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A global bibliographic review of soil variability trends on arable land: An impetus to sustainable land management

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SUMMARY

Crop production is significantly affected by soil properties under the influence of climate, management practices, and geographical location. Soil variability affects the development, quality, biochemical reactions, and heterogeneity of soil. The most recent research has focused on soil variability monitoring, highlighting the importance of soil testing. This review aimed at identifying global research trends and assessing soil testing in monitoring variability on arable land, based on the bibliographic method. Literature search in Scopus Database (2020-2023) yielded 8,898 documents, refined to 815 articles. VOSviewer 1.6.20 Software was used for analysing exported data. The results revealed a growing emphasis on monitoring soil variability, with key countries including India, United States of America (USA), China, Australia, Canada, United Kingdom, and Brazil. Funding mainly came from Asia, North America, and Europe. Common monitoring approaches included soil tests and remote sensing, focusing on organic carbon, nitrogen, phosphorus, potassium, microorganisms, and soil moisture. However, digital illiteracy and high costs were major hindrances to using remote sensing and modern soil testing tools. The study suggests that whereas soil variability monitoring is essential for sustainable land management, development of affordable soil testing equipment and improved digital education are needed for its enhanced adoption.

Keywords: *Soil testing; remote sensing; soil properties; soil monitoring; arable land*

INTRODUCTION

Consistency in the quality and composition of soil is a necessary consideration, yet it is rarely achieved due to differences within fields (Zhang and Zijian, 2023), and within particular locations in terms of properties (Duman et al., 2023). Additionally, the variability may be expressed in both spatial and temporal dimensions (Vogeler et al., 2022). A review by Bisht and Chauhan (2020) highlights the sources of soil variability, which include the fundamental disparities at soil development, tillage-induced erosion, and regular errors from improper use of fertilisers and manures. Studies reveal that soil variability largely results from complex interactions among climate, topography, and climate-land use, where soils show clear, diverse spatial variability (Lobb, 2021; Mwendwa et al., 2022). Additional contributors to this variability include levels of fertilisation and field manuring, particularly in orchards (Hou et al., 2021). Soil variability impacts the quality and quantity of agriculture in several ways, such as permanent displacements of soil surface material (Alamanis and Dakoulas, 2022), increased chances of slope failure (Nguyen et al., 2023), and lowering the yield of crops and the entire ecosystem (Juhos et al., 2015), among others.

Soil variability has often been associated with inconsistency in soil properties (Bhunia et al., 2018), necessitating effective strategies for sustainable land management. In addition, soil monitoring has been identified as a means to track variations in soil health parameters (Feeney et al., 2023), and to detect excessive fertilisation levels on arable land (Blunk and Gioia, 2022). Constant monitoring and analysis of soil quality relationships require constant, up-to-date, and detailed strategies, as recommended by Abdu et al. (2023). The use of modern devices is recommended for this task, including soil temperature sensors, moisture sensors, pH meters, tensiometers, and conductivity sensors (Lavanya et al., 2023). Additionally, geostatistical tools are applied to analyse the exactness and reliability of soil parameters derived from spatial distribution images (Jezierski and Kabala, 2021). Results from the use of these tools provide insights into the responses of biotic and abiotic components to farmer-induced changes. Thus, monitoring strategies need to be designed and applied to suit the measurable scales (Peñas et al., 2023). However, several challenges have been identified in the use of these tools, according to Lagos et al. (2020) and Sahbeni et al. (2023). Among the key challenges are high costs, limited accuracy due to confoundng factors such as thick vegetation cover, and inconsistent definition of measurement volumes (Hao et al., 2023; Saha et al., 2021; Fan et al., 2022).

Several authors argue that soil variability monitoring is accomplished through rigorous soil testing (Andrews et al., 2003; Lawrence, 2016; Zhang et al., 2017; Wade et al., 2021; Reijneveld et al., 2022). Much of the literature has focused on the processes and methods of soil testing. Some recommend including soil sampling, handling, and extraction methods, followed by the organisation of soil analysis correlation results (Noble et al., 2019), while others additionally suggest the use of soil tests (Murrell et al., 2021) and (Fageria & Nascente, 2014). From these reviews, it is evident that soil testing consolidates monitoring processes (Kaur et al., 2023). In contrast, many reports have concluded that soil tests either significantly underestimate or overestimate the availability of certain nutrients, such as potassium (Anderson et al., 2010; Geisseler and Miyao, 2016; Nyirenda, 2022; Silveira

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and Kohmann, 2020). Other studies have highlighted drawbacks, such as the difficulty of obtaining suitable methods for varied soil types (Mukherjee and Lal, 2014; Palinkas et al., 2015; Vereecken et al., 2016; Liu and Li, 2023; Vanino et al., 2023).

