



Review [Revisión]

PEDOLOGY, A DISAPPEARING SKILL IN EASTERN AFRICA? A REVIEW†

[LA PEDOLOGÍA, ¿UNA HABILIDAD QUE DESAPARECE EN ÁFRICA ORIENTAL? UNA REVISIÓN]

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SUMMARY

Background. Pedology is the study of soil genesis in its natural state. One way to assess the strength and productivity of a scientific field is to measure the number of publications over time. The number of soil papers published worldwide has almost doubled in the last ten years. However, that has not been the case in Eastern Africa, where this review is conducted. The scarcity of research in pedology motivates this study. **Objectives.** To review and analyze trends of publications in pedology/soil survey for the last ten years in (2010 - 2019) in Eastern Africa. **Methodology.** A search of scientific literature using *Google* and *Google Scholar* was conducted from 2010 - 2019. The search terms used were - soil survey, soil characterization, pedological characterization, and each of the Eastern African countries (Ethiopia, Kenya, Uganda, Tanzania, Rwanda, and Sudan). We then scrutinized the abstracts to find quantitative data on geographical locations. Additional articles were reviewed by checking through the reference lists of relevant studies in the peer-reviewed articles. **Results.** 56 scientific articles, 3 MSc/PhD theses reports, and 4 project reports/ proceedings were included for the full review. Out of this, 39 journal papers were identified and reviewed based on the years they were published, and the countries where they were published. Most articles were published in 2018. The data was then split into two segments, from the years 2010 - 2014 and 2015 - 2019. Between the years 2015 to 2019, a total of 36 articles were published compared to the years 2010 to 2014 where a total of 15 articles were published. This shows a slight increase in publications for the years under study. From the 56 articles, Ethiopia records the highest number of published articles from various journals having a total of 25 papers constituting 45% closely followed by Tanzania, having 27% equivalent to 15 papers. Kenya comes third in the overall ranking at 13% with 7 papers. The last three countries are Sudan, Rwanda, and Uganda with 10%, 3%, and 2% respectively. **Implications.** The results suggest that pedology seems to be a disappearing skill in the Eastern Africa region. Though there has been a spike in publications from 2015-2018, the current situation must be improved as there are limited publications from 2010 - 2019. **Conclusion.** The study shows that there have been a low number of publications in Eastern African countries. Ethiopia which has the highest number of publications shows the most promise in soil pedology publications. There is a need for an increase in pedology research which is important for agricultural production and land use planning.

Key words: pedology; publications; Eastern Africa.

RESUMEN

Antecedentes. La pedología es el estudio de la génesis del suelo y los levantamientos de suelos en su estado natural. Una forma de evaluar la fuerza y la productividad de un campo científico es medir el número de publicaciones a lo largo del tiempo. El número de estudios sobre suelos publicados en todo el mundo casi se ha duplicado en los últimos diez años. Sin embargo, ese no ha sido el caso en África oriental, donde se realiza esta revisión. La escasez de investigación en pedología motiva este estudio. **Objetivos.** Revisar y analizar las tendencias de las publicaciones en pedología/levantamiento de suelos durante los últimos diez años (2010 - 2019) en África Oriental. **Metodología.** Se realizó una búsqueda de literatura científica utilizando Google y Google Scholar entre 2010 y 2019. Los términos de búsqueda utilizados fueron: estudio de suelos, caracterización de suelos, caracterización pedológica y cada uno de

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los países de África oriental (Etiopía, Kenia, Uganda, Tanzania, Ruanda, y Sudán). Luego examinamos los resúmenes para encontrar datos cuantitativos sobre ubicaciones geográficas. Los artículos adicionales se revisaron revisando las listas de referencias de estudios relevantes en los artículos revisados por pares. **Resultados.** Se incluyeron 56 artículos científicos, 3 informes de tesis de maestría/doctorado y 4 informes/actas de proyectos para la revisión completa. De estos, se identificaron y revisaron 39 artículos de revistas en función de los años en que se publicaron y los países donde se publicaron. La mayoría de los artículos se publicaron en 2018. Luego, los datos se dividieron en dos segmentos, de los años 2010 - 2014 y 2015 - 2019. Entre los años 2015 y 2019, se publicaron un total de 36 artículos en comparación con los años 2010 a 2014, donde se publicaron un total de 15 artículos. Esto muestra un ligero aumento en las publicaciones para los años bajo estudio. De los 56 artículos, Etiopía registra el mayor número de artículos publicados de varias revistas con un total de 25 artículos que constituyen el 45 % seguido de cerca por Tanzania, con un 27 % equivalente a 15 artículos. Kenia ocupa el tercer lugar en la clasificación general con un 13 % con 7 artículos. Los últimos tres países son Sudán, Ruanda y Uganda con 10 %, 3 % y 2 % respectivamente. **Implicaciones.** Los resultados sugieren que la pedología parece ser una habilidad que está desapareciendo en la región de África Oriental. Aunque ha habido un aumento en las publicaciones entre 2015 y 2018, la situación debe ser mejorada como lo evidencia las publicaciones limitadas de 2010 a 2019. **Conclusión.** El estudio muestra que ha habido un número reducido de publicaciones en los países de África oriental. Etiopía, que tiene el mayor número de publicaciones, muestra las más promisorias en publicaciones de pedología del suelo. Es necesario aumentar la investigación en pedología, que es importante para la producción agrícola y la planificación del uso de la tierra.

