Reflections on the first State of the Map Conference in Malawi

Patrick Ken Kalonde[A,B], Blessings Chiepa[A,B], Joshua Kacheyo[C], Edith Kalagho[D,E], Wonderful Kunje[F], Tarcizio Tobias Kalaundi[G], Clinton Nkolokosa[A,H], Priscilla Kapolo[A,E,I], Zola Manyungwa[I], Mphatso Ben[I], Faith Chimphondah[J,K], Prince Time Matope Aaron[I], Marvin Wandale[A,K], Precious Chisuse[C], Susan Chibophe[L], Upile Chelewani[L], Lemekezani Davie Mtachi[I], Glory Jemimah Mwamughunda[I], Christine Mhone[M], Godfrey Kandikana[D], Nellie Ziyenda[N], Gumbi Gumbi [O], Rachel Kumwenda Kaunda[P], Charles Kapachika[K], Geoffrey Kateregga[Q], Fanuel Meckson Bickton[A,R]

Affiliations

[A]*Malawi-Liverpool-Wellcome Programme, Post Office Box 30096, Chichiri, Blantyre 3, Malawi*

[B]*Liverpool School of Tropical Medicine, Pembroke Place, Liverpool L3 5QA, United Kingdom*

[C]*Malawi University of Science and Technology, P.O. Box 5196, Limbe, Malawi.*

[D]*Mzuzu University, P / Bag 201, Luwinga, Mzuzu, Malawi.*

[E]*Spatial Girls Network, Lilongwe, Malawi.*

[F]*Malawi Red Cross Society, 14 Presidential Way, Post Office Box 30096, Lilongwe 3, Malawi*

[G]*Trocaire Malawi, Area 3 Plot No.18, P/Bag A47 Lilongwe, Malawi*

[H]*Department of Biological and Environmental Sciences, University of Stirling*
Stirling, FK9 4LA, Scotland UK.

[I]*University of Malawi, P.O. Box 280, Zomba.*

[J] *Department of Disaster Risk Management, Blantyre District Council, P.O. Box 97, Blantyre.*

[K]*Malawi University of Business and Applied Science, Private Bag 303, Chichiri, Blantyre 3, Malawi*

[L]*Lilongwe University of Agriculture and Natural Resources, P.O. Box 219. Lilongwe.*

[M]*Caring Hands Center, Lilongwe, Malawi.*

[N]*Civil Service Commission, P.O. Box 30133, Capital city, Lilongwe 3.*

[O]*Malawi Spatial Data Platform, Malawi National Spatial Data Center, Department of Surveys, Lilongwe, Malawi.*

[P]*Drone Link, Lilongwe, Malawi.*

[Q]*Humanitarian OpenStreetMap Team, 1100 13th Street NW Suite 800 Washington, D.C. 20005.*

[R]*Kamuzu University of Health Sciences, Private Bag 360, Chichiri, Blantyre 3, Malawi*

Correspondence email: pkalonde@mlw.mw

This manuscript is a non-peer-reviewed preprint submitted to EarthArXiv and is currently under consideration for peer review.

ABSTRACT

State of the Map (SotM) conferences are important events that enable OpenStreetMap (OSM) contributors and users to present and discuss their work. However, when international SotM conferences are held in the Global North countries, participation by African geospatial scientists is not guaranteed due to various barriers, including travel costs and visa restrictions. Conversely, locally held SotM conferences within Africa mitigate these barriers. Such conferences have been held in different African countries. Malawi hosted its first SotM conference in 2024 at the Malawi University of Business and Applied Sciences (MUBAS), bringing together its local geospatial science community to discuss the landscape of the field in the country. In this paper, we reflect on the conference's proceedings, positive developments, opportunities, and challenges facing Malawi's geoscience community. The paper contributes to the broader understanding of how African countries are leveraging geoscience and identifies areas for further growth and collaboration.