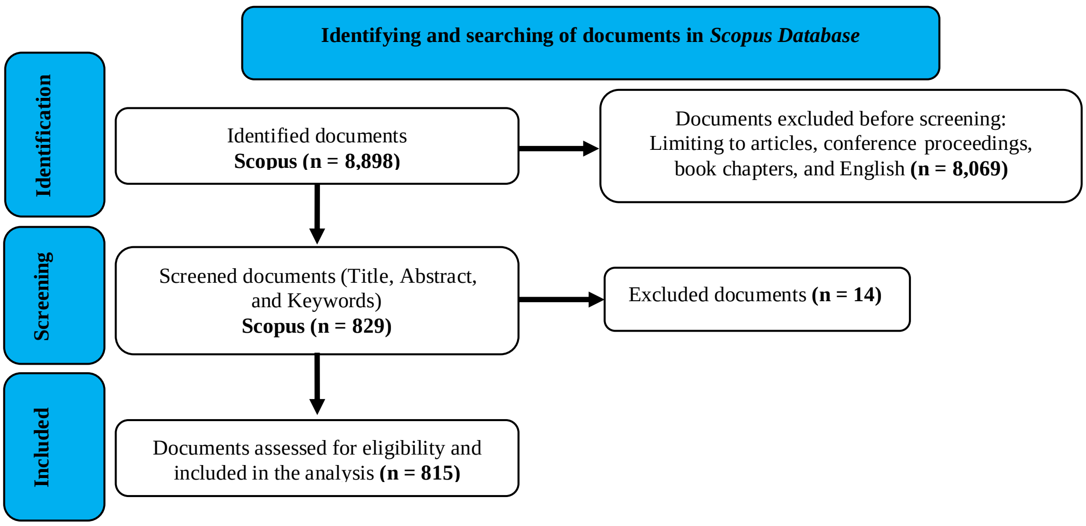
Globally, many countries have embarked on linking soil testing with the monitoring soil variability to address sustainable land management challenges (FAO 2020). Countries such as India, the USA, China, Australia, Canada, United Kingdom, and Brazil, Ethiopia, and Kenya have been funding soil monitoring research to examine changes in soil nutrients, moisture levels, and the status of soil microorganisms (Alqadad et al., 2017). Additionally, agricultural robots have been integrated into remote sensing technologies to predict soil property changes (Weiss et al., 2020). However, according to Dubovik et al. (2021), these innovations face major limitations ranging from digital illiteracy to high costs, partly because the technologies keep changing from time to time. Moreover, significant gaps remain regarding how to ensure sustainable land management (Quinton and Feiner, 2023). For instance, there has been no explicit inquiry into the latest focus of soil monitoring process. Yet, despite a recommendation by Mishra et al. (2019), even the prediction of future soil property changes was not comprehensively pursued. In some cases, literature on the characterisation of soils has been analysed using visualisation software, particularly VOSviewer (Bezak et al., 2021; Hirawan et al., 2022; Xu et al., 2022). Together with other scientific perspectives (Rieder and Kneisel, 2023; Richer-de-Forges et al., 2023), it remains important to understand the latest focus of research on monitoring soil variability (Rossel et al., 2016). Therefore, the aim of this bibliographic analysis is to highlight the latest research focus on the use of soil tests as tools for monitoring soil at a global scale, and to evaluate the applicability of these soil testing methods in supporting sustainable land management worldwide.

MATERIALS AND METHODS

Strategy for identifying and searching of documents

The search for literature was performed in Scopus database starting using a search query, TITLE-ABS-KEY ("soil test*") AND PUBYEAR > 2019 AND PUBYEAR < 2024. This database is considered as highly genuine, complete, and extensive in handling bibliometric analyses, citation patterns, and authorship trends. Scopus also provides highly curated collections of journals, books, and conference proceedings. In this case, the database was intended to provide a comprehensive set of publications for the study, offering sources that were more credible, trusted, qualitative, and relevant as supported by a number of researchers (Schotten et al., 2017; Baas et al., 2020; Hashem et al., 2023). A further search query created was (TITLE-ABS-KEY(("Soil test*" AND ("Soil variability" OR "Fertility" OR "Nutrient*"))) AND PUBYEAR > 2019 AND (LIMIT-TO (DOCTYPE,"ar") OR LIMIT-TO (DOCTYPE,"cp") OR LIMIT-TO (DOCTYPE,"ch") OR LIMIT-TO (DOCTYPE,"re") OR LIMIT-TO (DOCTYPE,"bk"))) for the period 2020–2023. The authors wanted to capture the recent developments while maintaining a manageable scope of the study as highlighted by some scientists (Donthu et al., 2021; Chen and Xiao, 2016). "Soil test*" was maintained in the search query due to its critical attachment to soil properties that address variability. We included alternative words, "fertility" and "nutrient", to widen the search equation for soil variability and the rest of the context. Besides, we disaggregated names of 'China' and 'United Stated of America' and, also, soil-related parameters like biomass and forestry. This is because their preliminary search never gave worthwhile results regarding arable land. *Figure 1* indicates the search strategy used and consequent production of 815 final documents from the originally identified 8,898 documents.