Palabras clave: pedología; publicaciones; África oriental.

INTRODUCTION

Pedology is the study of soil genesis (formation) and soil survey (mapping) in their natural state (Wilding, 1994). Hence, soil classification and characterization are fundamental disciplines under the umbrella of pedology. Pedologists provide the link between soil sciences and other soil disciplines. This is an often understated role for pedologists and one that has been poorly explored in Eastern Africa. In developing countries, especially in Eastern Africa, where research funds are limited, the availability of pedogenic information and proper classification of soils will be of great importance in adopting well-tested management technologies (Fikre, 2003). Soil pedology is instrumental in mapping soil in the landscape so that its potential uses can be enhanced (Omuto, 2013). Knowledge of soil has a great impact on the quality of crops and the yield that a farmer will realize and the appropriate management for the soils (Msanya *et al.*, 2003; Matu, 2018).

Pedology integrates and quantifies the distribution, formation, morphology, and classification of soils as natural landscape bodies with soil survey considered as the mapping the distribution of the soils (Basher, 1997). Pedological characterization is defined as the gathering of soil information by systematic identification, grouping, and delineation of different soils occurring in the locality (Tan, 1995; Kebeney *et al.*, 2015). Karuma (2019) opines that pedological characterization provides vital information and knowledge on soil characteristics and gives a clear understanding of soil genesis, morphology, classification, and spatial distribution of soils in an area. Soil characterization data helps in the correct classification of the soil to serve as a basis for a more detailed evaluation of the soil as well as gather

preliminary information on nutrient, physical or other limitations needed to produce a capability class for crop production (Msanya *et al.*, 2003; Karuma *et al.*, 2015; Msanya *et al.*, 2016; Karuma, 2019). Pedological information is important to land users especially farmers who use the data to decide on what crops and management practices are best suited for the optimal and sustainable production of crops (Mbage *et al.*, 2017).

According to Hartemink and Mcbratney (2008) and Mao *et al.* (2015), one way to assess the strength and productivity of a scientific field is to measure the number of publications over time. About 42,000 soil papers are published annually, and the number of papers almost doubled in the past 10 years. Most of the publications have come from China, and about one-third of all soil papers are presently from China compared to 4 % in 1999. The increase in papers has been accompanied by higher impact factors of the core Soil Science journals. *Geoderma Regional* is a global soil science journal that has attracted papers from all over the globe, it has downloads and citations from all over the globe – and all of that is increasing (Hartemink, 2019).

In the 1990s and early 2000s, there was widespread pessimism on the status of soil science in most parts of the world. This was mainly due to dwindling research budgets, reduced number of students, and the overall perception that soil science and pedology were dead and buried (Muchena and Kiome, 1995; Hartemink, 2008). The role and status of soil science, more specifically, soil pedology, as a discipline is currently under substantial consideration. There are reasons for concern because the number of students entering research-based university programs in soil science has been declining in many areas. Subjects

that require knowledge of soils in various environmental sciences and tasks are being addressed by non-soil scientists. A sign of a negative spiral has surfaced in universities, a dwindling number of students with a decreasing number of soil science faculties (IUSS, 2006).

From the 1900s to the present, many journal papers, conference proceedings, students' theses, bibliographies with annotations in the field of soil science have been presented and or published covering a wide range of soil science topics. These publications, and by no means not exhaustive, were analyzed according to the several fields of soil science that include soil fertility, soil biology, soil physics, soil chemistry, soil conservation, irrigation and drainage, tillage, soil survey, and land evaluation and soil genesis and classification. For each of these categories, attempts were made to include other details such as location, the year when the study was undertaken, soil type and crop under investigation (Mumba and Gachene, 2019). Research in pedology remains scanty, which poses a threat in agricultural planning advisory for sustainable agricultural production. The scarcity of research in pedology motivates this review, in which we intend to explore the current state of pedology and soil survey, its future, trends of publication and location of the study for the past ten years (2010 – 2019) in selected Eastern African countries. According to Biggs *et al.* (2018), the soil science profession must work with the Government to ensure that such soil science data is captured into the future, as a public benefit from private industry. This issue is lacking in the Eastern African region as there is a lack of recognition and support on the importance of soil science at the policy level (IUSS, 2006). This review aims at analyzing the need for pedology and soil survey in Eastern African and its implications on agricultural productivity. Specifically, the study will be done to review and analyze trends of publications in pedology/soil surveys for the last ten years in (2010 - 2019) in Eastern Africa.

MATERIALS AND METHODS

Since this is a review paper, a search of scientific literature using Google and Google Scholar was conducted from 2010 - 2019. Soil survey reports provide useful information for land use planning, however, they are not available online hence excluded in this study. The search terms used were – soil survey, soil characterization, pedological characterization, and each of the Eastern African countries (Kenya, Uganda, Tanzania, Ethiopia, Rwanda, and Sudan). We then scrutinized the abstracts to find quantitative data on geographical locations. Additional articles were reviewed by

checking through the reference lists of relevant studies in the peer-reviewed articles (Horsley *et al.*, 2011). The papers were then scrutinized to find quantitative data on journal papers, their publishers, year of publication, and location/country. The papers chosen were those that indicated systematic identification, grouping, and delineation of different soils occurring in a locality, specifically, papers that show a clear understanding of soil genesis, morphology, classification, and spatial distribution of soils in an area. From all those procedures, 56 scientific articles, 3 MSc/PhD theses reports, and 4 project reports/ proceedings were included for the full review.

