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INHALT

GUEST EDITORIAL

Open Science in Africa – Impact in Action

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Open science is often introduced through its instruments: repositories, open licences, mandates, platforms. This issue asks a different question: what does open science actually do, once it enters a patent office, a university library, or a bicycle ride around the shore of a Kenyan lake? The three studies gathered here, the first fruits of a joint issue between the *Bavarian Journal of Applied Sciences (BJAS)* and the *Zambia Journal of Library & Information Science (ZAJLIS)*, answer that question at three different scales: continental, national, and classroom — and together, they provide compelling evidence of how Open Science delivers real impact in action.

The issue itself has a history worth telling, because it mirrors the very argument made above: infrastructure does not assemble itself. *OSCAR 2.0 – Towards Open Science Communities Development in Sub-Saharan Africa Region*, co-funded by the European Union, exists because a project principal at the European Policy Development and Research Institute (EPDRI), in Moldova, drew three European partners around a shared set of aims for open-science community-building — the VU University in the Netherlands, the Deggendorf Institute of Technology (DIT) in Germany, and the International School for Social and Business Studies (ISSBS) in Slovenia; and Joint Minds Consult, which joined the project as its knowledge partner, did the quieter work of bringing the African side of the table into being: the University of Zambia, which coordinated the project, and the University of Barotseland, in Zambia; the University of Botswana, Botho University, and the Botswana Institute for Technology Research and Innovation (BITRI), in Botswana. It was from that vantage point standing between the two constellations of institutions it had helped assemble that Joint Minds Consult proposed something simpler than another consortium meeting: that the partnership showcase open science research on its own account, working through Deggendorf. That proposal is the reason a Zambian publishing platform is co-editing alongside a Bavarian one today, and the reason this issue exists at all. Bringing BJAS and ZAJLIS together to co-publish is itself a small experiment in the principle both journals exist to promote: that scholarship travels further, and means more, when the infrastructure carrying it is shared, rather than owned. Whether that experiment succeeds will be judged less by this first instalment, than by whether the partnership stretching from Gaborone and Lusaka to Deggendorf, and the wider community of practice OSCAR 2.0 is building, outlasts the project's funding cycle.

Across the African continent, the policy case for open science has largely been won. The African Union's Agenda 2063 and its Science, Technology and Innovation Strategy for Africa (STISA-2034), the UNESCO Recommendation on Open Science, and a growing list of national policies all converge on the same commitments: broaden access, strengthen infrastructure, deepen collaboration. What remains unsettled is whether those commitments change what researchers, institutions, and students actually do. Each contribution in this issue tests that question against evidence, and each finds the same pattern in a different register: real, measurable progress, running up against structural friction that policy alone has not dissolved.

Cruz Romero, Stahlschmidt and Wang open the issue at continental scale, tracing the paper trail from open access science into the patent applications it eventually informs. Coupling bibliometric data from OpenAlex with global patent-citation records, they show that African-affiliated research is well connected internationally, concentrated in health and engineering fields that match the continent's own stated development priorities, and when it is open measurably more likely to be picked up by patent applicants than closed-access work in the same journal issue. That last finding matters: openness appears to buy African science a visibility it would not otherwise command. Yet the same data show that most of the literature actually cited in African patent applications is still not open at all. Declared policy and cited practice are, for now, running on separate tracks, a finding with direct implications for how governments and institutions weigh the return on open access investment against other R&D priorities.

A parallel gap opens up at national scale in the article that follows, an examination of two decades of open access development in South Africa, built jointly on bibliometric analysis and a policy audit of the country's research institutions. South Africa's publication output and its share of open access work have both grown well past the global average, and roughly a third of its institutions now have a formal open access policy in place: genuine achievements. But the study is careful not to let growth stand in for equity. Green open access, the cost-effective route built on institutional repositories, delivers the strongest citation impact of any access model, while Diamond open access — free to publish and free to read — remains the least visible internationally, starved of the indexing and discoverability that would let it compete. Article processing charges continue to sort researchers by what they can afford rather than what they have found, and English continues to dominate a scholarly landscape that produces almost nothing in the country's other ten official languages. The paper's own phrase for the risk this creates a "pay-to-be-seen" regime that could stand as a caution for open access transitions well beyond South Africa.

The issue's third contribution moves from policy to pedagogy, and from the page to the field. Researchers from the Deggendorf Institute of Technology and the University of Passau describe a field-trip methodology that sends geography teacher training students to Kenya's Lake Naivasha region, armed with little more than bicycles, smartphone cameras, and the participatory mapping platform PUBinPLAN. Combining Photovoice with public participation GIS, the students turn their own photographed impressions into georeferenced, openly licensed teaching material — Open Educational Resources, built to update and enrich a well-known school atlas map of a landscape reshaped by the cut-flower trade, geothermal power, and safari tourism. It is a study that practises what much open-science policy only preaches, converting a single field exercise directly into a public good. It is also, admirably, the one contribution in this issue willing to interrogate its own limits: the authors note plainly that the perspectives captured were overwhelmingly those of German visitors, rather than Kenyan residents, and they name that as a post-colonial problem for the method to solve, not a footnote to excuse. Open data, the paper insists by its own example, is not automatically equitable data; whose camera, and whose questions, still shape whose knowledge gets opened.

Read together, these three studies triangulate a single argument. Open science in Sub-Saharan Africa is not failing to take hold; the evidence in this issue shows growth in visibility, in citation impact, in policy uptake, and in genuinely novel participatory practice. What is failing to keep pace is the infrastructure, financing, and reflexivity

that would let openness deliver on its own promise of equity, rather than simply its promise of access. A patent examiner will still find more closed literature than open in the African-affiliated science she reviews. A South African researcher without institutional support will still weigh an article processing charge against a citation advantage – the two cannot cleanly be added or averted. A field trip built to decentre a single European atlas can still, without asking, recentre a single European gaze. None of this is an argument against open science. It is an argument for treating it as unfinished infrastructure that needs continued investment, continued scrutiny, and continued attention to whose interests it is currently built to serve.

That is precisely the work OSCAR 2.0 and this joint issue set out to do, and it is why we hope this is the first of several such collaborations between BJAS and ZAJLIS rather than a one-off. Open science communities, as the project's own title insists, are built, rather than declared. They need shared publishing infrastructure of the kind this issue represents; they need funding models, green repositories with reliable rights retention, sustainably indexed Diamond platforms, fair transformative agreements that do not simply shift the cost of visibility onto the researchers least able to bear it; and they need methods, like the Photovoice work described here, that treat participation and reflexivity as part of the science rather than an afterthought to it.

We commend these three studies to our readers, not as a finished picture of open science in Africa, but as an honest and well-evidenced sketch of the distance still to travel and an invitation to help close it.

The Guest Editors

Christine W. Kanyengo (University of Zambia, Lusaka)
Tuesday Bwalya (University of Zambia, Lusaka)
Javier Valdés (Deggendorf Institute of Technology)
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Open Science in Afrika – Wirkung in der Praxis

Open Science wird oftmals vor dem Hintergrund der damit verbundenen Instrumente betrachtet: Open-Science-Repositorien, -Lizenzen, -Mandate, -Plattformen. Diese Ausgabe beschäftigt sich jedoch mit einer ganz anderen Frage:: Was bewirkt Open Science eigentlich, wenn das Konzept in einem Patentamt, einer Universitätsbibliothek oder einer Radtour am Ufer eines kenianischen Sees Einzug hält? Die drei in diesem Heft enthaltenen wissenschaftlichen Beiträge, die ersten Publikationen im Rahmen einer gemeinsamen Sonderausgabe des Bavarian Journal of Applied Sciences (BJAS) und des Zambia Journal of Library & Information Science (ZAJLIS), beantworten diese Frage auf drei verschiedenen Ebenen: auf kontinentaler, auf nationaler und auf Klassenzimmer-Ebene – und liefern gemeinsam überzeugende Belege dafür, wie Open Science in der Praxis echte Wirkung entfaltet.

Diese Ausgabe selbst hat eine Geschichte, die es wert ist, erzählt zu werden, denn sie spiegelt genau das oben vorgebrachte Argument wider: Infrastruktur entsteht nicht ohne positive Wirkkräfte. OSCAR 2.0 – „Towards Open Science Communities Development in Sub-Saharan Africa Region", kofinanziert von der Europäischen Union, existiert, weil ein Projektleiter am European Policy Development and Research Institute (EPDRI) in Moldawien drei europäische Partner für eine Reihe gemeinsamer Ziele beim Aufbau von Open-Science-Communities gewinnen konnte: die Vrije Universiteit Amsterdam (VU) in den Niederlanden, die Technische Hochschule Deggendorf (THD) in Deutschland und die International School for Social and Business Studies (ISSBS) in Slowenien. Joint Minds Consult, ein Institut, das als Wissenspartner in das Projekt einstieg, leistete zudem die eher im Hintergrund stattfindende Arbeit, um auch die afrikanische Seite des Projekts ins Leben zu rufen: die University of Zambia, die das Projekt koordinierte, die University of Barotseland in Sambia, die University of Botswana, die Botho University in Botswana und das Botswana Institute for Technology Research and Innovation (BITRI). Auf den Fundamenten dieser institutionellen Kooperationen aufbauend schlug Joint Minds Consult vor, die Partnerschaft nicht allein als eine Abfolge von projektbezogenen Treffen zu verstehen, sondern weit darüber hinaus originäre Open-Science-Forschung zu verbreiten und zu präsentieren, in praktischer Zusammenarbeit mit Deggendorf. Dieser Vorschlag ist der Grund dafür, dass heute eine sambische Publikationsplattform gemeinsam mit einer bayerischen als Mitherausgeber fungiert, und der Grund dafür, dass die vorliegende Ausgabe überhaupt existiert. Die Kooperation des BJAS und des ZAJLIS ist ein kleiner, konkreter Ausdruck des Prinzips, das beide Zeitschriften verfolgen: dass Wissenschaft weiter reicht und mehr Bedeutung erlangt, wenn sie nicht in isolierten, geschlossenen Systemen entsteht – sondern getragen ist von offenen und geteilten Infrastrukturen. Ob dieses Experiment gelingt, wird weniger an dieser ersten Ausgabe gemessen werden als vielmehr daran, ob die Partnerschaft, die sich von Gaborone über Lusaka bis nach Deggendorf erstreckt, und die breitere Community of Practice, die OSCAR 2.0 im Begriff ist zu entstehen, den Förderzeitraum des Projekts überdauern werden.

Auf dem gesamten afrikanischen Kontinent ist der Umsetzungsplan für Open Science weitgehend verwirklicht worden. Die Agenda 2063 der Afrikanischen Union und ihre Strategie für Wissenschaft, Technologie und Innovation in Afrika (STISA-2034), die Empfehlung zu Offener Wissenschaft (Open Science) der UNESCO sowie eine wachsende Zahl nationaler Maßnahmen laufen alle auf dieselben Verpflichtungen hinaus: eine Erweiterung des Zugangs, Stärkung der Infrastruktur und Vertiefung der Zusammenarbeit. Ungeklärt bleibt, ob diese Verpflichtungen tatsächlich Einfluss darauf haben, was Forscherinnen und Forscher, Institutionen und Studierende konkret tun. Alle Beiträge in der vorliegenden Ausgabe stellen diese Frage anhand von Evidenz auf den Prüfstand und kommen jeweils auf unterschiedlichen Ebenen zu demselben Ergebnis: echte, messbare Fortschritte stoßen auf strukturelle Hindernisse, die durch politische Maßnahmen allein nicht beseitigt werden konnten.

Cruz Romero, Stahlschmidt und Wang beleuchten im ersten Beitrag das Thema auf kontinentaler Ebene und verfolgen den Weg der wissenschaftlichen Veröffentlichungen aus dem Open-Access-Bereich bis hin zu den Patentanmeldungen, in die diese schließlich einfließen. Durch die Verknüpfung bibliometrischer Daten aus OpenAlex mit globalen Zitierungen von Patenten zeigen sie, dass die Forschungsaktivitäten in Afrika international gut vernetzt sind, sich auf die Bereiche Gesundheit und Ingenieurwesen konzentriert – was den vom Kontinent selbst festgelegten Entwicklungsprioritäten entspricht – und dass sie, wenn sie offen zugänglich ist, messbar häufiger von Patentanmeldenden aufgegriffen werden als nicht frei zugängliche Arbeiten in derselben Zeitschriftenausgabe. Diese letzte Erkenntnis ist von Bedeutung: Die freie Zugänglichkeit scheint der afrikanischen Wissenschaft eine Sichtbarkeit zu verschaffen, die sie ansonsten nicht erreichen würde. Doch dieselben Daten zeigen auch, dass der Großteil der Literatur, auf die in afrikanischen Patentanmeldungen tatsächlich Bezug genommen wird, nach wie vor überhaupt nicht offen zugänglich ist. Die erklärten Zielmaßsetzungen und die Praxis des Zitierens verlaufen derzeit auf getrennten Gleisen – eine Erkenntnis, die direkte Auswirkungen darauf hat, wie Regierungen und Institutionen den Nutzenertrag von Investitionen in Open Access gegen andere Prioritäten im Bereich F&E abwägen.

Im zweiten Artikel, einer Untersuchung der zwei Jahrzehnte währenden Entwicklung von Open Access in Südafrika, die sich sowohl auf bibliometrische Analysen als auch auf eine Bestandsaufnahme und Überprüfung der institutionellen Policies der Forschungseinrichtungen des Landes stützt, wird eine parallele Lücke auf nationaler Ebene aufgezeigt. Sowohl der Output an Publikationen in Südafrika als auch der Anteil an Open-Access-Veröffentlichungen sind deutlich über den weltweiten Durchschnitt angestiegen, und etwa ein Drittel der südafrikanischen Institutionen verfügt mittlerweile über eine formelle Open-Access-Richtlinie: Das sind echte Errungenschaften. Die Studie achtet jedoch darauf, Wachstum nicht mit Gerechtigkeit gleichzusetzen. Green Open Access, der kosteneffiziente Weg auf der Grundlage institutioneller Repositorien, erzielt von allen Zugangsmodellen die größte Zitationsimpakt, während Diamond Open Access – kostenlose Veröffentlichung und kostenloser Zugang – international gesehen nach wie vor die geringste Sichtbarkeit hat, da es bei diesem Publikationsmodell an der Indexierung und Auffindbarkeit mangelt, die es wettbewerbsfähig machen würden. Artikelbearbeitungsgebühren (Article-Processing Charges, APCs) führen weiterhin dazu, dass Forschende danach klassifiziert werden, was sie sich leisten können, und nicht danach, was sie herausgefunden haben. Zudem dominiert Englisch nach wie vor eine Wissenschaftslandschaft, in der in den anderen zehn Amtssprachen des Landes so gut wie nichts veröffentlicht wird. Der Artikel selbst bezeichnet das damit verbundene Risiko als ein „Pay-to-be-seen"-System und formuliert damit eine Warnung, die für die Transition zu Open Access weit über Südafrika hinaus relevant sein könnte.

Der dritte Beitrag in dieser Ausgabe wendet sich von der Politik der Pädagogik zu und von der Theorie zur Praxis. Wissenschaftler der Technischen Hochschule Deggendorf und der Universität Passau beschreiben eine Exkursionsmethodik, bei der angehende Geografielehrerinnen und -lehrer in die Region um den Naivasha-See in Kenia entsandt werden – ausgestattet mit kaum mehr als Fahrrädern, Smartphone-Kameras und der GIS-basierten digitalen Partizipationsplattform PUBinPLAN. Durch die Kombination von Photovoice mit einem partizipativen GIS verwandeln die Studierenden ihre eigenen fotografischen Eindrücke in georeferenziertes, offen lizenziertes Unterrichtsmaterial – sogenannte „Open Educational Resources" –, das dazu dient, eine bekannte Schulatlaskarte von einer Landschaft, die durch den Handel mit Schnittblumen, Geothermie-Projekte und den Safari-Tourismus geprägt ist, upzudaten und zu ergänzen. Es handelt sich um eine Studie, die das umsetzt, was viele Open-Science-Strategien nur predigen, indem sie eine einzelne Feldübung direkt in ein öffentliches Gut transformiert. Bewundernswerterweise ist sie zudem der einzige Beitrag in dieser Ausgabe, in dem bereitwillig die eigenen Limitationen hinterfragt

werden: Die Autoren weisen in aller Deutlichkeit darauf hin, dass die erfassten Perspektiven überwiegend von deutschen Besucherinnen und Besuchern und nicht etwa von Einwohnerinnen und Einwohnern Kenias stammten, und sie sehen das als postkoloniales Problem – nicht als Randnotiz zur Entschuldigung, sondern als eine echte methodische Aufgabe, die angegangen werden muss. Offene Daten – das macht die Studie anhand ihres eigenen Beispiels deutlich – sind nicht automatisch gerechte Daten; wessen Kamera die Wirklichkeit erfasst und wessen Fragen gestellt werden, prägt weiterhin, wessen Wissen überhaupt zugänglich gemacht wird.

In der Zusammenschau untermauern diese drei Studien eine einzige These: Open Science fasst in Subsahara-Afrika durchaus Fuß; die in dieser Ausgabe vorgestellte Evidenz zeigt einen Anstieg der Sichtbarkeit und des Zitierimpacts, eine Zunahme der politischen Umsetzung sowie eine wirklich neuartige partizipative Praxis. Was jedoch nicht Schritt hält, sind die Infrastruktur, die Finanzierung und die kritische Reflexion, die es dem Grundsatz der Offenheit ermöglichen würden, sein Versprechen der Gerechtigkeit einzulösen – und nicht nur einfach ihr Zugangsversprechen. Eine Patentprüferin wird in den von ihr geprüften wissenschaftlichen Veröffentlichungen mit afrikanischem Bezug nach wie vor mehr Closed-Access- als Open-Access-Literatur vorfinden. Ein südafrikanischer Forscher ohne Unterstützung durch seine Institution wird nach wie vor die Artikelbearbeitungsgebühr gegen den potenziellen Vorteil abwägen, häufiger zitiert zu werden – beides lässt sich weder gegeneinander aufrechnen noch vermeiden. Eine Feldexkursion, die darauf abzielt, die Dominanz eines einzigen europäischen Deutungsrahmens aufzubrechen, kann dennoch unbeabsichtigt wieder einen europäischen Blickwinkel ins Zentrum rücken. All dies ist kein Argument gegen Open Science. Es ist vielmehr ein Argument dafür, Open Science als unvollendete Infrastruktur zu betrachten, die kontinuierliche Investitionen, eine kontinuierliche Überprüfung und kontinuierliche Aufmerksamkeit dafür erfordert, wessen Interessen sie aktuell dient und für wen sie letztlich ausgestaltet ist.

Genau das ist das Ziel von OSCAR 2.0 und unserer gemeinsamen Ausgabe, und deshalb hoffen wir, dass dies nicht nur eine einmalige Aktion bleibt, sondern der Beginn einer Reihe weiterer solcher Kooperationen zwischen dem BJAS und dem ZAJLIS ist. Open-Science-Communities werden – wie der Titel des Projekts selbst betont – aufgebaut und nicht einfach nur ausgerufen. Sie bedürfen einer gemeinsamen Publikationsinfrastruktur, so wie sie in dieser Ausgabe genutzt wurde; sie bedürfen Finanzierungsmodellen, „grünen" Repositorien mit zuverlässiger Rechtewahrung, nachhaltig indexierten Diamond-Open-Access-Plattformen, gerecht ausgestalteten Transformationsvereinbarungen, die die Kosten für die Sichtbarkeit nicht einfach auf diejenigen Forschenden abwälzen, die sie am wenigsten tragen können; und sie benötigen Methoden wie den hier beschriebenen „Photovoice"-Ansatz, bei denen Partizipation und Reflexion nicht erst im Nachhinein berücksichtigt werden, sondern von Beginn an Bestandteil der wissenschaftlichen Arbeit sind.

Wir empfehlen unseren Leserinnen und Lesern diese drei wissenschaftlichen Beiträge – nicht als abschließendes Bild von Open Science in Afrika, sondern als ehrliche und empirisch fundierte Skizze des Weges, der noch vor uns liegt, sowie als Einladung, zu seiner Verkürzung beizutragen.

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Open Science Dynamics and Science-Technology Linkages in Africa

Roberto Cruz Romero[1] **Stephan Stahlschmidt**[1] **Jian Wang**[2]

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ABSTRACT

This study examines how open access (OA) shapes innovation activity in Africa by analysing the scientific literature cited in patents. Using open bibliometric data from OpenAlex and global patent-to-paper citation data from Marx and Fuegi (2022), we explore how OA has been involved in the scientific literature referenced by African patents, as well as characteristics of co-authorship, topic, interdisciplinarity. Our analysis focuses on a qualitative exploration of the cited literature in patents followed by a quantitative study of the influence of OA in the science-patents link. In the qualitative study we find that the African science system is well interconnected with research-intensive partners across the globe and that the applied nature of the research produced aligns with the bloc's established policy goals. Research in the region is mostly focused in key development areas, such as health and engineering sciences; the latter is true across regional and internationally connected research collaborations. OA, on the other hand, seems to still trail behind non-open sources, which may be conditioned by application processes. Furthermore, in the quantitative study we explore whether OA facilitates the knowledge flow from science to patents and its specific effect for African science and African patents. We implement a matched regression analysis based on papers published in the same journal issue (with and without OA), and we find that, compared with a corresponding closed-access paper in the same journal issue, OA papers' probability of being cited by patents is approximately 4 percentage points higher ($p < 0.001$). This effect is significantly larger for African-affiliated papers. When focusing on citations by patents from African applicants, the OA effect is substantially larger for USPTO (about 10 percentage points) but is not statistically significant for EPO, despite a similarly elevated point estimate. Within these citations, however, the OA advantage no longer differs significantly by the cited paper's own regional affiliation. These findings suggest that while OA serves as a crucial mechanism for elevating the global visibility of African science into technological innovation, its influence is mediated by the existing search and citation practices of inventors. We thus offer nuanced evidence for the development and consolidation of a dynamic open science environment; promoting OA can amplify the contribution of African research to global technological development, but strengthening the direct science-patent pipeline requires broader strategic policy interventions beyond access licensing alone.

