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Authorship patterns in Africa's groundwater literature: Indications for helicopter research?

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ABSTRACT

Groundwater plays an essential role in Africa and corresponding research is vital to resource management and long-term planning. However, the level of research output and the mode of international research collaboration on the continent have been questioned. In particular, cases of "helicopter research" have been reported. The term implies that scientists from wealthy nations do research in lower-income countries without involving local collaborators.

To investigate the phenomenon in a groundwater context, we performed a bibliometric study by extracting and analyzing (meta)data from Clarivate's Web of Science database for the time period 1991–2020. Here, we particularly focused on authors and their affiliations.

The analysis showed that there is a pronounced intra-continental imbalance and that much of the groundwater research output in Africa is produced by Egypt, Nigeria, South Africa, Tunisia, and Morocco – larger countries with a *relatively* high Gross Domestic Product. These nations apparently "own" their research, i.e., papers about groundwater in these countries include local (co-)authors (affiliation in the concerned country), or at least authors with an African affiliation. However, this does not apply to a number of other African countries, implying that local scientists do not spearhead corresponding studies which points towards helicopter research.

To foster effective groundwater research and counteract the above-mentioned development, various players have to contribute, including local governments, funding organizations, individual researchers, but also journals.

1. Introduction

Groundwater is Africa's most precious natural resource (Adelana and MacDonald, 2008). The latter authors state three main reasons for this: 1) the natural storage is large, 2) the water quality is often good, and 3) groundwater infrastructure (e.g., hand dug wells) is affordable, also to poor communities. The volume of groundwater on the African continent is estimated to be about 0.66 million km^3 – >100 times the annual renewable freshwater resources and 20 times the freshwater stored in African lakes (MacDonald et al., 2012). Because of the vulnerability of surface water, also with respect to climate change, groundwater is mostly seen as a solution to meet rising water demands.

However, despite efforts in publication of syntheses and reviews at the national, regional, and continental levels, groundwater data are still relatively sparse and the resulting limited understanding of aquifer systems represents a serious obstacle for the sustainable management of the groundwater (Gaye and Tindimugaya, 2019). Many countries need to undertake strategic assessments of their groundwater resources and prioritize corresponding investments and institutional strengthening. Hence, research cooperation between developing and developed countries is encouraged by many funding agencies. Such international collaborations can be very beneficial in terms of information sharing and capacity building, but recently questions have been raised about ethical conduct and inclusion and integration of host nation authors. The practice of scientists from wealthy nations visiting lower-income countries, collecting samples, publishing the results with little or no involvement from local scientists, and providing no benefit for the local community is referred to as helicopter, parachute, or neocolonial research (Minasny et al., 2020). This issue cuts across various disciplines (Dahdouh-Guebas et al., 2003; Rochmyaningsih, 2018) and has, for instance, been documented in biology (Stefanoudis et al., 2021) and medicine (Costello and Zumla, 2000), but also in geoscience (Minasny et al., 2020; Nature Geoscience, 2022; North et al., 2020).

Considering this background, the present study targets publications on groundwater research carried out in Africa. In particular, it addresses the question whether this science is done in collaboration with local (or

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at least African) research institutes. We also strive to discover any distinct spatial patterns on the continent as well as factors that influence these trends.

2. Data and methods

This study uses a bibliometric approach and the methodology is inspired by the investigation of North et al. (2020). Yet, while their study focuses on the (under-)representation of African authors in high-impact geoscience literature, the present research addresses groundwater-related articles, irrespective of the journals' presumed reputation.

2.1. Search strategy

The presented bibliometric analysis relies on the Web of Science (WoS) database (Clarivate; https://www.webofscience.com). Reasons include the user-friendly interface of the database, the availability of an "Advanced search" option, and the fact that it is rather comprehensive. Importantly, the portal also allows extraction of a range of relevant metadata. WoS is hence a popular tool for systematic reviews and bibliometric analyses (Fernández-Raga et al., 2017; Ke and Zhang, 2024; North et al., 2020; Schulz et al., 2024).

For the survey, the "Advanced search" tool of WoS was utilized. Here, the fields *Topic* (denoted *TS* in WoS) and *Address* (*AD*) were most relevant. Boolean operators such as "OR", "AND", and "NOT" were included when required.