RESULTS AND DISCUSSION

Temporal Frequency Distribution of Published Pedological Papers: (2010-2019)

The review considered the frequency of publications for each country and the years of publication in soil pedology in Kenya, Tanzania, Uganda, Rwanda, Ethiopia, and Sudan. Within the time frame of the study (2010 - 2019), a dataset with a range of two years against each country's publications was done. For example, between 2010 and 2012, nine papers were published, Ethiopia recording three articles, the highest number of publications within that range. From 2013 - 2015, Sudan published three articles while Kenya published two articles, while Ethiopia and Rwanda had none. The highest number of publications from our study was done between 2016 and 2018, a total of 29 articles, Ethiopia recording the highest with 15 articles while Uganda within that range. In 2019, a total of 7 papers were published, Ethiopia recording the highest with three papers, Kenya and Tanzania recording two papers each, and Sudan, Uganda, and Rwanda not recording any publications (Figure 1). This trend could be attributed to diminishing donor support in the field of soil science compared to other fields of agronomy which has affected both research and capacity building and lack of recognition and support on the importance of soil science at the policy level (IUSS, 2006).

The data was then split into two segments, from the years 2010 - 2014 and 2015 - 2019. This was then used to compare the period when most articles were published to help determine if pedology is progressing or regressing without putting the countries into consideration. Between the years 2015 to 2019, a total of 36 articles were published compared to the years 2010 to 2014 where a total of 15 articles were published. Could this show that pedology is progressing? Several questions raise our curiosity and they include some of the following: What is the force behind the spike in publication over

the years? Are there incentives in the individual countries to publish? Is the publication student-led? By this, we attempt to believe all graduate students are required to publish in their universities. This is evident by the institutional affiliations of the authors and in their acknowledgment sections.

From the year 2015 to 2018 there has been an increase in the number of publications and a slight decrease in 2019. Except for one publication from 2015 to 2019, the authors of the other publications have institutional affiliations, the authors being graduate students, lecturers, department heads, and professors from universities around Eastern Africa. There were three student-led publications, specifically PhD and MSc. Theses that were included in this review. In Kenya, for example, it is a requirement by the Commission for University Education of Kenya (CUE) that all graduate students have to publish at least a paper or two in recognized journals before they graduate (Odhiambo, 2016). This also applies to Tanzania where most of the pedology papers came from (SUA, 2018).

Spatial distribution of pedological publications

From the study, a total of 56 published articles, 3 MSc/PhD theses, and 4 project reports/proceedings were sampled across six countries within the Eastern

Africa region. From the 56 articles, Ethiopia records the highest number of published articles from various journals having a total of 25 papers constituting 45 %. Tanzania follows with 27 % an equivalent to 15 papers. Kenya comes third in the ranking at 13% with 7 papers. The last three countries are Sudan, Rwanda, and Uganda with 10 %, 3 %, and 2 % respectively (Figures 2 and 3).

Ethiopia was the highest publisher of articles and this could be attributed to the presence of the Ethiopian Soil Information System (EthioSIS) - a project launched by the Ethiopian Government's Agricultural Transformation Agency (ATA) in 2012. It was designed to map soils and campaigns spearheaded by the Ethiopian Federal Ministry of Agriculture and Natural Resources in collaboration with the Ministry of Environment and Forestry and international non-governmental Organizations in June 2015. This initiative shows a strong priority on soils. This initiative has helped Ethiopians make informed land-use decisions and to better manage soil resources and hence the increase in the number of publications in Ethiopia since its launch in 2012. EthioSIS, Ethiopia's catalog of national soil data, uses satellite technology and extensive soil sampling to produce high-resolution soil maps for each region. It provides farmers with localized, actionable data for making climate-smart farming decisions that boost