Figure 1. **PRISMA-style flowchart showing the literature search strategy used**



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Criteria for excluding and including documents

Screening of documents focused on two major items, namely; abstracts and keywords. This was extended to full text in some instances. We considered all document types that were suited to bibliography on testing of soils in the process of monitoring its variability on arable land. Five screening stages of exclusion were applied to the retrieved documents in this order: All documents with only soil test, documents with only soil monitoring, documents with only clear soil test and monitoring details, those with both soil test and monitoring details but not reported on arable land, and those with a combination of soil monitoring and other land survey details but without their effects. *Table 1* below is a summary of how documents were excluded and included, including a description/reason(s) for performing a decision at each screening stage.

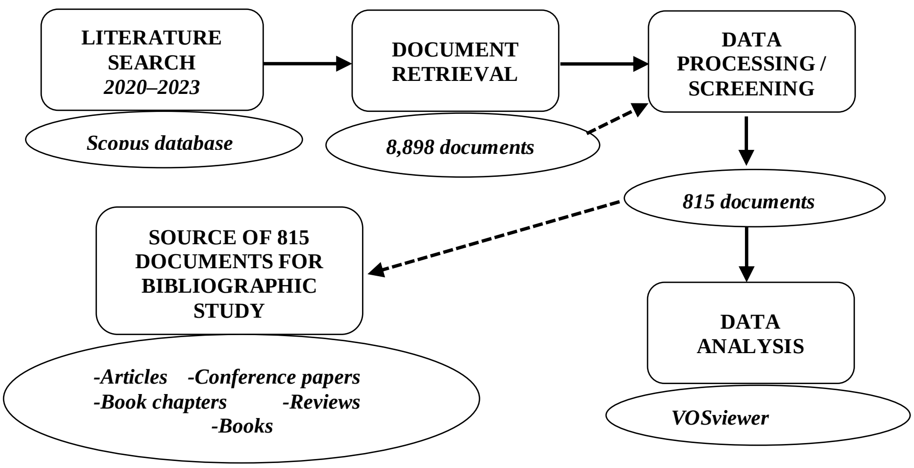
Table 1. **Criteria for inclusion and exclusion of abstracts and full texts of the documents**

Screening stage	Decision taken	Description of decision on document
1	No	"Excluded" – Soil test was part of the study but without clear details on soil monitoring.
2	No	"Excluded" – Soil monitoring was part of the study but without details on soil variability.
3	No	"Excluded" – Both soil test and monitoring details included in the study but no clear connection to the variability of soil.
4	No	"Excluded" – Soil test, monitoring details, and variability of soil were included in the study but not reported on arable land.
5	No	"Excluded" – Soil monitoring combined with other land survey details, but no effect of monitoring and/or monitoring + other land survey details on the value of soil on arable land.
6	Yes	"Included" – When the study qualified to be included in review of full text, following stages 1, 2, 3, 4, and 5 in the affirmative.

Process for exporting and analysing of data

Screened data were exported to a compressible comma-separated values (CSV) file format containing citation information, bibliographical information, abstract and keywords, funding details, and other relevant information (Williams et al., 2023; Dubovik et al., 2021). Analysis of data (*Figure 2*) and construction of bibliometric connections was done using *VOSviewer* Software. For instance, co-authorship of countries followed chosen thresholds, leading to corresponding numbers of citations (Oliveira et al., 2019; Bukar et al., 2023). Accordingly, a detailed analysis was made concerning connections of index keywords, author keywords, and funding organisations, as recommended by Singh et al. (2023).

Figure 2. **Process summary of literature search, data exportation, and data analysis**



*Initial search retrieved 8,898 documents (2023–2025). Screening and filtering steps reduced this to 815 documents, including articles, conference papers, book chapters, reviews, and books. Final analysis was conducted using VOSviewer software.

RESULTS AND DISCUSSION

Categories of included literature, and representation of document type and subject area

The exported data contained the latest global research focus on the value of testing soils, and its scope; documents by type; documents by subject area; documents by funding sponsor; and documents by affiliation. These categories made up 815 documents (articles) used for evaluating soil testing as a way of monitoring soil variability on arable land.

In terms of document type, most (663) were Articles, representing 81.3%, followed by 105 Conference papers (13%), 26 Book chapters (3.2%), 19

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Reviews (2.3%), and 2 Books (0.2%), as represented by *Figure 3*. Twenty three (23) subject areas were traced in the above document types. The number of appearances and percentage for the top ten (10) subject areas were; Agricultural and Biological sciences (473) 33.3%, followed by 302 Environmental science (21.3%), 126 Engineering (8.9%), 84 Earth and planetary science (5.9%), 83 Computer science (5.8%), 64 Biochemistry, Genetics and Molecular biology (4.5%), 39 Energy (2.7%), 29 Social sciences (2.0%), 27 Chemistry (1.9%), and 25 Physics and Astronomy (1.8%). These were followed by 24 Immunology and Microbiology (1.7%), 24 Materials science (1.7%), 23 Decision sciences (1.6%), 21 Mathematics (1.5%), 17 Medicine (1.2%), 14 Business, Management and Accounting (1%), 12 Chemical engineering (0.8%), 10 Multidisciplinary (0.7%), 10 Pharmacology, Toxicology and Pharmaceutics (0.7%), 5 Neuroscience (0.4%), 4 Economics, Econometrics and Finance (0.3%), 3 Veterinary (0.2%), and 1 Nursing (0.1%). The percentage appearances in the extracted documents by the top ten (10) subject areas are indicated in *Figure 4*, totaling to 88.1% and excluding the rest of the subject areas that total to 11.9%.