The *TS* field includes article title, abstract, and keywords (author-defined keywords and WoS *Keywords Plus*). Here, we searched for "groundwater" and for a given target country (sequentially all African countries), assuming that the research is groundwater-related and carried out in the mentioned country (see also North et al., 2020; note: not necessarily by the country). The corresponding search string was *TS = (groundwater AND [target country])*.

To gain insight into the involved institutions and the corresponding countries, we targeted author affiliations in the *AD* field. The following aspects were studied:

1. Number of articles for a given target country

   TS = (groundwater AND [target country]).

2. Number of articles for a given target country, with at least one local (co-)author (affiliation with address in that country)

   TS = (groundwater AND [target country]) AND AD = ([target country]).

3. Number of articles for a given target country, with at least one African (co-)author (affiliation with address in Africa)

   TS = (groundwater AND "[target country]) AND AD=([list of African countries])".

4. Number of articles for a given target country, with local corresponding author (affiliation with address in that country)

The address of the corresponding author (*Reprint Address*) is not directly available as a WoS search field, but is part of the metadata that can be exported (e.g., to Microsoft Excel). Hence, the exported metadata from search 1 were screened and articles were counted when the target country appeared in the *Reprint Address* column.

It is emphasized that the outlined method (searches 2–4) is not capable of identifying the (co-)authors' actual nationality, but rather targets the country in which their institution is located. The approach does also no reveal to what extent a certain (co-)author was actually involved in the research (see Minasny et al., 2020).

All search results were restricted to *articles* that were published in English during the period 1991–2020, covering a 30-year time span. The search was completed on 9 December 2021. For comparison, corresponding searches were also conducted for selected non-African countries. Four countries were chosen: USA, Germany, Netherlands, and Greece. We performed a WoS search using the same concept as for the African target countries, but adapted the method to the respective continents. For instance, USA was studied in an American context, and Germany, Netherlands, and Greece in a European framework.

2.2. Pitfalls and post-processing

The obtained data were screened for errors and false positives. It was found that some terminology for certain countries overlaps with geographic or geological terms. For example, a search for "Niger" may return results not only for the country Niger, but also for "Niger Delta", "Niger River", or "*Niger aspergillus*" (see North et al., 2020). Separating Democratic Republic of the Congo and Congo was also required. In addition, potential overlapping with "Congo craton" and "Congo red" was considered. The difference between Chad and Chad Basin (latter extends to parts of Niger, Nigeria, etc.) was taken into account too. Here, the Boolean operators AND, OR, and NOT were used.

We also considered variations in country names (e.g., Ivory Coast, Côte d'Ivoire, etc.) and changes. Examples for the latter include Somalia/Somaliland, Swaziland/Eswatini, etc. To achieve desired results, the names (past and present) were included in the *target country* search string.

2.3. Data analysis

The obtained data were entered in a spreadsheet for further analysis. Numbers of articles with a local (co-)author, African (co-)author, etc. were converted into percentages for each country, considering the total number of groundwater-related articles for that country. Moreover, a Helicopter Research Index (HRI) was calculated, inspired by the Neo-Colonial Relations Index of Nagtegaal and Bruin (1994). The HRI is the ratio between the number of articles *without* a local (co-)author and the (total) number of articles for a given country (on a given topic). High values are no definite proof of helicopter research, but are likely to point towards its potential occurrence. The HRI can hence be seen as a proxy for the phenomenon.

Finally, to gain a better understanding of the obtained results and to put them in perspective, complementary data such as country size, population, annual precipitation amounts, and Gross Domestic Product (GDP) were taken into account (FAO, 2019).

3. Results

Results of the bibliometric analysis are shown in Fig. 1 (for details, see Supplementary Data). The African publishing landscape (for groundwater-related articles) is dominated by a few African countries (Fig. 1a). In terms of article output, the following countries form the Top Five: Egypt (685 articles), Nigeria (655), South Africa (651), Tunisia (533), and Morocco (437). These countries are hereafter referred to as Research-Intensive (RI). At the lower end of the spectrum, 18 countries have an article output of <10 papers each (see Supplementary Data).