Die Studie untersucht, wie Open Access (OA) Innovationstätigkeiten in Afrika prägt, indem sie die in Patenten zitierte wissenschaftliche Literatur analysiert. Anhand offener bibliometrischer Daten von OpenAlex und globalen Wissenschafts-Patent-Zitationsdaten

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von Marx und Fuegi (2022) untersuchen wir, wie OA in die von afrikanischen Patenten referenzierte wissenschaftliche Literatur eingebunden wurde sowie Merkmale von Koautorenschaft, Thema und Interdisziplinarität. Unsere Analyse konzentriert sich auf eine qualitative Untersuchung der zitierten Literatur in Patenten, gefolgt von einer quantitativen Studie zum Einfluss von OA auf die Verbindung zwischen Wissenschaft und Patenten. In der qualitativen Studie stellen wir fest, dass das afrikanische Wissenschaftssystem gut mit forschungsintensiven Partnern weltweit vernetzt ist und dass die angewandte Natur der Forschung mit den festgelegten politischen Zielen des Blocks übereinstimmt. Die Forschung in der Region konzentriert sich hauptsächlich auf Schlüsselentwicklungsbereiche wie Gesundheits- und Ingenieurwissenschaften; Letzteres gilt für regionale und international verbundene Forschungskooperationen. OA hingegen scheint weiterhin hinter nicht-offenen Quellen zurückzubleiben, die durch Anwendungsprozesse bedingt sein können. Darüber hinaus untersuchen wir in der quantitativen Studie, ob OA den Wissensfluss von Wissenschaft zu Patenten fördert und welche spezifischen Auswirkungen sie auf afrikanische Wissenschaft und afrikanische Patente haben. Wir führen eine gematchte Regressionsanalyse auf Basis von Artikeln aus derselben Fachzeitschrift (mit und ohne OA) und stellen fest, dass im Vergleich zu einem entsprechenden Closed-Access-Artikel derselben Fachzeitschrift die Wahrscheinlichkeit, von Patenten zitiert zu werden, etwa 4 Prozentpunkte höher ist (S. < 0,001). Dieser Effekt ist bei afrikanisch assoziierten Artikeln signifikant größer. Konzentriert man sich auf Zitationen von Patenten afrikanischer Antragsteller, ist der OA-Effekt für USPTO deutlich größer (etwa 10 Prozentpunkte), aber für EPO trotz einer ähnlich erhöhten Punktschätzung nicht signifikant. Innerhalb dieser Zitationen unterscheidet sich der OA-Vorteil jedoch nicht mehr wesentlich durch die regionale Zugehörigkeit des zitierten Artikels. Diese Ergebnisse deuten darauf hin, dass OA zwar ein entscheidender Mechanismus ist, um die globale Sichtbarkeit afrikanischer Wissenschaft in technologische Innovationen zu erhöhen, sein Einfluss jedoch durch die bestehenden Such- und Zitierpraktiken von Erfindern vermittelt wird. Wir bieten somit nuancierte Belege für die Entwicklung und Konsolidierung einer dynamischen Open-Science-Umgebung; die Förderung von OA kann den Beitrag afrikanischer Forschung zur globalen technologischen Entwicklung verstärken, doch die Stärkung der direkten Wissenschaft-Patent-Pipeline erfordert über die reine Zugangslizenzierung hinausgehende strategische politische Interventionen.

KEYWORDS

Open science, patent analysis, open access, innovation, bibliometrics

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1. Introduction

The idea of open science (OS) as a vehicle for innovative research has also been consolidated into policies that range from the supra-national (e.g., UNESCO's *Recommendation on Open Science*, 2022) to the regional (e.g., EU's *Open Science Policy*, or the African Union's *Science, Technology and Innovation Strategy*, 2024) or even the national (e.g., the German Research Foundation's plan for evaluation of proposals; or South Africa's open science policy, 2024). Hence, the advancement of OS and innovation research represents one of the most promising pathways for achieving sustainable development and consolidating global research competitiveness. The latter is an underlying factor of a landscape of intense scientific collaboration, where academic and resource mobilities tend to shape the opportunities for research areas. The examples above serve as reflection of the interconnectedness of different scientific systems. Moreover, many policies have been developed to foster and sustain a collaborative scientific exchange system that incorporates steadily available research funds as well as competitive grants.

For instance, in the context of African academic systems, there is a great variety of funding, infrastructure, or policy directives emanating from national or regional sources.[3] Yet, there appears to be a common understanding of the importance of science and technology as drivers of growth and inclusion. The Science, Technology and Innovation Strategy for Africa (STISA 2034) serves as example of the continental motivation that seeks to "call for governments, academia, civil society and the private sector, to unite in harnessing the power of science, technology and innovation (STI) to unlock the continent's full potential" (African Union, 2024, p. 3).[4] As such, it becomes clear that the path towards establishing robust OS ecosystems hinges upon a delicate balance between public funding schemes, strong university-industry (U+I) programmes and dynamic scholarly networks. However, the continental bloc still contains great disparities to be dealt with, in order to fully motivate the adoption of overarching policies. Hence, it is relevant to address, at least, three dimensions that make up a harmonious landscape for OS and innovation; first, the policy frameworks in place, then the infrastructural conditions and, finally, the collaboration linkages that can support the development of OS.

1.1. Open Science as Policy Norm

Across Africa, the policy landscape for OS remains characterised by promising, yet fragmented initiatives – "although progress has been made in terms of Open Science and Open Data practices, more awareness needs to be created and further advocacy efforts are required" (ASSAf, 2024, p. 4). For example, the African Union's (AU) *Agenda 2063* serves as a blueprint that positions science, technology and innovation as integral elements within Africa's development trajectory. The Agenda explicitly emphasises the development of information and communications technology (ICT) infrastructure for enhancing connectivity and collaboration in science, technology, and innovation. Similarly, the AU's Commission has also developed the *Science, Technology and Innovation Strategy for Africa* (STISA-2034), explicitly focusing on concepts such as open data, open innovation, and collaborative research and innovation frameworks. OS is then framed within the guiding principles of the framework and understood as a "collective benefit" (African Union, 2015, p. 6), upon which knowledge, and the progress derived from it, are commonly shared.

However, the policy landscape still reveals significant challenges in terms of specificity and scope. Many policies lack the detailed implementation mechanisms and resource allocations necessary for effective operationalisation (Dosso et al., 2022; cfr. Omini, 2019). Resources are crucial when considering the costs of publishing OA articles in specific journals from specific fields. This tension between openness and intellectual property protection extends beyond publishing costs to patenting itself, where faculty and institutional patenting practices have long had to balance commercialisation incentives against open science norms (Fabrizio & Di Minin, 2008). Generally, costs for accessing published materials are often a hurdle that declarative norms usually overlook (Bezuidenhout et al., 2017), as this tends to be a problematic dimension of OS in terms of material access to science. Issues of institutional support for OS, for example regarding university libraries, highlights the key gaps between policy and practice. Further dimensions of access are left unexplored and, thus, omitted from the potential benefits into the scientific, economic, and technological (Wang et al., 2025).

Policy alignment is therefore crucial to overcome the atomisation of academic systems, particularly where potential for greater interlinking is present (ASSAf, 2019). *The African Open Science Platform* (AOSP), for example, is a precise indication of the already existing efforts to drive OS as a key component of development and equity through access to knowledge (Participants of African Open Science Platform Stakeholder Workshop et al., 2018).[5] Whether this objective can be achieved

[3] See the African Union's Agenda 2063 – a comprehensive set of policy aspirations that set out to influence the continent's policy-making contexts into adopting more or less harmonious steps towards sustainable development. The Agenda is designed along the lines of 10-year plans and, in the case of science and technology – as with all other fields of political-economic relevance – it is set to overhaul the system and "[b]uild and expand an African knowledge society through transformation and investments in universities, science, technology, research and innovation" (2015, p. 15)

[4] STISA 2034 is the second presentation of such policy framework. It was formulated as an action plan in accompaniment of the already mentioned Agenda 2063; the STISA 2034 represents thus the second 10-year iteration of the policy intended to incentivise science and technology development in the coming years.

[5] See https://openscience.africa/ for a complete overview of several initiatives for OS in the African continent.

depends on the coordination strategies of governments and regional entities, as they can promote the construction and/or consolidation of necessary technical infrastructure. The policy landscape described above provides the motivating context for our empirical analysis, although we do not operationalize specific policy instruments directly. Instead, our empirical approach relies on OA status and regional (African, USA, EPO) affiliation as observable proxies for the underlying access and infrastructural disparities that these policy debates address, built on the premise that some degree of coordination benefits the knowledge flows from science to innovation, facilitated by the policies on OA and collaboration.

1.2. Collaboration and Partnerships as Drivers for Innovation

International collaboration has emerged as both a critical enabler and a complex challenge in Africa's pursuit of OS consolidation. The patterns of collaboration between African institutions and international partners, particularly European universities and research organisations, demonstrate the transformative potential of strategic partnerships whilst highlighting the need for more balanced and sustainable collaborative frameworks. Similar to the detrimental effects of *brain drain*, Mwelva et al. (2020, p. 10) problematise some of the efforts for North ↔ South cooperation as "helicopter science". The latter means that "collaboration with global north partners, funded by northern agencies, are frequently dominated by northern scientists, who fly in, collect data from their African partners, then fly out". This framing sets the stage for an extractivist approach to research and shuts down many pathways for effective collaboration.

However, numerous initiatives are in place to bolster international collaboration in a matter that acts as a structural support and not dependence mechanism. For instance, both AU and the European Union (EU) issued a so-called *Joint Vision for 2030* in early 2022. The declaration explicitly recognises the importance of research and innovation in the bilateral relationship. The policy seeks to foster capacity building in relation to the design and implementation of ICT solutions as one of the most crucial areas of policy action acknowledged by most assessments (see ASSAf, 2019; Vallejo et al., 2019).[6] Additionally, the consolidation of a strong intellectual property regime that recognises the role of local research bodies that facilitate or indeed carry out relevant parts of data gathering or analysis processes.

A more symbolic advantage gained from intense collaboration networks is seen in the knowledge production and its later recognition. As per other regional and global trends, co-authored works (particularly those with inter-regional collaboration) tend to be cited increasingly often (Huang et al., 2024; cfr. Iyandemye & Thomas, 2019). While OS encompasses a broad range of practices, including open access to publications, open data, open methods, and open peer review, our analysis turns specifically to open access (OA): the free, immediate availability of published research articles. OA increases the visibility of scholarly works to broader audiences (Nishioka et al., 2020); for instance, considering the visibility gains in the context of innovation and applied research, leading to increased citations in patents (Jia et al., 2026; Maddi, 2024). Considering the framework to bolster OS in the African contexts, the dissemination of OA content signifies a great tool for addressing the (still unresolved technical and financial) inequalities of the academic landscape (see Bryan & Ozcan, 2021). So, for illustration, cases like the Scielo repository in the Latin American case, may also function as a reference point from which to guide specific policy implementations. This focus may lead to offset the otherwise positive concentration of partnerships with European institutions, reinforcing instead South ↔ South collaborations.

1.3. Research Aim

Following the theme of innovation and the surrounding elements that determine a successful OS environment, the research seeks to connect the corresponding OA dimension, in terms of published research articles, with an innovation-oriented perspective. We examine how OA is associated with knowledge diffusion from science to technological innovation, and how these associations are contingent on region, particularly Africa. Thus, this contribution focuses not only on the OS environment conditions, but also on the political-economic implications that give way to the uptake in OS practices that push innovation. We therefore

[6] In addition to the already mentioned Recommendations on Open Science, UNESCO has also elaborated guidelines on Open Educational Resources (OER) and on Science, Technology and Innovation Policy Instruments.

also focus on how open innovation (OI) – the intertwinement of OS practices within a dynamic innovation environment – represents the specific political-economic (structural) conditions that determine the intensity of public-private co-production in innovation activities (e.g., through co-authorship or funding).

Recent work has begun to map how scientific research feeds into technological innovation through patent citations more broadly (Dorta-González et al., 2025), and we extend this line of inquiry by centring the OA dimension of this science–patent link within the African context. Through a coupling of bibliometric and patent data sources, we look to analyse the knowledge flows from scholarly literature into the knowledge structure of patents. Particularly, we are interested in assessing the bridging dynamics that OA literature may have in relation to patents' references. From this perspective, we analyse how the OA transformation has affected innovation processes in the diverse African countries and, from this analysis, highlight the enabling factors that socio-economically or from an academic regulatory perspective influence the knowledge flows, e.g., collaboration practices. These dimensions inform policy action from both academia and public sector officers, providing evidence for objective-oriented initiatives in the research and development (R&D) and innovation sectors.

2. Data and Methods

The empirical approach follows a descriptive-inferential coupling of the scholarly and patent data. At first instance, we conduct an exploratory analysis of different data sources in order to fully characterise the knowledge flows and their scholarly nature. Whilst, at a second stage, we conduct a matched regression analysis based on a stylised model of publication data focusing on the differences between papers published in hybrid journals. Together, these two lenses offer a complementary outlook into the trends and conditions of an expanding OS environment, namely scientific publishing and innovative research.

Regarding the descriptive exploration, we use open bibliometric data from the OpenAlex (OAL) database and open patent citation data from the Marx and Fuegi (Marx, 2024; Marx & Fuegi, 2020; see also Marx & Scharfmann, 2024; Abbasiantaeb et al., 2025). We complement these data with additional patent data from PATSTAT with affiliation data for each patent applicant, offering more fine-grained information on affiliation patterns. Further, we focus on the literature being cited in patents, whether front page or in-text, and its metadata. To this regard, we use this distinction only for the descriptive section. Because we are interested in identifying the OA-based transfer of scholarship through patents' knowledge structure, we aim to characterise the extent to which affiliations in African countries are present in this dataset, alongside collaboration patterns and disciplinary distributions. The affiliation metadata in both patent and OAL datasets allow us to filter to only African countries in the patents' applicants list and, thus, to focus only on the scholarly items cited in these patents. This includes all listed applicants; that is, regardless of their legal persona (individual or companies) – in this sense, we capture all effects in the patent landscape.

We thus matched these two datasets through the OAL (unique) identifiers and obtained a sub-set with complementary information about patent applicants and academic researchers. Given that OAL item metadata also includes affiliation information, we are also able to complement the data and create a patent-to-paper link on two levels: a) one describing the affiliation and collaboration network of the patent applicants, and b) another describing the same features for scientific articles. The filtering of the patent data is done according to the applicants' country data, and the scholarly items are then matched through the citation keys. The dataset comprises patent publications published between 2000 and 2023 citing scholarly articles published as early as 1907 and up to 2021.

We narrow down further to focus on a specific type of OA licensing, namely the hybrid type. Hence, we group match the journal and issue metadata and extract all items from journal issues where at least one item labelled as hybrid was published (that is, an OA item published in a subscription-based journal). So, we keep all patent-cited articles, and then for each patent-cited article we randomly sample a non-cited article in the same journal issue, to construct an analytical (matched) dataset that is balanced in terms of predicted outcome, i.e., being cited by patents. The rationale for this step is that being cited by patents is rare, which makes standard statistical analysis problematic.

This approach allows us to identify the effect of OA publishing, i.e., the unrestricted accessibility of scientific publications, on transfer of the respective content into patents while controlling for other confounding factors, such as fields of study. Figure 1 visually exemplifies the features for each level of analysis and the structure of the data.

Thus, the a) qualitative exploration is based only on papers cited in African patents,[7] which have been published in the hybrid journals. This intersection allows us to characterise the African innovative R&D landscape. The b) quantitative study, on the other hand, uses the matched hybrid journals dataset, i.e., all papers cited in the patent dataset (regardless of the patents' location). The statistical estimation seeks to provide some evidence regarding the affiliation of authors, the patent offices (i.e., USPTO [United States Patent and Trademark Office] or EPO [European Patent Office]), and the interaction of OA and institutional affiliations (grouped at regional level, controlling for the author affiliation in, e.g., African institutions). More on this below.

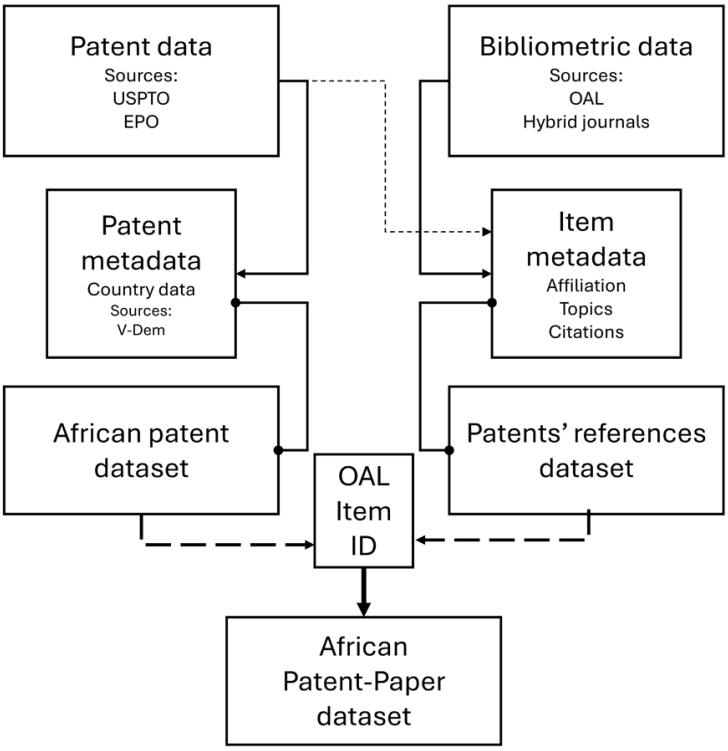

Figure 1: Patent and bibliometric data workflow.

Table 1 shows a quick summary of the filtered data on African patents (i.e., with at least one African institutional affiliation) based on the corresponding patent office, as well as the access type for the cited papers. The access status is given according to OAL's classification, distinguishing between closed and open (and from the latter we highlight the share of hybrid items as they represent our feature of interest for the logistic regression below).

Category	n	%
Patents	2239	100.00
USPTO	*1596*	*71.28*
EPO	*643*	*28.72*
Papers cited	10945	100.00
Closed	*6650*	*60.76*
Open	*4295*	*39.24*
Hybrid*	***546***	***4.99***

Table 1: Summary count of patent and papers (from patents with at least one African affiliation)

[7] By African patent publications we refer to the patents where, grouped by each patent number, at least one listed applicant's country affiliation matches any country in the African continent. Given the format of the country data (ISO-3166-2 two-lettered country codes), for the specific case of Namibia (country code "NA") there was a manual check and a character string matching to avoid false positives (as with no data NA).

2.1. Data Description

Marx and Fuegi's dataset includes data from many patent offices around the world, yet we filtered and matched only the USPTO and the EPO offices due to the concentration of counts for these two entities. Patents are identified by their filing/granting office, coded as US (USPTO) and EP (EPO) in both Marx and Fuegi's dataset and in PATSTAT, from which we draw applicant affiliation data. We describe the location data of the references cited in each patent; i.e., if they are cited in the front page or in the body of the text (or both). Following our approach, we then filter to only the patents with an African(-based) applicant, looking to further delineate the role of affiliation in relation to OA citation. Hence, our dataset for the *qualitative* exploration comprises nearly 60 thousand patent-paper reference links, from 2,239 unique patents and 10,945 unique cited papers.

For the *quantitative* study, based on the matched regression analysis (subsequent section), we make use of the matched hybrid subset, which represents a total of 2.6 million cited articles. These cited items make up a further filter, as we are interested in matching cited items with non-cited items from the same journal issues – by construction only hybrid journals. Thus, after matching complete cases from the respective journals, we come up with a balanced sample of 4.4 million citation links (more below). The matching is done on the basis of the closed/open binary, with the hybrid option providing the control filter. That means that the estimation approach only distinguishes if a published item is OA or not, in relation to the matched sample of articles published in hybrid journals.

Figure 2, an explorative approach of the qualitative dataset, shows a summary of different temporal dynamics for each group (patents and paper citations), and within each of the categories of citation (only in the front page, only in the text, or in both). We then couple these features with the access category for each cited paper. The provenance of front-page citations differs by patent office: at the EPO, front-page references are added exclusively by examiners during the search report process, whereas at the USPTO front-page references are primarily supplied by applicants via the Information Disclosure Statement, with examiners adding further citations during examination. Given this cross-office heterogeneity in who supplies front-page citations, we pool both citation locations within each office-specific regression model, as our interest lies in the overall likelihood of a paper being cited in a patent's knowledge structure rather than in attributing citation behaviour to a single actor. At first glance, a small lag between item citations and patent publication is observable, which speaks of a preferential tendency for more recent literature (despite the long tail of older papers). Moreover, following up on the shares of OA papers cited in general, despite the overall predominance of non-OA papers cited, the trend for OA papers increases with time (inversely: there is an apparent down take in citing non-OA references).

Although our interest lies in the internal comparison of hybrid journals,[8] in terms of their OA publications, and their influence in patent citations we nonetheless call to attention the OA developments after the year 2000.[9] In part, this is relevant to observe the patent trends (increasing from 25 in the year 2000 to over 250 by the year 2010), with a similar pattern following the total number of patent citations as well as the share of OA articles cited (increasing from a share of around 30% OA citations in 2003 to over 40% after 2010). The lower panels (e) also reflect the distribution of OA references (vis-à-vis non-OA) in each reference location. Though this trend is rather influenced by the role of patent examiners in accessing and incorporating literature (e.g., the difference between front page and in-text shares – see Bryan & Ozcan, 2021). The latter may reflect a preference for more consolidated research and/or consolidated journals – OA would represent an afterthought. Though, as shown below, this trend is correlated with the time dimension, as the usage of OA references has grown in the last years of the sampled data (where in-between access licenses are still the most common; i.e., *green* and bronze *models*).

As for visibility and ease of *findability*, front page literature is assumed to hold more general research meant to show the innovation potential (novelty) of applications, whereas in-text reference may contribute to specifics of the patent process (Bryan & Ozcan, 2021; cfr. Wang & Verberne, 2024). This could be the reason for

[8] The number of hybrid items (i.e., published in hybrid journals) reflects an under-counting, evidencing how patent publications from teams with at least one African institutional affiliation opt for research published mainly in non-OA, subscription-based journals.

[9] The latter is meant to reflect the influence of policies, in particular that of the Budapest Open Access Initiative from 2002, where signatories sought to push OA to scientific publications through self-archiving and OA journals.

the positive tendency towards the use of more OA references in the front pages of patents than in the text body (*e*). The ratio for references cited in *both* locations appears more balanced, in addition to cover a small overlapping share, as shown by the blank periods in this category. In general, there appear to be considerable differences between front-page and in-text referencing practices and the type of referenced sources. And, whilst non-OA seems to still be the largely dominant type of cited literature, intermediate licensing models seem to gain terrain.