Figure 3. **Percentage representation of documents by type**

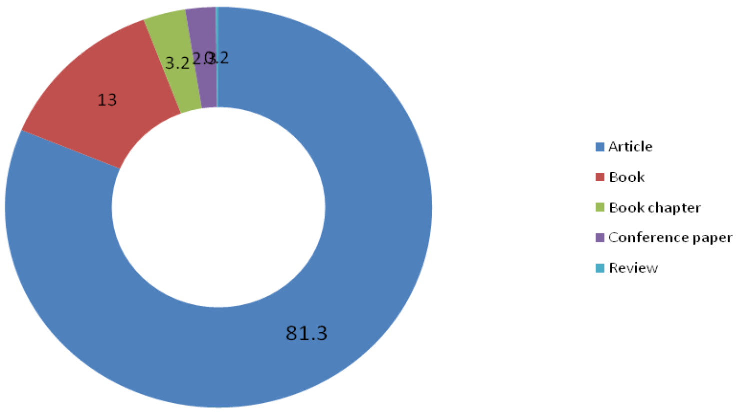
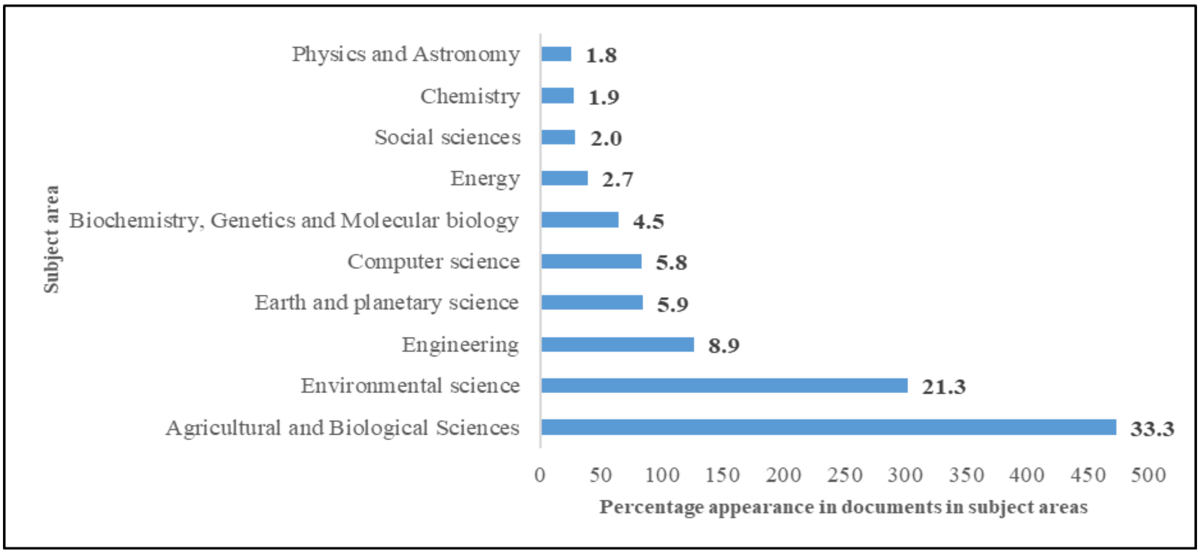


Figure 4. **Percentage appearances in the extracted documents by the top ten (10) subject areas**



*The figures indicated along the bars of the graph are a representative percentage of the top subject areas that appeared in the search on soil testing in the monitoring of soil variability.

The dominance of journal articles over other document types reflects the preference of soil variability researchers for peer-reviewed outlets as the main channel of scholarly reporting. Such reporting aligns with bibliometric norms in agricultural and environmental sciences, where peer-reviewed articles carry the highest weight in disseminating research findings (Hérubel, 2020). The relatively low representation of reviews suggests a gap in synthesising existing knowledge, which could hinder researchers from accessing integrated insights on soil variability.