Most articles include a local (co-)author, but corresponding percentages show appreciable scatter (Fig. 1b). Cape Verde shows the highest value (92%; 11 out of 12 articles), but also the RI countries exhibit a high fraction of articles with a local (co-)author. The same applies to Algeria and the Ivory Coast. The average fraction accounts for 43%. Throughout the continent, 24 out of the studied 55 African countries show a fraction of at least 50%. There are also nine countries with a value of 0%, but it was also observed that these nine countries show low article numbers in general (<10 each).

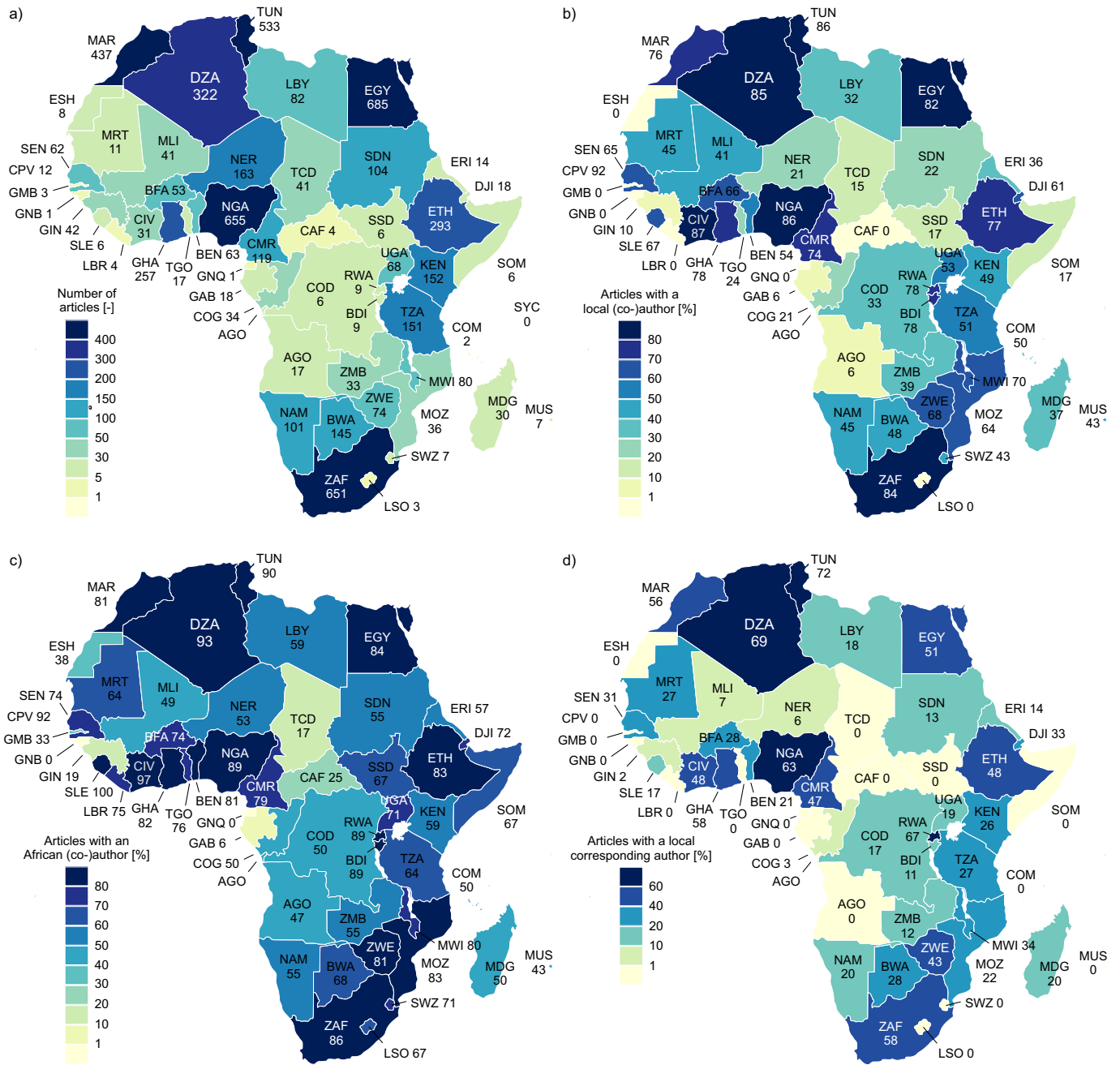

Fig. 1. Map showing the results of the bibliometric survey. a) Number of groundwater-related articles (1991–2020), found in WoS using the outlined method, b) Percentage of articles with a local (co-)author, c) Percentage of articles with an African (co-)author, d) Percentage of articles with a local corresponding author. Note: Percentage values often result from division of fairly small numbers. Abbreviations represent United Nations country codes (https://unstats.un.org/unsd/methodology/m49/).