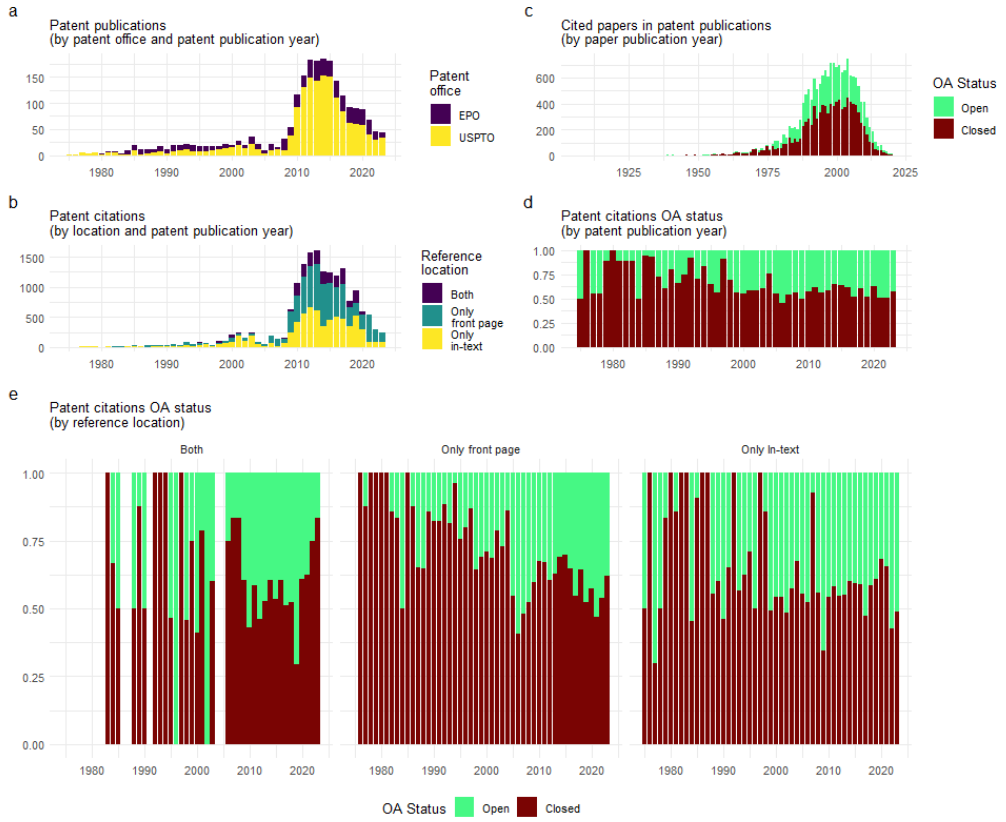

Figure 2: Patent-paper dynamics (by publication year, reference location, and reference access type, from patents with at least one African affiliation).

3. Results

3.1. Qualitative Insights

We now focus on a qualitative exploration of the main features of the scientific contribution of scholarly works cited in patents. To reiterate, the data contains the nearly 11 thousand papers cited in the over two thousand patents from African institutional affiliations (or at least one given multiple applicants). First, we narrow down the affiliations of the papers' authors in order to assess the extent to which collaboration patterns appear. Expectedly, the USA stands out as the predominant host of scholars whose work is cited in patents. With nearly 45% of all authors based in the USA,[10] the landscape seems skewed towards this scientific system, where grant searching and patents are based on highly competitive paradigm (Frakes & Wasserman, 2021; Graham et al., 2015). Moreover, when compared according to the authorship composition (single- vs. co-authored), a similar trend is maintained, reflecting the dynamics of cooperation that endure. Notable shifts occur in some positions regarding the number of collaborators; it may be indicative of national levels of collaboration based on specific working groups. USA-affiliated scholars show a relative advantage, as their work gets national and international attention given the language feature.

[10] For comparison, this proportion is much higher than the USA share for overall publications in the WoS or Scopus, for instance. For a detailed breakdown, see: https://bibliometrie.info/forschung/arbeitsberichte/.

Furthermore, there is approximately an average of four co-authors per paper in the entire dataset, showing a tendency towards intense collaboration from the academic side. In general, around 10% of the cited papers are single-authored, with a large majority of multi-authored papers (and a few with quite high author counts, with some few over 100). Similarly, the affiliation per organisations (universities or research institutions) follows a similar pattern, with at least one paper with ~60 authors affiliated in respectively different institutions. There is a wide variety of individual affiliations, which goes to show the interaction of regions and disciplines. So, in order to make sense of the affiliation patterns in collaborative works, we group countries by their geographic region (in order to avoid a very clear over-representation of the USA given their weight in geopolitical distributions) and match the co-authorship links for each cited paper.

Table 2 shows how the regions relate to each other in terms of their conditional probability for collaboration. That is, for each row, we show the normalised counts of fractional authorships for papers with more than one author (around 90% of cited papers). By estimating the conditional probability, we see the likelihood of one region collaborating with others (e.g., how likely is that an author affiliated in an institution in Western Africa appears in a paper also co-authored by a scholar affiliated in Eastern Africa – in our data, the probability is close to zero). Different to a cosine similarity measure, the conditional probability indicates the relative strength of that co-appearance. In addition, the table also gives indication to our assumption of intense internal collaboration, as regions collaborate more strongly inwards, suggesting a strong spatial determination to scientific work relevant for patents; in particular if that work serves an innovative purpose that would feed into innovation realisation processes (i.e., patents). This phenomenon offers contradicting evidence for the robust policy frameworks in place in

Region	Northern Africa	Middle Africa	Western Africa	Eastern Africa	Southern Africa	North America	Central America	Caribbean	South America	Northern Europe	Western Europe	Eastern Europe	Southern Europe	Eastern Asia	South-Eastern Asia	Central Asia	Southern Asia	Western Asia	Oceania
Northern Africa	*0.62*	*0.00*	*0.00*	*0.00*	*0.00*	*0.07*	*0.00*	*0.00*	*0.00*	*0.01*	*0.23*	*0.00*	*0.03*	*0.00*	*0.00*	*0.00*	*0.00*	*0.01*	*0.01*
Middle Africa	*0.00*	*0.48*	*0.01*	*0.00*	*0.05*	*0.08*	*0.00*	*0.00*	*0.00*	*0.09*	*0.25*	*0.00*	*0.04*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Western Africa	*0.00*	*0.01*	*0.54*	*0.00*	*0.02*	*0.19*	*0.00*	*0.01*	*0.00*	*0.07*	*0.12*	*0.00*	*0.03*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Eastern Africa	*0.00*	*0.00*	*0.00*	*0.47*	*0.06*	*0.17*	*0.00*	*0.00*	*0.00*	*0.13*	*0.13*	*0.00*	*0.01*	*0.01*	*0.00*	*0.00*	*0.01*	*0.00*	*0.00*
Southern Africa	*0.00*	*0.00*	*0.00*	*0.01*	*0.73*	*0.08*	*0.00*	*0.00*	*0.00*	*0.07*	*0.06*	*0.01*	*0.01*	*0.00*	*0.00*	*0.00*	*0.01*	*0.01*	*0.01*
North America	0.00	0.00	0.00	0.00	0.01	0.89	0.00	0.00	0.00	0.02	0.03	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00
Central America	0.00	0.00	0.00	0.00	0.00	0.13	0.66	0.00	0.09	0.02	0.04	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.02
Caribbean	0.00	0.00	0.03	0.00	0.00	0.11	0.00	0.72	0.04	0.04	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
South America	0.00	0.00	0.00	0.00	0.01	0.09	0.03	0.00	0.73	0.04	0.04	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.01
Northern Europe	0.00	0.00	0.00	0.00	0.02	0.08	0.00	0.00	0.00	0.79	0.05	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.01
Western Europe	0.01	0.00	0.00	0.00	0.01	0.07	0.00	0.00	0.00	0.03	0.83	0.01	0.02	0.01	0.00	0.00	0.00	0.01	0.00
Eastern Europe	0.00	0.00	0.00	0.00	0.01	0.13	0.00	0.00	0.00	0.03	0.10	0.67	0.02	0.01	0.00	0.01	0.00	0.01	0.00
Southern Europe	0.01	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.01	0.03	0.07	0.01	0.78	0.01	0.00	0.00	0.00	0.00	0.00
Eastern Asia	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.88	0.01	0.00	0.01	0.00	0.00
South-Eastern Asia	0.00	0.00	0.00	0.00	0.01	0.10	0.00	0.00	0.00	0.03	0.05	0.00	0.01	0.08	0.67	0.00	0.03	0.00	0.01
Central Asia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.48	0.00	0.00	0.00	0.48	0.00	0.00	0.00
Southern Asia	0.00	0.00	0.00	0.00	0.02	0.07	0.00	0.00	0.00	0.03	0.04	0.00	0.00	0.04	0.01	0.00	0.77	0.00	0.01
Western Asia	0.01	0.00	0.00	0.00	0.02	0.13	0.00	0.00	0.00	0.04	0.10	0.01	0.01	0.01	0.00	0.00	0.00	0.65	0.00
Oceania	0.00	0.00	0.00	0.00	0.01	0.08	0.00	0.00	0.00	0.04	0.02	0.00	0.01	0.02	0.00	0.00	0.01	0.00	0.80

Table 2: Conditional probability matrix for co-authored papers

the African bloc for incentivising science and technology advancements.

Moreover, in order to visually understand the flows of cooperation links that make up the literature in this sub-sample, we build a network of authorship co-occurrence in the papers. This relationship counts the joint share of participations per the co-authorship entities named. In this case, we group the affiliation data from all papers by countries and then by the respective geographic region, adding up the

fractional counts of author attribution in each one. So, we estimate the paper-region matrix (M, where X_t X is the matrix) and then the fractional shares assigned to each region by summing the products of the shares pairings ($M_{i,j} = \sum pX_{p,i} \times X_{p,j}$, where $X_{p,i}$ represents the fractional share of paper p for region i). Further, we overlay the network onto a world map projection so as to better communicate the relationships – the nodes in the figure represent each region's centroid weighted by the participation share (i.e., the number of co-authorships).

Complementary to the conditional probabilities, the network visualisation offers a more intuitive approach to understanding collaboration patterns, as it shows the connections between regions. The nodes are representative of each region, whilst the width of the edges connecting them is indicative of the strength of the estimated links. This visualisation serves also as evidence of the strong centrality of the so-called Global North regions (North America and Western Europe represent the biggest nodes in this network arrangement). However, given the scope of the sample analysed, we see a relative importance of Eastern and Middle African regions in terms of collaborations. These regions not only collaborate intensely within, but also between regions. For instance, plot **b** of the figure below shows only the flows coming from or directed to African institutions (affiliations). As such, the African continent has an important relationship with the most research-intensive regions; in particular, the Southern African region where, admittedly, the nation of South Africa takes most of the credit, as being one of the most research-intensive countries in the region and in the continent. Notwithstanding, there appears to be a knowledge link between the collaborative work in the different African regions and the patents. From a policy perspective, this entails

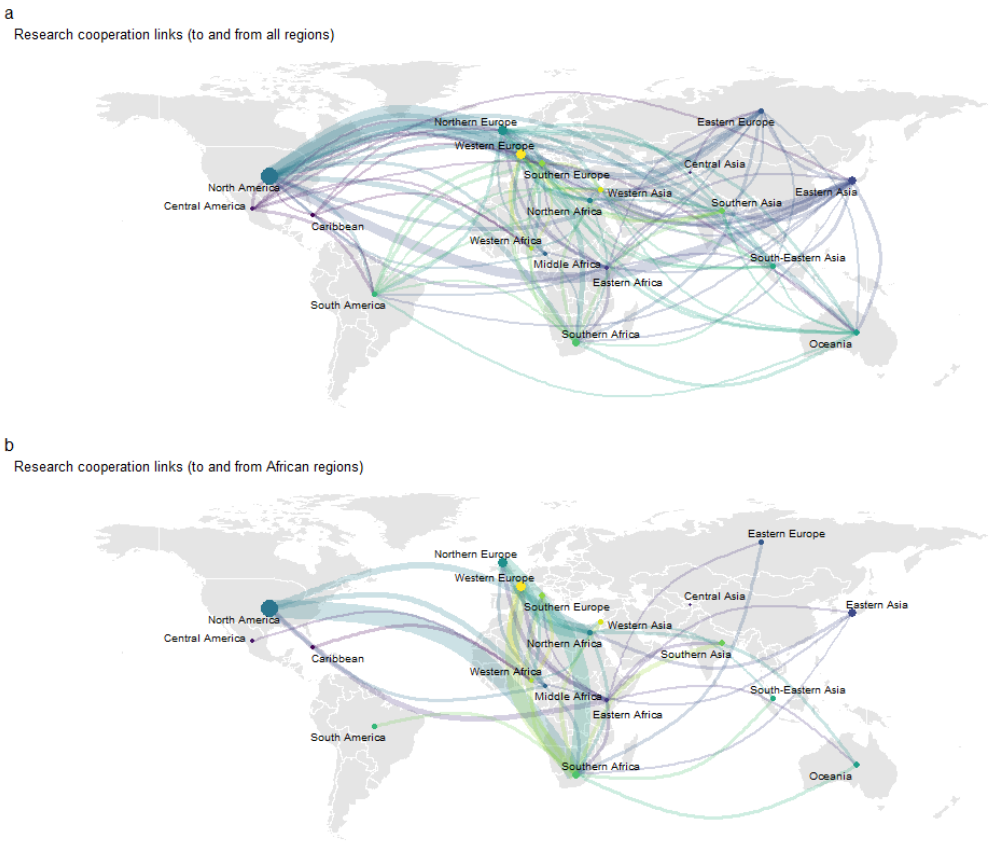

Figure 3: Cooperation patterns in papers cited in African patents.

great promise, as it poses the African context in a strategically relevant position of research collaboration.

3.1.1. Topics

Notably, a thematic subdivision of the cited papers offers indication of specific thematic directions, as a substantial part of the affiliate institutions show a tendency towards the technological and health sciences fields. One of these cases in best exemplified with the *Centers for Disease Control and Prevention* (CDCP) from Kenya, or the *Council for Scientific and Industrial Research* (CSIR) from Ghana, with numerous collaborations in the cited papers. Linking this back to the context of African science and technology policy, the CDCP is an example of a medical and health sciences institution that is also a reflection of one of the key policy areas sketched in the *Agenda 2063*, namely, public health.

Following this intuition, we look at the field distribution in the cited papers from African patents. This is relevant twofold: a) these are the papers cited directly by the patents, and b) these citations show the multidisciplinary basis underpinning specific patenting processes. For instance, organisational studies, psychological assessments, or even economic analyses can be part of the prior knowledge for a patent and, thus, we emphasise the need to comprehensively assess the broad variety of these sources. For that, we group the papers per patent (the number of papers cited in each patent) according to the OAL topic classification (as per OAL's domain and field names). In addition, since we are parting from this perspective (science flows into patents), we underline the value of the academic classifications over the structured patent typologies. We seek to better understand what types of topics are entering the patents' knowledge base regardless of where the patent is classified or what type of innovation is being filed.

Figure 4 shows that a strong indication of topics directed towards health and medicine sciences dominate, both in magnitude and the distribution of counts. The general field of medicine is followed by biotechnology and then by immunology; fields that correspond to an emphasis on public health and cost-effective health solutions. The case of e-medicine comes to mind as an example of an area that can profit from this thematic emphasis (e.g., the case of telemedicine in the wake of COVID-19, Dodoo et al., 2021). Moreover, the prevalence of medicine-focused research remains even when separating the sample into the OA and non-OA sides.

Likewise, in the fields of engineering and agricultural sciences, the energy sector has seen efforts made to advance the research & development (R&D) and implementations relating to efficiency and sustainable development (Ahodode, 2023). In this same line, this pattern follows the objectives stated in the STISA, as the push for collaboration in key areas of science and technology seems to be the driver of academic output. Similarly, the OA feature does not seem to greatly dilute the distribution, as it could be said, that it is the preponderance of OA literature that pushes the distribution. OA papers seem to be cited even more in the key fields named before, although the non-OA cited papers come from a wider variety of disciplinary fields. As for African patents, the topic distribution does not differ greatly, with the large majority in medicine and the life sciences. The social sciences remain far behind in the disciplinary contribution to

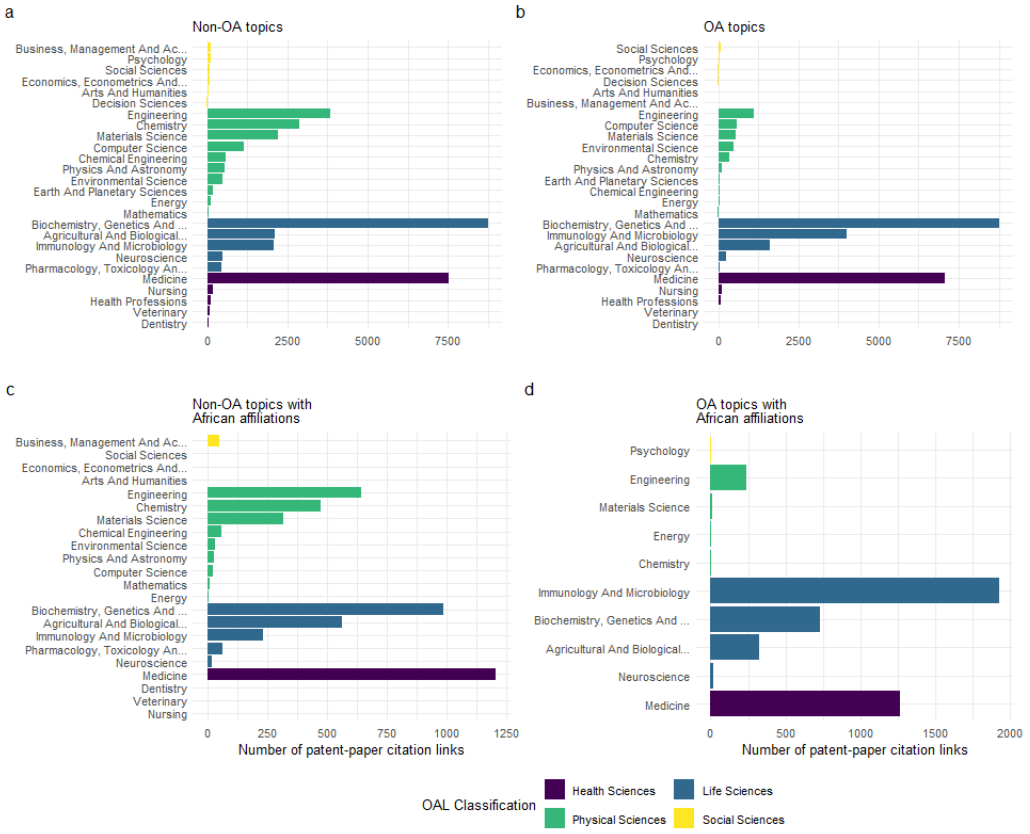

Figure 4: Topic distribution in papers cited..

patents, however, the order and proportion of fields of study seen for African-affiliated researchers differs slightly, which may suggest some more precise objects of study.

3.1.2. Open Access

Moreover, carrying on to the specific OA characteristic of the literature cited (central to the argument for OS), we find that it remains largely closed. This presents the full picture as to what literature is mostly found and used in specific fields; as noted above, a structural predisposition for non-OA may play a role for patent applicants and examiners alike. Yet, the OA dimension is relevant for fields of medicine and biotechnology, arguably the largest most research intensive and funded fields. Despite a broad trend for non-OA literature, sub-fields such as immunology and biotechnology – key political-economic areas of development for the African regions – already show an overtake of OA in patents' cited sources. We do not hypothesise on this regard but highlight the disciplinary differences that underpin our approach. That is, in most fields of study, a large share of the knowledge produced and, consequently, being cited in patents remains closed (under subscription or pay-to-read licenses). In terms of our argument, this is preliminary proof that policy declarations are still somewhat decoupled from effective OS results. Further, we only show OA vs. non-OA groups in order to more clearly present these trends.

The plots below (Figure 5) reflect the total and yearly distributions of the shares of OA papers being cited in African patents. Closed (non-OA license) is the most common access model found in the sample. It seems, however, that in recent years there has been an inverse trend where, proportionally, OA formats catch up with the non-OA – this is more clearly seen in the health sciences and in the life sciences, where field-specific journals transition into broader OA licensing schemes (with gold or hybrid formats – not shown separately; similar to the trends observed in more general contexts – see Cruz Romero & Stahlschmidt, 2025). This trend

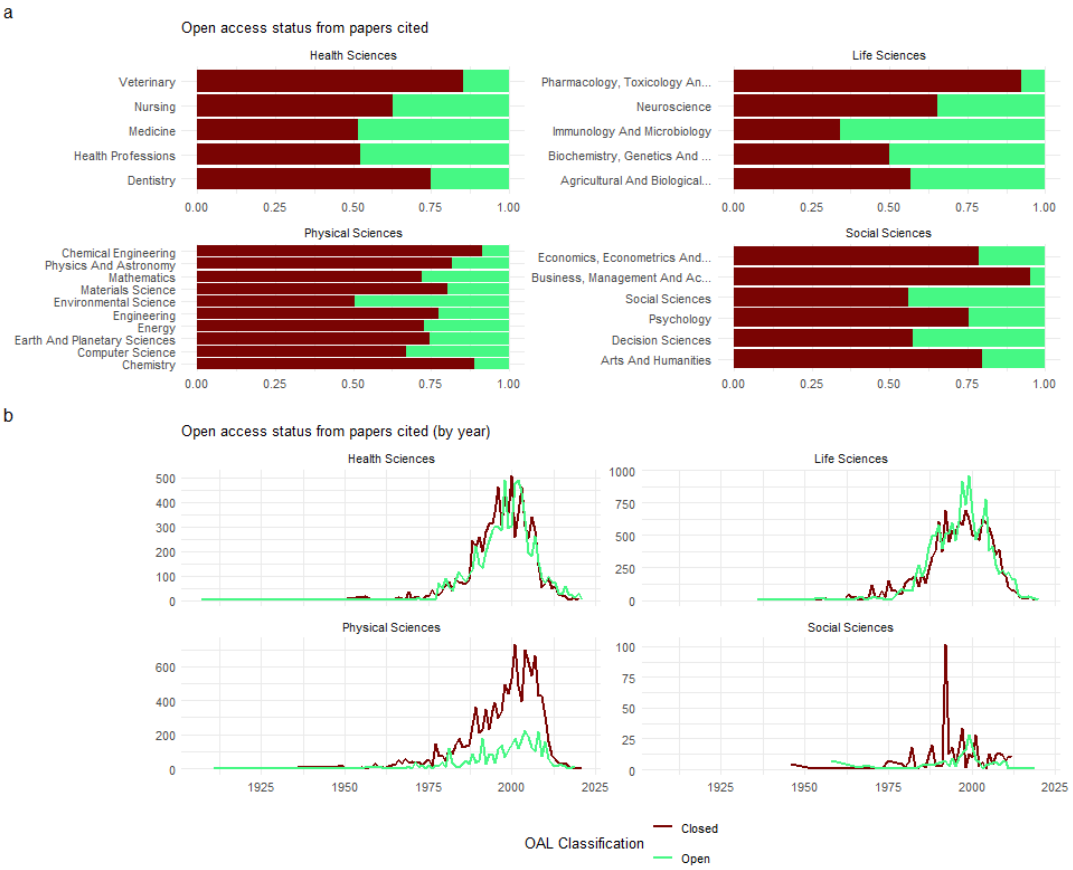

Figure 5: Open access information in papers cited.

is part of a global movement driven partly by *transformative* agreements (e.g., DEAL) and, in the case of many African countries, with the transfer effect of initiatives like Research4Life.

3.1.3. Interdisciplinarity

Now, moving to the relative difference in these fields' distribution, we focus on the concentration of fields per patent. To address this, we estimate an interdisciplinary distance measure, which takes a normalised cosine similarity and maps it on to a matrix. Fundamentally, we set this as the difference between each field's appearance in the topic distribution for each patent's cited papers (it takes the form of *Dist = 1 - norm(Cosine Similarity*) – again, as per OAL's topic classification). The goal is to estimate the degree of disciplinary differences encompassing each patent's knowledge base. The patents in the data have approximately 51 citations on average (the minimum being one and the maximum being 249, with an interquartile range of 56). This means that an important proportion of the patents cites just two or fewer papers (1,187 – over half of the patents), and around two-thirds of the patents cited ten (10) or less papers (2,185).