Keywords: SotM, Knowledge exchange, Malawi, Africa, GIS

Background

Geographical Information Systems (GIS) have opened opportunities for capturing, storing, and analyzing both simple and complex data with location information (hereafter referred to as 'spatial data'). This has created new opportunities in land use planning [1], supply chain management, environmental monitoring, disease surveillance [2], disaster monitoring [3], and even public safety and security, particularly by identifying specific areas associated with criminal activities [4]. A notable trend in GIS has been the rise of 'open' data and software tools, such as OpenStreetMap (OSM) [5], and Open-Source Software for geospatial analysis [6]. Access to open software tools and data resources empowers individuals and communities, who would have otherwise lacked access to such resources, to engage in the use of spatial data to solve societal challenges.

Access to open data and tools varies across the globe. Africa experiences slow adoption of emerging digital technologies [7]. Ironically, Africa stands to gain the most from

emerging geospatial technologies given its unique demographic factors, including a youthful population that represents an abundance of human resources and a myriad of challenges, including widespread poverty, environmental degradation, disasters, and the need to mitigate and adapt to changing climatic conditions. The current situation raises critical questions: Are African countries leveraging GIS to address their challenges? What role do Africans play in the global growth of GIS, and how can the continent use these technologies for its development? To address these, it is not enough to simply assess GIS adoption; we must also understand how it is being applied to tackle the continent's specific challenges and examine GIS innovations emerging from Africa. This understanding can be achieved through a bibliometric analysis of studies or conference proceedings related to GIS and Africa. However, it is widely acknowledged that many researchers in Africa face barriers to publishing their work, and GIS related scientific publications from Africa are scant [8]. For example, between 1973 and 2017, Africans authored only 2.3 percent of the global literature in the field, with more than half of this contribution coming from South Africa alone [9]. Notably, this trend extends beyond GIS. During the COVID-19 pandemic, African professional societies remained largely silent, reinforcing the notion that solutions would rely on external 'knowledge transfer' or 'capacity building' [10]. Additionally, participation in international conferences is often limited; with most of them being hosted in the Global North, attendance by Africans is not guaranteed due to high travel costs and visa restrictions [11,12]. Therefore, exploring discussions from regional or national conferences can provide valuable insights into how GIS is being used locally.

State of the Map (SotM) are important knowledge exchange meetups which focuses much on OSM developments, hosted globally, continentally, and at the country level. In Africa, SotM has been held in Uganda, Kenya, Rwanda, Tanzania, Cameroon, Togo, Madagascar, and Nigeria (https://wiki.openstreetmap.org/wiki/State_of_the_Map). Malawi hosted its first SoTM conference in 2024 at the School of the Built Environment of the Malawi University of Business and Applied Sciences (MUBAS). This event brought together local researchers, practitioners, and policymakers to reflect on and discuss the country’s GIS landscape. This paper reflects on the conference, highlighting the GIS

landscape in Malawi, the conference proceedings, positive developments and opportunities, and challenges facing the GIS community in the country. In doing so, the paper contributes to the broader understanding of how Malawians are leveraging GIS while identifying areas for further growth and collaboration.

Brief history of the Malawi geospatial community

Geospatial science in Malawi has long been driven by the government, academia, private companies, and humanitarian organizations. The government's Department of Surveys and Urban Planning has historically conducted cadastral and aerial surveys, maintaining, and managing a national spatial data repository. Local universities with occasional support from international counterparts particularly from Kenya, South Africa, the United States, the United Kingdom, the Netherlands and Peoples Republic of China have provided the technical human resources. As of January 2025, six Malawian public universities and two private universities offer courses in GIS, while the Malawi University of Science and Technology (MUST) offers a full undergraduate program in GIS, the University of Malawi offers an undergraduate program in Geography that includes foundational components of GIS, Mzuzu University offers postgraduate programs, namely Master of Science and doctoral studies in Geoinformatics. Additionally, several GIS short courses are offered by different universities, and in 2020, the African Drone and Data Academy was introduced to build capacity in drone technology and Geospatial Analysis [13].

While it is challenging to determine when Free and Open-Source Software for Geospatial (FOSS4G) and OSM gained traction in Malawi, the establishment of the Malawi Spatial Data Platform (MASDAP: https://www.masdap.mw/), a portal to facilitate the sharing of spatial data, in 2013 was a significant milestone. The devastating floods of 2015 accelerated this momentum, with the Red Cross Society spearheading efforts to map affected communities, which helped guide disaster response and recovery. Additionally, humanitarian agencies such as Médecins Sans Frontières (MSF) and Cooperazione Internazionale (COOPI) utilized GIS in their initiatives and advanced crowdsourcing

concepts by working with Humanitarian OpenStreetMap Team (HOT), Missing Maps and hosting mapathons (mapping events where participants collaboratively update OSM data for a chosen location). In 2016, M-Hub (https://mhubmw.com/), a technology and innovation hub, launched the Malawi Mappers initiative to improve the coverage of OpenStreetMap (OSM) by mapping unmapped roads and other features across the country.

