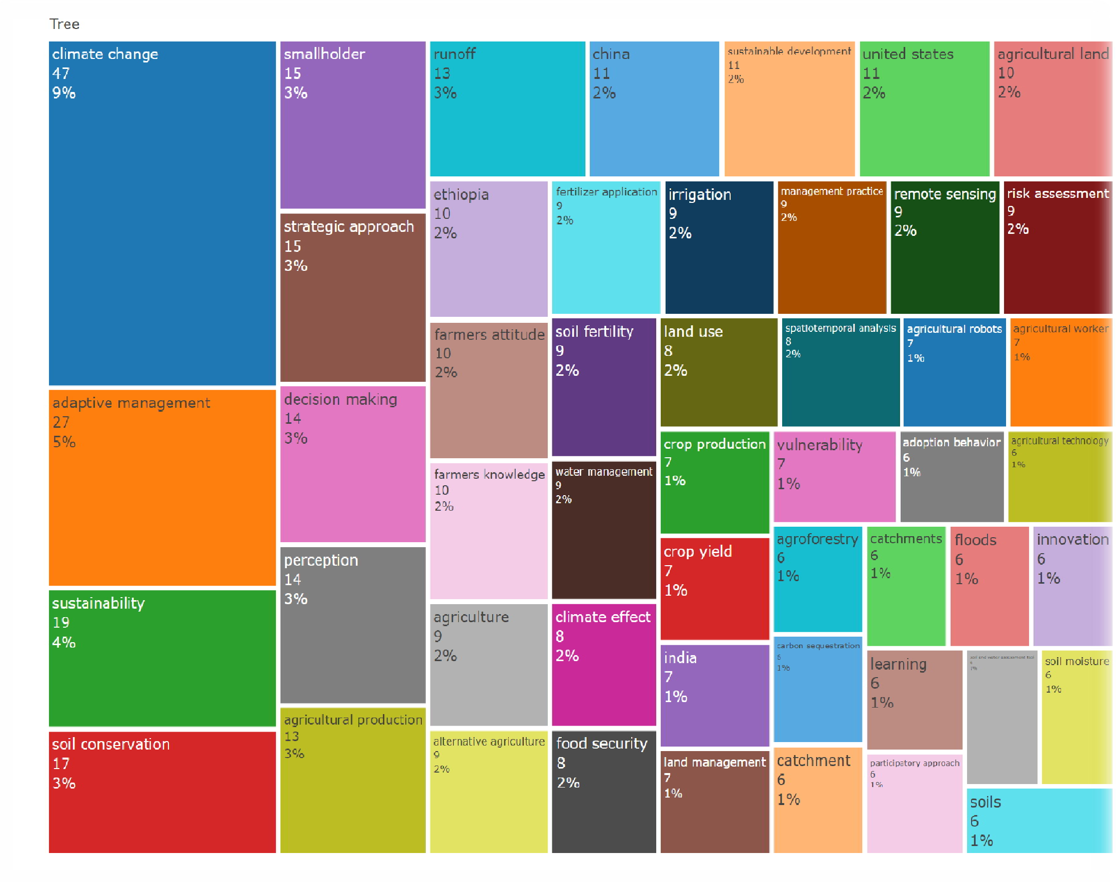


Fig 9: ***Tree Map shows soil health Management***

Their layout consists of a series of stacked rectangles whose dimensions correspond to those of the corresponding data valves. Each smaller rectangle in a data tree branch represents a node's size inside the branch, while the broad rectangle serves as its representation. On extension, a tree map illustrates the fundamentals of managing soil health. Within the context of soil health management strategies, social perception pertains to the continuous and sensory motor processes that are stimulated and modified by certain classes of items that are encountered during social interactions. (Sarkar et al 2021) Making decisions involves considering several possibilities and deciding which is best for the health of the soil. (Mahra & Associates, 2022) Farmer Growing agriculture according to local circumstances requires knowledge, which is a skill. (Kaur et al. 2020)