Interestingly, there are notable patterns relating to a clustering effect of specific subfields. For example, chemical engineering, business and accounting, and health profession seem to be the most distanced in terms of being cited within a same patent. That is, these disciplines are mostly cited alongside papers with a similar disciplinary classification. The latter hints at a strong intra-disciplinary co-citation. On the contrary, biochemistry, genetics and molecular biology appear rather close to agricultural and biological sciences, suggesting a close co-citation of papers within these fields. A similar behaviour characterises the life sciences and medicine fields. Noteworthy though, the social sciences seem to be closely related to most other fields; this may be due to misclassification or, as seen from above, business or economics papers being cited in common with medicine or

engineering papers.

Furthermore, Table 3 summarises different scores of diversity and/or concentration in the scholarly papers cited by (African) patents. We first estimate a Herfindahl–Hirschman Index (HHI) for measuring the concentration of topics across the overall distribution. Secondly, we plainly invert the HHI to link it to diversity (as per Gini-Simpson). Finally, we estimate a Rao-Stirling (RS) diversity score for the topic distribution (Stirling, 2007; cfr. Wang et al., 2015; Wang & Verberne, 2024). Both the HHI and RS scores are meant to indicate how diverse or not topics are spread across fields and, in this case, in their citations in patents. All values range 0–1. The results indicate a relative diversity; whereas the HHI (and the inverse HHI) signal to a high diversity of topics in the papers cited by patents, this must be cautiously acknowledged based on the previous insight. That is, a few fields seem to be cited almost exclusively (chemical engineering), whilst others – rather dissimilar – appear to be more closely linked. In this sense, the RS score is indicative of such phenomenon. This suggests that there is a moderate diversity possibly weighted by variety of fields (thus the apparent closeness between humanities and business and accounting, for example). Then, it seems that topic citations in

HHI	Inverse HHI	RS
0,17	0,83	0,30

Table 3: Diversity scores in patent citations

patents may be interdisciplinary and distributed across multiple fields, but those fields tend to be more related/adjacent rather than spanning highly dissimilar domains

3.2. Quantitative Insights

The second stage of our analysis is based on an inferential approach to the patent-to-paper data. This set of analysis is not restricted to African patents and their references but instead examines linkages between all scientific articles and all patents across geographic regions. Again, the empirical base for this approach is a large paper-patent citation link dataset, based on the matching for OA and non-OA articles in hybrid journals. Thus, we are interested in whether OA facilitates the knowledge flow from science to technological innovation, for example by facilitating the diffusion of open publications in general and/or by making the open publications more visible when applicants or examiners search for relevant prior art at various stages of the innovation and patenting process.

We aim to examine (1) whether OA increases the likelihood of a scientific paper being cited by patents and, more importantly, (2) how this association is stronger (or weaker) for African papers, and finally (3) how this association is stronger (or weaker) for African patents. One key feature of our empirical strategy to incorporate journal issue fixed effects. In other words, we are comparing open vs. closed access articles in the same journal issue, ruling out any differences in terms of topic, timing, journal visibility at the fine-grained journal-issue level. Following this empirical strategy, by construction, our sample restricts to hybrid journal issues where both open and closed articles are present.

Moreover, being cited by patents is a rare event, which may lead to biased estimates in traditional statistical models. Accordingly, we keep all patent-cited articles as the treatment group, and for each of them we randomly sample a non-cited one in the same journal issue for the control group, yielding a balanced dataset for analysis. As noted, this analysis is restricted to hybrid journal issues where there are both open and closed access article present. The final analytical sample consists of approximates 4.4 million articles.

3.2.1. Variables and Descriptive Statistics

Table 4 reports the descriptive statistics for each variable included in our model. The first four variables are our dependent variables; these are binary variables and represent whether a paper is cited by any patents in the USPTO or the EPO offices: *I(USPTO)*, *I(EPO)*, and if they are cited by patents from African applicants in USPTO or in EPO patents: *I(African patents in USPTO)*, *I(African patents in EPO)*, respectively. In our setting, Open Access is the key explanatory variable, more specifically, it indicates whether

a paper is open or not. We track whether a paper includes affiliations from Africa, EPO member states, or the United States: *I(African affiliation), I(US affiliation), I(European affiliation)*.[11] We also control for the number of co-authors, countries, and references, which take natural logarithm for regression analysis in order to control for large absolute differences. The specification is as follows:

$$I(Cited\ by\ patents) = \beta_0 + \beta_1 \cdot Open_Access + \beta_2 \cdot log(Countries) + \beta_3 \cdot African_Affiliation + \beta_4 \cdot US_affiliation + \beta_5 \cdot European_Affiliation + \beta_6 \cdot (Open_Access \times African_Affiliation) + \beta_7 \cdot (Open_Access \times US_affiliation) + \beta_8 \cdot (Open_Access \times European_Affiliation) + \beta_9 \cdot log(References) + \beta_{10} \cdot log(Authors) + \alpha_i + \varepsilon_i$$

Variable	Description	Obs	Mean	Std. dev.	Min	Max
I(USPTO)	Cited by USPTO patents	4425433	0.4459853	0.4970739	0	1
I(EPO)	Cited by EPO patents	4425433	0.1577769	0.3645317	0	1
I(African patents in USPTO)	Cited by USPTO patents from African applicants	4425433	0.0015551	0.0394041	0	1
I(African patents in EPO)	Cited by EPO patents from African applicants	4425433	0.0002935	0.0171302	0	1
Open Access	Open Access	4425433	0.3333807	0.4714213	0	1
I(African affiliation)	Paper with author affiliation in Africa	4425433	0.0082584	0.0904997	0	1
I(US affiliation)	Paper with author affiliation in the US	4425433	0.3559636	0.4788043	0	1
I(European affiliation)	Paper with author affiliation in Europe	4425433	0.3225750	0.4674617	0	1
Authors	Number of authors	4231022	4.8138420	7.6734200	1	2367
Countries	Number of countries	3827539	1.2059520	0.6167942	1	72
References	Number of references	4425433	30.1925200	37.3733500	0	11399

Table 4: Descriptive statistics

3.2.2. Model Specification and Regression Estimates

Table 5 shows the estimation results for 12 different specifications, three for each of the dependent variables. Each of these sub-sets include a base estimation, which only accounts for the number of references, the number of authors and the OA status. The second specification is expanded with affiliation variables, capturing the effects of researchers' geographic location. Then, the full specification includes interaction effects to test whether OA and regional affiliation have a compounded effect on the probability of being cited by patents. These different estimations make up our modelling approach, by which we try to identify the relationship that increased visibility (OA) has on a set of otherwise comparable articles (matched from the same journal issues).

In this sense, columns 1–3 show specific effects for papers being cited in USPTO patents. Because the dependent variable is binary and the model is linear, each coefficient represents the change in the probability (in percentage points) of a paper being cited, associated with a one-unit change in the corresponding independent variable, holding other covariates and journal-issue fixed effects constant. The results indicate that papers with a greater number of authors and references are more likely to be cited by USPTO patents (*Column 1*). Column 2 adds the number of countries and regional dummies. Papers originating from the United States are the most likely cited, while those from Africa are the least; papers from Europe and the rest of the world fall in between. OA generally

[11] As a short-hand, we refer to African papers (as well as USA and European papers) to those papers with at least one such regional affiliation in its author list. The same applies when we refer to patents; e.g., African patent means patent publications where the affiliation information (individual or organizations) includes an African address.

increases the likelihood of being cited by patents, even when comparing papers published in the same journal issue and controlling for the number of countries, authors and references, by approximately 4.1 percentage points ($\beta = 0.041$, $p < 0.001$). Column 3 further interacts open access with regional dummies. it shows that the positive effect of open access is particularly strong for African papers (1.5 percentage points higher than for the reference group) but weaker for US papers (1.5 percentage points lower than for the reference group), suggesting that OA enhances the translation or visibility of African science into patents.

On the specific effects for EPO patent citations, columns 4–6 reveal similar patterns. Both the number of authors and references are positively associated with the likelihood of being cited by EPO patents (Column 4–6). Column 5 adds the number of countries and regional dummies: As with USPTO citations, papers with a USA institutional affiliation remain the most likely to be cited, while papers with an African institutional affiliation remain the least. One difference is that European-affiliated papers are more likely to be cited than those from the rest of the world. The main effect of OA on EPO citation likelihood is similarly positive, increasing the probability of citation by approximately 3.8 percentage points ($\beta = 0.038$, $p < 0.001$; Column 5). Column 6 further interacts open access with regional dummies: again, the positive effect of OA is significantly stronger for African papers (3.1 percentage points higher than the reference group) and weaker for USA papers (1.8 percentage points lower than the reference group).

Further, we then turn to USPTO citations from African applicants (columns 7–9). Column 8 shows that African papers are the most likely to be cited, followed by USA papers, with European and other international papers being the least likely to receive citations. This finding reflects localized knowledge diffusion, where knowledge diffusion is stronger with geographic proximity (Jaffe et al., 1993). The positive effect of OA is smaller for USA papers, while for African, European, and other regions' papers, the effect is not significantly different. This suggests that papers with institutional affiliations in the USA already enjoy high visibility, and therefore the additional visibility conferred by OA is more limited.

Finally, results for EPO citations from African applicants (Columns 10–12) show a slightly different pattern. Column 11 shows that African papers remain the most likely to be cited, but no significant differences emerge among papers from USA, European, and the rest of the world.

	I(USPTO)			*I(EPO)*			*I(African patents in USPTO)*			*I(African patents in EPO)*		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
Open access	.044***	.041***	.047***	.034***	.038***	.047***	.090***	.101***	.150***	.035	.088	.147+
	(.001)	(.001)	(.002)	(.002)	(.002)	(.003)	(.022)	(.026)	(.042)	(.052)	(.058)	(.085)
I(African affiliation)		-.072***	-.077***		-.070***	-.081***		.672***	.707***		.883***	.888***
		(.003)	(.004)		(.006)	(.008)		(.037)	(.043)		(.051)	(.061)
I(US affiliation)		.115***	.120***		.066***	.073***		.154***	.184***		.037	.071
		(.001)	(.001)		(.001)	(.002)		(.023)	(.027)		(.045)	(.057)
I(European affiliation		.004***	.002*		.028***	.029***		.001	.006		.009	.031
		(.001)	(.001)		(.001)	(.002)		(.022)	(.026)		(.042)	(.050)
Open access x			.015*			.031*			-.133			-.017
I(African affiliation)			(.007)			(.013)			(.084)			(.096)
Open access x I(US			-.015***			-.018***			-.084+			-.078
affiliation)			(.002)			(.003)			(.044)			(.085)
Open access x			.003+			-.004			-.019			-.063
I(European affiliation)			(.002)			(.003)			(.043)			(.083)
ln(Countries)		-.055***	-.055***		-.052***	-.051***		-.118***	-.116***		-.048	-.041
		(.001)	(.001)		(.002)	(.002)		(.033)	(.033)		(.067)	(.068)
ln(Authors)	.072***	.079***	.079***	.091***	.094***	.094***	.102***	.106***	.107***	.074**	.085**	.088**
	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.012)	(.015)	(.015)	(.027)	(.032)	(.032)
ln(References)	.114***	.106***	.106***	.116***	.110***	.111***	.205***	.209***	.209***	.136***	.114***	.115***
	(.000)	(.001)	(.001)	(.001)	(.001)	(.001)	(.006)	(.008)	(.008)	(.015)	(.021)	(.021)
Journal issue fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-sq (within)	.052	.046	.046	.058	.043	.043	.133	.137	.138	.085	.176	.177
Obs	3743501	3398922	3398922	1342655	1217219	1217219	13060	11746	11746	7128	6308	6308
Journal issues	442984	427910	427910	249667	242304	242304	6332	6153	6153	6087	5449	5449
F	35292***	14315***	10032***	18957***	5329***	3729***	618***	192***	136***	47***	67***	50***

Standard errors shown in parentheses.. + p<0.1, * p<0.05, ** p<0.01, *** p<0.001

Table 5: Matched sample fixed effects linear models

The main effect of OA here is similarly large in magnitude (β = 0.088) but does not reach statistical significance. Column 12 further interacts open access with regional dummies: there are no significant regional differences in the effect of OA.

4. Discussion

Several policy norms drive the development of OS in the African continent (the African Union's *Agenda 2063* and the accompanying STISA policy as key examples). These frameworks aim to further develop the technical infrastructure needed for consolidating a vibrant OS environment – which is based on OA as its key socio-technical dimension (e.g., the *African Open Science Platform* – see Participants of African Open Science Platform Stakeholder Workshop et al., 2018). We part from this backdrop in order to characterise the innovative landscape observable through patent citations, and we argue that the knowledge transfer from scholarly articles into patents' citation structures is facilitated by a policy-driven increase in visibility and access.

From this coupling of observed trends and established norms, we observe that OA does play a role in the uptake of citations in patents. Yet, despite the underpinning comprehensive policy framework, the overall effect of increased visibility for being cited in patents becomes limited. This mismatch raises questions regarding the role of OA for the consolidation of an OS environment, particularly in a context where access to knowledge and collaborative practices could help boost and consolidate open innovation practices.

Furthermore, we assess the specific thematic directions of research articles cited in patents from African applicants and we see that these are indicative of the policy problems already acknowledged by national, regional, and supra-national entities. The collaborative efforts with other regions similarly reflect the motivations of African-affiliated scholars to interact with a global scientific system (cfr. Mwelva et al., 2020). However, problems with distribution of resources and the (non-)readiness of access infrastructure may be undermining factors (ASSAf, 2019). Despite African-based scientific articles gaining more attention for patent citations, non-OA sources remain the most cited references in patents. This is nearly cross-cutting in relation to which field is being cited, from health sciences to social sciences. Our inferential analysis also sheds light on this issue.

The incentives for the scientific production and communication (in terms of access licensing) seem to differ from those relating to the innovative R&D framework (Ahodode, 2023, cfr. Gebremariam, n.d.). That is, when we shift the citation outcome to citations from African patent applicants specifically, the OA advantage for African science disappears. African inventors cite African research regardless of OA. This pattern suggests two co-existing dynamics; first, African patent applicants already operate with heightened awareness of African research, meaning that locality and context-specific research is already important in this regard. Second, and more critically, this null finding points to the structural decoupling anticipated initially, in that the incentives governing patent-based innovation do not automatically align with the incentives governing academic OA policy (for example, see Wang et al., 2017). The normative and practical sides of OS policies enter here into a tension, which magnified by the dynamism and fast-paced rhythm of innovative research. Notably, patents also originate from a variety of research backgrounds (R&D teams, specialised offices, and small-, mid-, and large companies); these origins may contribute to an even more dispersed incentive structure, OA makes African research more visible to global inventors but does not, by itself, bridge the science–innovation pipeline within the continent. We do not delve deeper into the specific traits that make up these patterns, but our findings, both descriptive and inferential, are indicative of an underlying structure of practices.

On a more specific note, the matched regression analysis also sheds light on the academic authorship, and how it generally seems to play different roles as to whether it can make a difference in citations in patents. Our estimations, however, cannot distinguish between specific mechanisms as to how does OA operate (e.g., through lower access costs for inventors, or through enhanced search engine discoverability, to name a few). This distinction would be relevant for policy purposes given that, if the mechanism is primarily cost reduction, then institutional subscriptions and repository infrastructure (the AOSP model, for instance) could be framed as direct solutions. Yet, if the

mechanism is primarily discoverability, then metadata standards, indexing practices, and search optimisation become equally important – which are similarly dependent on infrastructural development.

For instance, in more specific terms, academic authorship in the USA appears to be rather inelastic to the visibility benefits of OA, whilst in African countries the effect suggests contrary directions, depending on the access type of the paper cited. The overarching policy implication is that there is a strong base already part-taking in international science networks and sharing globally. Thus, policy should be aimed at amplifying these ties whilst, as it has been proposed hitherto, promoting and consolidating an OS environment propelled by OA at its core. Taken together, these findings suggest that there are underlying elements pointing to a fracture between expected policy outcomes and effective R&D practices. Our goal of understanding how OA shapes OS practices and, with it, a dynamic OI framework leaves the questions of this decoupling open for future research.

There are clear limitations to our approach, mostly regarding the data itself. We do not distinguish between individual or collective (companies) patent applicants, nor between academic and non-academic sectors more broadly. Prior work has shown that scientific output from non-academic sectors carries distinct citation and impact patterns (McManus et al., 2021), suggesting the academia–industry composition of patent applicants is a relevant avenue for future work given our focus on the science–patent interface. We also omit problematising the cost dimensions of innovative research, neither for OA licenses nor for patenting processes. Similarly, our matched regression design allows us to offer only a limited scope of all cited scholarly literature, thus only permitting us to analyse this specific scope.

5. Conclusions and Outlook

In this paper we set out to characterise the open science dynamics in African patents. To do so, we parted from a general perspective, describing the African open science paradigm from its policy-driven framework. We found that a diverse set of instruments and high-level documents exist and share a common goal of broadening the access, infrastructure, and development to and of OS practices in the continent. Yet, most of the tools and documents recognise the inherent and systemic limitations imposed by a lack of resources and the still existing barriers to infrastructure interoperability.

Our descriptive-inferential approach highlights specific elements relating to the limitations noted above. Whilst, on the one side, African patents are focused primarily on areas of key interest for national and regional development, their knowledge base (citation patterns) reflects citation practices shaped by the formal patenting framework. Put otherwise, whilst OA is pursued from a policy perspective in relation to academia, there is little to connect this pretence with the innovative patent-based research process, where OA is of secondary interest.

From the inferential study we presented, we can directly answer our three research questions. First, OA significantly increases the likelihood of a scientific paper being cited by patents. Second, this effect is significantly stronger for African-affiliated papers in the general citation models. Third, however, when focusing specifically on citations by African patents, OA's effect no longer shows an additional premium for African-affiliated science. Together, these findings indicate that OA's benefit for African science operates primarily through global visibility rather than through strengthening the direct science-to-patent pipeline within Africa. We contribute to the knowledge on patents and the academic transfer into innovative and applied research, as well as on specific area studies focusing on innovation. Open questions on specific effects and mechanisms are left open for future research to explore.

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Open Access in South Africa: Quantitative and Qualitative Perspective on the Development of Research Publications and its Impact over Two Decades

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ABSTRACT

Open Access (OA) has become a key driver for improving the accessibility, visibility, and impact of scholarly communication. Despite substantial progress, significant structural and financial inequalities continue to shape its implementation, particularly in the Global South. This study investigates the long-term development of the OA transformation in South Africa between 2000 and 2022. Specifically, it examines OA publishing patterns, citation impact, language of publication, Gold OA first authorship, and the implementation of institutional OA policies.

The study combines a bibliometric analysis of Web of Science (WoS) publication and citation data with a systematic evaluation of institutional OA policies. The results demonstrate substantial growth in both publication output and OA adoption, with South Africa exceeding the global average in the proportion of OA publications. Green OA consistently achieved the highest citation impact, while institutions with formal OA policies showed greater improvements in research impact than institutions without such policies. At the same time, high article processing charges and limited international visibility of Diamond OA journals remain important barriers to equitable participation.

By integrating bibliometric evidence with policy analysis, this study provides one of the first comprehensive assessments of the long-term development of OA in South Africa. It contributes empirical evidence on how different OA pathways and institutional policies influence research visibility and impact in a Global South context. The findings suggest that strengthening Green OA, improving the sustainability and international discoverability of Diamond OA, and promoting fair publishing agreements are key strategies for supporting an equitable and effective OA ecosystem.

Open Access (OA) hat sich zur zentralen Triebfeder für die Verbesserung der Zugänglichkeit, der Sichtbarkeit und des Impacts wissenschaftlicher Kommunikation entwickelt. Trotz erheblicher Fortschritte ist die Umsetzung von OA nach wie vor von erheblichen strukturellen und finanziellen Ungleichheiten geprägt, insbesondere im Globalen Süden. Diese Studie untersucht die langfristige Entwicklung der OA-Transformation in Südafrika im Zeitraum von 2000 bis 2022. Konkret werden darin das Publikationsverhalten im Bereich Open Access, der Impact von Zitierungen, die Veröffentlichungssprachen, die Erstautorschaft bei Veröffentlichungen in Gold-Open-Access-Zeitschriften sowie die Umsetzung institutioneller Open-Access-Richtlinien untersucht.

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Die Studie verbindet eine bibliometrische Analyse der Publikations- und Zitationsdaten aus dem „Web of Science" (WoS) mit einer systematischen Auswertung der institutionellen Open-Access-Richtlinien. Die Ergebnisse zeigen einen erheblichen Anstieg sowohl beim Output an Publikationen als auch bei der Nutzung von Open Access, wobei Südafrika beim Anteil der Open-Access-Publikationen über dem weltweiten Durchschnitt liegt. Green OA erzielte durchweg den höchsten Zitations-Impact, während Institutionen mit formellen OA-Richtlinien größere Verbesserungen in Bezug auf den Impact von Forschungsleistungen verzeichneten als Institutionen ohne solche Richtlinien. Gleichzeitig stellen hohe Publikationsgebühren und die begrenzte internationale Sichtbarkeit von Diamond-Open-Access-Zeitschriften weiterhin erhebliche Hindernisse für eine gerechte Teilhabe dar.

Durch die Verknüpfung bibliometrischer Belege mit der Analyse zu Open-Access-Richtlinien liefert diese Studie eine der ersten umfassenden Bewertungen der langfristigen Entwicklung von Open Access in Südafrika. Sie liefert empirische Belege dafür, wie verschiedene Open-Access-Modelle und institutionelle Richtlinien die Sichtbarkeit und den Impact von Forschung im Kontext des Globalen Südens beeinflussen. Die Ergebnisse deuten darauf hin, dass die Stärkung von „Green OA", die Verbesserung der Nachhaltigkeit und der internationalen Auffindbarkeit von „Diamond OA" sowie die Förderung fairer Publikationsvereinbarungen zentrale Strategien zur Unterstützung eines gerechten und effektiven Open-Access-Ökosystems sind.

KEYWORDS

Open Access, bibliometrics, research policy, publication impact, Global South, South Africa

Open Access, Bibliometrie, Forschungsstrategie, Publikations-Impact, Globaler Süden, Südafrika

1. Introduction

Since its inception, the Open Access (OA) movement has been working towards better international scholarly exchange. Thus, this leads to improving the findability and visibility of scholarly research, increasing citation rates, and promoting (inter)national cooperation. Nevertheless, high article processing charges (APCs) charged by commercial international publishers have led to imbalances in the publication and citation process of scientific findings–particularly at the expense of researchers not affiliated with institutions, early-career researchers and countries with limited resources (Vervoort et al., 2021).