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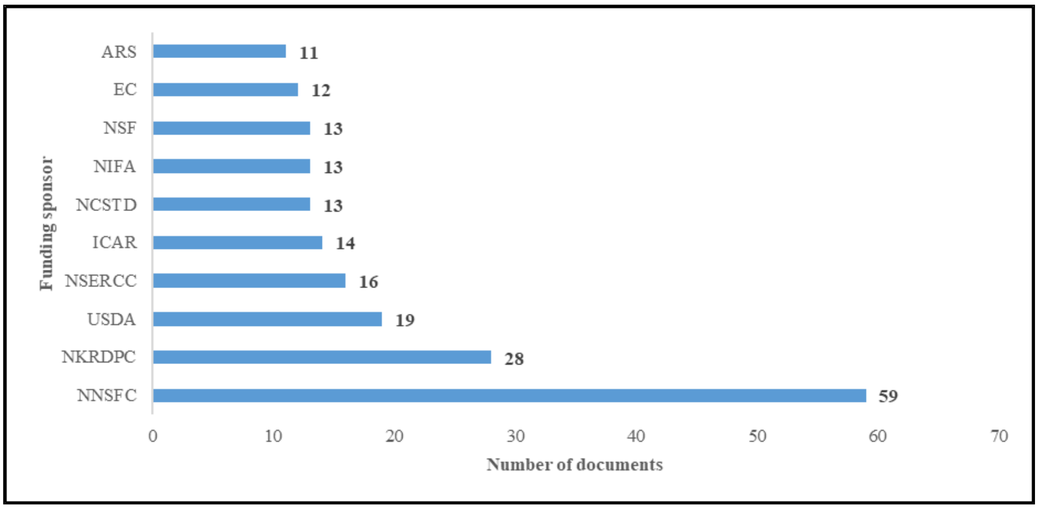
Regarding subject areas, Agricultural and Biological Sciences and Environmental Science together accounted for over half of all publications, reaffirming the centrality of agronomy and sustainability in soil research. Interestingly, Computer Science and Engineering appeared as growing areas, pointing to the integration of digital tools, precision agriculture, and modelling approaches. This trend connects adequately with the growing application of remote sensing, AI, and machine learning in soil monitoring (Rossel et al., 2016). However, limited contributions from Social Sciences and Economics highlight an under-explored dimension, thus, the socio-economic and policy aspects of soil management. Addressing this gap could strengthen the practical translation of soil variability research into sustainable farming practices.

Representation of documents by funding sponsor

The funding sponsors were represented by documents produced from scholarly work. The ten (10) top-most sponsors included the National Natural Science Foundation of China (59 documents), National Key Research and Development Program of China (28 documents), United States Department of Agriculture (19 documents), Natural Sciences and Engineering Research Council of Canada (16 documents), Indian Council of Agricultural Research (14 documents), National Council for Scientific and Technological Development (13 documents), National Institute of Food and Agriculture (13 documents), National Science Foundation (13 documents), European Commission (12 documents) and Agricultural Research Service of the United States of America (11 documents) as reflected in *Figure 5*. This pattern highlights the prominent role of Asia and North America in financing soil research, consistent with Chankseliani (2023), who observed similar geographic concentrations in research funding. Interestingly, while European sponsors like European Commission contributed fewer documents overall, their involvement often targeted cross-disciplinary and collaborative projects, suggesting a strategic focus on global soil monitoring networks rather than merely the volume of publications. Comparatively, funding patterns indicate disparities in research support across regions, with African countries appearing less frequently due to infrastructural and financial limitations (Myeni et al., 2019; Khechba et al., 2021). This observation underscores the need for increased international collaboration, as suggested by Minasny et al. (2020), particularly to support capacity building in under-represented regions. By linking funding sources to research outputs, it becomes evident that global soil variability monitoring is not only shaped by scientific priorities but also by geopolitical and economic factors that influence which countries can lead or participate in this research. However, basing on the proposal by Sandström (2009), Davies et al. (2022), and Minasny et al. (2020), it is not clear whether these funding organisations were operating in partnership or in isolation. A publication by Minasny et al. (2020) notes the ability of digital soil mapping of soil properties, and recommends application of global collaboration to ease the work for farmers and researchers from less developed countries.

Figure 5. **Documents by funding sponsor**



*NNSFC (National Natural Science Foundation of China), NKRDPC (National Key Research and Development Program of China), USDA (United States Department of Agriculture), NSERCC (Natural Sciences and Engineering Research Council of Canada), ICAR (Indian Council of Agricultural Research), NCSTD (National Council for Scientific and Technological Development), NIFA (National Institute of Food and Agriculture), NSF (National Science Foundation), EC (European Commission), ARS (Agricultural Research Service of the United States of America)

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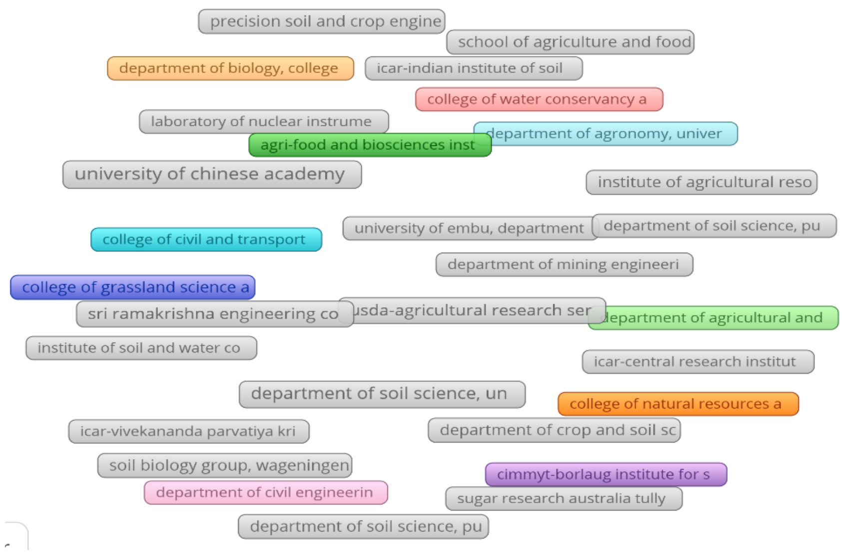
Representation of documents by affiliation