Malawian university students also began contributing to OSM in 2016, this was facilitated by YouthMappers, a global network of student led chapter that empowers university students to contribute to the humanitarian and development mapping efforts using OpenStreetMap (OSM) and other related open-source tools [14]. Between 2015 and 2021, YouthMappers contributed 7.1 million new edits to OSM across Africa [15]. By 2018, interactions among locally based GIS experts, university students and other OSM users led to the creation of a national-wide WhatsApp group to foster knowledge exchange. The community has previously contributed towards improving OSM data by targeting mapping of physical infrastructure to potentially support humanitarian emergency response. Over time, this group evolved into an informal Community of Practice, known by its members as 'OSM Malawi' As of August 2024, the community comprised of 133 active members.

The road to Malawi's first SotM Conference

The OSM Malawi WhatsApp group has grown alongside interest for a physical gathering inform of a conference, bearing lessons from African OSM communities such as Tanzania, Uganda, Kenya, Ethiopia, and Nigeria. By 2024, members of the OSM Malawi WhatsApp group began hosting online monthly talks. To accommodate in-depth discussions, a physical conference was seen as an opportunity to strengthen local collaborations, share knowledge, and critically reflect on the state of geospatial sciences and their openness in Malawi. A committee comprising volunteers applied for an official SoTM license from the OpenStreetMap Foundation, secured financial support from the HOT (https://www.hotosm.org/opensummit23-24) and the British Council for the

conference and administrative support from the Malawi-Liverpool-Wellcome Research Programme and MUBAS. The conference was organized under the theme *“Reflecting on the growth of the Geospatial industry in Malawi and the path towards sustainable development”.* It was scheduled for two days (18-19 July 2024), with the first day dedicated to training workshops and talks on career development, while the second day was reserved for keynote speeches, panel discussions and research presentations.

Local experts led the training sessions on the first day, introducing participants to the basics of GIS analysis using QGIS, followed by advanced GIS techniques utilizing Digital Earth Africa's sandbox and Google Earth Engine. Practical sessions focused on improving OSM through hands-on training using iD Editor and Java OpenStreetMap Editor. Additionally, there was a workshop on basic research methods in Geography, offering foundational skills for data collection and analysis. A career talk facilitated by alumni of the Commonwealth Scholarships explored opportunities for postgraduate training and strategies for building impactful careers. This session was particularly valuable as most of the attendees were university students, eager to expand their academic and professional horizons.

The second day of the conference shifted towards thematic presentations, covering a diverse range of topics. Presentations were grouped into key focus areas: humanitarian emergencies; environmental management and conservation; health; urban planning and economic development; and water supply, sanitation, transportation and food security (Figure 1).