In South Africa, limited funding, unequal internet access, lack of awareness, APC-based barriers imposed by publishers, questions about copyrights and a lack of guidelines are challenging the transition from the traditional subscription model to OA (Kodua-Ntim & Fombad, 2024; Czerniewicz & Goodier, 2014; Piron, 2023). Despite the challenging circumstances, South Africa is considered a pioneer in the development of regional OA platforms such as SciELO SA (https://www.scielo.org.za/), AmeliCA (https://amelica.org/index.php/en/home/) and the African Open Science Platform (https://aospea.org/).

The project "Die Wirksamkeit von Open Access im Globalen Süden erforschen – Erkenntnisse in die gelebte Praxis der TH Köln beispielhaft umsetzen (WO–TH K)" (Exploring the impact of open access in the Global South – implementing findings in the practical work of the TH Köln [WO–TH K])[2] therefore examines the effects and institutional measures for OA in South Africa. The aim is to provide an overview of the effects discussed in the literature, regional measures and empirical findings on the OA landscape–for example, on citation impact.

In this context, the following six research questions were developed specifically in relation to OA in South Africa:

[2] The project aims to achieve two key objectives: (1) To research the effectiveness of OA in the Global South (GS), particularly in Brazil, Mexico and South Africa, in order to compare it with the situation in Germany. (2) To implement the findings into the practice of promoting OA at the TH Köln and to examine their applicability to other universities.

(RQ1) How did research activity in South Africa (publication output) develop during the observation period from 2000 to 2022?

(RQ2) What is the impact of research in South Africa based on classic bibliometric citation indicators, and how has this developed over the observation period?

(RQ3) Which international journals does South Africa have access to?

(RQ4) In which language do authors in South Africa predominantly publish?

(RQ5) What is the proportion of Gold OA first authorships among South African researchers?

(RQ6) How has the institutional implementation of OA policies developed over time, and how does it align with data-driven trends in OA?

The article is divided into five chapters: this introduction, an overview of the current state of research, the study design, the results of the data evaluation and the policies, and our implications with the conclusion.

2. State of Research

According to Hulin (2024), South Africa is regarded less as a producer of scientific research publications and more as a consumer. This is not due to a lack of quality in the research, but rather to its lack of visibility. A study by Czerniewicz & Wiens (2013) shows that South African research was virtually invisible in search engines for a long time. However, OA can significantly increase the visibility and reach of research findings (Piwowar et al., 2018; Robinson-Garcia et al., 2020). Accordingly, OA is highly regarded in South Africa, as evidenced by numerous national and institutional initiatives. In the same year, South Africa joined the SciELO programme and published its own national collection from 2013 onwards. Since 2015, the National Research Foundation (NRF) has mandated that all government-funded projects must publish their research findings in OA. The Department of Science, Technology and Innovation (DSI) enshrined this requirement in law. In addition, the AfricArXiv preprint repository was founded in 2018. With 52 institutional repositories (OpenDOAR), South Africa occupies a leading position in Africa in the field of OA (Ezema & Onyancha, 2017b; Fox & Hanlon, 2015). As a result, South Africa's contribution to the global research output is around 1% in 2024 (Hulin, 2024), with universities accounting for approximately 90% of national publications. Around half of the publications indexed in the WoS on innovations in Africa appear in OA (Jauhiainen & Ouma Mugabe, 2024). The leaders in OA publishing in South Africa are the Stellenbosch University, the University of Cape Town, the University of KwaZulu-Natal, the University of Pretoria and the University of the Witwatersrand (Raju et al., 2015). Green OA dominates, while Diamond OA is only slightly prevalent, accounting for around 7–9% (Hulin, 2024). According to Czerniewicz & Goodier (2014), the reason for the dominance of the green route is that it is more cost-effective and enables greater visibility despite limited financial resources. As research currently stands, there is a lack of a comprehensive analysis of the data-driven trends in scientific output in South Africa over time, particularly with regard to the shift towards OA, i.e. the changing proportion of subscription-based publications and OA publications. The following research question emerges from this gap in literature:

(RQ1) How did research activity in South Africa (publication output) develop during the observation period from 2000 to 2022?

In addition to increased visibility, OA has an effect on the impact of research publications. While numerous studies support the idea of an open access citation advantage (OACA), the extent of this advantage varies (Wagner, 2010; McCabe & Snyder, 2014; Archambault et al., 2014; Tennant et al., 2016; Bautista-Puig et al., 2020). However, other research has found no significant citation benefit from OA alone (Dorta-González et al., 2017), instead highlighting factors such as selection bias and the advantages of early access to preprints (Moed, 2007; Craig et al., 2007). Consequently, it remains challenging to establish broad generalisations regarding the existence of OACA (Swan, 2010; McCabe & Snyder, 2014; Langham-Putrow et al., 2021). Furthermore, the studies conducted either focus on Africa as a whole, showing a clear OA citation advantage (Ezema & Onyancha, 2017a; Ajibade & Muchaonyerwa, 2023; Onyancha et al., 2024), or on individual South African journals. For instance, the transition of the South African Journal of Business Management

to OA resulted in an 8% increase in citations (Skelly, 2023). Studies by Verma & Sonkar (2021) identified the South African Medical Journal, HTS Theological Studies, PLOS One, and others as journals with a particularly high impact. However, there is a lack of extensive, differentiated studies on the development of OA in South Africa. This therefore raises the following question:

(RQ2) What is the impact of research in South Africa based on classic bibliometric citation indicators, and how has this developed over the observation period?

Another factor contributing to the increased visibility of research results is access to established international journals, as well as the growing number of open-access journals. OA has also contributed to the emergence of new structures within the publishing landscape, including the establishment of new journals, thereby influencing researchers' publication behaviour. Teixeira da Silva et al. (2019) stated that many African researchers prefer to publish in international journals with a high impact factor in order to increase their own impact and, consequently, their h-index. Local journals are mainly chosen for their regional relevance or SAPSE accreditation (Beer, 2005). With currently 169 titles, South Africa ranks second in Africa (Directory of Open Access Journals [DOAJ]: as of October 2025). Local journals typically provide free access and charge none or significantly lower APCs than international journals, such as PLOS One[3], whose APCs are essentially unaffordable for many researchers in the Global South (Czernie**wicz & Goodier,** 2014; Dijkstra et al., 2017). There is a lack of empirical research examining how the publication behaviour of South African researchers has changed in the context of OA. In particular, it remains unclear whether access to international journals has increased and whether this has, in turn, led to a greater tendency to publish in international journals. This gives rise to the following research question:

(RQ3) Which international journals does South Africa have access to?

Another important factor is the language used in scholarly publications, which can act as a barrier. English dominates around 94% of all WoS publications worldwide. In South Africa, the vast majority of OA journals indexed in the DOAJ also predominantly accept English submissions, with limited representation of Afrikaans, Xhosa, Southern Sotho, Venda and Zulu (Hulin, 2024). In fact, all OA journals are published in English, with only 21 accepting articles in Afrikaans and just two accepting articles in Xhosa (Hulin, 2024). Despite South Africa's lead in having 18 LOTE (Languages Other Than English) journals in Africa, only 16 research articles in the country's official languages were published between 2000 and 2020 (Naidoo et al., 2024). Institutional repositories also reflect this trend, with only 15 universities hosting Afrikaans documents (Bangani, 2018). An analysis of open science publications in Africa indexed in Scopus reveals that nearly 99% are published in English (Ankamah et al., 2025). However, this analysis was based on a limited data set of just 302 publications. Previous studies of language distribution have either focused on journal level or repository level. There is a lack of meaningful insights based on extensive publication data analysed over time, which raises the subsequent question:

(RQ4) In which language do authors in South Africa predominantly publish?

Apart from the aforementioned advantages of greater visibility and impact of OA publications, the transition to OA also has its drawbacks. In particular, publishing in internationally recognised Gold OA journals involves financial barriers, as Gold OA requires authors to pay article processing charges (APCs). Between 50% and 75% of Gold OA journals depend on APCs (Robinson-Garcia et al., 2020). In 2021, the first transformative agreements were concluded by SANLiC[4]. In particular, researchers from the Global South (GS) face considerable disadvantages compared to those in the Global North (GN), struggling to secure institutional funding or financial grants to cover APCs. Although some publishers grant waivers under transformative agreements for low- and middle-income countries, South Africa, as an upper-middle-income country, is usually excluded–only two universities receive discount on article processing charges (APC) for their publications with Springer Nature (Patronella Zulu & Twum-Darko, 2023). One possible approach to covering the APCs is to

[3] The average APCs for PLOS One are USD 2,382: https://plos.org/fees/.
[4] South African National Library & Information Consortium: https://sanlic.ac.za/.

enter into co-authorship arrangements with researchers from institutions or countries with greater financial resources. In a survey by Gallardo et al. (2024) 87% of the researchers surveyed from South Africa reported using co-authorship to share APC costs. For example, South African researchers had a higher share of payments by international co-authors (5.6%). Nevertheless, authors from the GS/periphery countries continue to pay APCs as frequently as their counterparts in Western countries (Kieńć, 2017). However, as research currently stands, there is a lack of data-based evidence showing a potential increase in co-authorship, which raises the following question:

(RQ5) What is the proportion of Gold OA first authorships?

The transition to OA is shaped by developments at multiple levels, including those of individual researchers, national governments, and research institutions. Therefore, the implementation of OA policies at both national and institutional levels represents a key mechanism for guiding this transformation. They provide the framework outlining the rights and responsibilities associated with the implementation of OA at institutions (Franz & Kindling, 2025; Huang et al., 2020). To date, there is a lack of research that compares the OA transition from the perspective of institutional measures with a publication data-based perspective on researchers' publishing behaviour. Accordingly, the following research question addresses this gap:

(RQ6) How did the implementation of OA policies at research institutions develop over time, and does this reflect the data-driven development of individual OA initiatives?

3. Study Design

Bibliometric indicators - particularly publication and citation metrics - serve as internationally recognised measures for research evaluation (Tunger et al., 2021; Palomares-Montero & García-Aracil, 2011) and therefore form the basis of the analysis of South African research. However, simple indicators such as the h-index or citation rate (CPP) do not adequately capture the complexity of scholarly communication because they do not account for structural differences or heterogeneous publication and citation behaviour across countries, institutions and disciplines. To enable fair comparisons, normalised indicators were therefore employed. Subject- and journal-based normalisation compensates for structural differences. While subject normalisation requires the assignment of publications to subject categories—which is challenging due to the lack of coherent disciplinary boundaries and the limited granularity or multiple assignment WoS categories—journal-based normalisation according to Archambault et al. (2011) provides a more robust basis for comparison. Accordingly, the weighted J-factor (Ball et al., 2009) was used as the principal impact indicator. It compares the citation rate of publications from a research institution with the average citation rate of publications of the same document type published in the same journal and the same year. A J-factor of 1 (100%) therefore indicates citation performance equivalent to the journal average all over the world.

The bibliometric evaluation was based on publication records retrieved from the WoS, one of the leading multidisciplinary citation databases, using a local installation of it: access to the database was provided by the Competence Centre for Bibliometrics, which also offers access to Scopus; however, both databases overlap by approximately 90% at the document level (Ball & Tunger, 2006). The analysis covered the period from 2000 to 2022 and included all publications with at least one author affiliated with a South African research institution. To ensure a consistent and comparable dataset, only scholarly document types relevant to research communication were included (document type "Article"), whereas non-scholarly publication types were excluded (e.g. document types "Proceedings Paper" or "Conference Abstract"). Based on these data, publication output, the proportion of OA publications, Gold OA first authorship and the weighted J-factor were calculated on country level to analyse temporal developments and research impact.

The analytical workflow comprised four consecutive steps. First, bibliographic records were extracted and prepared for analysis, i.e. the standardisation of institution names. Second, publications were classified according to their OA type assigned by using the WoS OA classification, distinguishing between Gold, Green, Hybrid, Bronze and Closed Access publications. Third, based on these data, publication output, the proportion of OA publications, Gold OA first authorship and

the weighted J-factor were calculated for the observation period.

Finally, the bibliometric findings were complemented by an evaluation of institutional OA policies in South Africa. The Registry of OA Repository Mandates and Policies (ROARMAP)[5] served as the primary source for identifying institutional policies and was supplemented by systematic searches of the websites of all South African universities and publicly funded research institutions to ensure the broadest possible coverage. Only officially adopted and publicly accessible OA policies were included. The policy analysis examined implementation dates, policy content and implemented OA measures. By combining bibliometric analysis with institutional policy evaluation, the methodological approach provides a transparent and reproducible framework for assessing the long-term development and impact of OA in South Africa.

4. Results of the Quantitative Analysis and Evaluation of the Policies

4.1 How did research activity in South Africa (publication frequency) develop during the observation period from 2000 to 2022?

The following section shows the development of the total publications in the WoS overall and in South Africa, alongside the proportion of OA publications. First, Figure 1 illustrates the temporal development of publications in the WoS overall and in South Africa between 2000 and 2022.

The evaluation of the WoS data shows a significant increase in publication activity during the observation period–both worldwide and in South Africa. Globally, the number of recorded

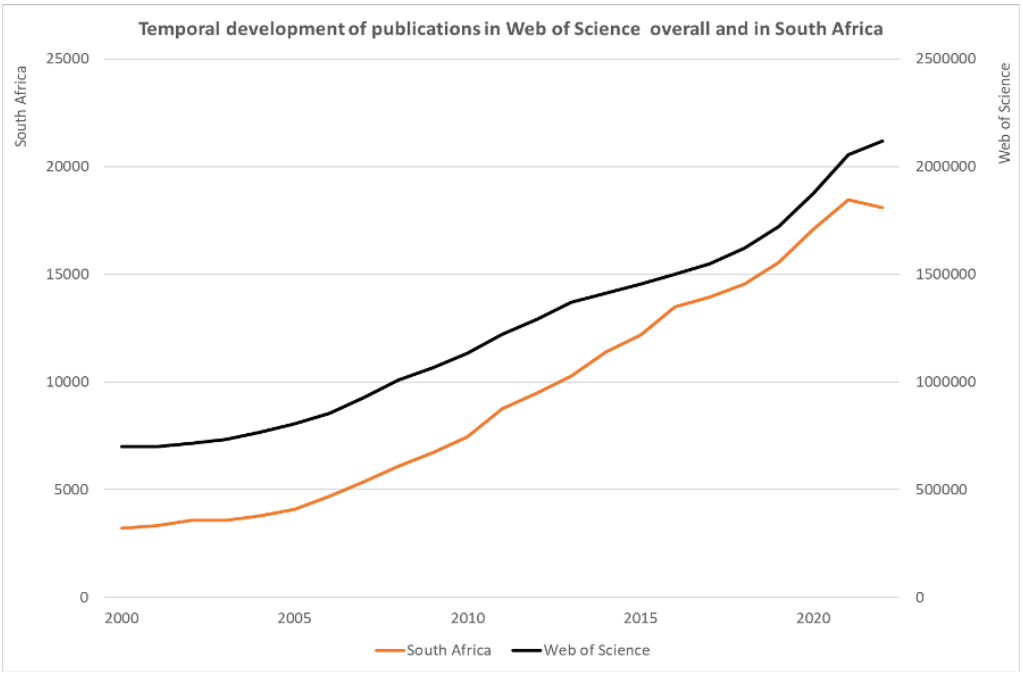

Figure 1: Temporal development of publications in the WoS overall and in South Africa between 2000 and 2022.

publications grew from around 700,000 (2000) to over 2.1 million (2022). South Africa's publications recorded a continuous, sometimes disproportionate growth: rising from 3,219 (2000) to a peak of 18,472 (2021), followed by a slight decline to 18,085 (2022). Both curves run largely parallel to each other and indicate a similar growth trend. Noteworthy is South Africa's stronger relative increase compared to the global average: The national share of all WoS publications has increased from 0.45% to 0.85%, almost doubling. The following section examines, in Figure 2, the development of OA publications published between 2000 and 2020 in South Africa, using global OA publications as a benchmark for comparison.

[5] This international register documents the OA requirements of research institutions. ROARMAP enables research institutions to register their OA policies and list specific details, e.g. date of introduction and individual measures. It subsequently uses this information to map the development of OA policy implementation worldwide on a country-specific basis, as well as the percentage introduction rate.

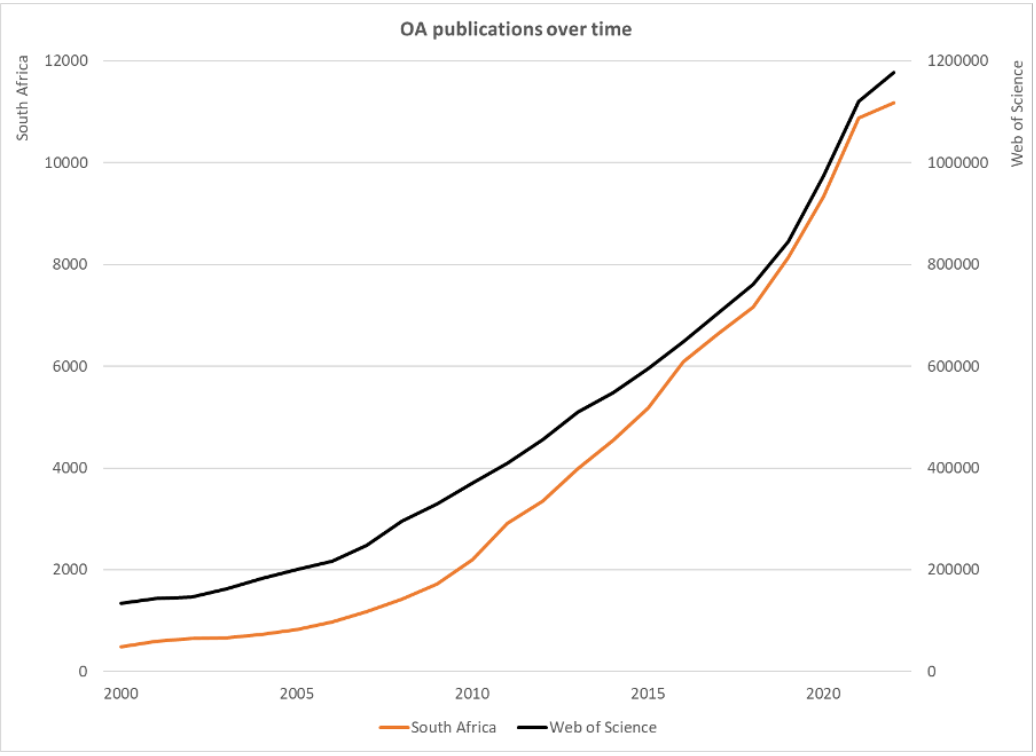

Figure 2: Development of OA publications between 2000 and 2020.

In the period between 2000 and 2022, OA publications increased significantly both in South Africa and worldwide, with an exponential trend in some cases. In South Africa, the number grew from 491 (2000) to 11,180 (2022). Globally, the number of gold OA publications increased from around 20,000 to around 700,000 during the same period. While South Africa grew relatively strongly, especially between 2010 and 2018, the global increase accelerated from 2018 onwards and exceeded South Africa's absolute growth. Since then, the curves have exhibited a near-parallel trajectory–an indication of a globally driven dynamic in the expansion of Gold OA.

The OA share over time (OA publications as a share of all publications from the country in the WoS) shows a continuous and significantly increase for South Africa: from around 15% (2000)–compared to around 20% worldwide–to 62% (2022). Since 2010, South Africa has consistently maintained a higher share than the WoS total. Figure 3 illustrates the temporal

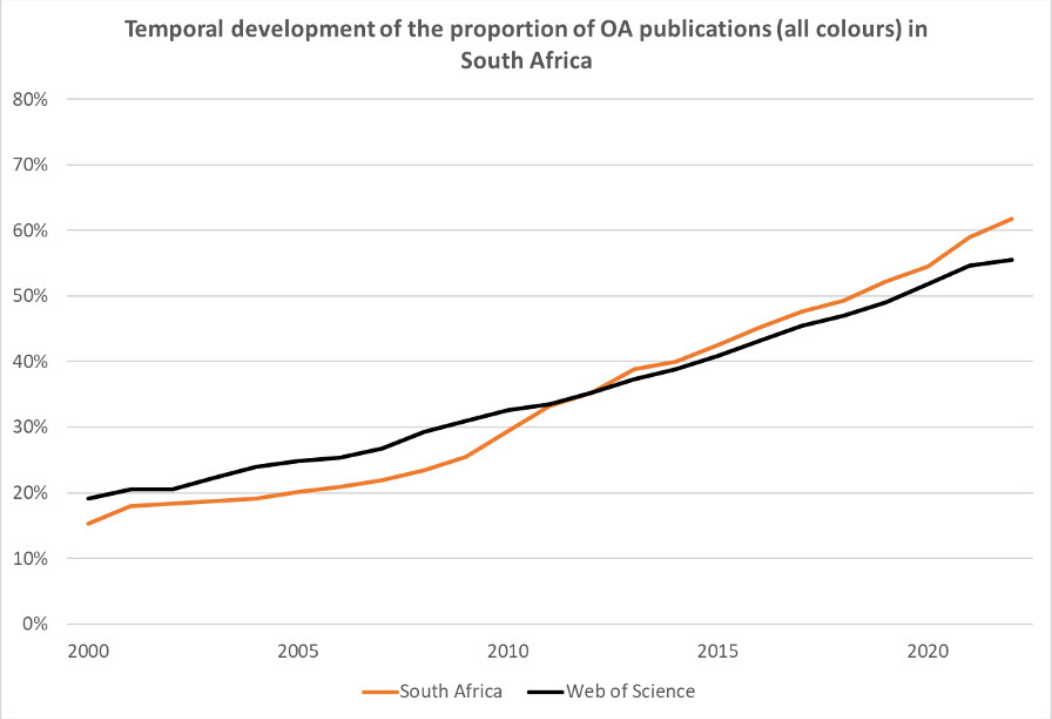

Figure 3: Temporal development of the proportion of OA publications (all colours) in South Africa.

development of the percentage shares of OA publications in South Africa and worldwide. The differentiation according to OA ways reveals varying conditions, costs and visibility: Gold OA is frequently associated with high APCs, especially in WoS- or Scopus-listed journals, which offer the highest visibility. Therefore, the Gold OA share is an important indicator. Until 2007, South Africa followed the global trend (0.5% → 3.5%). Since 2008, the trend decoupled: by 2022, the Gold OA share had risen to approximately 40% of all journal publications (global 33%). Thus, South Africa has been publishing successfully and visibly in WoS journals, despite the high APCs. Green OA publications are more widespread than Gold OA publications throughout the duration of the studied period, and in 2022 reached a share of around 50%, although the momentum has slowed in recent years. Nevertheless, this applies to both Gold and Green, South Africa's share exceeds the corresponding WoS benchmark. Figure 4 shows the individual shares of Gold OA and Green OA publications in South Africa and worldwide.