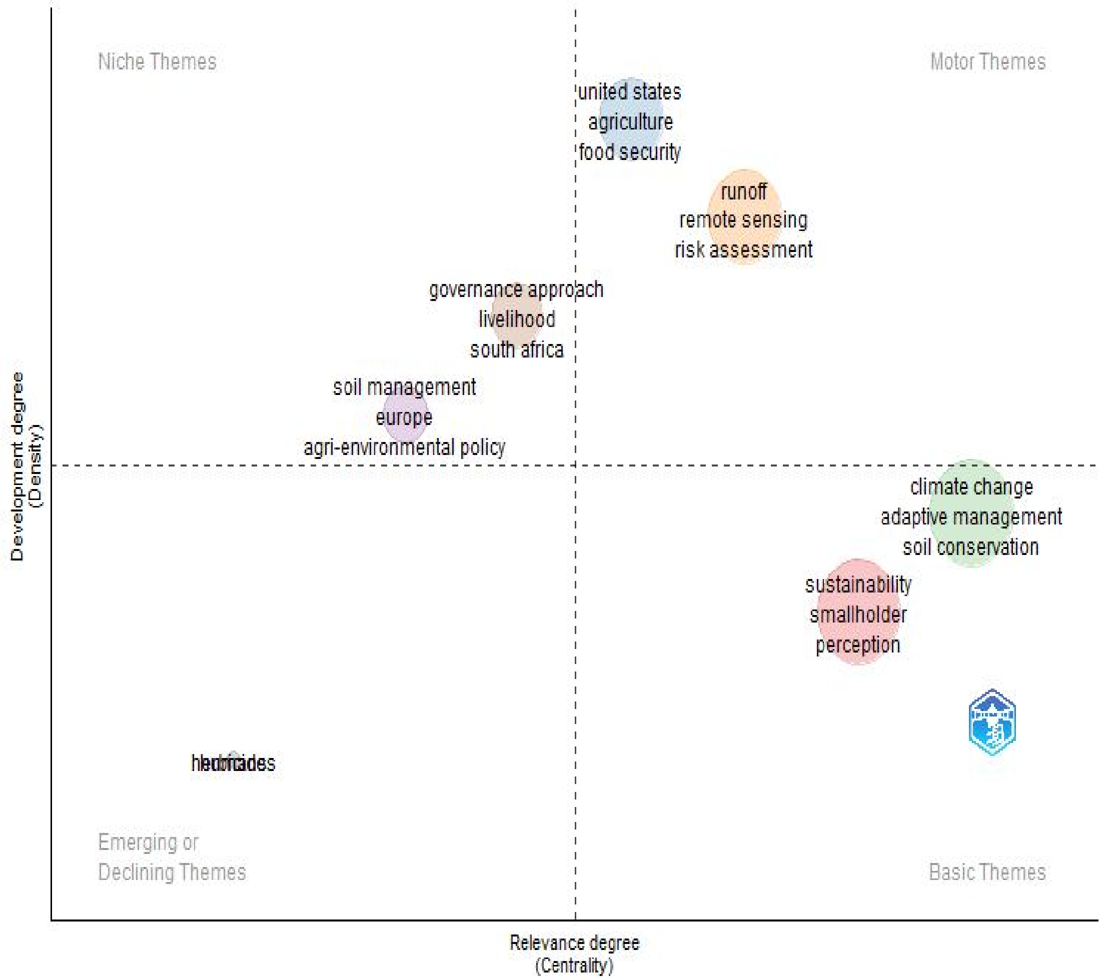
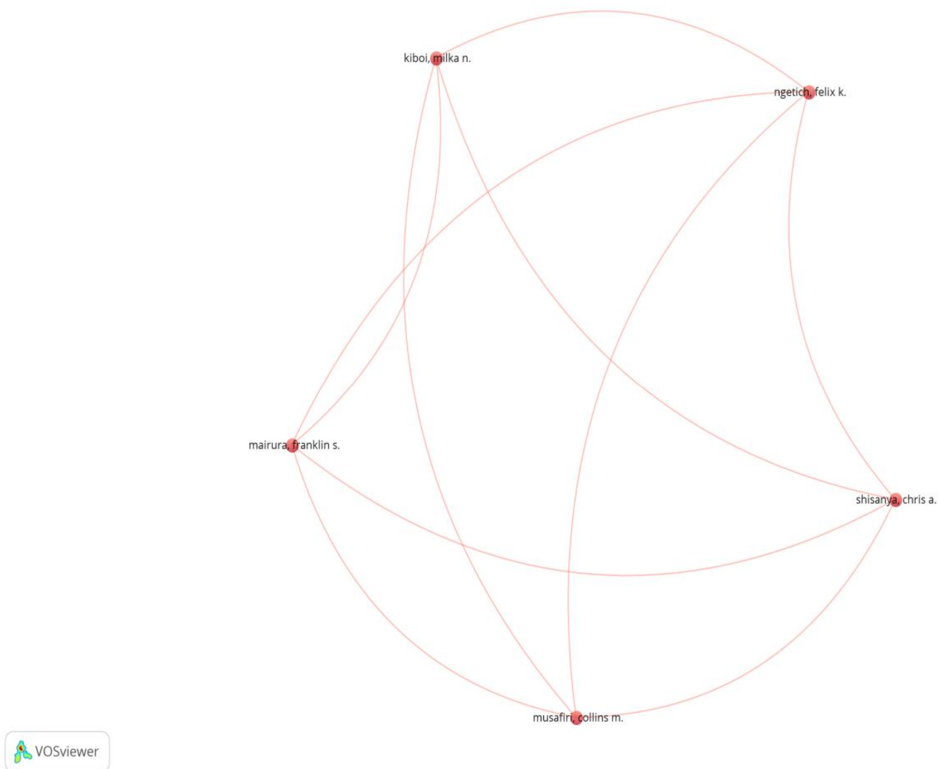


Fig 10Shows *Thematic Map of soil health Management*

Source: R Studio.