The closeness of the organisations or scholarly institutions as represented by the *VOSviewer* map of *Figure 6* indicates how the study could not be handled in isolation (Keohane, 1998). Citation of organisations was mapped within the network visualisation, giving such organisations a more focal position and contribution of the categorised literature (Cheng et al., 2021; Song et al., 2022). *Figure 6* is, thus, a display of the network map extracted from the VOSviewer visualisation in regard to soil testing and monitoring on arable land (Xiao et al., 2023). The network for affiliation disclosed strong collaboration clusters among Asian, North American, and European institutions, which dominate global soil research. The clustering reflects both geographic proximity and the concentration of research infrastructure and funding in these continents, resounding earlier findings on funding disparities (Chankseliani, 2023). The institutions from Africa and Latin America were visibly low, suggesting challenges in cross-regional participation that are likely linked to funding and capacity constraints (Myeni et al., 2019).

Furthermore, while VOSviewer mapping highlights institutional connectedness, it does not capture the distinct quality of collaborations, such as equitable partnerships. As earlier warned by Portenoy (2017), raw citation counts may overstate the influence of larger institutions while overlooking the contributions of smaller but strategically important actors. This suggests the integration of additional indicators, such as co-funding mechanisms and joint authorship networks, to better capture the multi-dimensional impact of global soil research collaborations.

Figure 6. **Documents from mapped citations with organisations or scholarly institutions**



Latest global research on soil testing in the soil variability monitoring process

There was a varying record of appearances, starting with India (216) and ending with Venezuela (1). Though many African countries are said to face funding and infrastructure challenges in soil variability monitoring compared to those of North America and Europe (Myeni et al., 2019; Khechba et al., 2021), Ethiopia recorded 14 appearances despite Mozambique trailing with only 1 appearance. The results of this study (*Figure 7*) reveals that all continents of the globe were involved in testing processes and increased investigations of soil variability monitoring, suggesting the universality of soil testing. Also, this geographical representation revealed strong contributions from countries in Asia, North America, and Europe. The high output from India is noteworthy, considering the country's on-going challenges of soil degradation and nutrient imbalance (Bhattacharyya et al., 2015), and this may reflect strong national investment in soil testing initiatives towards food security strategies. Conversely, contributions from African countries, such as Ethiopia and Mozambique, were limited, and this illustrates the uneven capacity for soil monitoring and research within the continent. Myeni et al. (2019) confirm soil, specifically moisture, as a variable that can be monitored and tested through temporal and spatial resolution of remote sensing to provide accurate estimates. According to Rossel et al. (2016), there is a worldwide collection of soil spectral data that is easily linked with the physical and chemical soil properties. Specifically, the visible to near-infrared (vis-NIR) data facilitates predicition of soil attributes, condition, and functions, without necessarily applying traditional laboratory soil testing methods. Rossel et al. (2016) argue that such methods are very costly and laborious, requiring physical soil sample collection and use of chemical reagents. Modern soil variability monitoring methods like spectroscopy could further ease the local predictions of soil attributes and type in a given land area compared to traditional methods.

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Figure 7. **Countries representing the latest global research focus on the value of testing soils**