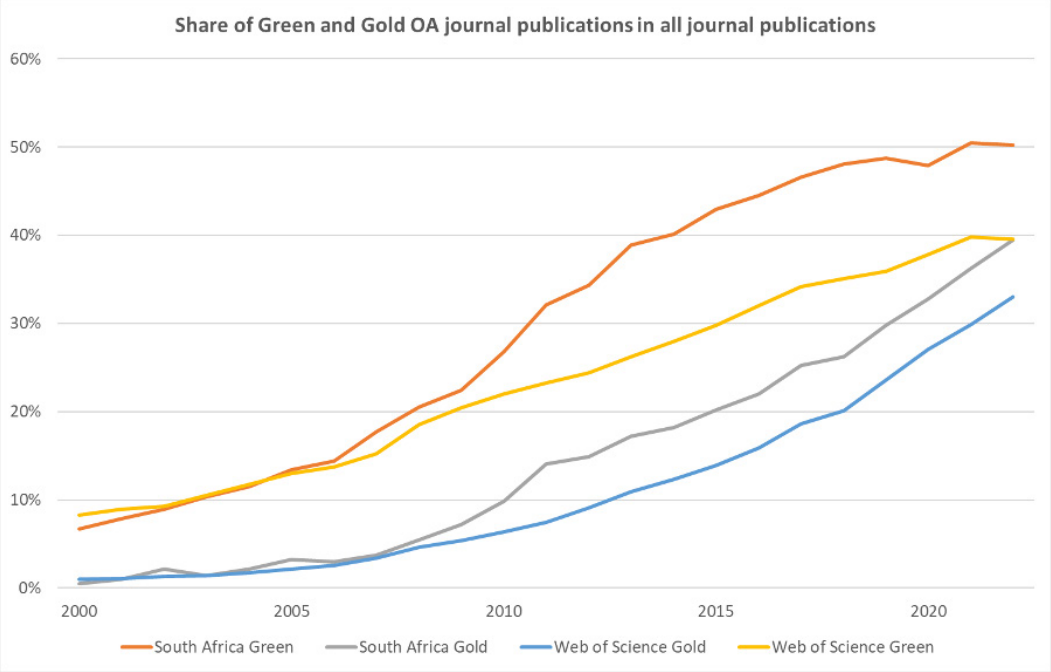

Figure 4: Share of Green and Gold OA journals publications in all journal publications.

The following section begins by examining the overall shares of the individual OA models within the WoS over the period from 2000 to 2024: the distribution of publication models in the Web of Science changed substantially between 2000 and 2024 (Figure 5). At the beginning of the observation period, scholarly publishing was dominated by Closed Access, accounting for approximately 80% of all publications. Over time, however, its share declined continuously, reaching around 44% by 2024. Despite remaining the single largest publication model, Closed Access was no longer the dominant model of dissemination when all OA models were considered collectively.

This development was primarily driven by the increasing adoption of Gold and Green OA. Gold OA remained negligible until the mid-2000s but expanded rapidly from around 2008 onwards, reaching approximately one quarter of all publications by the early 2020s. Green OA also exhibited sustained growth throughout the entire observation period, increasing from less than 10% in 2000 to nearly 20% by 2024. Together, these two models account for the majority of the overall increase in OA publishing.

In contrast, Bronze OA followed a different trajectory. While it represented a comparatively large share of publications at the beginning of the study period, its importance gradually diminished over time, falling to only a small proportion of the total output by 2024. Hybrid OA, although almost absent in the early years, increased steadily from the 2010s onwards and reached approximately 10% of all publications by the end of the observation period.

Overall, the results illustrate the profound transformation of scholarly communication over the past two decades. The continuous decline of Closed Access and the simultaneous expansion of the different OA models demonstrate the ongoing transition towards a publication system in which openly accessible research has become the predominant form of scientific dissemination. The slight increase in the proportion of Closed Access publications observed in 2024, accompanied by a corresponding decline in Gold OA, may indicate a temporary shift in publishing patterns rather than a reversal of the long-term trend. In Figure 5 we examine the proportion of each OA model in the WoS over time.

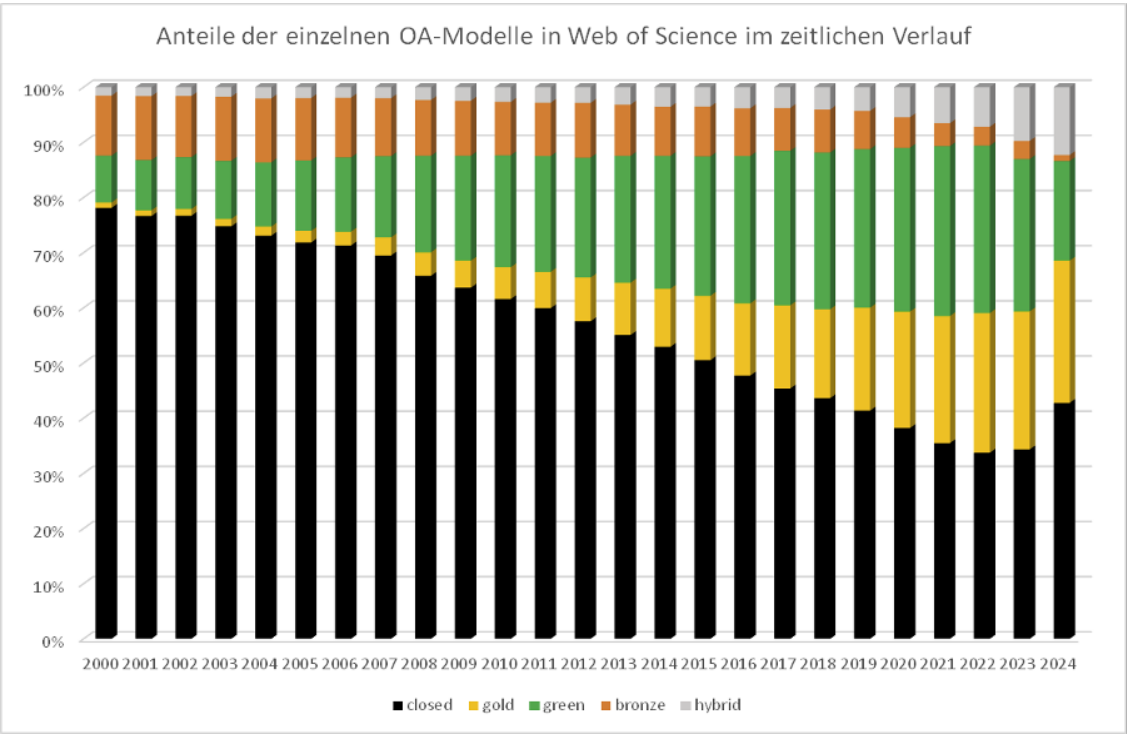

Figure 5: The proportion of each OA model in Web of Science over time.

Compared with the global trend shown in Figure 5, South Africa exhibits a substantially faster transition towards OA publishing (Figure 5a). While Closed Access remains the largest publication model worldwide in 2020, accounting for approximately 40% of all WoS publications, its share in South Africa has already declined to less than 30%. Consequently, OA becomes the dominant publication model considerably earlier and more pronounced in South Africa than at the global level. Although both figures demonstrate a continuous shift from subscription-based publishing towards OA, the South African publication system adopts this transition at a significantly higher pace. In contrast, Figure 5a examines the development of the individual relative OA shares over time in South Africa. The composition of OA also

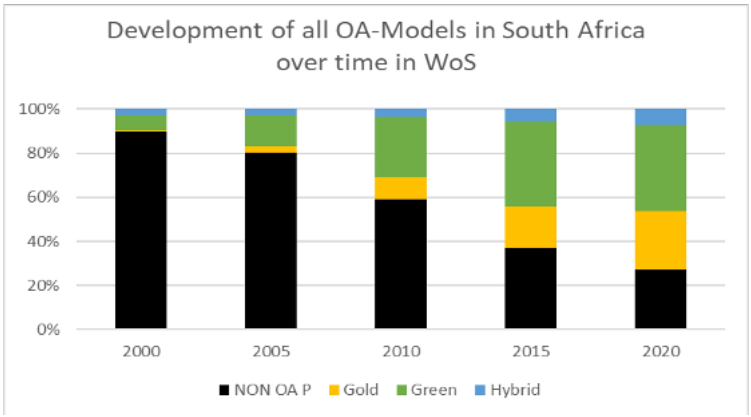

Figure 5a: Development of all OA models in South Africa over time in WoS.

differs between the global and the South African publication landscape. Whereas the worldwide increase in OA is driven by both Gold and Green OA, with Green OA remaining slightly below one fifth of all publications, South Africa is characterised by a particularly strong expansion of Green OA. By 2020, Green OA accounts for approximately 40% of all publications, making it the dominant OA model in the country. Gold OA also increases steadily and reaches around one quarter of all publications, while Hybrid OA remains of comparatively minor importance. These findings suggest that the growth of OA in South Africa has been driven primarily by repository-based dissemination, complemented by increasing publication in Gold OA journals, resulting in a substantially higher overall level of OA than observed in the global publication system.

4.2 What is the research impact in South Africa based on classic bibliometric citation indicators, and how has this developed over the observation period?

The impact of OA in South Africa is examined from several perspectives using the normalised journal factor (J-factor). Initially, an institutional comparison of the development of OA and closed publications demonstrates the impact of publications grew during the period 2000–2020, in line with a rising productivity. The calculation of the J-factor is based on a large volume of data, whilst as an indicator it is both very robust and resistant to fluctuations. For this reason, the J-factor is calculated only for every fifth year of publication, starting with the first year of observation in this study, namely 2000. As the J-factor is calculated at five-year intervals, its observation period ends, somewhat unusually, in 2020. The overall impact increased by around 12%. OA impact grew at an above-average rate of around 18%, while the impact of closed publications remained virtually stagnant over the period (+2%). Thus, OA publications generate higher overall impact, thereby confirming the positive effect of increased visibility. The following Figure 6 shows the development of the weighted J-Factor of all research institutions over time for OA publications vs. closed publications.

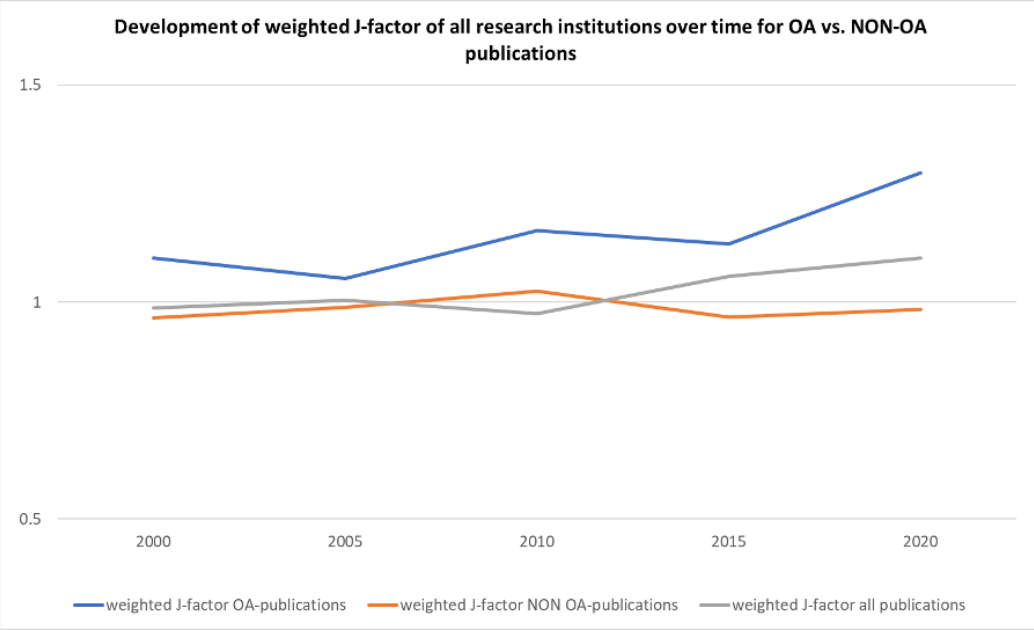

Figure 6: Development of weighted J-factor of all research institutions over time for OA vs. closed publications.

The following section differentiates and explains the development according to OA routes: in the period between 2000 and 2005, the impact of Gold OA publications increased by approximately 35%, whilst the impact of Green OA publications declined by around 7%. From 2005 to 2010, the impact of both OA routes increased (Green OA +11%, Gold OA +17%). From 2015 onwards, the impact of Green OA increased by 18%, while Gold OA remained virtually stagnant (~+1%). Overall, Green OA generated the higher impact over the entire period–plausibly due to multiple distribution channels (journal website and repository). Figure 7 shows the development of weighted J-factors of all research institutions over time for Green OA vs. Gold OA publications.

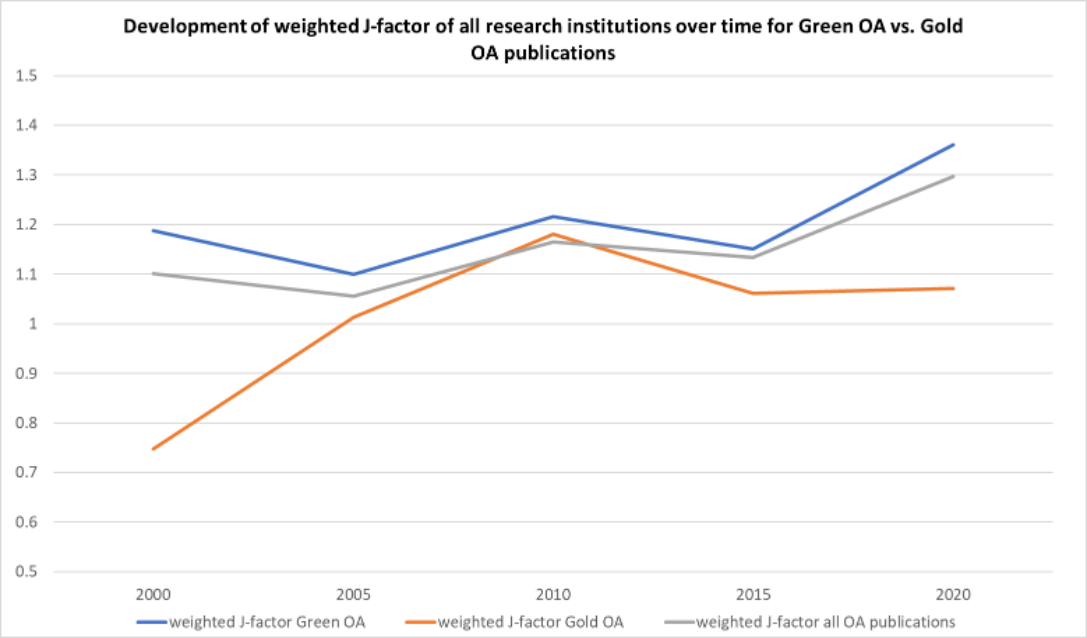

Figure 7: Development of weighted J-factors of all research institutions over time for Green OA vs. Gold OA publications.

4.3 Which journals does South Africa have access to?

There have been fundamental changes in South Africa's publication behaviour over the last 20 years: newly founded journals, particularly those that publish OA, now dominate WoS publications. PLOS One–one of the largest interdisciplinary OA journals–emerged as the most prolific publisher in 2022, with a total of 284 publications, closely followed by Sustainability with a publication count of 239. All works in which South Africa is listed as the institutional affiliation of at least one author were counted, regardless of the first authorship. The analysis of the top journals and other titles shows that South Africa has access to high-ranking WoS journals and regularly publishes in them, especially in OA journals. This provides the country with a solid basis for international visibility. Table 1 presents the top 10 journals by publication count for South Africa in the WoS in 2000 and 2022.

Journal	2000	2022
SOUTH AFRICAN JOURNAL OF SCIENCE	**101**	88
SOUTH AFRICAN MEDICAL JOURNAL	**77**	0
WATER SA	**54**	26
MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY	**29**	175
BOTHALIA	**28**	9
JOURNAL OF THE SOUTH AFRICAN INSTITUTE OF MINING AND METALLURGY	**28**	0
SOUTH AFRICAN JOURNAL OF PSYCHOLOGY	**27**	20
ONDERSTEPOORT JOURNAL OF VETERINARY RESEARCH	**25**	8
SOUTH AFRICAN JOURNAL OF WILDLIFE RESEARCH	**25**	0
AFRICAN ENTOMOLOGY	**24**	7
JOURNAL OF THE SOUTH AFRICAN VETERINARY ASSOCIATION-TYDSKRIF VAN DIE SUID-AFRIKAANSE VETERINERE VERENIGING	**24**	0

Journal	2000	2022
PLOS ONE	0	**284**
SUSTAINABILITY	0	**239**
INTERNATIONAL JOURNAL OF ENVIRONMENTAL RESEARCH AND PUBLIC HEALTH	0	**236**
SCIENTIFIC REPORTS	0	**207**
MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY	29	**175**
HTS TEOLOGIESE STUDIES-THEOLOGICAL STUDIES	0	**173**
ENERGIES	0	**123**
SOUTH AFRICAN JOURNAL OF BOTANY	19	**121**
BMJ OPEN	0	**112**
MOLECULES	0	**111**

Table 1: Top 10 journals by publication count from South Africa in the WoS in 2000 and in 2022

The comparison of the top ten journals in 2000 and 2022 reveals a substantial shift in publication venues. In 2000, the leading journals published between 24 and 101 papers and included many locally or nationally oriented journals. By 2022, publication output had become concentrated in considerably larger journals, led by PLOS ONE (284), Sustainability (239), International Journal of Environmental Research and Public Health (236), and Scientific Reports (207). Several of these major publication venues had emerged or expanded in the context of the growth of OA publishing and recorded no publications in the dataset in 2000. At the same time, several journals prominent in 2000 had disappeared from the publication output by 2022. Overall, the comparison indicates a shift from smaller, often local or national publication venues towards larger, internationally oriented journals, many of them associated with the expansion of OA publishing.

4.4 In which language do authors in South Africa predominantly publish?

National languages play an ambivalent, yet strategically relevant role in the OA context. In terms of international visibility, English continues to dominate: English publications in high-ranking OA journals–especially Gold OA–achieve a larger audience reach, higher citation impact and enhanced visibility in global databases (WoS, Scopus).
However, the intensity of the preference for the English language can vary depending on the subject areas, especially in more regionally oriented subject areas. OA publications in the national language also strengthen social participation. Nevertheless, if they are not included in international journals but are indexed on national/regional platforms such as SciELO (Collection South Africa) or in university repositories, this can lead to a separation from the international discourse if comprehensive indexing does not take place.

An examination of the development in the WoS and SciELO reveals that in 2000, 94% of all publications were in English, and by 2022 this figure had risen to 98.8%. Even SciELO, which started in 2005 with a comparatively modest proportion of English publications (approximately 20%), has since witnessed a significant increase. Publishing in English is therefore effectively necessary for achieving international visibility; whereas publications in national languages primarily address local communities, and are often indexed by regional platforms. Figure 8 illustrates the development of the language shares in SciELO and the WoS between 2000 and 2020.

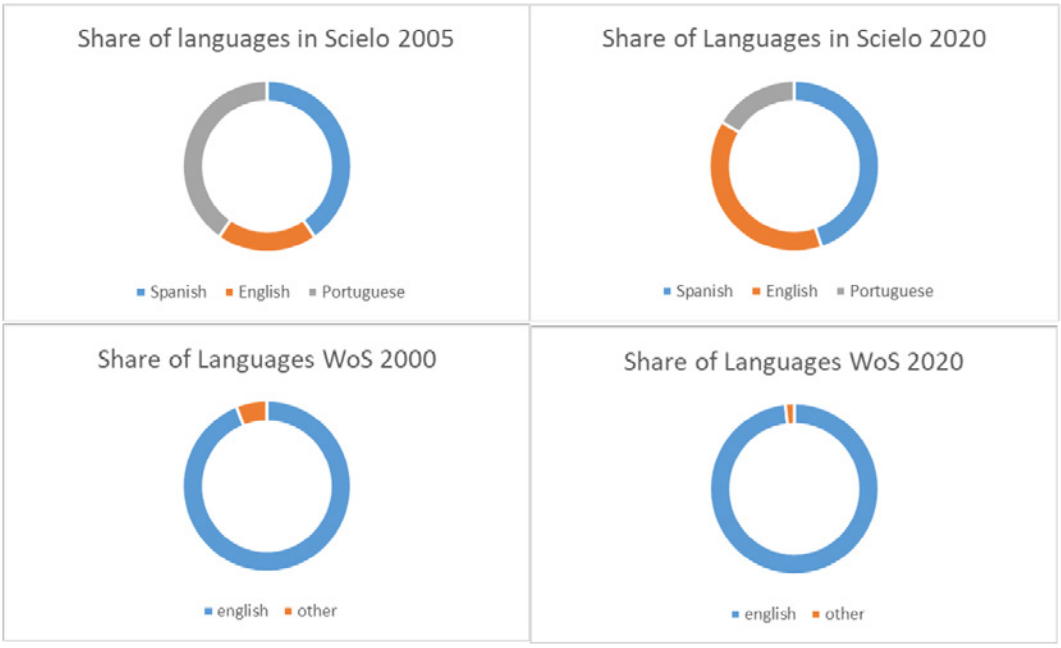

Figure 8: Share of languages in Scielo and the WoS.

4.5 What is the proportion of Gold OA first authorships?

First authorship of a publication means that the first author, designated as "corresponding author", is primarily responsible for both the publication process, and the payment of the APCs. In addition, first authorship plays a prominent role, as scholarly publications with multiple authors are invariably cited with the first authors' name, which promotes scientific reputation. For this reason, first authorship is essential for a scientist, but in the context of OA it also involves significant financial costs. The development of Gold OA first authorship in South Africa can be demonstrated by determining the percentage of first authors in Gold OA publications compared to the total number of first authors in all OA publications in South Africa. This reflects the extent to which the financial resources for paying Gold OA are available in South Africa. Since a solitary indicator has little significance, therefore there is a necessity to relate it to another indicator: for this purpose, the proportion of first authors in global Gold OA publications compared to the first authors of all OA publications in the WoS worldwide is set as the reference quantity.

South Africa is undergoing a dynamic catch-up process: in 2008, the share of Gold OA first authorship was 26%. By 2013, more than half of all OA first authorship were Gold OA; in 2022, the share was around 73%. In comparison with the overall performance of the WoS, South Africa's performance was above average for the entire period. South Africa has thus undergone a significant transformation over the past decade and a half, with Gold OA gaining in importance–despite ongoing financial obstacles. Figure 9 shows the proportion of Gold OA first authorships by South African authors among all OA first authorships.