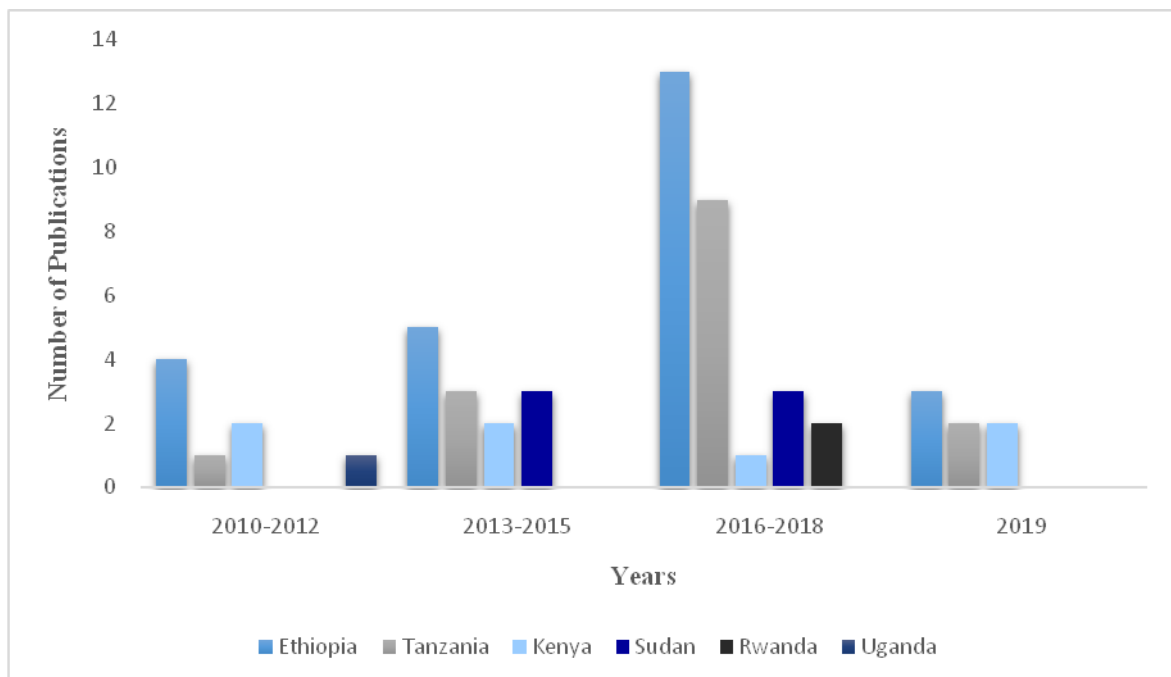


Figure 1. Temporal frequency distribution of pedological publications done from 2010-2019 in Eastern Africa.

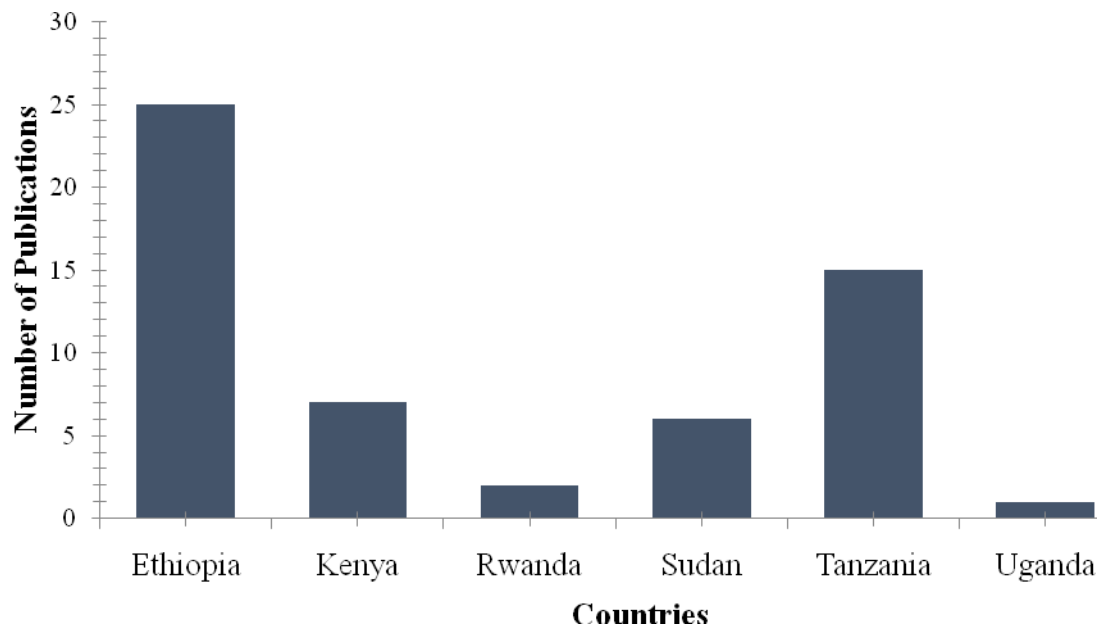


Figure 2. The number of pedological publications in the Eastern African Countries for the period 2010-2019.