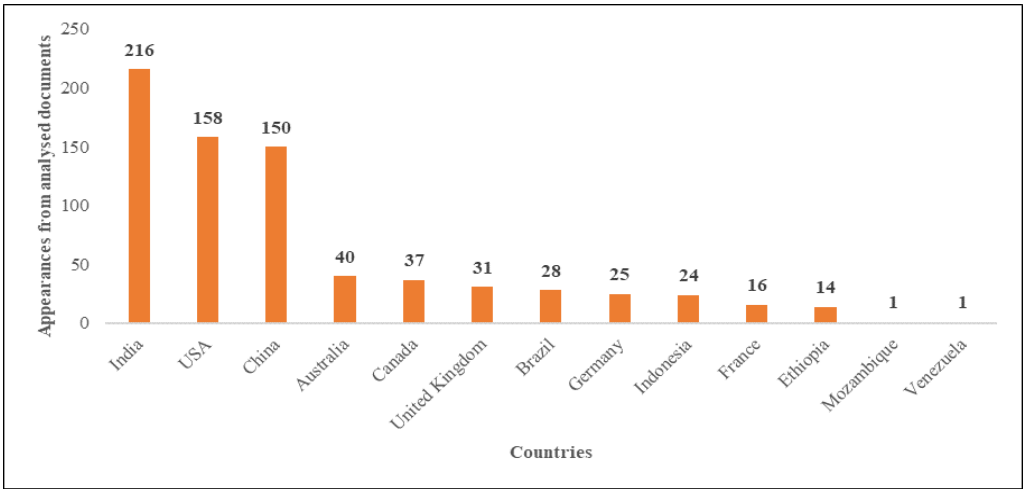

Figure 7 above implies a strong pick-up interest in soil testing processes by the globe. These findings from scholarly work suggest that soil testing for the purpose of monitoring their variability is a global concern (Seaton et al., 2020). However, the progression rate for such processes needs clear research scrutiny. Based on this, it would be worthwhile to investigate the rate at which individual continents or countries are adopting the soil monitoring processes (Leeuwen et al., 2017). In some instances, traditional soil monitoring, especially sampling, is negatively affected by lack of valuable biological soil parameters. Secondly, according to Leeuwen et al. (2017), issues of single laboratory use on testing the soil samples may complicate the process, thereby requiring the use of fast, modern devices.

Scope of soil tests in the soil variability monitoring on arable land

The number of appearances, as identified by both index and author keywords, for some of the most featuring keywords in all the analysed documents were; soil testing (425), soils (297), nutrients (171), phosphorus (135), fertilisers (111), nitrogen (110), soil fertility (107), crops (88), fertiliser application (73), and soil nutrient (73). Those appearances represented individual portions of the keywords used in documenting research work on soil tests as 52.1%, 36.4%, 21%, 16.6%, 13.6%, 13.5%, 13.1%, 10.8%, 9%, and 9% respectively (Heuschele et al., 2023; Sohoulande et al., 2022; Singh et al., 2023; Wang et al., 2022; Ying et al., 2023). Soil testing appearing in 425 instances (52.1%) makes it the most dominant keyword. Words such as soils, nutrients, phosphorus, fertilisers, nitrogen, soil fertility, and fertiliser application are closely associated with soil testing. This strong connection emphasises nutrient management, soil health, fertility restoration, and crop productivity, which underscores its pivotal role in variability monitoring and sustainable land management. As described by Tiwari et al. (2023), these aspects guide farmers in land management through wise use of fertilisers, hence keeping soils healthy by correcting pH imbalances, growing better crops, and protecting the environment. In addition to nutrient profiling, soil tests provide vital information for mapping spatial variability in arable land, which further facilitates site-specific management practices that narrow yield gaps and improve the productivity of land. Relatedly, the bibliometric data reveal an increasing trend towards integrating advanced testing methods, such as spectroscopy and remote sensing, which are used alongside traditional laboratory tests. However, advanced methods make large-scale soil monitoring more precise, cost-effective, and less destructive (Rossel et al., 2016; Leeuwen et al., 2017).

Based on the earlier researches in Agricultural and Biological Sciences (33.3%), Environmental Science (21.3%), and others, such as Computer Science and Engineering (aggregated 14.7%), confirm that soil tests involve technological innovations that improve conventional agronomy. Recent studies, such as Cleary et al., 2023, note the use of digital cameras and smartphones as devices that expand the scope of testing soil by enabling rapid, non-invasive data collection and interpretation. This offers a solution to the current global challenges of pollution, excessive chemical use, and degradation of arable land since they offer environmentally friendly soil testing.

Connecting the index keywords from VOSviewer

This study found out the index keywords directed to the essence of the study, as some researchers (Crispim et al., 2022) observed. These results from *Figure 8* confirm the existing evidence of index keywords being a right representation of the research foci and theoretical backgrounds of any academic study (Corrin et al., 2022). All index keywords, including soil testing, soil fertility, nitrogen, fertiliser application, and agricultural robots, directly relate to managing soil responsibly, which is essential for long-term agricultural sustainability.