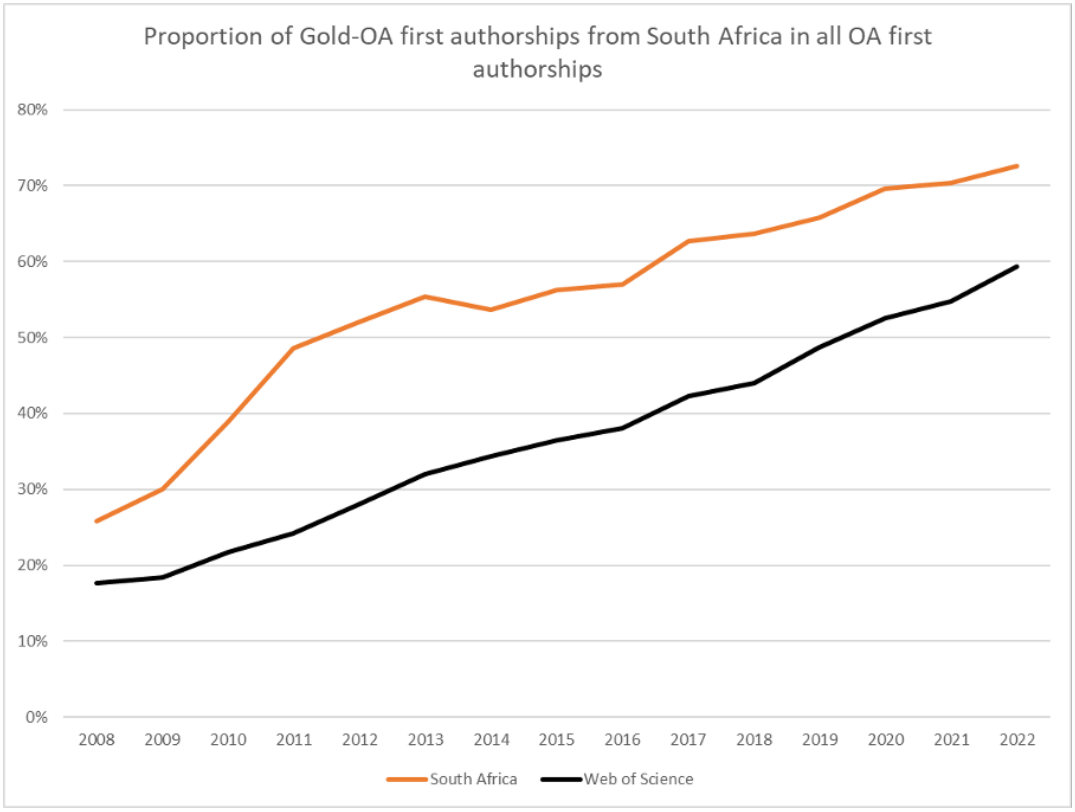

Figure 9: Proportion of Gold OA first authorships from South Africa in all OA first authorships.

4.6 How did the implementation of OA policies at research institutions develop over time, and does this reflect the data-driven development of individual OA initiatives?

The following analysis provides an overview of the development of OA policy implementation at South African research institutions over time. Figure 10 presents the change over time in the adoption of OA policies in South Africa, expressed as a percentage.

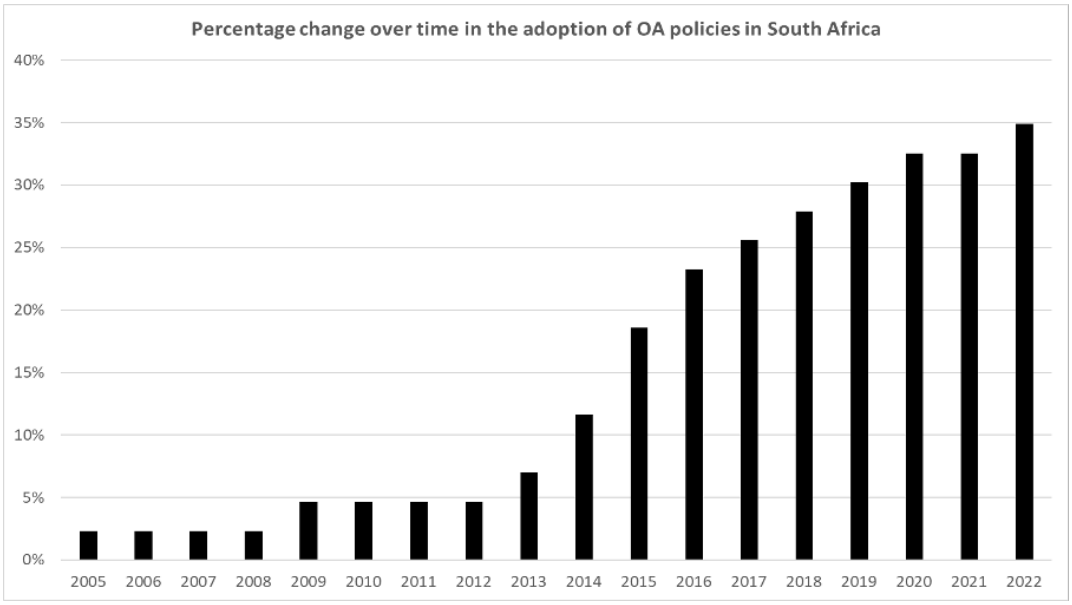

Figure 10: Percentage change over time in the adoption of OA policies in South Africa.

South Africa's first OA policy was introduced by the Council for Scientific and Industrial Research (CSIR) in 2005, followed by the first university OA policy at the University of Pretoria in 2009. By the end of 2016, 10 institutions (around 23% of all 42 institutions) had implemented an OA policy; the most recent policy introduction occurred in 2022. At present, around 35% of all institutions have publicly accessible OA policies; while an additional 37% provide OA-related information via their websites. Figure 11 shows the proportion of OA measures included in the OA policies of higher education institutions. These policies outline

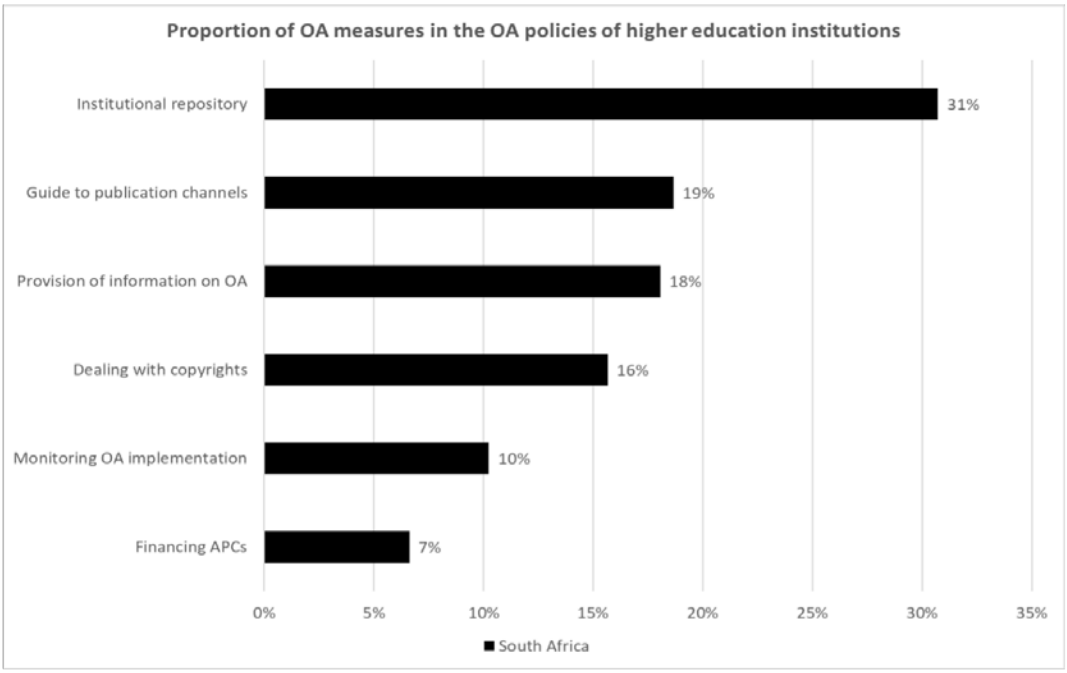

Figure 11: Proportion of OA measures in the OA policies of higher education institutions.

specific measures that individual institutions have undertaken to promote OA. The priority is the operation of institutional repositories (31%). Guidelines on publication channels, information provision and usage rights are close behind (19–16%), followed by monitoring (10%) and financing (7%).

The measures in detail: all institutions operate repositories; whilst 87% of policies emphasise compliance with relevant guidelines (quality standards, metadata, embargo periods, archiving permission). Under the section titled "Guide to publication channels", all policies require the deposit of publications (including metadata), and 47% additionally require the deposit of research data. Furthermore, 60% recommend OA publications in accredited peer-reviewed journals (as defined by the DoE/DHET criteria).

In terms of information provision, 40% emphasise support for repository submissions, while 20% focus on issues related to APCs. 67% recommend the use of Creative Commons licences[6] or the SPARC[7] Author Addendum; whereas 47% advise against comprehensive transfers of rights. 47% of institutions provide reviews of the implementation of OA measures, and around 60% explicitly mention periodic or continuous adjustments to their OA policy. With regard to the financing of research, 33% recommend including APC budgets in third-party funding applications, 27% offer publication funds, and 13% refer to transformative agreements. The absence of explicit mentions does not preclude the existence or development of such measures.

[6] Creative Commons (CC) is a non-profit organisation that provides six different ready-made and standardised free license agreements for the protection of authors' rights.
[7] The SPARC Author Addendum, on the other hand, is a legal instrument that gives authors the option of retaining their rights to their scientific publications as an addendum to their publishing contract.

5. Implications and Conclusion

The objective of this article is to examine the influence of South African OA initiatives on scholarly communication from several perspectives in order to draw sustainable conclusions regarding the identification of factors to consider when providing support for OA. The findings in accordance with the research questions are presented below:

(RQ1) How did research activity in South Africa (publication frequency) develop during the observation period from 2000 to 2022?

The development of publication frequency enables the drawing of conclusions about the dynamics and growth of scholarly production. Overall, South Africa has significantly expanded its publication activity and increased its international visibility: this is evidenced by a continuous increase in the total number of publications, nearly doubling its share of all WoS publications, alongside an above-average growth in OA publications. Particularly noteworthy is the rise in Gold OA, with South Africa now exceeding the global average. This suggests that, despite financial challenges such as limited funds to cover high APCs, South Africa is successfully publishing in high-ranking, internationally visible journals. Consequently, South Africa is positioning itself as an increasingly visible and competitive player in the global science system.

(RQ2) What is the research impact of South Africa's publications based on classic bibliometric citation indicators, and how has this developed over the observation period?

Bibliometric indicators, particularly citation metrics, were used to evaluate the impact, by measuring the extent to which research from South Africa is cited internationally. The analysis reveals a clear trend: OA publications achieve a higher overall impact, benefiting from increased visibility. Our findings thus align with the existing literature on the existence of OACA and extend the analysis of individual journals in South Africa (Ezema & Onyancha, 2017a; Ajibade & Muchaonyerwa, 2023; Onyancha et al., 2024) to encompass the total volume of publications and the development of OACA over time. It has also emerged that Green OA publications predominate in South Africa and achieve a higher citation impact than Gold OA publications due to their distribution across multiple channels. They are accessible both via the journals and additionally via repositories. Diamond OA, by contrast, has the lowest impact of all OA routes.

(RQ3) Which journals does South Africa have access to?

A key aspect is access to publications in scientific journals in South Africa. The study examined the extent to which researchers have access to specialist journals–an essential prerequisite for participation in global scholarly communication. The analysis indicates that there has been an increase in the accessibility of high-ranking WoS journals between 2000 and 2022, and that South African researchers are increasingly publishing in them. This enhances international visibility and generates a higher impact. However, it should be noted that high APCs continue to constrain the use of both renowned subscription and OA journals (Czerniewicz & Goodier, 2014; Dijkstra et al., 2017).

(RQ4) In which language do authors in South Africa predominantly publish?

The language of publication influences visibility, reach and potential citation frequency. Despite OA initiatives such as national databases (e.g. SciELO), local journals or LOTE journals, over 90% of publications from South Africa continue to be published in English. The data-driven analysis at publication level confirms the prevailing view that the English language dominates academic publications. This is attributed to the fact that researchers are motivated not only by altruistic considerations but also by career-related objectives. (e.g. reputation, employment, third-party funding) that are strongly impact-oriented (Mack, 2012). Given that English is widely spoken globally, whereas national languages tend to have a limited reach, accordingly, researchers prefer to publish in English.

[6] Creative Commons (CC) is a non-profit organisation that provides six different ready-made and standardised free license agreements for the protection of authors' rights.
[7] The SPARC Author Addendum, on the other hand, is a legal instrument that gives authors the option of retaining their rights to their scientific publications as an addendum to their publishing contract.

(RQ5) What is the proportion of Gold OA first authorships?

Additionally, cooperation activities and networks were examined by the percentage of first authorships in Gold OA publications in all OA publications from South Africa, in relation to the global share of first authorships in Gold OA publications in all OA publications worldwide. This reflects national publication strategies and provides indications of global inequalities concerning access to APC-based OA publishing. Although, according to the survey by Gallardo et al. (2024), 87% of the South African researchers surveyed use co-authorship to share the costs of APCs, the analysed publication data paints a different picture. During the observation period, the proportion of first authorships in Gold OA publications increased significantly. However, this progress must be assessed in a differentiated manner: Rising proportions may create increasing financial burdens related to APCs (especially with regard to possible price increases by publishers), which disproportionately affect researchers in the Global South. Since Gold OA is often associated with substantial APCs, a low proportion of Gold OA may indicate economic or institutional barriers rather than a lack of willingness to engage in OA. Accordingly, support measures (publication funds, transformative agreements, consortium models), alongside the strengthening of alternative OA models, are necessary to enable equitable visibility. For the advancement of OA, it is therefore crucial to consider both the quantity as well as the quality and fairness.

(RQ6) How did the implementation of OA policies at research institutions develop over time, and does this reflect the data-driven development of individual OA initiatives?

The evaluation of OA policies has shown the extent to which OA has been institutionally embedded in South Africa and which measures are predominantly applied. Around 35% of institutions have implemented OA policies over time, marking a significant institutional advancement, and representing an important milestone in the transformation toward OA. Furthermore, the presence of OA measures within the framework of institutional OA policies appears to increase their impact. Given the dominance of Green OA in South Africa, many institutions have extensive institutional repositories; the protection of authors' rights is also a high priority. Nevertheless, the financial conditions for the adoption of APCs remain a significant obstacle as only a limited number of institutions currently allocate budgets to cover publication fees.

Overall, OA is perceived by researchers as essential for reach, reception and social benefit, however, it often remains inaccessible due to high APCs. Diamond OA platforms (e.g. SciELO) are used, yet are still insufficiently indexed and recognised internationally, while hybrid options play a negligible role. Language is identified as a second major hurdle: although publishing in English maximises global visibility, it simultaneously marginalises locally relevant research in national languages and restricts inclusive access to knowledge. Collectively, these factors contribute to the risk of a "pay-to-be-seen" regime, whereby visibility remains purchasable, and OA only partially fulfils its promise of equitable access.

The following efficient policy paths can be deduced from the findings:

(i) **Green OA** with reliable rights retention, and self-archiving as a cost-effective model;
(ii) **Diamond OA** with professional quality assurance, sustainable funding, and international discoverability;
(iii) **equitable, transparent contract models** with cost control and effective OA targets.

This endeavour must be accompanied by robust data triangulation, reproducible analytical workflows, and an assessment of broader impacts. Should the aforementioned financial and language obstacles be dismantled, and indexing limitations overcome, OA in South Africa has the potential to fulfill its fundamental promise much more comprehensively: to ensure unhindered, equitable access to scientific knowledge, with a measurably higher impact.

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BAVARIAN JOURNAL OF APPLIED SCIENCES®

Photovoice and PPGIS as Methods to Create Open Educational Resources for Enriching School Atlas Maps – The Case of Lake Naivasha Region, Kenya

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ABSTRACT

Motivated by questions about how people perceive unfamiliar environments and how encounters with new places influence them, this article presents the results of a geography field trip with geography students from the University of Passau to Lake Naivasha in Kenya. The educational concept underlying this field trip combines the methods of photovoice and participatory mapping to create open data for enriching school atlas maps. Photovoice is a qualitative research method that uses photography as a medium to explore how individuals perceive and interpret places, with a particular focus on their subjective perspectives. In this case study, a map of Lake Naivasha from the Diercke World Atlas served as a starting point. The participating pre-service geography teachers were given three hours to answer geographical questions about Lake Naivasha by taking photographs. Afterwards, the results were critically discussed, and the students shared and compared the photos. For this purpose, the Public Participation Geographic Information System (PPGIS) tool PUBinPLAN was used. As a result, participants assumed the role of experts by investigating the unfamiliar region through their subjective impressions (photos), thereby developing a deeper understanding of the region. The photographs can also be made available as open data for use in school lessons and research to gain valuable insights into the students' spatial perception.

Der Artikel präsentiert Ergebnisse und Erkenntnisse einer konstruktivistischen Arbeitsphase während einer geographischen Exkursion an den Lake Naivasha (Kenia) mit Geographie-Lehramtsstudierenden der Universität Passau. Das zugrundeliegende exkursionsdidaktische Bildungskonzept basiert auf den Methoden der Reflexiven Fotografie (Photovoice) und dem Partizipativen Kartieren. Mittels dieser Zugänge haben die Studierenden den Raum erschlossen und dabei Daten in Form von Fotos und Beschreibungen generiert, die georeferenziert gesammelt und aufbereitet worden sind.
Reflexive Fotografie ist eine qualitative Forschungsmethode, die Fotografie als Medium nutzt, um subjektive Wahrnehmungen, Eindrücke und Interpretationen festzuhalten und zu reflektieren. Die teilnehmenden Lehramtsstudierenden hatten drei Stunden Zeit, um ihren geographischen Fragen nachzugehen. Als Ausgangspunkt für die Exkursion diente ein Kartenblatt des Diercke Weltatlas zum Lake Naivasha, wodurch die Reflexive Fotografie mit einer kritischen Reflexion von Karten verschränkt wurde. Dabei erfolgte eine kritische Diskussion der Ergebnisse, die die Studierenden zuvor digital hinterlegt hatten. Hierzu wurde PUBinPLAN, ein Public-Participation-Geographic- Information-System-(PPGIS-)Tool, verwendet. Die Teilnehmenden übernahmen dabei die Rolle von Expertinnen und Experten, indem sie die Region durch ihre subjektiven Eindrücke (Fotos) analysierten, um so ein vertieftes Verständnis der Region zu entwickeln. Die entstandenen

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Posts lassen sich als Open Data weiternutzen, um die Auseinandersetzung mit der Region Naivasha im Unterricht zu differenzieren.

KEYWORDS

Open Educational Resources (OER), Photovoice, Participatory Mapping, Open Data

Offene Bildungsressourcen, reflexive Fotografie, partizipatives Kartieren, offene Daten

1. Introduction

Current dynamics in the Naivasha region of Kenya are of considerable interest from geographical perspectives. The complexity and controversy of the region's development processes can be analysed using maps. Focusing on rose cultivation and monoculture in greenhouses, the Naivasha/Kenya case study has become a well-established topic in geography education in recent years.

The cultivation of roses in Kenya has developed dynamically over the past few decades. The boom began in the 1990s. Since then, the population of the city of Naivasha, the centre of rose cultivation in Kenya, has grown from around 30,000 to over 300,000 today; and approximately 90,000 jobs have been created in the cut flower industry (Styles 2019, 5). Up to 70 % of the employees are women (ibid.). In 2023, sales amounted to 430.2 tonnes (Kenya Export Promotion and Branding Agency, 2024). Fairtrade flower sales in Germany have also risen significantly in recent years. However, this is only partly due to increased demand. Price and appearance are often the only decisive criteria that influence the purchase of roses (Gemählich 2020, 31). Using the Naivasha region as a case study allows us to map and discuss the perspectives surrounding the rose industry and land use conflicts.

In addition to various teaching materials and exam questions, the topic has also found its way into school textbooks. The corresponding map in the new Diercke World Atlas[3] (Westermann 2023, 161.4) was also at the centre of the discussion. The topics presented in this map make it possible to explore the complexity and controversies surrounding regional development in Naivasha in greater depth. This is particularly successful because, in addition to the large-scale cultivation of cut flowers, the map also covers topics related to energy geography and tourism geography. The map from the Diercke World Atlas, freely accessible geodata such as OpenStreetMap and aerial photographs (Figure 1) were used to prepare the field trip to this region with teacher training students from the

[3] With the new edition of the Diercke World Atlas (2023), the map section has been changed (Map 161.4). While the 2015 edition showed the northeast shore of Lake Naivasha with the Flower Business Park in the centre, the new map focuses on the south shore (Figure 1, map 1).

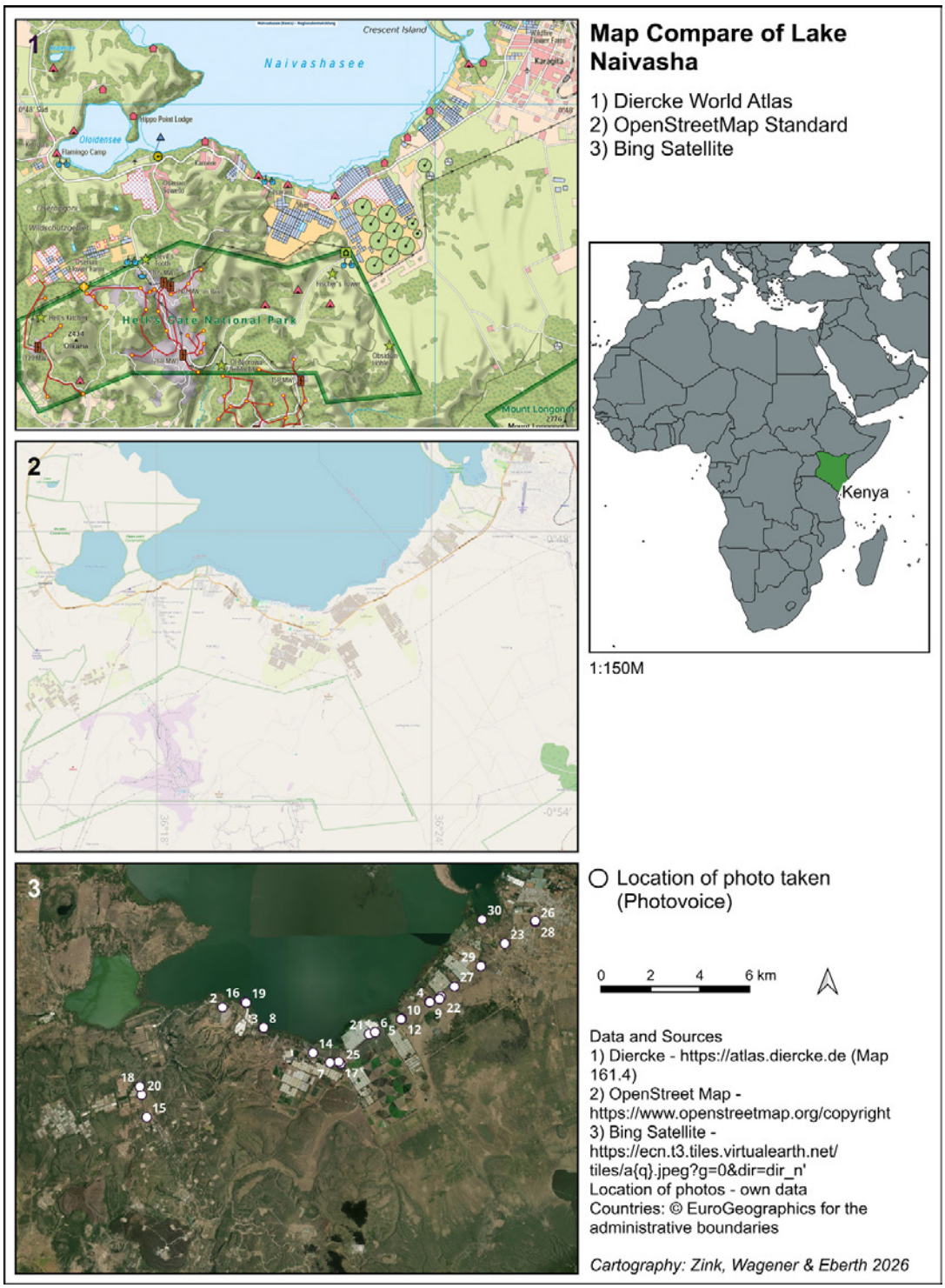

Figure 1: Map Compare of the south shore of Lake Naivasha (Kenya).