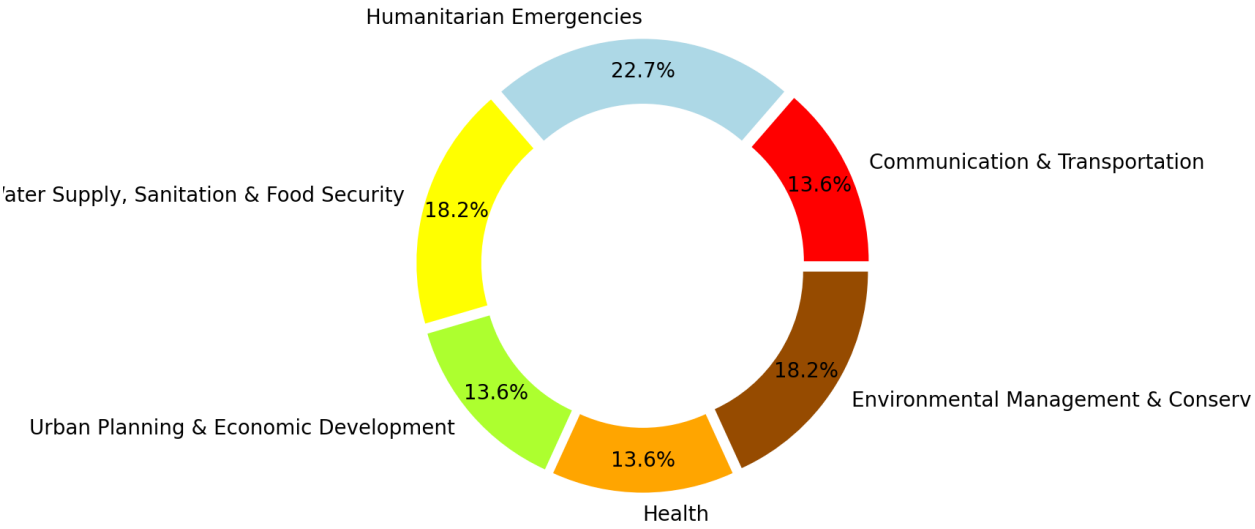

Figure 1: Distribution of the conference discussions by theme.

Overview of the GIS work presented during the SoTM

Table 1 presents a summary of the presentations delivered during the SoTM. The presentations explored GIS applications across multiple thematic areas, reflecting key societal challenges in Malawi. In the context of humanitarian emergencies and environmental management, geospatial technology has been instrumental in disaster preparedness and environmental conservation. In the past decade (2015 to 2025), Malawi experienced wide scale humanitarian emergencies emerging from tropical cyclones and storms. Presenters highlighted GIS based flood vulnerability assessments, landslide susceptibility modeling, and the use of drones for emergency response. These presentations highlighted the emerging potential impact of GIS in improving management of disasters. Similarly, environmental monitoring efforts leveraged remote sensing to track shoreline fluctuations in Lake Malawi, ecosystem service values, and waste accumulation. With the rising frequency of extreme weather events and shifting human settlement patterns, the presentations underscored the need for long-term environmental

monitoring strategies and the proactive integration of monitoring to inform immediate action.

The role of GIS in health, urban planning, and economic development was equally pronounced. Spatially referenced health data was used by presenter who identified rabies exposure hotspots and validated health facility catchment areas. This highlighted the potential of geospatial data in studying disease patterns, quantifying burdens and developing spatially targeted health interventions. Drone technology was also showcased as a tool for improving medical logistics in remote areas. In the realm of urban planning, studies mapped service deprivation and multidimensional poverty, offering insights into disparities in infrastructure and essential services. Furthermore, the concept of smart cities was explored, with discussions on digital systems for monitoring urban growth and infrastructure development. These presentations emphasized the potential of GIS in promoting equitable access to healthcare and fostering sustainable urbanization.

Water, sanitation, security, transportation, and communication infrastructure remain critical areas where GIS-driven solutions offer actionable insights. One of the presenters mapped water distribution and highlighted spatial inequities in access to clean drinking water. Another presenter highlighted the implications of meteorological water deficits on agricultural productivity. Given Malawi's heavy reliance on rainfed agriculture, the findings emphasized the importance of monitoring water availability to strengthen drought resilience. In transportation and communication, GIS applications were used to analyze road accident risk factors and optimize locations for electric vehicle charging stations. Additionally, research on mobile network signal coverage revealed the need for strategic placement of communication towers to enhance connectivity. These presentations highlight the growing importance of spatial data in enhancing infrastructure, promoting sustainability, and addressing emerging development challenges in Malawi.