The degree to which African (co-)authors are involved in groundwater research in Africa is also relevant. The data show strong intra-continental involvement (Fig. 1c). In fact, most of the articles published in the studied time period feature an African (co-)author (average fraction 61%), and the highest percentages were found for Sierra Leone (100%; 6 out of 6), Ivory Coast (97%), Algeria (93%), Cape Verde (92%; 11 out of 12), and Tunisia (90%), but also other RI countries score well (e.g., Nigeria, South Africa, Egypt). It was observed that 42 of the 55 studied countries have values of at least 50%, i.e., at least half of their groundwater-related articles include an African (co-)author, and there were only three countries with no African collaboration.

We also investigated to which extent African countries spearhead groundwater research conducted on their territory. To this end, we used corresponding author information (affiliation country) as a proxy (Fig. 1d). Here, calculated percentages are relatively low – the average value accounts for 21%. The five RI countries are in the Top Ten of the local corresponding author category, with Tunisia having the highest fraction of 72%. Some African countries with relatively small total article numbers also made it into the Top Ten. For example, Rwanda's fraction is 67% (6 out of 9 articles) and the value for the Ivory Coast is 48% (15 out of 31 articles). In general, there are only eight African countries with a value of at least 50%, i.e., the bulk of the African countries appear in the groundwater literature without a local corresponding author.

The above-mentioned scatter in the total number of articles (Fig. 1a) also becomes apparent in Fig. 2. It is noteworthy that the African