The spatial distribution of one or more particular data themes for chosen geographic regions is displayed on a thematic map. The four key Basic topics are perceptions of smallholders, sustainability, adaptive management, and climate change. Allen et al. (2022), Westgate et al. (2023), Keith et al. (2021), Roux et al. (2019), Rishi et al. (2020) looked into the themes of adaptive management, which include using soil health and gathering information to ensure close feedbacks between decision makers and ecosystem change. In 2022, Corina Hoppner and Lorraine E. Whitmarsh Stress that because of their limited ability to adapt, smallholder farmers are more likely to be impacted by climate change. A few of the problems caused by climate change are its effects on livelihoods, agricultural productivity, and ecosystems. (Schach's, 2023)centered on sustainability, human dignity, equitable distribution, and fairness are the three core concepts that comprise our understanding of justice. The runoff, risk assessment, etc., were covered in the motor topics. The idea of "risk" is frequently associated with the potential for negative outcomes in reality as an individual due to human behaviour or natural events (Starr and Whipple 2020). Soil management, governance approaches, and other topics are covered in the niche themes.



A bibliometric analysis carried out between 2020 and 2023 on the different categories of articles on soil health from the Scopus database collection ignored the significance of the issue. According to Shayanna, Mayura Franklin, and Kobuleti's network diagram, the co-authorship analysis of the author, who has at least five publications and twenty-five citations, shows that the writers tried to collaborate with other authors in the Soil Health on Extension techniques. The giant bubble and other authors are connected by a thick line. This suggests that the author has worked with more authors than just one. In addition, the network's thorough study revealed that two writing teams operate together in the Soil Health section.

As stated by Shanaya and Chris (2020), Knowledge specialists organize households based on visible assets by applying the participatory ranking technique. In summary, group farming systems are analysed using statistical data analysis methods such as principal component analysis (PCA), also referred to as "dimensional data reduction," and clustering analysis (CA) in the multivariate analysis. The lack of information and the high cost of inputs are two of the main reasons Ethiopian farmers are reluctant to adopt new technology. According to Collins and Mustaf's (2022) investigation, the Integrated Soil Project aims to change farmers' perspectives by providing them with knowledge and training on the use of organic fertilizer, composting with effective microorganisms (EMOs), vermicompost, and bio slurry, as well as on the use of technology and techniques like biofertilizer and small-scale mechanization for minimum tillage.