Table 1: Summary of the research presentations

Theme	Presentation Topic	Presenters affiliation	Stage of Study	Key Insights	Relevance/Impact	Methodology
Humanitarian Emergencies	Flood Vulnerability Assessment	Mzuzu University	Proposal	Identifies areas vulnerable to flooding	Supports disaster risk reduction	GIS-based modeling
	Flood Infrastructure Exposure Database	Catholic University of Malawi	Proposal	Tracks infrastructure exposed to floods	Enhances flood resilience planning	Geospatial data tracking
	Drone Technology for Disaster Response	Malawi University of Science and Technology	Ongoing	Captures real-time disaster data	Strengthens emergency response	UAV & remote sensing
	Zomba Mountain Landslide Susceptibility	University of Malawi	Proposal	Identifies high-risk zones using geological data	Helps prevent infrastructure damage	Seismic frequency modeling
	Rainfall-Induced Landslide Modeling	Malawi University of Science and Technology	Proposal	Analyzes slope stability risks	Aids mitigation planning	Factor of safety approach
Environmental Management & Conservation	Lake Malawi Shoreline Changes	MUBAS Research Team	Completed	Tracks shoreline fluctuations (1993-2023)	Assesses climate & water level trends	Satellite imagery analysis
	Waste Hotspot Mapping via Drones	Wind Ride Aeros	Ongoing	Uses UAV data for waste monitoring	Supports urban waste management	Drone-based mapping
	Ecosystem Service Trends in Mzuzu City	Mzuzu University	Completed	Analyzes ecosystem changes (2001-2063)	Informs urban sustainability strategies	GIS-based trend analysis
	Geospatial Innovations for Environmental Conservation	University of Malawi	Proposal	Explores geospatial science's potential in conservation.	To ai development of a framework for technology driven conservation.	Survey and interviews with stakeholders
Health	Rabies Exposure Hotspot Mapping	Malawi Liverpool Wellcome Research Programme	Ongoing	Identifies high-risk areas	Aids targeted vaccination & public health planning	GIS-based spatial analysis
	Healthcare Accessibility & Catchment Mapping	Malawi Liverpool Wellcome Research Programme	Ongoing	Assesses patient travel times & facility catchments	Optimizes healthcare service delivery	Geospatial modeling
	Drone-Based Medical Logistics	Swoop Aero	Ongoing	Uses drones to transport medical supplies	Improves healthcare access in remote areas	UAV technology
Urban Planning & Economic Development	Urban Deprivation Dashboard	Malawi University of Science and Technology	Proposal	Explores geospatial visualisation tools for deprivation assessment	Supports data-driven urban policy	Spatial visualization tools
	Multidimensional Poverty Mapping	Mzuzu University	Proposal	Maps poverty-related deprivations	Informs targeted interventions	GIS-based analysis
	Smart Cities & Digital Urban Management	808 Computing	Proposal	Uses digital systems to track infrastructure	Enhances urban planning & governance	Spatial data & dashboard tools
Water Supply, Sanitation & Food Security	Water Kiosk Distribution Mapping	Mzuzu University	Ongoing	Evaluates clean water accessibility	Supports equitable water distribution	GIS analysis
	Meteorological Water Deficit Mapping	Malawi University of Business and Applied Sciences	Proposal	Assesses water availability for agriculture	Enhances drought preparedness	Climate & water modeling
	Drone based mapping of dam siltation	Malawi University of Business and Applied Sciences	Proposal	Quantification of dam siltation using Structure from Motion	To support management of dams, key water supply reservoirs in Malawi.	Drone-based mapping
	Water quality assessment from drone images	Malawi University of Business and Applied Sciences	Ongoing	Estimation of surface water quality from drone images	To improve water quality estimation	Drone based mapping
Communication & Transportation	Mobile Network Signal Weak Zones	Malawi University of Business and Applied Sciences	Completed	Identifies poor coverage areas	Enhances network expansion planning	Viewshed analysis
	Road Accident Risk Factors on M5 Road	Malawi University of Business and Applied Sciences	Ongoing	Analyzes road accident patterns	Supports traffic safety improvements	Spatial & speed behavior analysis
	Electric Vehicle Charging Station Site Selection	Mzuzu University	Proposal	Optimizes locations for EV infrastructure	Supports green energy transition	Multi-criteria decision analysis

Focused panel discussion

A highlight of the day was a panel discussion that explored the role of geospatial data in national development. During this session, a representative from the Malawi National Planning Commission emphasized the importance of aligning ongoing geospatial research with the Malawi National Research Agenda [16], underlining the potential for research to drive policy and planning at a national level. Furthermore, it was mentioned that Malawi Geographic Information Council (MAGIC) has been created by law which among others it is to enforce national spatial data standards, establish and maintain data access points, assist development of national spatial data infrastructure [17]. It has been argued that accessible and open spatial data infrastructure have potential to contribute towards solving the problems facing society today [18]. However, worries were raised on whether the committee would be effective. The audience of the panel discussions also argued that there are missed opportunities, particularly given how Malawi is underutilizing its growing GIS human resource despite having numerous paper-based systems that need digitization and limited GIS workforce especially at the scale of local government. They noted that the government internship program, introduced years ago, has not been structured not only to effectively tap into this talent but also to contribute towards providing necessary practical experience in using digital technology especially in the development context. This led to a suggestion for a separate discussion with the national planning commission and officials from the ministry of labor which oversees the internship program.