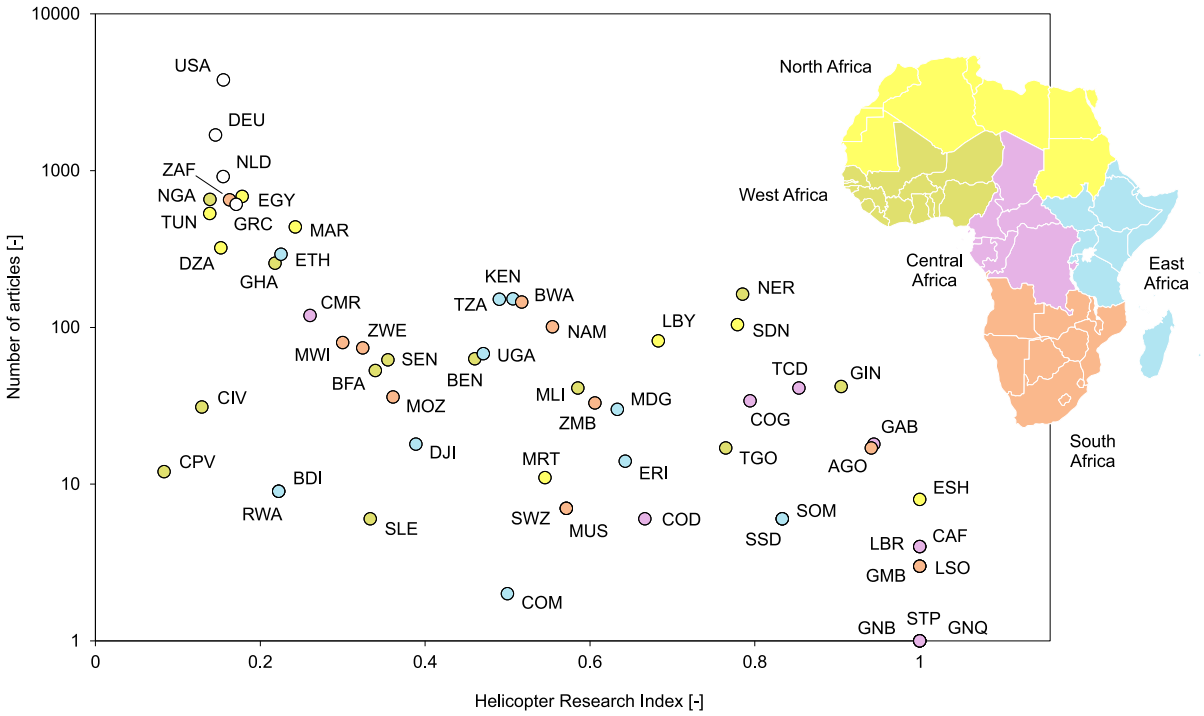

Fig. 2. Scatter plot showing the total number of groundwater-related articles (note the log axis) and the calculated Helicopter Research Index (HRI) for each country. The latter are color-coded based on the region they are associated with. For comparison, data for USA, Germany, Netherlands, and Greece are included (white symbols).

countries with the largest output (Egypt, Nigeria, South Africa, Tunisia, Morocco) cluster in the top left corner of the plot, i.e., they have a low HRI (<0.3).

However, countries with article numbers of a few hundred or less show more variable HRIs. Several countries exhibit an HRI of 1 (e.g., Liberia, Central African Republic, Gambia, Lesotho), but show few publications in general.

Because the countries are color-coded based on their associated region, the plot also offers the possibility to look for systematic differences between regions and hence spatial trends, but interestingly, no such pattern is apparent. Instead, there are countries with high and low article numbers as well as HRIs within each region. In fact, several individual countries dominate the groundwater-related publication landscape of their respective region, e.g., Nigeria (West Africa), Ethiopia (East Africa), or (the Republic of) South Africa (South Africa).

In terms of (missing) clustering, the group of comparison countries represents an exception (white symbols in Fig. 2). Maybe not surprisingly, most of these countries score high in groundwater research. Absolute article numbers account for 3789 (USA), 1687 (Germany), 916 (Netherlands), and 609 (Greece). Here, local (co-)authors are often very common, resulting in generally low HRI values (<0.2). Within their respective continents, the comparison countries show at least 87% continent-based authorship (see Supplementary Data). Percentages of articles with a local corresponding author are somewhat lower, but exceed 70%.

4. Discussion

Summing up the article numbers found for each African country yields a total of 5728 for the time period 1991–2020. The actual total output may be somewhat smaller, because articles could mention several African countries in their title or abstract, implying that a concerned paper is counted more than once. Nevertheless, it is tempting to compare this value with those for individual non-African countries such as the USA (3789) or Germany (1687). In this context, it is noteworthy that Africa is about three times bigger than the USA, but produced only roughly 50% more groundwater-related articles.

Our analysis demonstrated that the distribution of groundwater research output on the African continent is skewed towards a few countries such as Egypt, Nigeria, South Africa, Tunisia, or Morocco. This pattern is not only observed in the field of hydrogeology, but also in the geosciences at large. In their analysis of high-impact journal papers, North et al. (2020) also report a remarkable intra-African imbalance with a few dominating countries (South Africa, Egypt, Morocco, etc.) that largely match our list of the most-productive nations. These results are also in line with the findings of Sooryamoorthy (2018) who studied African output of scientific articles in general. The identified pattern raises questions concerning factors that influence the countries' academic productivity in the field of hydrogeology.

4.1. Factors influencing article output

Groundwater research in Africa is controlled by various aspects. These factors can individually or collectively affect a country's attention to research.

Geographic context is vital in this regard. It is, for instance, noteworthy that the most productive countries are fairly large (Fig. 3a). Yet, size is not the only important factor, which is illustrated by the fact that some equally large countries (partly bigger than Tunisia) are less productive than the Top Five.

Further, population is likely to play a role (Fig. 3b). A greater population not only implies more researchers, but also means that there are more water consumers and hence a greater need for (ground)water-related investigations. It hence comes as no surprise that the Top Five countries scatter in the upper right corner of Fig. 3b, and that countries with less inhabitants usually exhibit fewer publications.