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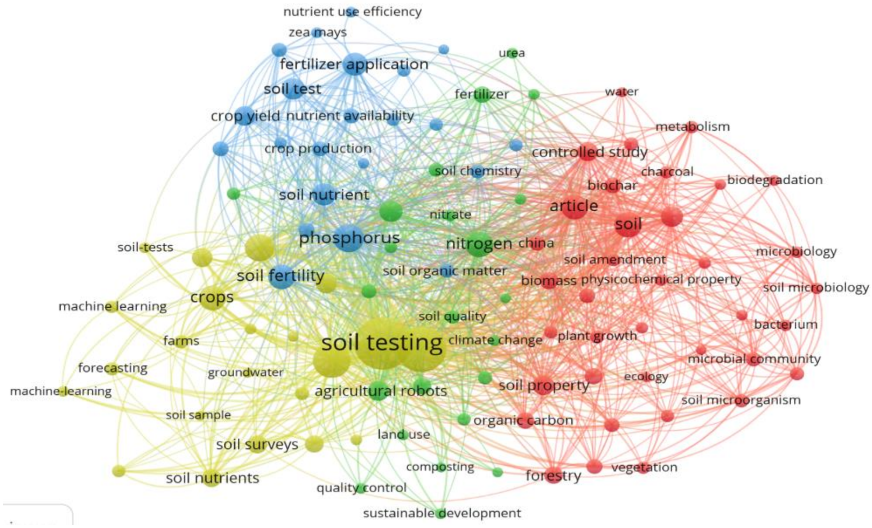
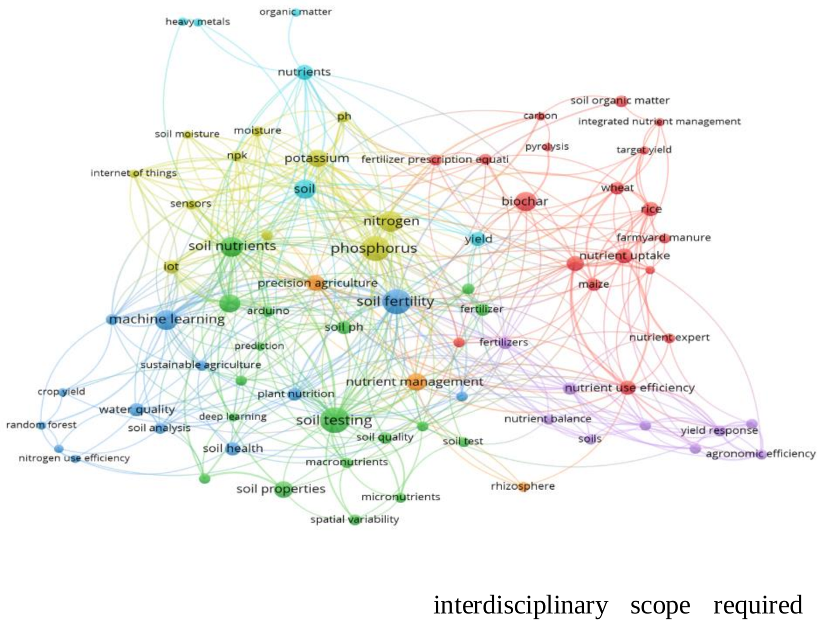
Figure 8. **Connection of the index keywords on the *VOSviewer* map**



Connecting the author keywords

Soil fertility, soil nutrients, nutrient management, soil, soil properties and many more were the author keywords as indicated in *Figure 9*. The visualisation map of these author keywords offered an ideal representation of the interests of this study (Lu et al., 2020). These linkages visually reflect core research interests in soil variability and nutrient management, which reinforces the role of soil testing in the sustainable management of land. Such results should be considered whenever similar existing author keywords on the *VOSviewer* map are used as evidence of consistent soil tests (Weaver et al., 2022). However, avenues for further studies should involve justification of soil tests using author keywords and logical text disambiguation (Tekli, 2016).

Figure 9. **Connection of the author keywords on the *VOSviewer* map**



CONCLUSIONS

Through this study for literature within 2020–2023, evidence of global research trends on soil testing and their implications for sustainable land management has been provided. The findings reveal that while Agricultural and Biological Sciences dominate subject areas (33.3%) and Articles dominate document types (81.3%), this concentration risks narrowing the interdisciplinary scope required for holistic soil variability monitoring. The under-representation of fields such as social sciences (2.0%) and economics (0.3%) highlights a critical gap since sustainable land management also relies on socio-economic feasibility and policy frameworks in addition to scientific advances.

The dominance of funding from Asia, North America, and Europe underscores significant regional

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investment in soil testing innovations. However, this also exposes disparities: African countries and other under-represented regions contribute less frequently, despite facing urgent soil degradation challenges. This imbalance suggests that without intentional global collaboration and equitable funding distribution, the promise of sustainable soil management may remain unevenly realised.

The analysis further demonstrates that while traditional soil testing methods remain central, modern techniques such as spectroscopy, remote sensing, and digital soil mapping are gaining momentum. These approaches directly support sustainable land management by reducing reliance on expensive, labour-intensive laboratory testing, and minimising land disturbance or pollution of land by chemical reagents, and improving precision in nutrient management. The implication is that global research is strongly oriented towards maintaining and restoring soil productivity, which is consistent with sustainability objectives, as improved nutrient management and soil fertility are essential for long-term agricultural resilience and food security. Nevertheless, the wider adoption of the approaches depends on accessibility of technology and institutional support, which are often insufficient in regions constrained by resources.

By linking keyword patterns with thematic emphases, this study shows that soil testing research consistently prioritises soil fertility, nutrient management, and restoration of degraded soils. These themes clearly align with the primary goal of sustainability. More still, for soil testing to fully serve as a tool for sustainable land management, future research must expand beyond laboratory-based and agronomic dimensions to include social, economic, and ecological perspectives.

Generally, this study highlights both achievements and gaps in global soil testing research. While progress has been made in advancing methodologies and broadening applications, sustainable land management demands stronger cross-regional collaboration, wider funding equity, and more integrative approaches. Recognising soil testing as a cornerstone of sustainable land management, the next strategic focus is to ensure that its benefits are accessible across regions and disciplines, enabling soil variability monitoring to serve as a true impetus for global sustainability.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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