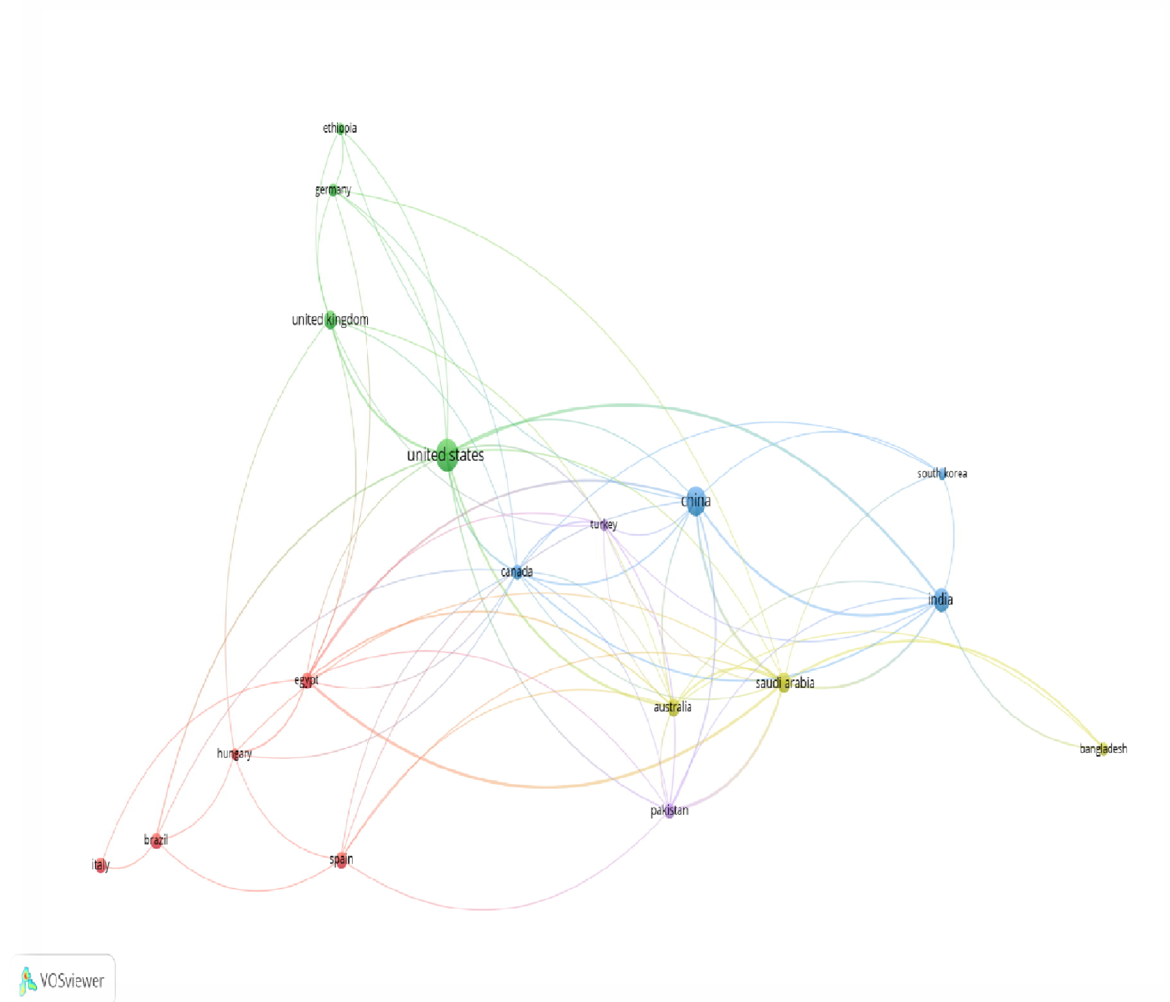


Fig 12*shows the Co-authorship among various countries*

Source: Vos viewer.

Co-authorship analysis of many countries' extension strategy studies that are published in Scopus, with a maximum of 25 papers and 39 citations related to soil health. The country has more connections for collaboration with other nations as the bubble gets bigger. Co-authorship countries are shown as clusters of various hues along with their links. Co-authoring countries including the UK, Germany, the US, Canada, and others are included in the red cluster. A group of co-authors from various countries is represented by the colour of their network in each cluster, much like this. U.S. Extension places a strong emphasis on transferring information to farmers directly through research and instruction. (Stacks, Don W., 2022). The development of extension approaches in the UK places a strong emphasis on the benefits of participatory rural appraisal for soil health management. (Tarzan 2020)

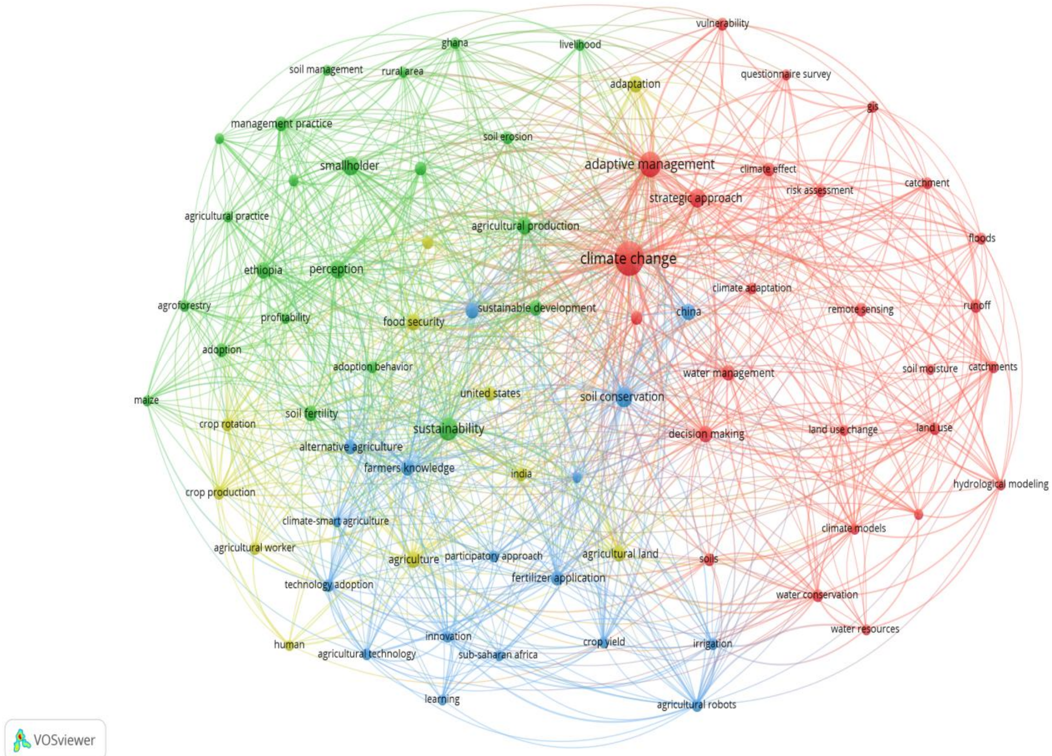
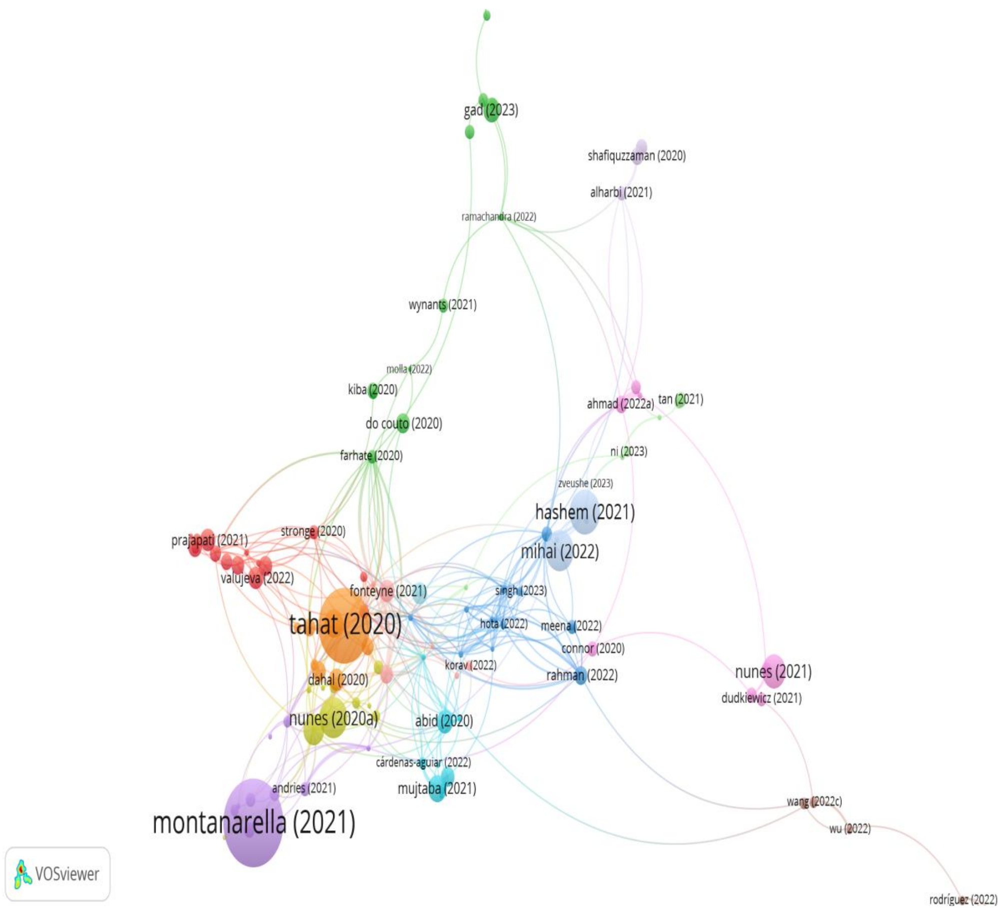