In addition, available water resources probably have a certain influence (Fig. 3c). If a country receives abundant precipitation, it is more likely to have surface water resources, which are more accessible and easier to tap than groundwater. In such a setting, groundwater research,

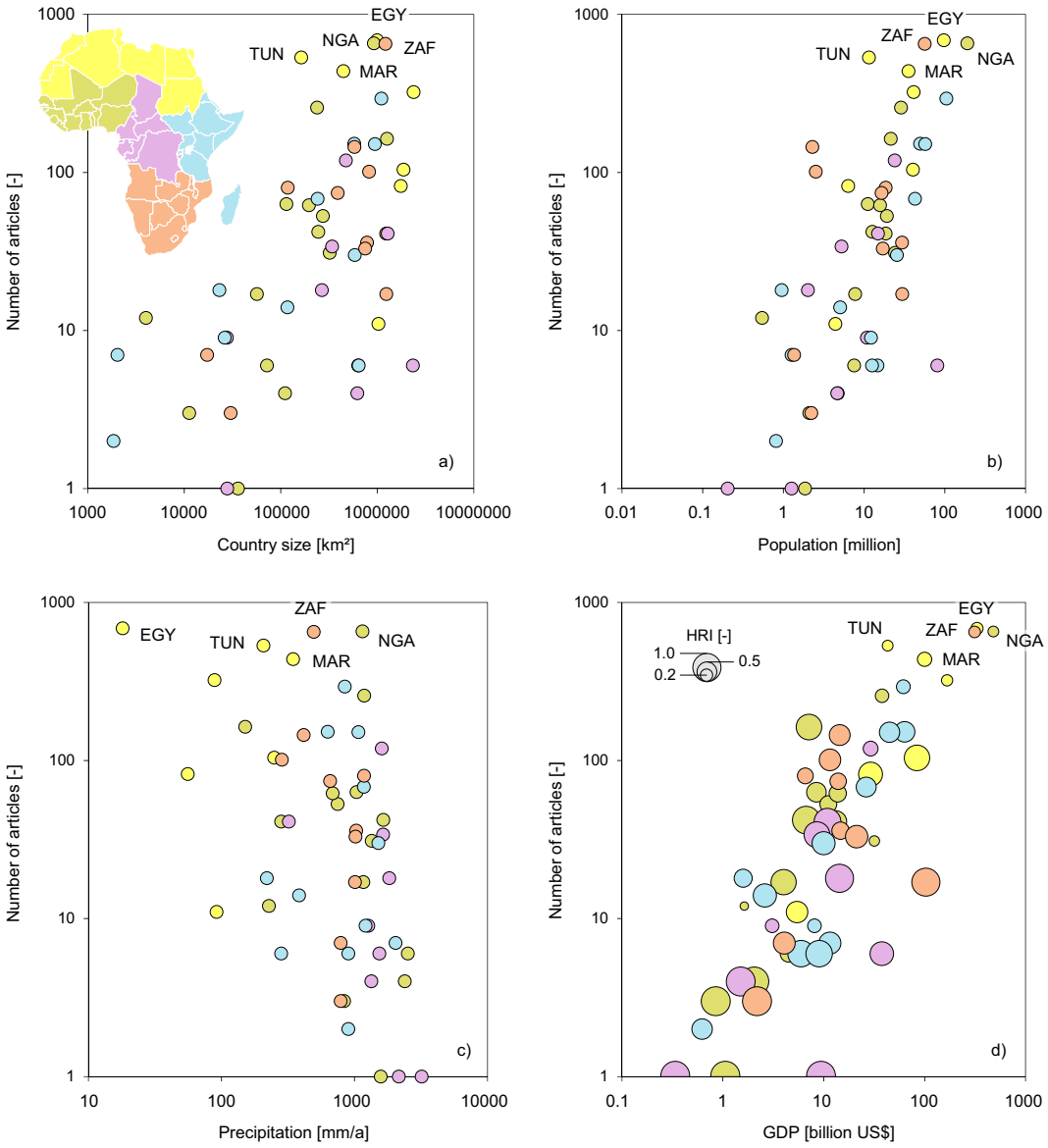

Fig. 3. Scatter plots showing article numbers in relation to a) country size, b) population, c) mean annual precipitation, and d) Gross Domestic Product (GDP). The latter plot also incorporates HRI values. Labels are limited to the Top Five countries.

and related publications, may not have the highest priority. It is interesting to note that Egypt, Tunisia, and Morocco indeed receive limited rainfall, but the comparably productive country Nigeria is much wetter. In this context, one should also keep in mind that the geological setting plays a role (not shown). If thick sedimentary aquifers are available for groundwater storage (like in North Africa), this facilitates hydrogeological studies too.