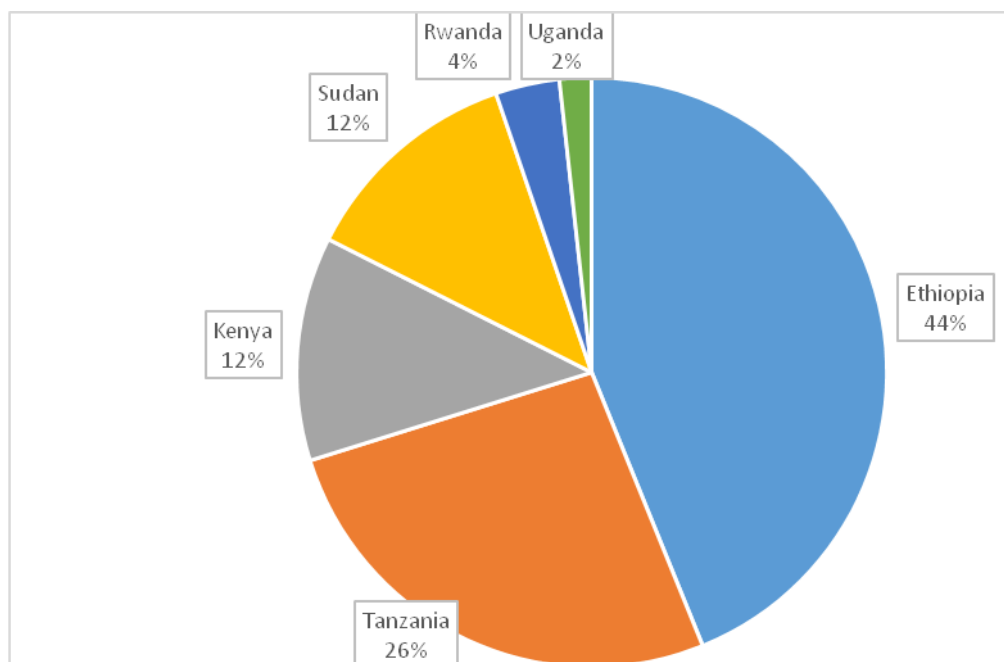


Figure 3. Distribution of published pedological journal papers across selected countries in Eastern Africa from 2010 – 2019.

productivity, improves resilience, and also leave a lower environmental footprint (World Bank, 2016).

Tanzania is the second-highest in the number of publications. Most of these publications are associated with the Sokoine University of Agriculture

in Tanzania. The authors are mostly members of the Department of Soil and Geological Sciences in the College of Agriculture. Funding of most publications in Tanzania is from the Regional University Forum for Capacity Building in Agriculture (RUFORUM), the innovative Agricultural Research Institute

(iAGRI) program, and the Alliance for Green Revolution in Africa (AGRA). The Tanzanian Soil Information Service (TanSIS) was established as a joint initiative with the Selian Agricultural Research Institute (SARI), funded jointly by Africa Soil Information Service (AFSIS) and SARI. It aims to develop soil and cropland conditions and monitor assessments for Tanzania. However, since it is an ongoing project, it is yet to be utilized by individual researchers and institutions in Tanzania.

Kenya is the third country after Tanzania to publish some articles since 2015. According to IUSS (2006), in the future of pedology, diminishing donor support in the field of soil science compared to other fields of agronomy has affected both research and capacity building. Lack of recognition and support on the importance of soil science at the policy level are some of the reasons why the future of soil science in Kenya is bleak unlike in the late 1970s and early 1980s when the soil was recognized, and funding was never a problem (Muchena and Kiome, 1995). In Kenya, we currently don't have a soil management policy to adequately address the challenges of soil management. The Commission for University Education of Kenya (CUE) also stipulates that all graduate students have to publish at least a paper or two before they graduate. According to Odhiambo, (2016), PhD students should be required to publish at least three papers because it takes an average of four years to complete a PhD program. However, most of the thesis cannot be published in most recognized international journals because of the low quality of research published by some students (Odhiambo, 2016). This can be evidenced by only three MSc and PhD theses among the 56 publications being reviewed that were available online under pedology.

Rwanda had the least papers published in the soil pedology discipline. According to Rushemuka *et al.* (2014), the soil map of Rwanda, known as CPR, (Carte Pédologique du Rwanda), offers potential as a tool for soil management. In practice, however, the CPR remains underutilized, mainly because of its inaccessibility to its potential users (e.g. policymakers, soil fertility experts, soil pedologists, agronomists, and extensionists). The inaccessibility is due to a lack of mastery of the soil taxonomy and the farmers' nomenclature so that they (soil scientists) can serve as interpreters between scientists from other disciplines and farmers. Moreover, policy-makers are largely unaware of the usefulness of soil maps in agricultural research and development planning. For this information to have an impact and be used effectively, awareness about the usefulness of this soil map should be recommended to the Rwandan soil scientists and hence inform policy. In a review by Rushemuka *et al.* (2014), it is also recommended that Rwandan soil scientists should be trained in the use of

Geographic Information System (GIS) software to enable them to exploit the digitized version/soft copy of the CPR and become familiar with the Rwandan biophysical environment. Further, Rushemuka *et al.* (2014) stated that almost all personnel involved in soil map's production and use were either killed or driven out, during the 1994 genocide and much information was lost and it took eight years (1994 - 2002) to rebuild the database and then publish the digitized version of the CPR. However, due to its inaccessibility to many potential users, the CPR, completed in 1990, has remained unused from 1994 to date.

Analysis of the choice of journals/publishers for the published papers

The review captured 39 journals where 56 articles on soil pedology were published. The frequency and spatial distribution of the publication of the research work, show that the evolution of soil pedology has stalled and over the past couple of years, a decline in the publication rate is recorded. As shown in figures 1 and 2 above, between the years 2010 - 2012, there had been a total of eight papers published and the number seemed to increase through to 2018. However, the year 2019, showed a significant decline in the number of papers published, with only 7 papers. Among the journals that recorded the highest number of publications include; *the International Journal of Plant and Soil Science*, *Journal of Soil Science and Environmental Management*, *East African Journal of Sciences*, and *the International Journal of Current Research in Biosciences and Plant Sciences*. On the other hand, most of the journals have at least one paper published over the time bracket specified (2010 - 2019). Three other journals namely; *the American Journal of Agriculture and Forestry*, *International Journal of Scientific and Research Publications*, and *the Eurasian Journal of Soil Science*, had published three articles each, *Geoderma Regional* and *Catena* journals having published two articles with the rest having one paper each in the last 10 years.