Fig 13 ***Shows the Co-occurrence of author keywords***
Source: Vos viewer.

The authors' term's co-occurrence, which has the fewest Soil Health Management-related keyword occurrences. Out of 89 keywords, only 1599 were found to meet the requirement. Bigger coloured word bubbles on the map indicate the number of articles that have been published using that keyword in Scopus as well as other research projects that are connected to it. Less research has been done on that specific keyword and fewer articles published are indicated by smaller coloured bubbles in Scopus. The network map showing the co-occurrence of author keywords indicates that researchers and experts who aspire to work in this subject concentrate on map-related keywords and work on specific keywords in limited amounts. Climate Change, Adaptive Management, Adaptation, Farmers Knowledge, Questionnaire Survey, Innovation, Technology Adoption is the term with the most suggestions.

Westgate et al. (2023), Allen et al. (2022), Roux et al. (2019), Keith et al. (2021), and Rishi et al. (2020) It was found that the procedure of gathering information for **Adaptive management** is what ensures tight feedbacks between decision makers and ecosystem change while making use of soil health. (Nagarajan, A., Goswami, R., Basu, D.2020); Chita, J. Freeman, K. Researchers found that by improving the use of resources for soil health, **Knowledge** Increased trust and message adoption were facilitated by SKN presenters who had farming, on-the-ground soil and land management skills in addition to practical or economical knowledge of soil management (e.g., liming, deep ripping, retention of ground cover) and farm management activities (e.g., stock, pasture, and crop management). Steed, Ellington, & Pratley (1993) have proposed this.

People are increasingly **Adopting** the Internet, networking, and communications technologies and integrating them into their daily lives, which is leading to the emergence of technologically enabled social structures. These structures are facilitating substantial modifications to various soil practices and revolutionizing human interaction and communication. (Baron, S., Patterson, A., Harris, K., and Agri, P. Beyond 2021)



Source: Viewer.

Fig *14 shows the Bibliometric Coupling*

Bibliographic coupling happens when two publications both refer to a third publication. We may presume that there is a relationship between the publications that are cited and the greater number of references because of this mutual interest in the same publications. This picture seems to be a Vos Viewer software-created network visualization. Furthermore, it illustrates the relationship between 157 Researchers who wrote publications on the subject of "Soil Health Management" and the extension approaches. Authors that have collaborated on several publications with other authors are indicated by big circles. (Montanelli, 2021). The little circles signify the authors' nods in relation to Tahat (2020) who produced less articles.