Positive trends and developments highlighted from the SoTM

We noted several important developments highlighting the use of GIS in Malawi. First, in terms of data capturing, the use of drone technology is worth noting. Drone imaging is known for transforming aerial surveillance especially by its ability to enable capturing of aerial imagery with high resolution enabling fine-scale monitoring. Though only few studies were presented on the use of drone technology, the existence of the African Drone and Data Academy and the Humanitarian Drone Testing Corridor has given Malawi a

unique opportunity to have the human resource and a place where new drone-based innovations can be tested. Opportunities for developing innovative drone-based solutions still exist especially in areas not limited to agriculture, disaster management and infrastructure monitoring. Additionally, the rise of private-sector involvement and the establishment of a regulatory body for geospatial activities indicate a maturing industry with increasing professionalization.

Crowdsourcing and open mapping initiatives, including mapathons, have gained popularity, contributing to the availability of up-to-date geospatial data. Most open mapping initiatives such as crowdsourcing using Humanitarian OpenStreetMap Tasking Manager as highlighted for mapping roads in Blantyre city. Such initiatives have potential to be scaled up to update OSM for the entire country. Furthermore, crowdsourcing mapping seems to be popular among university students, especially those that participated in university-based Youth Mappers chapters. Awareness of such approaches is important as these students would likely maximize the power of the crowd in their future mapping challenges.

Challenges and opportunities for growth of Malawi GIS Community

Despite these developments, the GIS community in Malawi faces persistent challenges that hinder progress. First, data sharing remains a major challenge. Although platforms like MASDAP exist, geospatial data is often siloed within organizations or held by individuals, restricting broader access and collaboration. This fragmentation reduces opportunities for developing data driven solutions to problems facing the country. Additionally, the formal integration of OSM and FOSS4G into GIS training at universities remains inadequate. Many students are introduced to these tools through external initiatives rather than academic programs, leading to a disconnect between theoretical learning and practical application. Strengthening university curricula to include these technologies could help build a more skilled workforce and advance local expertise in FOSS4G.

A lack of clear GIS research priorities further compounds these challenges. While research is being conducted, there is little consensus on the key questions GIS should address, or its alignment with national development goals. Moreover, most of the research presented overly focused on data generation. Lastly, as noted during the panel discussion, many GIS professionals and researchers continue to work in silos rather than in collaborative teams. This lack of coordination leads to duplicated efforts and missed opportunities for securing international grants and strengthening local capacity. Building GIS partnerships within the country can help create a more cohesive research and development environment.

Facing the future

While the SoTM Conference gave us the impression that there are important developments in the Malawian geospatial industry, we have come to appreciate that most of the efforts are uncoordinated, leading to missed opportunities to maximize the field's impact on development. Facing the future, we propose the formation of a technical committee to coordinate these efforts. Such a committee that can focus on clarifying research areas in the geospatial field, promoting FOSS4G development, developing and operationalizing data-sharing practices, and fostering collaborations between local experts. Creation of this committee could be facilitated by OSM Malawi or MAGIC, but it would be more impactful if the committee included representatives from government, academia, and key geospatial organizations. With this coordination in place, SoTM can serve as a 'reporting platform' for tracking progress on geospatial contributions towards addressing societal problems, sharing of latest trends in GIS and a tracker of access and absorption of geospatial technology in the country.

Acknowledgements

This research was funded in part by the Wellcome Trust through a strategic award to the Malawi-Liverpool-Wellcome Programme [grant number 206545/Z/17/Z]. For open access' sake, the author has applied a CC BY public copyright license to any author Accepted Manuscript version arising from this submission. The State of the Map Malawi Conference was supported by the Humanitarian OpenStreetMap's East and Southern Africa Hub and the Malawi British Council. The lead author is undertaking PhD studentship at Liverpool School of Tropical Medicine and the studentship is supported by the UK National Environmental Research Council (NERC) as part of the GCRF SPACES project [grant number NE/VOO5847/1].