University of Passau. Once there, the students explored the region, documented their own impressions through photographs, compared the local situation with the maps, and examined the region's current challenges. While the primary focus was on teacher education and the research question of how students perceive space and place, this article also highlights the potential of creating Volunteered Geographic Information (VGI) and making it available as Open Data and Open Educational Resources (OER).

The study presented is the result of a cooperation between the Deggendorf Institute of Technology

(DIT) and the University of Passau (UP). Geography teacher training students at the UP worked with the PUBinPLAN application developed at the DIT during the geography field trip to Lake Naivasha in Kenya.

2. Case Study and Local Background

In Naivasha, flower farms have increasingly occupied large areas in recent decades, which causes changes along the South Lake Road. In many cases, these farms have restricted access to the lakeshore. Despite some improvements in social and environmental areas in recent years, fundamental problems remain. Lake Naivasha is one of only two freshwater lakes in the Great East African Rift Valley and is of enormous ecological importance as a wetland. Increasing water pollution and declining biodiversity are associated with the flower farms (Böhme et al. 2017, 70f.). The lake's endemic fauna is considered to be endangered (Hornetz & Teucher 2017, 84). The sustainability of water-intensive rose cultivation in a region prone to water scarcity remains a matter of debate.

This also applies to the corresponding land use in a country with a rapidly growing population (Eberth 2019) and a corresponding need for agricultural land for growing food (both food crops and cash crops). It remains a matter of debate whether such land should be used for non-food cash crops rather than food production. Some farms have since been abandoned. One example is the former Twiga Roses farm, which was owned by the Indian company Karuturi Group. The farm occupied large areas of land and was criticised for its working conditions and treatment of workers. This has left huge areas devastated and around 3,000 workers unemployed (Eberth 2020). This aspect is also marked with a corresponding symbol on the new map in the Diercke World Atlas.

From an economic geography perspective, Kenya can be characterized as a highly dynamic country. The Kenya Vision 2030 development programme sets out ambitious goals for the country’s industrialisation. To achieve these goals, the expansion of electricity generation is an important prerequisite (Greiner and Klagge 2022). In addition to measures for decentralised power supply, which primarily target private households, large-scale and centralized projects also play an important role, as they enable a massive expansion of power generation capacities (ibid.). Besides investments in wind power, especially in the north of the country, Kenya's geothermal potential is being successfully harnessed on a large scale for power generation along the East African Rift Valley which provides excellent conditions for this form of energy production. The Olkaria geothermal power plants are located in the Lake Naivasha region.

Additionally, Kenya is undoubtedly a major tourist destination (Job 2017). Alongside well-known National Parks and reserves such as Amboseli, Masai Mara, and Samburu, Hell's Gate National Park is something special. Unlike other parks, it is not customary to go on safari in a jeep in Hell's Gate National Park, which is located south of Lake Naivasha. Here, visitors can explore the park on foot. Numerous bike rental stations in the immediate vicinity of the park rent out mountain bikes by the hour or day at reasonable rates.

This tourist highlight also explains why there are many restaurants, lodges, and campsites along the southern shore of Lake Naivasha. This aspect, which is marked on the new Naivasha map, makes it possible to discuss Kenya's importance as a tourist destination as well as variations of sustainable safari tourism, since here it is not only possible to do without a car, but necessary.

3. Field Trip Educational Concept

The concept presented here was developed for a field trip designed for pre-service geography teachers at the University of Passau. It consists of two modules arranged in a chronological order (see Figure 2).

The first module comprises the field trip itself, during which students collect their own geospatial data. As part of the didactic approach, students are assigned the following task directly on site:

a) Familiarise yourself with the map “Lake Naivasha (Kenya) Regional Development” and its legend in the Diercke World Atlas (2023; p. 161, map 4).

b) Identify three geographical aspects shown in the map section that are of particular interest to you. Formulate three corresponding geographical research questions based on these aspects.

Following this, students explore the region by bicycle for two hours, seeking answers to their own questions. Their task is to take photographs using their smartphone cameras with GPS enabled, uploading these images to an interactive web map, categorising them and providing textual descriptions. This activity combines the methods participatory mapping and photovoice. Data collection takes place within a digitally protected sandbox environment, which is only accessible to participants and project coordinators.

The second module involves the processing and publication of the collected data as an Open Educational Resource (OER). During a joint reflection session attended by the field trip leaders, the data were reviewed, supplemented, and prepared for publication. For this purpose, the previously protected interactive website has been made publicly accessible online, while the editing mode is disabled. The result is a static webpage that can be used for informational purposes, and which allows photos and their metadata to be downloaded. This data can then be used to enrich the "Lake Naivasha (Kenya) Regional Development" map in the Diercke World Atlas for use in geography lessons in German secondary schools. Additionally, the collected data can be shared and discussed with local stakeholders.

The structure of the educational concept is based on Eberth et al. (2025) and has been adapted for the field trip and the examination with the map in the Diercke World Atlas. The combination

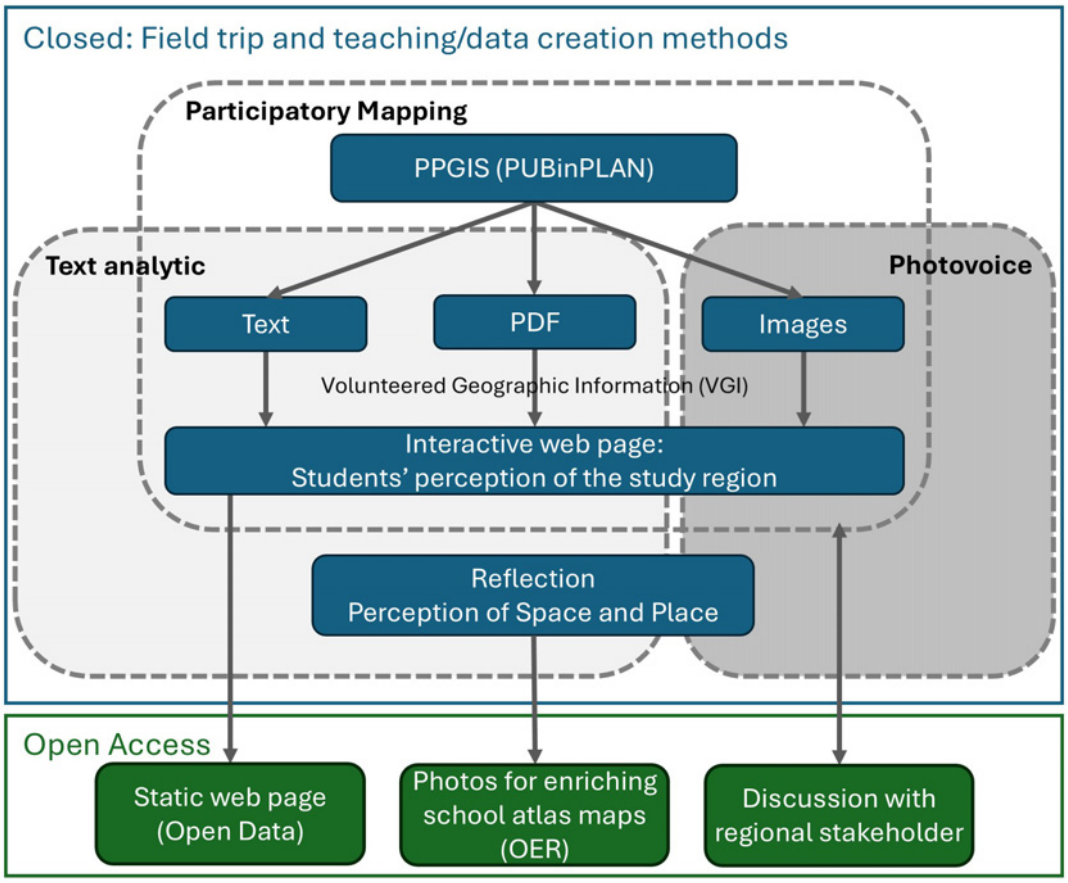

Figure 2: Concept of creating Open Data to enrich school atlas maps.

of participatory mapping and photovoice has already been established within the context of citizen science (Denwood et al. 2022; Soma et al., 2022). In addition to the inherently participatory nature of both methods, such projects often aim to make the collected data open access. Consequently, Creative Commons (CC) licensing is widely used in this regard.

4. Methods

In this case study, the methods Participatory Mapping (4.1) and Photovoice (4.2) were applied to capture participatory perspectives on spatial and social conditions. PPGIS facilitated the integration of local knowledge through map-based engagement, while Photovoice employed visual narratives to document the participants' subjective experiences. The following section briefly outlines both approaches and discusses their application within the research context.

4.1 Participatory Mapping

According to Malakar & Roy (2024), geospatial citizenship refers to the active and responsible engagement of individuals in understanding, utilising, and contributing to the geospatial environment. In this context, participatory mapping is an approach in which maps are created collaboratively with people who live in or are affected by a particular area. Although there are various terms used in the literature for digital platforms that adopt this approach – i.g. Geospatial Digital Participatory Platform (DPP) or Public Participatory Geographic Information System (PPGIS) which are discussed in terms of their strengths and weaknesses as well as the factors for success (Atzmanstorfer et al. 2025; Kahila-Tani 2019; Ramirez Aranda et al. 2023) – what all platforms have in common is that they offer users the opportunity to enter their own geodata on a map. These platforms are popular in regional and spatial planning, with widespread application, but also in education and school teaching and a focus on children (Ergler & Freeman 2020; Mansournia et al. 2024).

Currently, a large number of software tools for participatory mapping is available (Burnett 2023; Schmuderer et al. 2019). For the case study presented, PUBinPLAN was used. PUBinPLAN is based on the concepts of PPGIS (Zink et al. 2016; Küspert & Zink, 2017) and aims to foster transparency, inclusivity, and citizen involvement in spatial planning initiatives. Each project on the platform addresses a specific theme and geographic area, allowing participants to contribute georeferenced data – such as comments, photographs, and documents – via an interactive map interface. These geographically localised contributions can be liked, shared, and recommended, akin to social media interactions. All submissions undergo a structured moderation process to ensure adherence to platform standards. Because of its project-based design, PUBinPLAN can be used for various topics and user groups, including educational contexts in schools (Zink 2025) and universities (Eberth et al. 2025). The platform enhances the Photovoice method by enabling georeferenced photo contributions and facilitating peer comparison and discussion.

4.2 Photovoice

Photovoice uses photography as a medium to explore how individuals perceive and interpret places with the focus on the subjective perspective. The qualitative research method has now become established in both empirical social research (Rose 2016, 315; Eberth 2018) and geography teaching (Eberth et al. 2026; Eberth 2021) as a means of depicting subjective perceptions. "Photovoice is a method developed in particular by Carolyn Wang and Mary Anne Buries [...] and comes in part from a specific tradition of the Brazilian activist Paulo Freire. The point of action research is not just to study something, but to engage research participants and researches [and learners alike; author's note] in a process of social learning, analysis and empowerment, in the hope of eventually changing the social situation itself" (Rose 2016, 315).

Using Photovoice, learners take photographs of self-selected subjects with a specific guiding question in mind and then comment on the images, elaborating on the meaning of the subject.

5. Results from the Case Study Naivasha

In response to the local challenges described and the questions and tasks provided, the students took 30 photographs within the area covered by the map in the Diercke World Atlas. They had three hours to take photographs and used bicycles to explore the study area. The photographs were assigned to various categories: agriculture, tourism, energy

geography, infrastructure, and sustainability. Each image posted on PUBinPLAN includes a title, a description, and metadata specifying the location and time of capture.

A selection of these images and their associated metadata for four different categories is exemplarily presented in Figure 3. Entry 6 focuses on agriculture and outlines the advantages and disadvantages of Fairtrade



Figure 3: Examples of photos taken and their meta information.

certification as experienced by the participants on site. What is particularly noteworthy is that the post emphasises shortcomings related to working conditions – an issue that receives limited attention in European debates on Fairtrade. Fairtrade certification in the flower industry differs from certification schemes in sectors such as tea, cocoa, and coffee, where market access for small-scale farmers and the payment of minimum prices that are as constant as possible are important measures. Fairtrade-certified flowers, on the other hand, are usually traded and sold at the same conditions and prices as conventional flowers. Consequently, producers do not receive a price premium for their flowers. Instead, 10 % of the trading price can be used by a committee of workers for social and environmental issues (Gemählich 2020, 33).

Entry 21 addresses the transport infrastructure along South Lake Road. The accompanying photograph shows the buses which are used to transport workers home after their shifts. This company-provided transport system reflects the highly centralised organisation of production processes, yet it remains invisible on the map. The example illustrates how photographs can reveal everyday infrastructures and organisational arrangements that conventional

maps do not capture.

A similar observation can be made for Entry 24, which was assigned to the theme of energy geography. While the map only depicts the geothermal power plants and the major electricity transmission lines, the photograph and the students' comments highlight local-scale challenges. Although it is located only a short distance from facilities that generate substantial amounts of geothermal electricity, the water pump shown in the photo has no access to renewable energy. Such observations can stimulate critical reflection on power relations, unequal access to basic infrastructure, and the contrast between top-down development projects and local, bottom-up perspectives.

Entry 30 further demonstrates that maps do not always represent current conditions. The contrast between the map and the photograph is illustrated by a post entitled Safari tourism at Lake Naivasha, which states: "However, the road to the island marked on our maps no longer existed. Crescent Island was only formed by the rise in water levels. This rise in Lake Naivasha is due to unusually heavy rainfall in the Aberdare Mountains caused by climate change. Before that, it was a peninsula with a marked road" (see Figure 3). Here it becomes obvious that the photographs not only enrich the maps by providing additional information, but also help to verify, correct, and update the cartographic representations. Due to climate change, the lakeside changed significantly in the last years. Taken together, the entries show how photographs can complement static atlas maps and help geography students develop a deeper understanding of the Lake Naivasha region and reflexive cartography. Challenges related to tourism and energy, which are often described in abstract terms, become more tangible through the map on the one hand and, more importantly, through the geographically precise images on the other hand.

Consequently, the integration of photographs into classroom instruction contributes to the development of a critical understanding of maps. Atlas maps represent only a snapshot in time, whereas the environment is subject to dynamic change. Although photographs are also momentary, they can stimulate comparison and reflection (Eberth et al. 2025). A similar effect can be achieved by shifting from a bird's-eye view – such as satellite imagery provided by Google Maps or Microsoft Bing – to a ground-level perspective. Our approach partially mirrors functionalities found in Google Maps or Bing Maps, where user-generated images can be displayed. However, while those images also contain spatial and temporal metadata, they often lack descriptive context and a clearly defined purpose or task orientation. By categorising the images into thematic areas, the resulting educational material gains a focused content structure and can be purposefully integrated into teaching.

Both the photographs and the accompanying web page, including the interactive map, are made accessible via PUBinPLAN (https://pubinplan.th-deg.de/ex-kenia) after the field trip, following a critical reflection and review by the instructors. Reflection played a central role throughout the whole process and has taken place on at least three levels: At the level of disciplinary reflection (Level 1), students commented on each other's posts regarding geography concepts and theories and subsequently discussed their observations in a plenary session. They then engaged in a second level of reflection by critically reflecting on their personal perspectives, the emotions they experienced while conducting the fieldwork, and the ways in which their perspectives changed during the project. Post-colonial perspectives also featured prominently in these discussions (Level 2). Students recognised that it is impossible to completely set aside the European lens through which they perceive and interpret the local context. Consequently, one of the key conclusions of the discussions was that engaging with a wide range of local stakeholders during the exercise was essential for broadening and challenging their own perspectives. Finally, at the third level, students adopted a meta-reflective perspective on the exercise (Level 3). They critically considered which insights the exercise had made possible, as well as the limitations of the knowledge gained and the perspectives that remained inaccessible. This critical review process is also the reason why the project initially takes place in a protected digital environment and is only released afterward.

In summary, a curated set of annotated photographs for the Lake Naivasha region is supposed to be developed as OER. These 30 images could be used as freely accessible teaching and learning materials to complement and enhance the map in the Diercke World Atlas. The collected data thus contribute to both Open Education and Open Science and will be also

published at the University of Passau's OER-Hub which is an infrastructure provided by the local community of practice, which is working in Education for Sustainable Development and OER, coordinated by the project "moreBNE – Making Open Resources in Teacher Training" funded by the Federal Ministry of Research, Technology, and Space (BMFTR; https://www.uni-passau.de/morebne).

6. Discussion

From a postcolonial perspective, the potential and limitations of the approach must be critically examined, particularly regarding how it has been implemented to date. Although the project has broadened the range of perspectives on the mapped area and encouraged reflection on individual spatial perceptions, these are primarily the perspectives of white students from Germany. The perspectives of local people were not explicitly and continuously integrated, as they were not involved in the design of the exercise. Moreover, the digital tool itself was developed in Europe. Although students engaged with local people during the fieldwork, these interactions were initiated by the students and primarily took the form of interviews. This was only done to a limited extent by some students who had asked local people about their geographical interests.

Nevertheless, the methodological approach chosen here offers, in principle, a very good opportunity for cooperation with the local society, for example. The exercise could be modified slightly so that residents can transparently express their perspectives on current needs and regional development projects. Prepared as open data, this could also provide an opportunity for a broader participation process, involving residents in specific processes of spatial planning.

The case study presented used a map of Lake Naivasha from the Diercke World Atlas as a starting point. The study region was defined according to this map section. However, the methodology presented is not limited to this area, but can in principle be applied to other regions, other scales and other topics. To teach spatial understanding, it can also be helpful to integrate additional map representations or satellite images, as exemplified in Figure 1 with the Bing Satellite service. This allows other open data sets to be integrated and analysed. The results indicate that the combination of Photovoice and PPGIS enables an intensive and open exploration of (foreign) regions in short time. Participants take on the role of experts, and their photographs place subjective impressions at the centre of the process. These contributions provide researchers with valuable insights into spatial perception. On the other hand, both atlas maps and school geography lessons benefit from this additional resource.

7. Conclusion

This case study demonstrates the potential of combining Photovoice and PPGIS to create OER that complement existing school atlas maps. By collecting and reflecting on their own georeferenced photographs of the Lake Naivasha region, students were able to explore it from their own perspectives and critically engage with the spatial representations provided by the atlas map. In summary, three results can be highlighted:

First, the project highlights the importance of critically reflecting on which perspectives are represented in participatory mapping processes. While this approach allows learners to play an active role in producing knowledge, the new perspectives are predominantly those of German teacher training students. Future projects should therefore aim to involve local stakeholders more systematically in the creation and interpretation of geospatial data to truly enrich learning materials with local perspectives. Therefore, future field research projects are planned to be developed and conducted in cooperation with local organisations, thereby enabling the co-production of knowledge that benefits all participants involved.

Second, the results suggest that combining Photovoice and PPGIS is valuable for geography education, especially for developing a critical understanding of maps, spatial perceptions and regional development processes. Transforming learners from passive map users into active contributors of geospatial knowledge can foster reflexive and participatory geographical learning.

Thirdly, by making the results available as OER, geography teachers can integrate the materials into their lessons, enabling them both to critically examine existing school atlas maps (e.g. Diercke World Atlas) and to explore the topic and the region in depth with their pupils.

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CALL FOR CONTRIBUTIONS

BJAS Issue 10 (2027):

We are looking forward to receiving your contributions with a focus on applied sciences for the next issue in 2027. Please submit your article in line with our style guidelines and citation rules (see section Information for Authors) via the journal's website http://jas.bayern until February 28, 2027. Contributions may be submitted either in German or English. They will undergo a double-blind peer reviewing process. The publication of the issue is scheduled for autumn 2027.

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Reichen Sie sehr gerne Ihre wissenschaftlichen Beiträge mit Anwendungsbezug zur Begutachtung (double-blind peer review) für das nächste themenoffene Heft im Jahr 2027 ein. Die Einreichungsfrist ist der 28. Februar 2027. Die Veröffentlichung ist für Herbst 2027 geplant. Bitte beachten Sie die Informationen für Autoren, die Stilrichtlinien sowie die Vorgaben zur Zitierweise auf der Website des Bavarian Journal of Applied Sciences: https://jas.bayern.

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BJAS Issue 10 (2027)

The Bavarian Journal of Applied Sciences is seeking proposals from Guest Editors for the next issue of the journal to be published in 2027 (NO. 10).

Proposals should be submitted no later than 31 January 2027 to info@jas.bayern, and will be evaluated by the journal's Editorial Board for their relevance to the BJAS readership and their academic quality.

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For preliminary enquiries and submissions, contact Michelle Cummings-Koether and Kristin Seffer via **info@jas.bayern**.

Proposal format

The next issue of the BJAS can have a specific topic and address different disciplines or interdisciplinary approaches, or it can have a disciplinary focus. It shall have a strong focus on applied research but with a theoretical foundation. Collaborative proposals (2 or 3 guest editors) are particularly welcome.

Proposals should include information in the following sections:

- the proposed topic for the issue,
- a draft Call for Papers including the chosen theme, and target readership (max. 2 pages),
- Guest Editor profiles: names, affiliations, contact details, short biographical information,
- a list of potential reviewers.

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Guest editors will work in close collaboration with the Editors and journal administrators of the BJAS, whose role is to help with the editorial procedures (dissemination of the Call for Papers, refereeing process, communication with authors, preparation of manuscripts for publication, etc.).

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- writing a Call for Papers,
- assessing initial submissions, selecting and allocating reviewers for submitted and invited papers,
- selecting papers for the issue on the basis of the peer reviews; Guest Editors are in charge of acceptance/rejection/revision and resubmission decisions and liaise closely with the Editor on the process as a whole,
- helping authors respond to reviewers' and Guest Editors' comments to improve the quality of their paper,
- preparing the manuscripts of the issue in accordance with the published guidelines, so as to facilitate the publisher's work,
- checking the publisher's proofs, along with the authors.

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- 31 January 2027: Deadline for submission of proposals from Guest Editors
- 15 February 2027: Decision by the Editors advised by the Editorial Board
- 20 February 2027: Publication of the Call for Papers
- 31 July 2027: Deadline for submission of papers
- 30 November 2027: Deadline for finalizing complete manuscript
- 15 December 2027: Publication and print

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