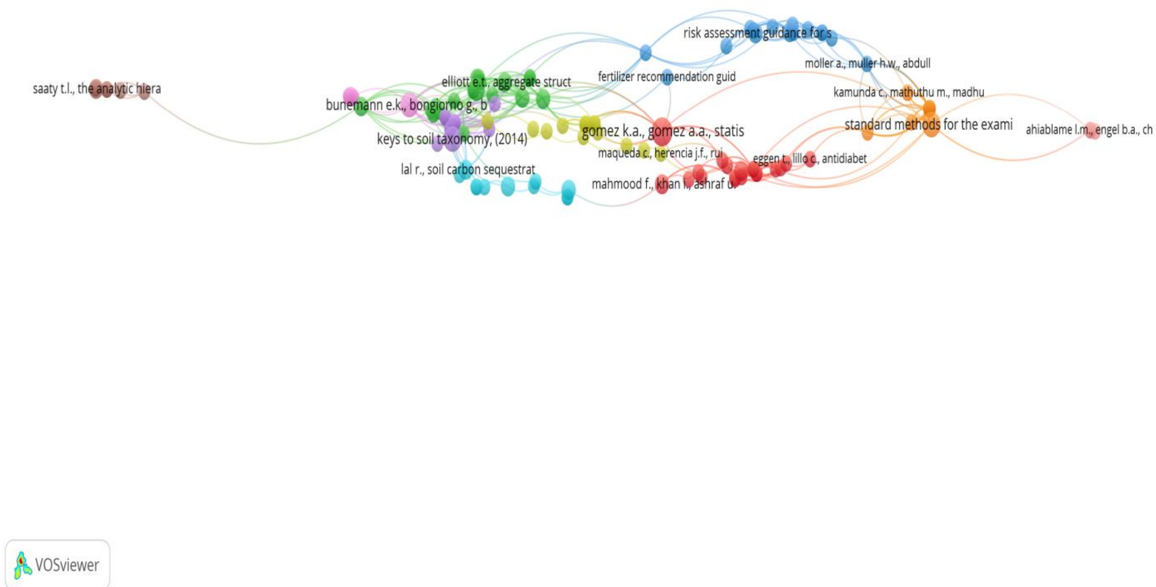


Fig 15 ***shows the Co- Citation of References***

Source: VOS viewer.

The co-citation of cited references must have a minimum of five citations. Out of the 15745 mentioned works, only 137 meet the requirement. as of March 4, 2024. As a result, there is inadequate connection between the network's 137 components. The following eight Groups may be seen on the network map: Brown, Red, Green, Violet, Orange, Blue, Pink, and Light Blue. How often writers' references are cited is reflected in the size of the enormous bubbles. The circles in the figure represent researchers, while the lines that connect them represent co-authorship.

People's opinions, attitudes, judgments, and sentiments, as well as broader cultural and societal dispositions they acquire toward threats to things we value, all play a role in how individuals perceive risk (Fischhoff, B., Lichtenstein, S., Slavic, P., Derby, S.L. & Keeney, 2021). Their focus was on the Soil Health Management on extension approaches.

SI.NO	Bibilometrics Analysis	Inferences
1.	Sources production over Time	Extension Methods for Soil Health The International Journal of Climate Risks Management(18) generates less publications than The Sustainability (Switzerland) Journal (53). The research gap in my findings is not addressed in this journal article.
2.	Authors' productivity of documents.	As expected by the Extension Approach on soil health, Lotka's Law characterizes the regularity with which writers publish on a topic. Roughly 37% of journalists produce a single piece, 10% contribute two articles, and so on. Therefore, fewer articles written by the authors will not close the research gap.
3.	Country Production over Time	Managing Soil Health Using Extension Methods China tops the world with the most publications (73), followed by Germany, India, the United Kingdom, and the USA (54,46,41, and 12 publications, respectively). However, many countries still place less emphasis on soil health extension approaches.
4.	Most Relevant Affliations	Publications from the Indian Council of Agricultural Research's Central Soil Salinity Research Institute [13]. With the fewest publications [07] and the fewest affiliations, Addis Abeba University does not fully close the research gap.
5.	Thematic Map	The other topics displayed on the Thematic Map are unrelated to the Research Gap.
6.	Co- Authorship of Authors	The two writers talked about how much farmers know about soil health. Many writers are required to address the research gaps.
7.	Co-authorship of many countries	Shows the Fewer Citations From Different Countries. It doesn't cover the holes in research.
8.	Co-occurrence of author keywords	The co-occurrence of authors' terms does not address the research gap; rather, it only specifies knowledge and adoption.

Future prospects:

- Encouraging farmers Knowlege and improving agricultural practices in a sustainable manner requires a holistic approach that incorporates affordable technology, inclusive involvement, and socioeconomic considerations, Through Training Workshops conducted by the Research institute.
- Building a strong soil knowledge network requires acknowledging the cultural context, utilizing social network analysis, and placing a high priority on capacity building.
- We may build an inclusive and empowered community committed to improving soil stewardship and agricultural resilience by recognizing regional practices, identifying social linkages, and cultivating knowledge.
- The necessity for focused interventions is shown by the smallholder farmers continued low adoption rate of integrated soil health management.
- Promoting sustainable farming methods requires addressing obstacles including resource availability, information sharing, and governmental support.
- Widespread adoption and better soil health results may be achieved via stakeholder collaboration and specially designed communication initiatives.
- Programs to raise awareness about Soil health card components and suggested actions are still necessary to encourage farmers to use them.
- Increasing the effectiveness of these services can result in better soil management techniques, which will eventually support sustainable agriculture and higher agricultural output.