A look into the factors that stimulate the frequency in publications is elucidated. Some of the factors include the article processing charge, which ranged from USD 70 to over USD 3000. The article processing charge (APCs) are the fees that some scholarly publishers charge authors of academic papers to publish their papers in Open Access journals. APCs are levied in 2 ways: (i) *Open Access Journal*, where the authors are charged to publish (ii) *Subscription-based Journal*, where the authors are charged to make their publication Open Access in an otherwise subscription-based collection. The APCs vary from

publisher to publisher and are primarily charged for published articles (Guy and Holl, 2015). For example, to publish in the *International Journal of Plant and Soil Science* (the journal with the highest number of publications) charges on average are 70 USD, this is slightly lower as compared to other journals like *Geoderma* and *Catena* (3550 USD and 3050 USD respectively excluding taxes). This could explain why the former journal has recorded more publications in Eastern Africa than the latter. The *Catena* and *Geoderma* journals are published by Elsevier which is a wide leading publisher of scientific books and journals.

About publishers, *ScienceDomain International* is the publisher of the *International Journal of Plant and Soil Science journal*, which has the highest number of publications in Eastern Africa in the last 10 years. This can be attributed to its lack of submission fees therefore if any manuscript is rejected during the peer review process, the authors don't have to pay any charge. This publisher also has memberships, annual individual membership of 30 USD during which there is no limit on the number of papers published by a member within the membership period. Also, there is an individual lifetime membership of 120 USD valid for five years. In both memberships, members enjoy 20 % discounts on the publication fees which is an average of 70 USD, as mentioned earlier.

The East African Journal of Sciences had a total of four published papers in the last 10 years and is published by Haramaya University in Ethiopia. The high number of publications can be attributed to a lack of publication fees. The only charges are the print subscription fees, 3 USD, and 1.4 USD for local institutions and individuals respectively while 50 USD for foreign institutions and 25 USD for foreign individuals. The lack of publication fees and low subscription fees for local publications in this journal has promoted its high publications in Ethiopia.

Academic Journal is a publisher with three journals out of the 39 in Eastern Africa in the last 10 years. These are the *Journal of Soil Science and Environmental Management*, which had among the highest number of publications, the *Journal of Ecology and the Natural Environment*, and the *African Journal of Environmental Sciences and Technology*. These journals have a manuscript handling fee of 550 USD. However, this publisher has a waiver policy that grants waivers to some corresponding authors that have limited funding. Authors from low-income countries may be granted up to a 75 % waiver while those from low middle-countries may be granted up to a 40 % waiver. This makes journals from the Academic Journals favorable to authors from Eastern Africa who fall in the low and middle-income categories. The International Journal

of Current Research in Bioscience and Plant Biology (IJCRBP) which had three publications is published by Excellent Publications. This journal has a wide scope including agricultural sciences, animal husbandry, biosciences, ecology, and environmental sciences, health science, and plant biology. The publication fee paid by authors is 100 USD.

With the countries, Ethiopia had 25 journal publications which highest. The *East African Journal of Sciences* had four publications which were the highest in the country, followed by the *Eurasian Journal of Soil Sciences* and the *Journal of Science and Environmental Management* which had two articles each. The other journals in Ethiopia had one publication each. In Tanzania, the *International Journal of Plant and Soil Science* had three publications; *the American Journal of Agriculture* had two publications while the rest of the journals had one publication each. In Kenya, the *International Journal of Plant and Soil Science* had three publications, *the Journal of Soil Science and Management* had two while the rest had one each. In Sudan, Rwanda, and Uganda, the journals had one publication each. Journals with high publications in Ethiopia, Tanzania, and Kenya had low to no publication fees and waivers for authors from low-income countries with limited funding.

Indexation of the Journals/Publishers of the published papers/Predatory Journals

Indexation is seen as a reflection of its quality and is considered to be of higher scientific quality as compared to non-indexed journals. Journal indexes (also called bibliographic indexes or bibliographic databases) are a list of journals, organized by discipline, subject, or type of publication (Balhara, 2012; Chawla, 2021). Major indexation services include Medline, PubMed, EMBASE, SCOPUS, EBSCO Publishing Electronic Databases, Web of Science and, Journal citation reports (Clarivate). Other indexation services/databases have come up e.g. the DOAJ, Google Scholar, Worldcat, Crossref, Journal seek, ProQuest, Index Copernicus, where most of our study papers were found. This latter indexation on the databases is debatable and remains a challenge (Balhara, 2012). Finding the best and most valid indexation services remains a challenge as some predatory articles are being indexed in scientific databases/libraries with potentially serious consequences (Chawla, 2021). Most of the papers in this study fall under the predatory journals/publishers list (predatoryjournals.com), and also available in several scientific databases/libraries. The use of Impact Factor (IF) has also being used as a proxy for the relative importance of a journal within its field. However, it has been criticized as it is not available

for all indexed journals. Both the indexation services and the predatory journals/publishers list remain controversial and are criticized for the manipulation and incorrect application (Balhara, 2012; Chawla, 2018, 2021).

Recommendations and final remarks

Based on the analysis of the current state of pedology, soil survey and its future and the trends of publication for the past ten years (2010 – 2019) in selected Eastern African countries, the following recommendations were made:

Support from the local and national government is required; there is a need for recognition and support on the importance of soil science at the policy level, to ensure the growth of soil science, specifically pedology research. This can be done by the formulation and implementation of effective soil management policies.