Finally, economical aspects may be an important driver of (groundwater) research and related publications (Fig. 3d). The plot indeed reveals that the Top Five nations are relatively wealthy, compared to other African countries. In turn, countries with lower GDPs show fewer publications. Apart from a few exceptions, there also seems to be a trend towards lower HRIs in the upper right part of the chart, i.e., the most productive nations exhibit higher percentages of papers with local authors (see Section 3, Fig. 2).

4.2. *Towards more equitable groundwater research in Africa*

It is clear that there is a pronounced dominance in groundwater research output in Africa by a few countries and partly elevated HRIs and low numbers of local corresponding authors point towards the existence of helicopter research.

To tackle the former aspect, some African countries should pay more attention to groundwater research. Some countries have abundant surface water resources and favorable climatic conditions, but surface water bodies can be relatively vulnerable to climate change and its detrimental consequences, and groundwater has the potential to be a major and relatively reliable water source in many regions. Hence, certain countries may want to increase their investments in groundwater-related Research and Development. While many articles feature at least one African author, these fractions could be further increased by strengthened intra-continental collaborations. Countries such as Egypt or South Africa, which consistently scored high in our analyses, should collaborate (even) more with other African countries. Additionally, we see value in establishing stronger relationships between the private sector, government institutions (e.g., geological surveys), NGOs, and universities.

To increase African paper output, but also to counteract helicopter research, international partnerships are vital, but institutions and universities in high-income countries need to re-evaluate their funding and

reward policies in a way that promotes working with developing countries in an equitable way (Jeffery, 2014). To foster good research partnership, true collaborations are key, i.e., local researchers should not only be included in the author list, but should be integrated in the research. While there is a growing body of literature on the topic, additional awareness campaigns on helicopter research may be necessary and various players could contribute to an improved situation, e.g., governments, funding agencies, universities, researchers, but also journals (Nature Geoscience, 2022).

4.3. Limitations of the study

Due to the chosen bibliometric approach, we see the studied phenomena through a WoS lens and, by definition, ignore non-WoS publications. Additionally, only articles written in English were considered for this study – publications in French or Arabic (official language in 21 and 11 African countries, respectively) were not included.

Further, our classifications as local or African author are purely affiliation-based, i.e., we did not make an attempt to analyze CVs of individual researchers. Hence, misclassifications are likely and researchers who originate from an African country but work abroad are not counted as a local or African author (note: ironically, this also applies to the first author of this article).

Finally, we have to keep in mind that we did not analyze author positions (e.g., first or senior author) and do not know to what extent listed authors were really involved in the published research (see Minasny et al., 2020).

5. Conclusions and outlook

This study was inspired by the research of North et al. (2020) in which the authors showed that there is a lack of international research partnership in high-end geoscientific research conducted in Africa and that African researchers are under-represented in high-impact geoscience publications. Complementary to this work, we studied articles dealing with groundwater in Africa. We observed that groundwater research output in Africa is relatively low (compared to some non-African countries) and heavily dominated by a few rather productive countries (Egypt, South Africa, Nigeria, etc.). The latter often "own" their research, i.e., the author list features local scientists, or at least an author with an African affiliation. Yet, there are also countries in Africa to which this does not apply, which likely points towards helicopter research.

A number of measures may help to mitigate this development. Developing countries should invest in their country's research infrastructure, making their research landscape less vulnerable to helicopter research. On the other hand, developed countries and their research sectors (e.g., funding agencies, scientists, journals) obviously have a role to play as well.

To better understand the underlying motivations and mechanisms and to eventually identify the most effective counter-measures, more research on the subject is necessary. While the present study adopted a bibliometric approach, interview- or questionnaire-based studies (see Dahdouh-Guebas et al., 2003) may provide additional valuable insights. Moreover, we can imagine that semi-automated analyses of researcher CVs and author contributions sections may be useful to better study the phenomenon. In contrast to our approach, such analyses may help to identify author nationalities and their actual role in published research, respectively.

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Declaration of competing interest

The authors declare no known conflicts of interest, whether personal, financial, academic, or otherwise, in the research presented.

Data availability

Supplementary sheet

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.earscirev.2024.104859 and https://github.com/Madaar49/Hydrogeology_Research-Africa.

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