Conclusion:

Prolongation methods for managing soil health that exclusively use co-occurence in bibilometric analysis key words for authors co-occurrence other than that, citations support the study through loktak law, co-citation, and sources production throughout time. references, a theme map, and co-authorship from several nations do not close the research divide.

INCLUSIVE STATEMENT

Funding: This Study was Funded by Anyone.

Conflict of Interest: They have no Conflict of Interest.

Ethical issues: In this Article no Ethical issues are not Addressed.

REFRENCES:

1. 1. Abhilash, P., et al. (2013). "Adaptive soil management." Current Science**104**(10): 1275-1276.

2. Ahmad, S., et al. (2016). "Implication of gypsum rates to optimize hydraulic conductivity for variable□texture saline–sodic soils reclamation." Land Degradation & Development**27**(3): 550-560.

3. Andrews, S. S., et al. (2004). "The soil management assessment framework: a quantitative soil quality evaluation method." Soil Science Society of America Journal**68**(6): 1945-1962.

4. Arseneau, M. (2022). An Exploration of Soil Health Extension in Ontario, University of Guelph.

5. Cherubin, M. R., et al. (2016). "A Soil Management Assessment Framework (SMAF) evaluation of Brazilian sugarcane expansion on soil quality." Soil Science Society of America Journal**80**(1): 215-226.

6. Chukwu, G., et al. (2014). "Linking pedology and extension: Emerging trend in optimizing fertilizer recommendations and sustaining soil health in Nigeria." Sky Journal of Soil Science and Environmental Management**3**(5): 42-49.

7. Darshan, M., et al. (2021). "Awareness on Soil Health Management Scheme by Farmers of Tumakuru District in Karnataka." Asian Journal of Agricultural Extension, Economics & Sociology**39**(10): 323-329.

8. Doran, J. W. and M. R. Zeiss (2000). "Soil health and sustainability: managing the biotic component of soil quality." Applied soil ecology**15**(1): 3-11.

9. Dubey, M., et al. (2022). "Comparing the Nutrient Management Pattern in Soybean and Rice based Cropping Systems by Soil Health Card holders and Non-holders." Indian Journal of Extension Education**58**(3): 83-87.

10. Islam, J. B., et al. (2015). "Quantitative assessment of toxicity in the Shitalakkhya River, Bangladesh." The Egyptian Journal of Aquatic Research**41**(1): 25-30.

11. Jha, A. K., et al. (2021). "On Farm Assessment of INM Techniques on Soil Health and Yield of Rice in Sahibganj, Jharkhand." Indian Journal of Extension Education**57**(4): 89-92.

12. Kang, J., et al. (2017). "Abiotic stress and its amelioration in cereals and pulses: a review." Int. J. Curr. Microbiol. Appl. Sci**6**(3): 1019-1045.

13. Karlen, D. L., et al. (2019). "Soil health assessment: Past accomplishments, current activities, and future opportunities." Soil and Tillage Research**195**: 104365.

14. Kaur, S., et al. (2020). "Farmers' knowledge of soil health card and constraints in its use." Indian Journal of Extension Education**56**(1): 28-32.

15. Khan, G. A. (2019). "Knowledge of sericulture extension workers about soil health cards." IJCS**7**(2): 534-538.

16. Khan, M. M., et al. (2023). "ROLE OF COMMUNITY CLINIC IN REDUCING CLIMATE CHANGE AND DISASTER-INDUCED HEALTH RISKS." Coastal Disaster Risk Management in Bangladesh: Vulnerability and Resilience.

17. Khan, M. M. and N. Mazumder "Challenges of the Coastal Communities towards Coping Strategies and Adaptation Options to the Scarcity of Safe Drinking Water."

18. LETA, G., et al. (2020). "Agricultural extension approach: evidence from an Integrated Soil Fertility Management Project in Ethiopia." Frontiers of Agricultural Science and Engineering**7**(4): 427-439.

19. M. Tahat, M., et al. (2020). "Soil health and sustainable agriculture." Sustainability**12**(12): 4859.

20. Mukhopadhyay, R., et al. (2021). "Soil salinity under climate change: Challenges for sustainable agriculture and food security." Journal of Environmental Management**280**: 111736.

21. Safikhan, S., et al. (2018). "Application of nanomaterial graphene oxide on biochemical traits of Milk thistle (Silybum marianum L.) under salinity stress." Australian Journal of Crop Science**12**(6): 931-936.

22. Sarkar, M., et al. (2015). "Study of hydrochemistry and pollution status of the Buriganga river, Bangladesh." Bangladesh Journal of Scientific and Industrial Research**50**(2): 123-134.

23. Sarkar, S., et al. (2022). "Innovative Extension Approaches for Diffusion of Nutrient Management Technologies." Soil Management for Sustainable Agriculture: New Research and Strategies: 283.

24. Soni, S., et al. (2021). "Variability of durum wheat genotypes in terms of physio-biochemical traits against salinity stress." Cereal Research Communications**49**: 45-54.