There is a need for increased donor support for increasing soil pedology research and capacity building. This can be done through adaptation and acquisition of new technology in soil science, for example, uptake of digital soil mapping and making the data available to the users (farmers, pedologists, and policymakers). The results should be disseminated in reputable refereed journals/platforms to increase the scientific literature in pedology.

Though there has been a spike in publications from 2015-2018, it leaves a lot to be desired due to the limited publications in the time frame under review. Ethiopia has shown the most promise in soil pedology advancement. This is attributed to the Ethiopian Soil Information System (EthioSIS), an initiative that shows a strong priority on soils. The EthioSIS aims to digitally map the soil nutrient status of all agricultural land in Ethiopia and establishment of soil-test-based information to facilitate accurate decision-making on fertilizer use and to provide evidence to address problematic soils (ATA, 2019). This initiative has helped Ethiopians to make informed land-use decisions and to better manage soil resources and hence an increase in the number of publications in Ethiopia since its launch in 2012.

In Kenya, there has been diminishing donor support in the field of soil science compared to other fields of agronomy and this has affected both research and capacity building and also a lack of recognition and support on the importance of soil science at the policy level. Soil survey reports done by the Kenya Soil Survey are not available online for use by other researchers. Few soil management reports are available online and they appear on the donors' web

pages (e.g. FAO – Food and Agriculture Organization of the United Nations). The reduced funding in pedology is one of the factors that have led to low publications in the country. Also, since it is a requirement by the Commission for University Education of Kenya (CUE) that all graduate students have to publish at least a paper or two before they graduate, unfortunately, most of the thesis cannot be published in most recognized international journals due to their low quality. This can be evidenced by the low number of MSc and PhD thesis reviewed in this study.

Rwanda, which has the least number of publications, can be attributed to the underutilization of the soil map of Rwanda (CPR) since the 1994 genocide. Since the rebuild of the database and publication of the digitized version of the CPR, it has remained unused to date due to its inaccessibility to many potential users. Training of Rwandan soil scientists in the use of Geographic Information System (GIS) software could enable them to exploit the digitized version/soft copy of the CPR and hence improve soil mapping in the country which is important in pedology as pedologists require soil map information in their research and eventually publications.

In the countries with the most publications- Ethiopia, Kenya, and Tanzania, several factors determined the number of publications that were made. The cost was one of the factors that the authors considered. Journals like *Catena* and *Geoderma* did not publish many papers due to their high publication costs, making them unaffordable for most authors. *The International Journal of Plant and Soil Science* and the *Journal of Soil Science and Environmental Management* had the highest number of publications. For the latter, the high publications can be attributed to the lack of submission fees therefore if any manuscript is rejected during the peer review process, the authors don't have to pay any charge and the authors also enjoy discounts off their publication fees. For the former, there is a waiver policy that grants waivers to some corresponding authors that have limited funding. Authors from low-income countries may be granted up to a 75 % waiver while those from low middle-countries may be granted up to a 40 % waiver. Therefore, these factors make these journals more prevalent in Eastern Africa.

CONCLUSION

The study shows that there have been a low number of publications in Eastern African countries. Ethiopia which has the highest number of publications shows the most promise in soil pedology publications. There is a need for an increase in pedology research which is important for agricultural production and land use planning.

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Conflict of interests. The authors hereby declare that they have no conflict of interest.

Compliance with ethical standards. The study did not involve human subjects and therefore no consent was required and/or authorization by an ethical or bioethical committee or equivalent declaration.

Data Availability. The data is available with the first author – Anne Karuma akaruma@uonbi.ac.ke upon reasonable request.