References

[1] Rahman MdM, Szabó G. Multi-objective urban land use optimization using spatial data: A systematic review. Sustain Cities Soc 2021;74:103214. https://doi.org/10.1016/j.scs.2021.103214.

[2] Chandran A, Roy P. Applications of geographical information system and spatial analysis in Indian health research: a systematic review. BMC Health Serv Res 2024;24:1448. https://doi.org/10.1186/s12913-024-11837-9.

[3] Curtis A, Mills JW. Spatial video data collection in a post-disaster landscape: The Tuscaloosa Tornado of April 27th 2011. Appl Geogr 2012;32:393–400. https://doi.org/10.1016/j.apgeog.2011.06.002.

[4] Cho S, Yuan M. Placial analysis of events: a case study on criminological places. Cartogr Geogr Inf Sci 2019;46:547–66. https://doi.org/10.1080/15230406.2019.1578265.

[5] Haklay M, Weber P. OpenStreetMap: User-Generated Street Maps. IEEE Pervasive Comput 2008;7:12–8. https://doi.org/10.1109/MPRV.2008.80.

[6] Cortés IM. Open-source software for geospatial analysis. Nat Rev Earth Environ 2023;4:143–143. https://doi.org/10.1038/s43017-023-00401-4.

[7] Astuti HM, Ayinde LA. Uneven progress: Analyzing the factors behind digital technology adoption rates in Sub-Saharan Africa (SSA). Data Policy 2025;7:e23. https://doi.org/10.1017/dap.2024.89.

[8] Ndu CG, Shoko M. Geospatial Big Data or Big Geospatial Data: A Bibliometric Review. South Afr J Geomat 2024;13:158–71.

[9] North MA, Hastie WW, Hoyer L. Out of Africa: The underrepresentation of African authors in high-impact geoscience literature. Earth-Sci Rev 2020;208:103262. https://doi.org/10.1016/j.earscirev.2020.103262.

[10] Gwenzi W, Rzymski P. When silence goes viral, Africa sneezes! A perspective on Africa's subdued research response to COVID-19 and a call for local scientific evidence. Environ Res 2021;194:110637. https://doi.org/10.1016/j.envres.2020.110637.

[11] Nakweya G. How visa rejections are stalling Africa's health research. Nat Afr 2024. https://doi.org/10.1038/d44148-024-00349-7.

[12] Velin L, Lartigue J-W, Johnson SA, Zorigtbaatar A, Kanmounye US, Truche P, et al. Conference equity in global health: a systematic review of factors impacting LMIC representation at global health conferences. BMJ Glob Health 2021;6. https://doi.org/10.1136/bmjgh-2020-003455.

[13] UNICEF. The African Drone and Data Academy n.d. https://www.unicef.org/innovation/AfricanDroneAcademy (accessed February 27, 2025).

[14] Solís P, Rajagopalan S, Villa L, Mohiuddin MB, Boateng E, Wavamunno Nakacwa S, et al. Digital humanitarians for the Sustainable Development Goals: YouthMappers as a hybrid movement. J Geogr High Educ 2020;46:80–100. https://doi.org/10.1080/03098265.2020.1849067.

[15] Boateng ENK, Manyungwa Z, Anderson J. Assessing YouthMappers Contributions to the Generation of Open Geospatial Data in Africa. In: Solís P, Zeballos M, editors. Open Mapp. Sustain. Dev. Goals Voices YouthMappers Community

Engaged Scholarsh., Cham: Springer International Publishing; 2023, p. 171–9. https://doi.org/10.1007/978-3-031-05182-1_15.
[16] Malawi Government. National Research Agenda Operationalizing the Malawi 2063 First 10-year Implementation Plan (MIP-1) 2023.
[17] Malawi Government. Land Survey Act. 2017.
[18] Dangermond J, Goodchild MF. Building geospatial infrastructure. Geo-Spat Inf Sci 2020;23:1–9. https://doi.org/10.1080/10095020.2019.1698274.