25. Wani, S. H., et al. (2020). "Engineering salinity tolerance in plants: progress and prospects." Planta**251**: 1-29

26. Al-Kaisi, M. M., & Yin, X. (2005). Tillage and crop residue effects on soil carbon and soil water retention. Soil and Tillage Research, 91(1-2), 105-118.

27. Andrews, S. S., Karlen, D. L., & Cambardella, C. A. (2004). The soil management assessment framework. Soil Science Society of America Journal, 68(6), 1945-1962.

28. Ashby, J. A. (1990). Evaluating technology with farmers: A handbook. International Potato Center.

29. Basche, A. D., Archontoulis, S. V., Kaspar, T. C., Jaynes, D. B., Sauer, T. J., & Parkin, T. B. (2016). Simulating long-term impacts of cover crops and climate change on crop production and environmental outcomes in a corn-soybean rotation. Agricultural Systems, 145, 50-63.

30. shby, J. A. (1990). Evaluating technology with farmers: A handbook. International Potato Center.

31. Basche, A. D., Archontoulis, S. V., Kaspar, T. C., Jaynes, D. B., Sauer, T. J., & Parkin, T. B. (2016). Simulating long-term impacts of cover crops and climate change on crop production and environmental outcomes in a corn-soybean rotation. Agricultural Systems, 145, 50-63.

32. Baumhardt, R. L., & Jones, O. R. (2002). Residue management and tillage effects on soil-water storage and grain yield of dryland wheat and sorghum for a clay loam in Texas. Soil and Tillage Research, 68(2), 71-82.

33. Blanco-Canqui, H., & Lal, R. (2007). Impacts of long-term wheat straw management on soil hydraulic properties under no-tillage. Soil Science Society of America Journal, 71(4), 1166-1173.

34. Bongiovanni, R., & Lowenberg-Deboer, J. (2004). Precision agriculture and sustainability. Precision Agriculture, 5(4), 359-387.

35. Braimoh, A. K., & Vlek, P. L. (2004). The impact of land-cover change on soil properties in northern Ghana. Land Degradation & Development, 15(1), 65-74.

36. Brennan, L., & McCown, R. L. (2001). Enabling better agricultural extension: Atheory-building case study in Western Australia. Agricultural Systems, 69(4), 213-234.

37. Bristow, K. L., Cook, F. J., & McGarry, D. (2000). Tillage and crop residue management effects on infiltration, surface runoff and soil loss. Soil and Tillage Research, 54(2-3), 185-197.

38. Brock, C., Gaudin, A., Hammermeister, A., & Martin, R. C. (2013). Weed suppression, yields and soil health indicators under annual intercrops and living mulches. Field Crops Research, 154, 62-71.

39. Cambardella, C. A., & Karlen, D. L. (1999). Spatial analysis of soil fertility parameters. Precision Agriculture, 1(1), 5-14.

40. Creamer, N. G., Bennett, M. A., Stinner, B. R., & Cardina, J. (1996). A comparison of four processing tomato production systems differing in cover crop and chemical inputs. Journal of the American Society for Horticultural Science, 121(3), 559-568.

41. Dalal, R. C., & Chan, K. Y. (2001). Soil organic matter in rainfed cropping systems of the Australian cereal belt. Australian Journal of Soil Research, 39(3), 435-464.

42. DeLonge, M. S., Ryals, R., & Silver, W. L. (2013). A lifecycle model to evaluate carbon sequestration potential and greenhouse gas dynamics of managed grasslands. Ecosystems, 16(6), 962-979.

43. Doran, J. W., & Zeiss, M. R. (2000). Soil health and sustainability: managing the biotic component of soil quality. Applied Soil Ecology, 15(1), 3-11.

44. Drinkwater, L. E., Wagoner, P., & Sarrantonio, M. (1998). Legume-based cropping systems have reduced carbon and nitrogen losses. Nature, 396(6708), 262-265.

45. Franzluebbers, A. J. (2002). Water infiltration and soil structure related to organic matter and its stratification with depth. Soil and Tillage Research, 66(2), 197-205.

46. Giller, K. E., Witter, E., Corbeels, M., & Tittonell, P. (2009). Conservation agriculture and smallholder farming in Africa: The heretics' view. Field Crops Research, 114(1), 23-34.

47. Hillel, D. (1998). Environmental soil physics: Fundamentals, applications, and environmental considerations. Academic Press.

48. Holland, J. M. (2004). The environmental consequences of adopting conservation tillage in Europe: reviewing the evidence. Agriculture, Ecosystems & Environment, 103(1), 1-25.

49. Lal, R. (2004). Soil carbon sequestration impacts on global climate change and food security. Science, 304(5677), 1623-1627.

50. Liu, X., & Herbert, S. J. (2002). Fifteen years of research examining tillage and residue management effects on soil carbon storage and carbon dioxide emissions. Soil and Tillage Research, 65(1), 95-106.

51. Lobell, D. B., Cassman, K. G., & Field, C. B. (2009). Crop yield gaps: their importance, magnitudes, and causes. Annual Review of Environment and Resources, 34, 179-204.

52. Magdoff, F., & Weil, R. R. (2004). Soil organic matter in sustainable agriculture. CRC Press.