REFERENCES

- Basher, L. 1997. Is pedology dead and buried? *Australian Journal of Soil Research* 35(5):979 - 994. DOI: <https://www.publish.csiro.au/sr/S96110>
- Biggs, R., G. D. Peterson, and J. C. Rocha. 2018. The Regime Shifts Database: a framework for analyzing regime shifts in social-ecological systems. *Ecology and Society*, 23(3):9. DOI: <https://doi.org/10.5751/ES-10264-230309>
- Chawla, D. S. 2018. The undercover academic keeping tabs on ‘predatory’ publishing. *Nature*, 555: 422 - 423
- Chawla, D. S. 2021. Hundreds of ‘predatory’ journals indexed on leading scholarly databases. *Nature*, <https://doi.org/10.1038/d41586-021-00239-0>
- Ethiopian Agricultural Transformation Agency, ATA, 2019: *EthioSis: Historical shift to digital soil mapping for targeted fertilizer use*. The Federal Government of Ethiopia.
- Fikre, M. 2003. Pedogenesis of major volcanic soils of the south-central rift valley region, Ethiopia. MSc Thesis. The University of Saskatchewan. Saskatoon, Canada. pp. 128.
- Guy M. and Holl A. 2015. Briefing paper: Article processing charges. *PASTEUR4OA Briefing Paper* http://pasteur4oa.eu/sites/pasteur4oa/files/resource/PASTEUR4OA_Briefing%20Paper_APCs_FINAL.pdf
- Hartemink, A. E. 2019. Open access publishing and soil science – Trends and developments. *Geoderma International*. DOI: <https://doi.org/10.1016/j.geodrs.2019.e00231>
- Hartemink, A. E., and Mcbratney, A. B. 2008. A soil science renaissance. *Geoderma*, 148(2): 123 - 129
- Horsley T., Dingwall O. and Sampson M. 2011. Checking reference lists to find additional studies for systematic reviews (Review). Cochrane Database of systematic reviews. <https://www.cochranelibrary.com/cdsr/doi/10.1002/14651858.MR000026.pub2/epdf/full>
- International Union of Soil Sciences (IUSS). 2006. *The Future of Soil Science*. CIP - Gegevens Koninklijke Bibliotheek, Den Haag. Wageningen. https://www.researchgate.net/publication/287490005_The_Future_of_Soil_Science
- Karuma, A. 2019. Soil Morphology, Physico-chemical Properties, Classification, and Potential of Selected Soils in Kenya. *International Journal of Plant & Soil Science* 30(6): 1 - 12. DOI: <http://www.journalijpss.com/index.php/IJPS/article/view/30193>
- Karuma, A., Amuri, N., Msanya, B., Gicheru, P., Mtakwa, P., and Gachene, C. 2015. Soil Morphology, Physico-Chemical Properties, and Classification of Typical Soils of Mwala District, Kenya. *International Journal of Plant & Soil Science*, 4(2), 156 - 170. DOI: <https://doi.org/10.9734/ijpss/2015/13467>
- Kebeeny, S. J., Msanya, B. M., Ng’etich, W. K., Semoka, J. M. R. and Serrem, C. K. 2015. Pedological Characterization of Some Typical Soils of Busia County, Western Kenya: Soil Morphology, Physico-chemical Properties, Classification and Fertility Trends. *International Journal of Plant & Soil Science*, 4(1): 29 - 44.
- Mao, G., Liu X., Du, H., Zuo, J. and Wang, L. 2015. Way forward for alternative energy research: A bibliometric analysis during 1994 - 2013. *Renewable and Sustainable Energy Reviews*, 48 (C): 276 - 286
- Matu, N. 2018. Daily Nation: Kenya Soil science. Retrieved from. (Access date: 11.02.2020). Retrieved from <https://www.nation.co.ke/lifestyle/mynetwork/Soil-science-broken-down-by-Nick-Mati/3141096-4801460-10o9fhoz/index.html>
- Mbaga, H.R., Msanya, B. M. and Mrema, J. P. 2017. Pedological characterization of typical soil of Dakawa irrigation scheme, Mvomero District, Morogoro Region, Tanzania. *International Journal of Current Research in Biosciences and Plant Biology*, 4(1):77 - 86.
- Msanya, B. M., Kaaya, A. K., Araki, S., Otsuka, H. and Nyadzi, G. I. 2003. Pedological characteristics, general fertility, and classification of some benchmark soils of Morogoro District, Tanzania. *African*

- Journal of Science and Technology, Science and Engineering Series*, 4 (2): 101 - 112.
- Msanya, B. M., Munishi, J. A., Amuri, N., Semu, E., Mhoro, L. and Malley, Z. 2016. Morphology, Genesis, Physicochemical Properties, Classification and Potential of Soils, Derived from Volcanic Parent Materials in Selected Districts of Mbeya Region, Tanzania, *International Journal of Plant & Soil Science*, 10(4):1-19.
- Muchena, F. N., and Kiome, R. M. 1995. The role of soil science in agricultural development in East Africa. *Geoderma*, 67: 141 - 157
- Mumba, E. and Gachene, C. K. K. 2019. Trends in soil science research in Kenya for the last 90 years – the missing gaps. In: *Proceedings of the 29th SSSEA Conference of the Soil Science Society of East Africa* held at the Lake Naivasha Lodge, Naivasha, Kenya. 18th - 22nd November.
- Odhiambo, T. 2016. Daily Nation. 'Why graduate students must publish their work in journals.' <https://www.nation.co.ke/lifestyle/Why-graduate-students-must-publish-their-work-in-journals/1950774-3202032-item-1-to561a/index.html>
- Omuto, C. T. 2013. Major soil and data types in Kenya. In: *Developments in Earth Surface Processes*, 16: 123 - 132.
- <https://doi.org/10.1016/B978-0-444-59559-1.00011-6>
- Rushemuka, P. N., Bock, L. and Mowo, J. G. 2014. Soil science and agricultural development in Rwanda: state of the art. A review. *Biotechnology, Agronomy, Society and Environment*, 18 (1):142 - 154 <https://popups.uliege.be/1780-4507/index.php?id=16828&file=1&pid=10902>
- Sokoine University of Agriculture, SUA. 2018. *Regulations and Guidelines for Higher Degrees*. 6th Edition. 92pp
- Tan, K. H. 1995. *Soil Sampling Preparation and Analysis*. Marcel Dekker, Inc. New York. Basel Hong Kong. 373pp.
- Wilding, L. P. 1994. Factors of soil formation: contributions to pedology. *Factors of soil formation: a fiftieth-anniversary retrospective*, (factors of soil formation), 15 - 30.
- World Bank, 2016. Scaling Climate-Smart Agriculture in Ethiopia from the ground up. <https://www.worldbank.org/en/news/feature/2016/11/08/scaling-climate-smart-agriculture-in-ethiopia-from-the-ground-up#:~:text=EthioSIS%20aims%20to%20change%20that,leave%20a%20lower%20environmental%20footprint.>